THE WORLD LEADER IN CLEAN AIR SOLUTIONS

PREpleat® M13
(MERV 13)



EXTENDED SURFACE PLEATED PANEL FILTERS

- High efficiency with low initial resistance
- 100% synthetic recyclable high-loft media
- 2-piece heavy-duty die-cut frame
- Expanded metal backing
- Double-wall frame
- Diagonal grid supports for maximum strength
- MERV 13

The PREpleat M13 pleated filter has a low initial resistance and supports achievement of LEED® credits by significantly improving Indoor Air Quality (IAQ) and reducing energy consumption.

The PREpleat M13 filter provides an initial efficiency of MERV 13 per ASHRAE Standard 52.2 at a resistance of only .20″ w.g. (2″ depth) when operating at airflow velocity of 375 FPM—and only 0.30″ at 500 FPM.

Superior Design and Construction

Media: 100% non-woven synthetic media manufactured from recyclable material.

Media Support: Diamond-shaped expanded metal maintains maximum support while avoiding air bypass.

Pleat Design: V-Pleat design minimizes resistance, keeping consistent pleat count, height, and shape.

Frame: Heavy-duty two-piece moisture-resistant frame includes diagonal and horizontal support members bonded to the media on the air entering and leaving sides. This is a durable frame for any commercial and industrial application.

Operating Temperature Limits: Maximum operating temperature is 180°F (82°C).

Applications

PREpleat M13 filters are designed for general air filtration in all types of cooling, heating, and ventilating systems. They can be used as prefilters to extend the life of higher efficiency filters or on their own. They are suitable for installation in front access holding frames and side access housings. These filters are excellent for upgrading from disposable panel filters, permanent filters, or media pads in metal frames where a higher level of cleaning is desired.

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PREpleat® M13 Filters

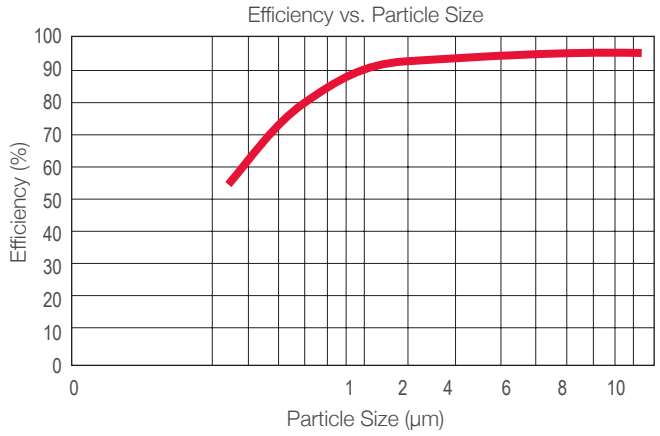
Performance Data

Filter	Pleats Per Linear Foot	Rated Initial Resistance (in. w.g.) 300 FPM	Rated Initial Resistance (in. w.g.) 500 FPM	Recommended Final Resistance (in. w.g.)	ASHRAE 52.2 MERV	Continuous Operating Temperature Limits
1″ PREpleat M13	15	.25	–	1.0	13	180°F (82°C)
2″ PREpleat M13	15	.16	.30	1.0	13	180°F (82°C)
4″ PREpleat M13	9	.10	.20	1.0	13	180°F (82°C)

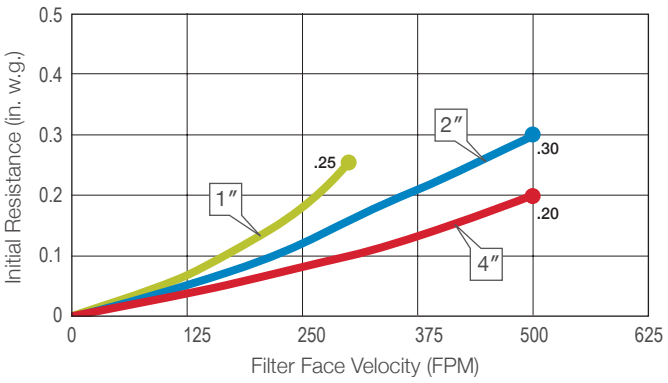
All performance data based on ASHRAE Standard 52.2. Performance tolerance conforms to Section 6.4 of ANSI/AHRI Standard 850-2013.

***Underwriters Laboratories Classification** – PREpleat M13 filters are UL Classified. Testing was performed according to UL Standard 900.*

Composite Minimum Efficiency Curve



Initial Resistance vs. Filter Face Velocity



Energy savings may be realized by operating the PREpleat M13 filters to a lower final resistance. Contact your local AAF Flanders representative for a Total Cost of Ownership analysis for your specific application.

Product Information – Standard Sizes

Nominal Sizes (Inches) (W x H x D)	Actual Sizes (Inches) (W x H x D)	Rated Airflow (SCFM) 300 FPM	500 FPM	625 FPM	Pleats Per Filter	Gross Media Area (sq. ft.)
10 x 20 x 1	9½ x 19½ x ¾	400	700	–	12	2.7
12 x 20 x 1	11½ x 19½ x ¾	500	850	–	14	3.1
12 x 24 x 1	11⅜ x 23⅜ x ¾	600	1000	–	14	3.7
14 x 20 x 1	13½ x 19½ x ¾	600	950	–	17	3.7
14 x 25 x 1	13½ x 24½ x ¾	750	1200	–	17	4.6
15 x 20 x 1	14½ x 19½ x ¾	650	1050	–	18	3.9
16 x 20 x 1	15½ x 19½ x ¾	650	1100	–	19	4.1
16 x 24 x 1	15½ x 23½ x ¾	800	1350	–	19	4.9
16 x 25 x 1	15½ x 24½ x ¾	850	1400	–	19	5.2
18 x 20 x 1	17½ x 19½ x ¾	750	1250	–	22	4.7
18 x 24 x 1	17½ x 23½ x ¾	900	1500	–	22	5.7
18 x 25 x 1	17½ x 24½ ¾	950	1550	–	22	5.9
20 x 20 x 1	19½ x 19½ ¾	850	1400	–	24	5.1
20 x 24 x 1	19½ x 23½ x ¾	1000	1650	–	24	6.2
20 x 25 x 1	19½ x 24½ x ¾	1050	1750	–	24	6.4
24 x 24 x 1	23⅜ x 23⅜ x ¾	1200	2000	–	29	7.4
25 x 25 x 1	24½ x 24½ x ¾	1300	2150	–	31	8.3
10 x 20 x 2	9½ x 19½ x 1¾	400	700	850	12	6.1
12 x 20 x 2	11½ x 19½ x 1¾	500	850	1050	14	7.3
12 x 24 x 2	11⅜ x 23⅜ x 1¾	600	1000	1250	14	8.8
14 x 20 x 2	13½ x 19½ x 1¾	600	950	1150	17	8.5
14 x 25 x 2	13½ x 24½ x 1¾	750	1200	1500	17	10.6
15 x 20 x 2	14½ x 19½ x 1¾	650	1050	1300	18	9.1
16 x 20 x 2	15½ x 19½ x 1¾	650	1100	1400	19	9.7
16 x 24 x 2	15½ x 23½ x 1¾	800	1350	1650	19	11.2
16 x 25 x 2	15½ x 24½ x 1¾	850	1400	1750	19	12.2
18 x 20 x 2	17½ x 19½ x 1¾	750	1250	1500	22	10.9
18 x 24 x 2	17½ x 23½ x 1¾	900	1500	1875	22	13.1
18 x 25 x 2	17½ x 24½ x 1¾	950	1550	1950	22	13.7
20 x 20 x 2	19½ x 19½ x 1¾	850	1400	1750	24	12.2
20 x 24 x 2	19½ x 23½ x 1¾	1000	1650	2100	24	14.6
20 x 25 x 2	19½ x 24½ x 1¾	1050	1750	2150	24	15.2
24 x 24 x 2	23⅜ x 23⅜ x 1¾	1200	2000	2500	29	17.5
25 x 25 x 2	24½ x 24½ x 1¾	1300	2150	2700	31	19.0
12 x 24 x 4	11⅜ x 23⅜ x 3¾	600	1000	1250	9	11.3
16 x 20 x 4	15½ x 19½ x 3¾	650	1100	1400	12	12.5
16 x 25 x 4	15½ x 24½ x 3¾	850	1400	1750	12	15.6
18 x 24 x 4	17½ x 23½ x 3¾	900	1500	1875	14	17.5
20 x 20 x 4	19½ x 19½ x 3¾	850	1400	1750	15	15.6
20 x 24 x 4	19½ x 23½ x 3¾	1000	1650	2100	15	18.8
20 x 25 x 4	19½ x 24½ x 3¾	1050	1750	2150	15	19.6
24 x 24 x 4	23⅜ x 23⅜ x 3¾	1200	2000	2500	18	22.6
28 x 30 x 4	27½ x 29½ x 3¾	1750	2900	–	21	32.6

PREpleat® is a registered trademark of Flanders Corporation in the U.S.

AAF Flanders®

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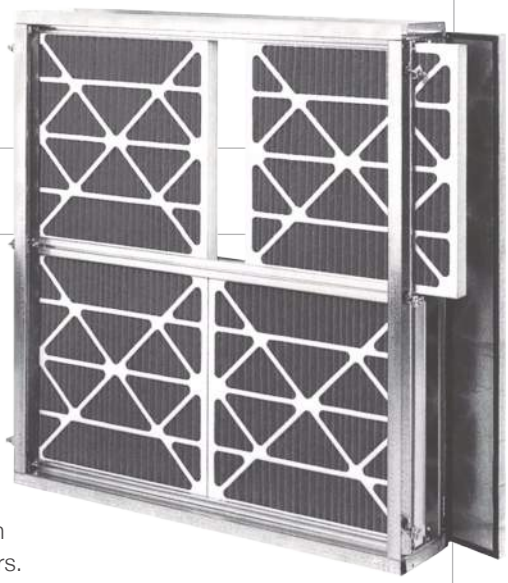
ISO Certified Firm

AFP–1–384 01/17

THE WORLD LEADER IN CLEAN AIR SOLUTIONS

SurePleat™

SIDE ACCESS FILTER HOUSINGS



- Units are constructed of durable 16-gauge galvanized steel
- "Z" channel support members reinforce all four corners
- All tracks and doors are fully gasketed
- Holding frames or fasteners are not required

SurePleat side access filter housings are minimum depth units designed to accommodate ASHRAE rated filters that are 2″ (standard), 4″, or 6″ (optional) in depth. They are factory assembled flanged units suitable for installation in a duct or next to an air handling unit. As little as 12″ of inline depth are required with no need for holding frames or fasteners.

SurePleat housings accommodate filters of different types and efficiencies up to 95% per ASHRAE Standard 52.1 dust spot test methods and ASHRAE 52.2 Test Standards. Filters are easily serviced through quick-opening access doors. Factory-gasketed channels and doors ensure positive sealing. The efficiency of fully-loaded housings is equal to that of the individual filters.

Versatility

Both prefilter and final filter requirements can be accomplished by using the combination 2″/4″ track. SurePleat housings are available in a wide range of sizes, up to 8 feet high and 12 feet wide. They can operate at face velocities up to 625 FPM with 4″ filters.

Options

- Double-walled insulation on doors only or on entire housing
- Drain tubes for moisture separators
- Flanges to connect with air handlers
- 1″ wide track for 6″ headered filters
- 4″ track
- Aluminum or 304 stainless steel construction

Construction

Housings are constructed of 16-gauge galvanized steel with upstream and downstream outwardly turned flanges. Units include "Z" channel vertical support members on all four corners.

Filter tracks are extruded aluminum and are gasketed with replaceable polypropylene pile air seals. Housings are equipped with two access doors that are sealed with neoprene gasketing on the perimeter. Doors are equipped with 1½″ positive sealing knobs made of UV-resistant plastic with corrosion resistant brass inserts. Construction of the top pan allows rainwater to drain off easily, so that additional weather proofing is rarely required.

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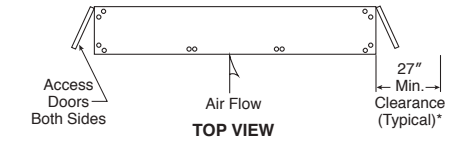
SurePleat™ Side Access Filter Housings

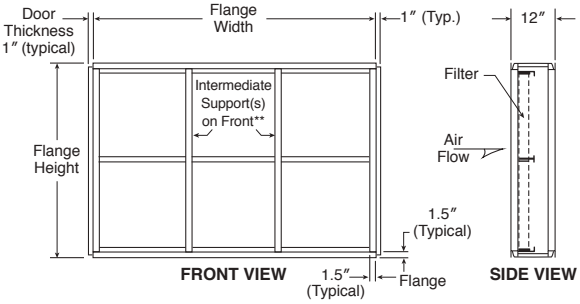
Performance Data

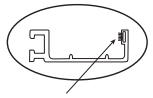
Height Code	Overall Flange Height (inches)	Face Velocity (FPM)	CFM Capacities and Dimensions										
			Width Code										
			10W	15W	20W	25W	30W	35W	40W	45W	50W	55W	60W
			Overall Flange Width										
			23⅜	34¾	46¾	58⅛	70⅛	81½	93½	104⅞	116⅞	128¼	140¾
05H	15	375	750	–	1500	–	2250	–	3000	–	–	–	–
		500	1000	–	2000	–	3000	–	4000	–	–	–	–
		625	1250	–	2500	–	3750	–	5000	–	–	–	–
10H	27	375	1500	2250	3000	3750	4500	5250	6000	6750	7500	8250	9000
		500	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000
		625	2500	3750	5000	6250	7500	8750	10000	11250	12500	13750	15000
15H	39	375	2250	–	4500	–	6750	–	9000	–	11250	–	13500
		500	3000	–	6000	–	9000	–	12000	–	15000	–	18000
		625	3750	–	7500	–	11250	–	15000	–	18750	–	22500
20H	51	375	3000	4500	6000	7500	9000	10500	12000	13500	15000	16500	18000
		500	4000	6000	8000	10000	12000	14000	16000	18000	20000	22000	24000
		625	5000	7500	10000	12500	15000	17500	20000	22500	25000	27500	30000
25H	62-7/8	375	3750	–	7500	–	11250	–	15000	–	18750	–	22500
		500	5000	–	10000	–	15000	–	20000	–	25000	–	30000
		625	6250	–	12500	–	18750	–	25000	–	27500	–	37500
30H	74-7/8	375	4500	6750	9000	11250	13500	15750	18000	20250	22500	24750	27000
		500	6000	9000	12000	15000	18000	21000	24000	27000	30000	33000	36000
		625	7500	11250	15000	18750	22500	26250	30000	33750	43750	41250	45000
35H	86-7/8	375	5250	–	10500	–	15750	–	21000	–	26250	–	31500
		500	7000	–	14000	–	21000	–	28000	–	35000	–	42000
		625	8750	–	17500	–	26250	–	35000	–	43750	–	52500
40H	98-7/8	375	6000	9000	12000	15000	18000	21000	24000	27000	30000	33000	36000
		500	8000	12000	16000	20000	24000	28000	32000	36000	40000	44000	48000
		625	10000	15000	20000	25000	30000	35000	40000	45000	50000	55000	60000

1. *Height and width code: The first numeral represents the number of 24″ x 24″ filters high or wide. If 24″ x 12″ filters are also used in the height or width, the second numeral is "5".*
2. *Dimensions are based on using nominal size 24″ x 24″ and 24″ x 12″ filters. Select filters from capacity chart for 2″ disposable filters; 2″ or 4″ PREpleat® filters; 6″ RAH RigidAir™; or 4″ PrecisionCell® mini-pleat filters.*
3. *For capacities other than those shown, ratio the face velocities.*
4. *Maximum recommended velocities: 2″ disposable filters, 300 FPM; 2″ pleated filters, 500 FPM; 4″ pleated filters, 625 FPM; 4″ PrecisionCell® filters, 625 FPM 6″ Rigid-Air™ and PrecisionCell® filters – see applicable capacity chart.*

Construction details






Typical Extruded Aluminum Filter Track with Polypropylene Seal Gasket

**Allow 27″ minimum clearance on one or preferably both sides for filter installations.*

***Intermediate supports furnished on housings over 4 ft. wide.*

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Inline Fans Options

Featuring TD-MIXVENT/TD-SILENT





Advancing Ventilation

The World's Leading Producer of Air Movement Products

Soler&Palau Ventilation Group

TD_0319
March 2019

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Overview TD-MIXVENT & TD-SILENT Series

Compact Size-TD Fans require minimum space

The S&P TD-MIXVENT & TD-SILENT series of in-line duct fans have been specially designed to maximize the airflow performance with minimal noise levels within the smallest and most compact of housing sizes. This makes the TD-MIXVENT & TD-SILENT series the ultimate solution for small to medium sized ventilation installations which require a high airflow to pressure ratio and occupy only the minimum space possible. Example: false ceiling voids, cabinets and many other limited space environments.

Easy to Install...fit and forget!

All the models in the TD-MIXVENT & TD-SILENT range have been designed with the professional contractor/ engineer in mind. All models include a “removable body” feature that enables the motor-impeller assembly to be completely removed or replaced without the need to interfere with the attached ducting.



Internal parts can be easily removed for mounting & servicing

Multitude of features-high specification

All models within the TD-MIXVENT & TD-SILENT range incorporate a powerful mixed flow impeller and internal air vanes located at the discharge end of the fan housing. This impeller and guide vane combination provides a smooth laminar air flow which in turn minimizes turbulence and noise, and generates an **excellent air flow to pressure performance ratio.**

Description

All of the TD-fans include the combination of a powerful motor, factory installed, to a mixed flow impeller. This motor and impeller combination enables the TD-fans to deliver high airflow performances with minimum noise generation against high static pressures typically found in ducted ventilation systems. The unique design of the support brackets, allows the motor and impeller assembly to be fitted or removed without dismantling the adjacent ducting and therefore, facilitating any installation or maintenance. The internal aerodynamic design of the TD-MIXVENT & TD-SILENT fans enable the units to generate large air volumes and pressures with the minimum of in-duct or radiated noise. The TD-fans offer the ideal in-line duct fan solution for a wide range of HVAC ventilation applications.

TD-MIXVENT & TD-SILENT Practical Installations

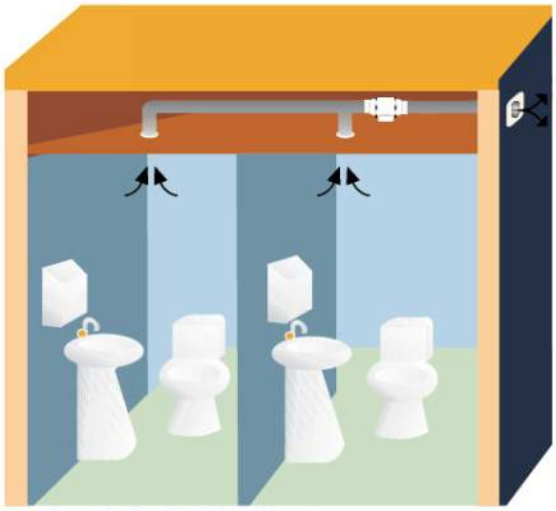
The TD-MIXVENT & TD-SILENT system offers the most versatile installation range on the market, as a result of its multiple combinations; it can be used in a large number of small and mid-range ventilation installations.



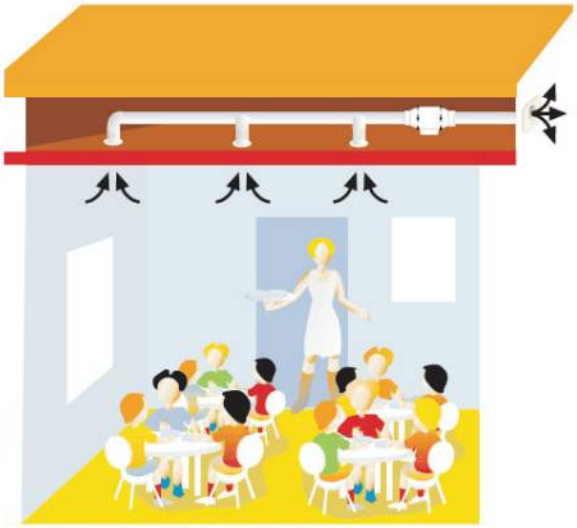
Domestic - Range Hood Exhaust



Commercial - Office



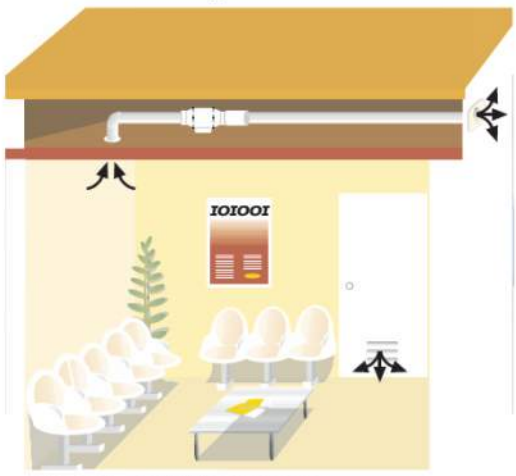
Industrial - Public Restroom



School - Dining Hall



Industrial - Locker Room



Health - Waiting Room

General Details of the TD-MIXVENT Range

S&P Exclusive Product



Low profile mixed flow fans, manufactured in plastic material (up to model 200) or in **galvanized steel** sheet protected with Epoxy paint (models 200, 250, 315, 355, and 400), with external terminal box, removable motor-impeller assembly and adjustable single-phase motor, Class B, IP44.



Construction characteristics

	100	100x1	125	150	200	250	315	355	400
Polypropylene housing	•	•	•	•	•				
Steel housing with epoxy coating						•	•	•	•
ABS fan blades	•	•	•	•	•				
Aluminum fan blades						•	•	•	•
Thermal link via fuse	•								
Thermal link with automatic reset		•	•	•	•	•	•	•	•
Permanently lubricated ball bearings	•	•	•	•	•	•	•	•	•

The extensive range of the TD-MIXVENT series makes it an effective solution for a wide range of residential and light commercial ventilation installations.

TD-MIXVENT Installation & Maintenance

Low Profile



The low profile of the fans in the TD-MIXVENT range makes them the ideal product for installations with low height limits, such as the case of suspended ceilings.

Easy to Install

1



Secure the support.

2



Make the connections.

3



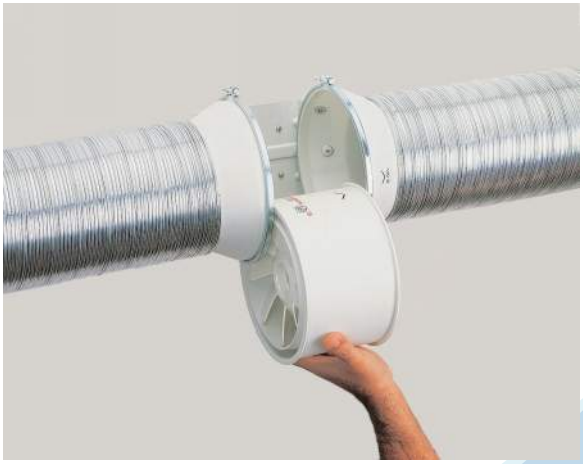
Connect the ducts.

Flexibility in Location



The fans can be connected at any point along the ventilation duct: along the duct or at the end.

Easy Maintenance



Removable body, for repair or cleaning, **without the need to touch the ducts.**

HVI CERTIFIED 2100

TD-MIXVENT Technical Specifications



Warranty
Five (5) year limited warranty.

Range
The TD-MIXVENT series consists of nine (9) nominal sized in-line fans. All models are specifically designed for direct connection in-line with industry standard diameter round ducting.

Construction
The TD-MIXVENT models 100, 100X1, 125, 150, and 200 are manufactured in tough reinforced plastic, models 250, 315, 355, and 400 have a metal casing and are finished in a tough epoxy-polyester paint coating. The TD fan duct connection flanges are manufactured from reinforced plastic, except for models 200, 250, 315, 355, and 400 which are constructed from epoxy-polyester coated metal.

Impellers
The impeller blades for models 100, 100X1, 125, 150, and 200 are molded in tough ABS plastic. Models 200, 250, 315, 355, and 400 are metal.

Long Life
Permanently lubricated motors are engineered for trouble-free continuous operation for 40,000 hours.

Motors
Models 100, 100X1 and 125 :
- Single-phase, 120V 60Hz, shaded pole (model 100), or permanent split capacitor (models 100X and 125). All motors include direct single speed connection and are also suitable for voltage speed control.
- Class ll electrical insulation (model 100) & Class l (models 100X1 and 125)
- IP 44 Protection
- Safety auto reset Thermal Overload Protection (fuse type)
- Self-lubricating sleeve bearings.
- Sizes 100-125: Suitable for working airstreams up to 104° F (40C)

Models 150, 200, 250, 315, 355, and 400:
- Single-phase induction asynchronous motor, with permanent capacitor and external rotor constructed of die cast aluminum. Models 150, 200, 355 and 400 feature single speed, fully speed controllable motors. Models 250 and 315 include direct dual speed (LS/HS) connection motors and are also suitable for voltage speed control.
- Class I electrical insulation
- IP 44 Protection
- Thermal Overload Protection
- Sealed For Life, ball bearings
- Size 200: Suitable for working airstreams up to 104 deg F (40C)
- Sizes 150, 250-400: Suitable for working airstreams up to 140 deg F (60C)

Performance characteristics

Models 250 and 315 include a direct single speed motor connection.

Model	Nom. RPM	Volts	Max. Watts	Speed	CFM v Static Pressure (SP) Ins. WG							Max. SP	Max operating temp. (ºF)	Wgt. (lbs)	Duct Dia. Ins.
					0"	0.125"	0.25"	0.375"	0.5"	0.75"	1.0"				
TD-100	2516	120	26	-	101	85	57	-	-	-	-	.4	104	4	4"
TD-100x1	2500	120	29	-	138	119	96	66	21	-	-	.45	104	6	4"
TD-125	2146	120	38	-	197	168	133	86	22	-	-	.55	104	6	5"
TD-150	2289	120	65	-	293	273	250	227	206	131	35	1.15	140	9	6"
TD-200	2781	120	184	-	538	495	458	418	367	190	10	1.625	104	13	8"
TD-250	2400	120	162	LS	541	475	418	355	295	218	170	2.03	140	21	10"
	3200	120	241	HS	754	715	680	640	606	520	405	2.53	140	21	10"
TD-315	2000	120	208	LS	751	670	545	420	285	190	130	1.62	140	31	12.4"
	2500	120	335	HS	1050	990	932	850	770	600	420	2.95	140	31	12.4"
TD-355	1536	120	522	-	2089	2013	1934	1855	1775	1591	1306	1.0	140	68	14"
TD-400	1559	120	916	-	3124	3032	2936	2836	2733	2505	2210	1.2	140	78	16"

Performance certified is for installation Type D: Ducted Inlet, Ducted Outlet. Performance ratings do not include the effects of appurtenances.

LS= Low Speed
HS = High Speed

S&P USA Ventilation Systems, LLC. certifies that all TD fan sizes shown herein are licensed to bear the AMCA Seal. The ratings shown are based on tests and procedures performed in accordance with AMCA Publication 211 and comply with the requirements of the AMCA Certified Ratings Program.

TD-100x1, TD-125, 150, and 200 are ENERGY STAR® qualified.

The TD-MIXVENT Models 100, 100x1 and 150 are California Title 24 compliant and meet ASHRAE 62.2 when installed with a CVC and other TD models are compliant when installed with a 3 way switch and remotely mounted speed control.

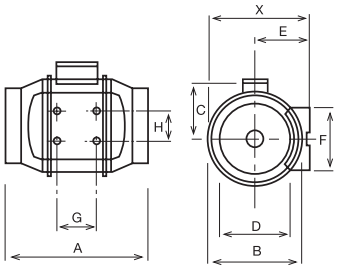
TD 250 & 315 are UL listed for outdoor use.

Sound characteristics

Fan sound levels are measured in sones. At this time there are no sone level test standards available through HVI due to the fact that remote mounted fan noise levels are in proportion to the following: type of duct, length of duct, fan distance from the intake source and other miscellaneous factors. However, it is generally accepted that remote mounted venting is usually quieter than standard (in room) venting.

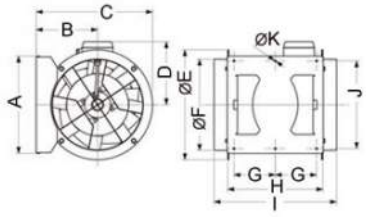
Dimensions (inches/mm)

Models 100-315



Model	X	A	B	C	D	E	F	G	H
TD-100	5 15/16 151	9 1/8 232	5 7/16 138	3 3/4 96	3 7/8 98	3 1/4 82	3 3/4 95	1 7/8 48	2 1/16 52
TD-100x1	7 3/8 188	11 15/16 303	6 15/16 176	4 1/2 115	3 13/16 97	3 15/16 100	3 9/16 90	3 1/8 80	2 3/8 60
TD-125	7 3/8 188	10 3/16 258	6 15/16 176	4 1/2 115	4 13/16 123	3 15/16 100	3 9/16 90	3 1/8 80	2 3/8 60
TD-150	8 3/8 212	11 5/8 295	7 7/8 200	5 127	5 13/16 147	4 7/16 112	5 1/8 130	3 1/8 80	2 3/8 60
TD-200	9 3/16 233	11 7/8 302	8 9/16 217	5 9/16 141	7 13/16 198	4 7/8 124	5 1/2 140	3 15/16 100	3 11/16 94
TD-250	11 7/16 291	15 3/16 386	10 11/16 272	7 9/16 192	9 3/4 248	6 1/8 155	6 5/8 168	5 11/16 145	5 1/2 140
TD-315	14 356	17 11/16 450	13 1/4 336	8 13/16 224	12 5/16 312	7 3/8 188	8 1/4 210	7 3/16 182	7 178

Models 355 - 400



Model	A	B	C	D	E	F	G	H	I	J	K
TD-355	14 13/16 376	9 3/8 238	17 3/4 451	8 13/16 224	16 3/4 425	13 15/16 354	6 5/16 160	14 1/2 368	18 11/16 475	13 3/8 340	5/16 8
TD-400	16 407	9 13/16 249	19 3/8 492	10 1/2 267	19 3/16 487	15 11/16 398	6 5/16 160	16 3/4 425	21 1/2 546	14 9/16 370	5/16 8

TD-MIXVENT KIT Bathroom Kits

If the strongest, quietest, bathroom exhaust system is what you seek…look no further. S&P offers the perfect solution with the most options. The TD-MIXVENT fan kits provide all the hardware needed to complete a simple in-line ducted ventilation installation. The kit includes a powerful TD in-line fan and exterior and interior grilles (with or without lights). Available in both Standard Exhaust Kits, for venting a single location, and Deluxe Exhaust Kits, for venting multiple locations with one fan.

The TD-MIXVENT fan kit is the ideal solution for any simple in-line ducted fan installation.
All TD kits have standard 7-year warranty.

Standard Exhaust Kits



KIT-TD100
- 1 TD100 exhaust fan
- 1 plastic round grille (PG-100)
- 1 exterior louvered grille (PER-100W)
- Integral mounting bracket

KIT-TD100x1
- 1 TD100x1 exhaust fan
- 1 plastic round grille (PG-100)
- 1 exterior louvered grille (PER-100W)
- Integral mounting bracket

KIT-TD150
- 1 TD150 exhaust fan
- 1 plastic round grille (PG-150)
- 1 exterior louvered grille (PER-150W)
- Integral mounting bracket

Deluxe Exhaust Kits



KIT-TD150-DV
- 1 TD150 exhaust fan
- 2 plastic round grilles (PG-150)
- 1 exterior louvered grille (PER-150W)
- 1 Y-fitting (SY-6)
- Integral mounting bracket

IMPORTANT: If venting in an non-insulated attic space, or in a cold climate, insulated flexible duct is strongly recommended for condensation issues.

Lighted Standard Exhaust Kits



KIT-TD100X1L
- 1 TD100x1 exhaust fan
- 1 Vent Light with LED Bulb (VLED-100)
- Integral mounting bracket

KIT-TD100X1H
- 1 TD100x1 exhaust fan
- 1 Vent Light with Halogen Bulb (VLH-100)
- Integral mounting bracket

KIT-TD100X1F
- 1 TD100x1 exhaust fan
- 1 Vent Light with Fluorescent Bulb (VLF-100)
- Integral mounting bracket

Lighted Deluxe Exhaust Kits



KIT-TD150L
- 1 TD150 exhaust fan
- 2 Vent Lights with LED Bulb (VLED-100)
- 1 Y-fitting (SY44-6)
- Integral mounting bracket

KIT-TD150H
- 1 TD150 exhaust fan
- 2 Vent Lights with Halogen Bulb (VLH-100)
- 1 Y-fitting (SY44-6)
- Integral mounting bracket

KIT-TD150F
- 1 TD150 exhaust fan
- 2 Vent Lights with Fluorescent Bulb (VLF-100)
- 1 Y-fitting (SY44-6)
- Integral mounting bracket

General Details of the TD-SILENT Range

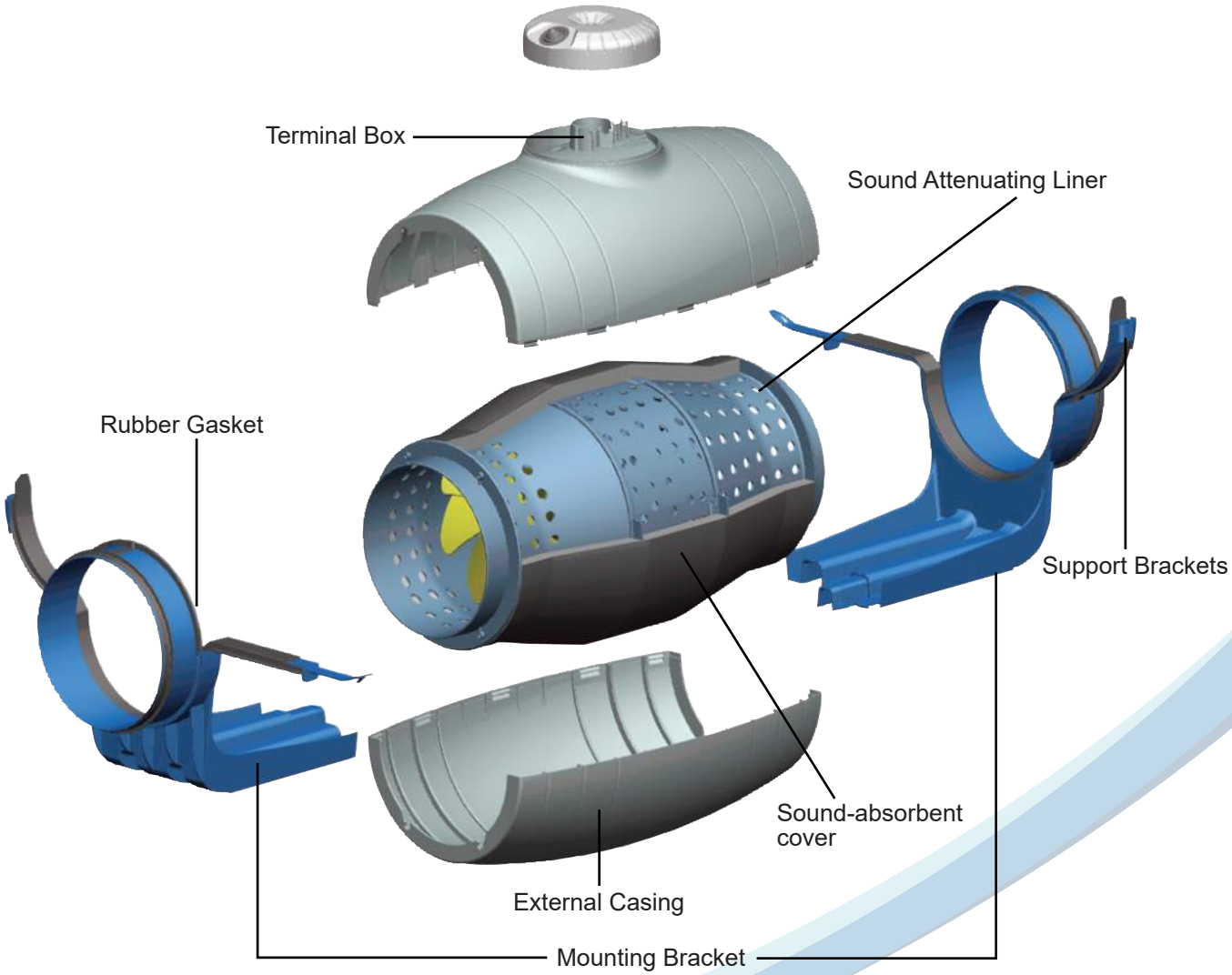
S&P Exclusive Product



As the name suggests these fans are extremely quiet, low profile “Mixed-flow” fans. Manufactured in plastic material with an external connection box, the body is easily dismantled with a full speed controllable, single speed motor. Sound waves are directed through the perforated inner skin and absorbed by a layer of sound-absorbent insulation. Plus the TD-SILENT is fitted with rubber gaskets on the inlet and outlet to absorb vibrations.

Construction characteristics

	125XS	150S	200S
Polypropylene housing	•	•	•
ABS fan blades	•	•	•
Thermal link with automatic reset	•	•	•
Permanently lubricated ball bearings	•	•	•



TD-SILENT Innovative Design Features

Low Profile



The low profile of the fans in the TD-SILENT range makes them the ideal product for installations with low height limits, such as the case of suspended ceilings.

Low Noise Levels



Sound waves produced inside the TD, are directed through the perforated inner skin and absorbed by the layer of sound-absorbent material.

Easy Maintenance



Bi-material support brackets, which in addition to simplifying installation, serve as joint seals.

Connection Box Rotates 360°



Connection box can be rotated 360º, to facilitate easy connection of the power cable.

Duct Air-Seals



Bi-material inlet and outlet incorporating a flexible washer to facilitate installation, absorb vibrations and provide a virtually **air-tight** seal.

Integral Mounting Bracket



Mounting bracket for installing on a wall or ceiling, incorporating twin-material support brackets for the motor section that absorbs vibration.

TD-SILENT Easy Installation

1



Loosen the clamps.

2



Open the clamps on both ends.

3



Remove the fan body.

4



Remove the terminal box lid.

5



Connect electrical supply.

6



Re-mount fan body by tightening the clamps.

TD-SILENT Technical Specifications



Warranty
Five (5) year limited warranty.

Range
The TD-SILENT consists of three (3) nominal sized in-line fans. All models are specifically designed for direct connection in-line with industry standard diameter round ducting.

Construction
The TD-SILENT models 125XS, 150S and 200S are manufactured in tough reinforced plastic. Sound waves are directed through the perforated inner skin and absorbed by a layer of sound-absorbent insulation. Plus the TD-SILENT is fitted with rubber gaskets on the inlet and outlet to absorb vibrations.

Long Life
Permanently lubricated motors are engineered for trouble-free continuous operation for 40,000 hours.

Impellers
The impeller blades are molded in tough ABS plastic.

Motors
Models 125XS:
Single-phase, 120V 60Hz, shaded pole induction asynchronous motor in die cast aluminum. All motors include direct single speed connection and are also suitable for voltage speed control.

- Class I electrical insulation
- IP 44 Protection
- Safety auto reset Thermal Overload Protection (fuse type)
- Self-lubricating sleeve bearings.
- Suitable for working airstreams up to 104 deg F (40°C)

Models 150S and 200S:
Single-phase induction asynchronous motor, with permanent capacitor and external rotor in die cast aluminum. All models include direct single speed connection and are also suitable for voltage speed control.

- Suitable for working airstreams up to 140° F (60°C).
- Class I electrical insulation
- IP 44 Protection
- Thermal Overload Protection
- Sealed For Life, ball bearings
- Sizes 200S: Suitable for working airstreams up to 104° F (40°C)
- Sizes 150S: Suitable for working airstreams up to 140° F (60°C)

Code Approval

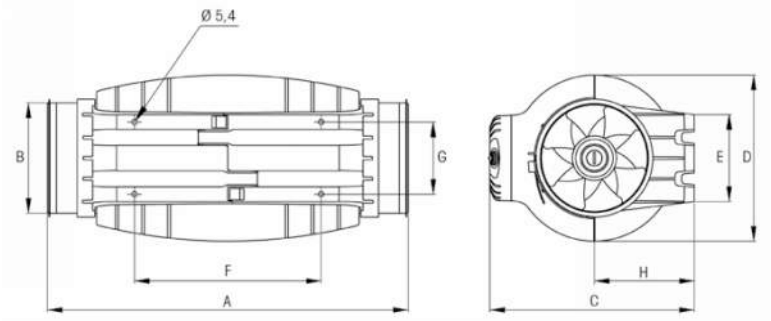
- All models have been independently safety tested by Underwriters Laboratories, Inc. and are UL and cUL Listed.
- Independently tested for Airflow Performance.
- The TD product range is certified by the Home Ventilating Institute (HVI) for Air Performance.
- All models are ENERGY STAR® qualified.

Air Performance

Model	Duct Dia. Ins.	Nom. RPM	Volts	Max. Watts	CFM v Static Pressure (SP) Ins. WG							Max. SP	Max operating temp. (ºF)	Wgt. (lbs)
					0”	0.125”	0.25”	0.375”	0.5”	0.75”	1.0”			
TD-125XS	5”	2500	120	36	203	175	138	84	33	-	-	0.6	104	11.9
TD-150S	6”	2700	120	65	333	315	286	271	257	178	77	1.2	140	13.2
TD-200S	8”	2200	120	122	530	503	472	443	415	349	204	1.2	140	19.2

The TD-SILENT Models 125XS and 150S are California Title 24 compliant and meet ASHRAE 62.2 when installed with a CVC and other TD models are compliant when installed with a 3 way switch and remotely mounted speed control.

Dimensions (inches)



Model	A	B Ø	C	D Ø	E	F	G	H
TD-125XS	22 5/8	3 13/16	9 15/16	8 1/16	3 15/16	9 13/16	3 1/4	4 3/4
TD-150S	19 1/16	5 13/16	10 13/16	8 11/16	4 9/16	9 13/16	3 3/4	5 1/4
TD-200S	22 3/8	7 13/16	12 7/8	10 3/8	5 11/16	13 3/8	5 1/16	6 7/16

TD-MIXVENT & TD-SILENT Accessories

FT622 - ASHRAE 62.2 Bath Fan Ventilation Control



The FT622 is designed to replace bathroom fan and light switches and provide both functions with one easy operation. The FT622 delivers a precise amount of ventilation, and is a simple solution to meet ASHRAE 62.2 in conjunction with an S&P fan.

FT247 - Programmable Fan Timer



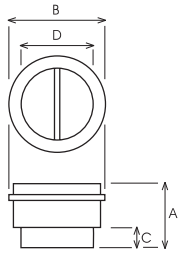
S&P offers the FT247 with easy programming for your bathroom fan ventilation needs. Simply set what time you want the fan to turn on and off and what day or days you want the fan to run.



MCA
Backdraft dampers are installed at the fans' discharge. They prevent the entry of odors, air currents and prevent heat leaks when the exhauster is not in operation.

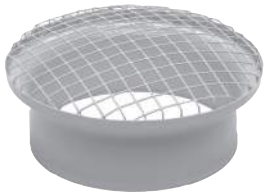
Model	Type TD
MCA-100	100
MCA-125	125
MCA-150	150
MCA-200	200
MCA-250	250
MCA-315	315

Dimensions (inches/mm)



MCA-100-315

Model	A	B	C	D
MCA-100	4 3/16 / 107	4 3/8 / 111	1 1/4 / 31	3 11/16 / 94
MCA-125	4 3/16 / 107	5 3/8 / 136	1 1/4 / 31	4 11/16 / 119
MCA-150	4 3/4 / 121	6 7/16 / 163	1 3/8 / 35	5 13/16 / 147
MCA-200	5 3/16 / 131	8 7/16 / 214	1 3/8 / 35	7 3/4 / 197
MCA-250	6 3/16 / 164	10 3/8 / 264	1 5/8 / 42	9 3/4 / 248
MCA-315	8 1/16 / 205	13 / 330	1 15/16 / 50	12 5/16 / 312



MRJ
Grilles fit on the suction and the discharge sides of the installation. They prevent the entry of foreign bodies which could damage the fan.

Model	Type TD
MRJ100	100
MRJ125	125
MRJ150	150
MRJ200	200
MRJ250	250



MBR
Flanges enable TD devices to connect in a series.

Model	Type TD
MBR-125	125
MBR-150	150
MBR-200	200
MBR-250	250

TD Bathroom Exhaust Grilles

Featuring Vent Lights and Premium Grilles

S&P's Grille Options give you the choice of seven (7) aesthetically pleasing grilles designed to match any bathroom decor. You can choose from our Vent Lights, Premium Grilles or Adjustable Grilles to fit your needs.

These grilles are designed to be used exclusively with one of S&P's TD remotely mounted inline for virtually silent bathroom ventilation. Inline fans give you the option to mount your grille over the shower, toilet, tub, or in multiple locations (dual vent).

With S&P's Grille Options the choice is yours!

Vent Lights

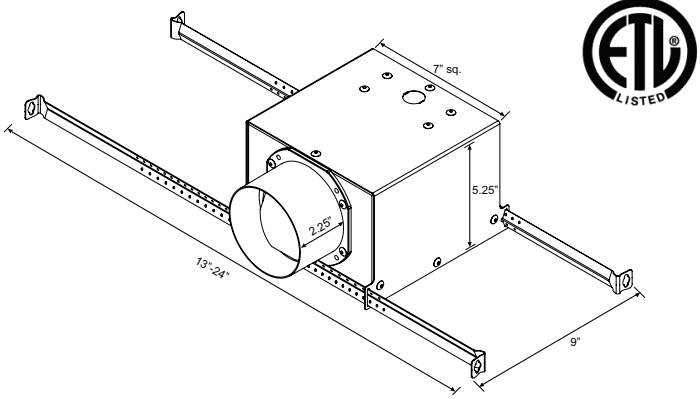
Available with LED Bulbs



S&P's new Vent Lights give you ventilation that is *"Out-of-Sight and Out-of-Mind"!* The Vent Lights appear to be a regular can light, and when combined with a remotely mounted fan, the noise and unsightly look of the traditional bathroom fan are gone! The Vent Lights are aesthetically pleasing grilles with lights that will match any bathroom decor.

Model	Description
VLED-100	Vent Light with PAR30 LED Bulb
VLH-100	Vent Light with PAR30 Halogen Bulb
VLF-100	Vent Light with Energy Star Rated Compact Fluorescent Bulb

Dimensions (inches)



Features:

- Longer duct collar for 4" duct
- Extendable hanger bars up to 24"
- 7.5" grille
- Built-in backdraft damper
- 3 bulb options

Why Choose the Vent Light with LED Bulbs?

S&P's respect for the environment extends to its Vent Lights with the optional LED Bulb. The benefits to the LED Bulbs include:

- Built to last a minimum of 60,000 hours, plus the LED's use a fraction of the energy that a traditional incandescent or halogen lamp uses
- LED's contain no mercury so they are easy to dispose of, unlike other energy efficient bulbs
- The LED lamps run cool and are shock resistant, making them safer for use in your home

Premium Grilles

PG



S&P's premium grilles come standard with steel collars for easy mounting and installation.

Model	Description
PG-100	4" Plastic Grille with 4" Steel Collar
PG-150	6" Plastic Grille with 6" Steel Collar

Grille Dimensions (in inches)



Grille	Dia.	Height	Fits Duct Dia.	Fits Collars
PG-150G	8 1/8	1 5/8	6"	PG-150D
PG-100G	4 5/8	1 1/2	4"	PG-100D

Collar Dimensions (in inches)



PG Collar

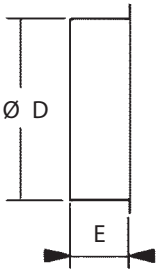
Collar	Diameter	Length
PG-100D	3 3/4	3 1/4
PG-150D	5 3/4	4 5/8

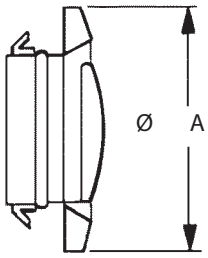
Adjustable Grilles

BOR/BOC



Exhaust grilles for bathrooms, toilets and other small rooms. All models offer an adjustable central valve to regulate the airflow.





Model	A	D	E	Weight (lbs)
BOR/BOC-100	145	100	50	1
BOR/BOC-125	145	125	50	1
BOR/BOC-150	204	160	50	1
BOR/BOC-200	244	200	50	1

Additional general assembly accessories



BOR/BOC
Round plastic/metal adjustable grille



MBR
Connection Flanges



FB
Filtering Box



PER-W
Plastic louver shutter



PER
High pressure aluminum louver shutter



GRA
Aluminum exterior fixed grilles



SR
Reducer



SY
Y sheet metal adapter



SIL
Acoustic attenuators

Electrical accessories



EPBT
Electronic push button timer



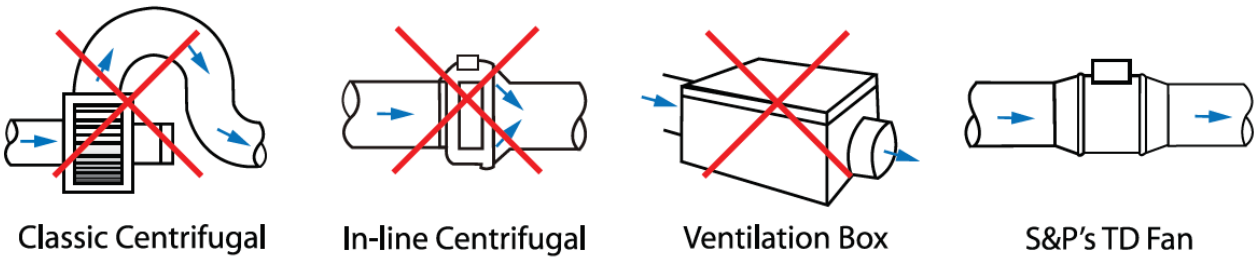
SCS
Speed control slide type



SC
Speed control

Mixed Flow Fans vs. Axial & Centrifugal Fans

	Noise Level	Air Volume	Static Pressure
Axial Fans • Low noise levels • High air volumes • Very little static pressure capability*	High Low	High Low	High Low
Centrifugal Fans • Higher noise levels • Lower air volumes • Very high static pressure capability*	High Low	High Low	High Low
Mixed Flow Fans** • Low noise levels • High air volumes • Significant static pressure capability*	High Low	High Low	High Low



*Static pressure is the ability of the fan to overcome resistance such as long or complicated duct runs.

Mixed flow fans (TD series) offer the best of both axial and centrifugal fans and are suitable for most air movement applications. S&P's **TD-MIXVENT & TD-SILENT Series has all the benefits of a mixed flow fan, plus it requires minimal space and it is easy to install.

PRF - Radon Mitigation Fans



PRF-100



PRF-150

Application

PRF fans are specifically designed for radon mitigation.

Specifications

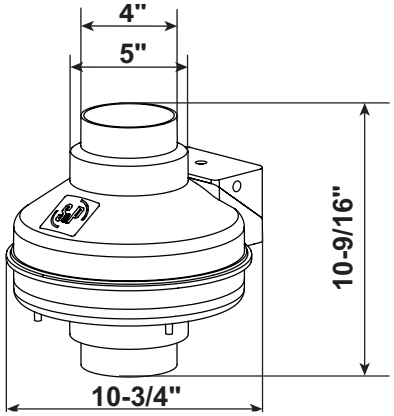
- Duct connections sized for easy fit with standard PVC couplings typically used in radon mitigation applications
- Totally Enclosed Air Over
- Fully sealed, high quality plastic housing
- Large, easily accessible, watertight electrical box for unobstructed wiring process
- Easily mount on duct pipe or use heavy-duty metal mounting bracket (sold separately)
- Significantly less expensive than comparable alternatives
- Thermal overload protection
- HVI Certified Performance
- cETLus certified
- 5-year warranty

PRF Performance

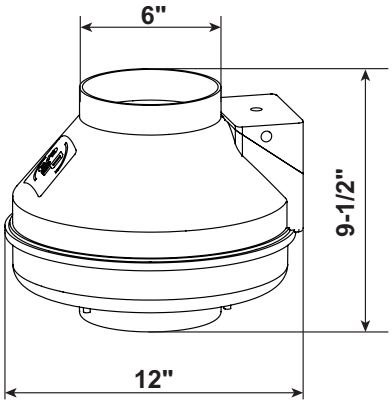
Model	Size	Electrical	Power (W)	Current (A)	CFM @ SP				RPM
					0.00	0.25	0.50	1.00	
PRF-100	4"	1/60/120V	91	0.77	169	147	126	82	3080
PRF-150	6"	1/60/120V	135	1.15	321	287	254	193	2890

Dimensions

PRF-100



PRF-150



Radon Installation Kits

Kits include two flexible white couplings with stainless steel hose clamps, a U-tube manometer, and radon system labels. The U-tube manometer (PR-M) is available to purchase separately.



Kit	Used with Model	PVC pipe size
PRFIK-43	PRF-100	3”
PRFIK-44	PRF-100	4”
PRFIK-64	PRF-150	4”

All specifications are subject to change without notice unless approved in submittal by S&P USA.

Also Available from S&P

PV-POWERVENT Fans



MODEL FEATURES

- Exhaust air up to 942 CFM with static pressure capabilities to 1.5” w.g.
- Galvanized steel casing with black backed enamel coating
- Pre-wired junction box
- Ideal for applications where space is limited
- Non-overloading backward inclined wheel for efficiency at higher static pressures
- AMCA Seal for Air Performance
- cULus Listed, Standard 507 & 705

Air Performance

Model No.	Nom. RPM	Volts	Max. Watts	CFM v Static Pressure (SP) Ins. WG									Max. SP	Duct Dia. Ins.
				0”	0.125”	0.25”	0.375”	0.5”	0.75”	1.0”	1.25”	1.5”		
PV-100	1400	115	57	108	100	92	85	78	66	52	33	18	1.70	4”
PV-100x	2880	115	84	153	142	130	120	111	96	80	63	34	1.85	4”
PV-125	2350	115	58	128	104	85	74	63	47	32	15	-	1.43	5”
PV-125x	2745	115	85	206	190	170	153	135	110	88	62	33	1.77	5”
PV-150x	2750	115	135	390	367	340	312	285	233	193	153	110	2.05	6”
PV-200	3100	115	130	402	375	350	327	296	239	179	135	85	1.94	8”
PV-200x	2930	115	180	544	515	485	446	415	360	312	273	230	2.64	8”
PV-250	3000	115	170	568	533	502	471	440	370	312	263	221	2.61	10”
PV-250x	3045	115	214	618	595	570	540	510	450	390	340	297	2.80	10”
PV-315	2920	115	200	669	640	610	581	552	489	427	368	309	2.21	12.4"
PV-315x	2730	115	365	943	903	860	815	766	628	511	440	389	3.9	12.4"

S&P USA Ventilation Systems, LLC. certifies that the PV range shown herein is licensed to bear the AMCA Seal. The ratings shown are based on tests and procedures performed in accordance with AMCA Publication 211 and comply with the requirements of the AMCA Certified Ratings Program.

Performance certified is for installation type D-Ducted inlet, Ducted outlet. Performance ratings do not include the effects of appurtenances (accessories). Speed (RPM or RPS) shown is nominal. Performance is based on actual speed of test.

SWF-SIDEWALL Fan



MODEL FEATURES

- Exhaust air up to 416 CFM with static pressure capabilities to 1.5” w.g.
- Galvanized steel casing with black backed enamel coating
- Pre-wired junction box
- Ideal for applications where space is limited
- Non-overloading backward inclined wheel for efficiency at higher static pressures
- cULus Listed

Air Performance

Model	RPM	Volts	Fre-quency	Current	Watts	CFM vs. Static Pressure (SP) Ins. WG								
						0”	0.125”	0.25”	0.375”	0.5”	0.75”	1.0”	1.25”	1.5”
SWF-100	2200	120	60 Hz	0.52 A	57	119	106	92	78	64	44	26	-	-
SWF-100X	2600	120	60 Hz	0.8 A	90	171	162	152	142	118	90	66	46	28
SWF-150	2600	120	60 Hz	0.8 A	90	235	221	197	181	168	122	81	60	27
SWF-150X	2800	120	60 Hz	1.0 A	115	354	332	310	287	266	230	192	147	96
SWF-200	2800	120	60 Hz	1.0 A	115	416	395	368	341	324	287	233	184	132

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Soler&Palau Ventilation Group

40MBCQ
Cassette Ductless System
Sizes 09 to 48

Carrier
turn to the experts

Product Data







NOTE: Image for illustration purposes only. Actual model may differ slightly.

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INDUSTRY LEADING FEATURES / BENEFITS

A PERFECT BALANCE BETWEEN BUDGET LIMITS, ENERGY SAVINGS AND COMFORT.

The 40MBCQ series ductless systems are a matched combination of an outdoor condensing unit and an indoor fan coil unit connected only by refrigerant tubing and wires.

The in−ceiling cassette fan coils are ideal for retrofit or modernization projects where a false ceiling is available. This selection of fan coils permits inexpensive and creative solutions to design problems such as:

- Add−ons to current space (an office or family room addition)
- Special space requirements
- When changes in the load cannot be handled by the existing system
- When adding air conditioning to spaces that are heated by hydronic or electric heat and have no ductwork
- Historical renovations or any application where preserving the look of the original structure is essential.

The ideal compliment to your ducted system when it is impractical or prohibitively expensive to use ductwork. These compact indoor fan coil units take up very little space in the room and do not obstruct windows. The fan coils are attractively styled to blend with most room decors.

Advanced system components incorporate innovative technology to provide reliable cooling performance at low sound levels.

LOW SOUND LEVELS

When noise is a concern, the ductless systems are the answer. The indoor units are whisper quiet. There are no compressors indoors, either in the conditioned space or directly over it, and there is none of the noise usually generated by air being forced through ductwork.

SECURE OPERATION

If security is an issue, outdoor and indoor units are connected only by refrigerant piping and wiring to prevent intruders from crawling through ductwork. In addition, since outdoor units can be installed close to an outside wall, coils are protected from vandals and severe weather.

FAST INSTALLATION

This compact ductless system is simple to install. A mounting bracket is standard with the indoor units and only wire and piping needs to run between indoor and outdoor units. These units are fast and easy to install ensuring minimal disruption to customers in the home or workplace. This makes the ductless systems the equipment of choice, especially in retrofit situations.

SIMPLE SERVICING AND MAINTENANCE

Removing the top panel on outdoor units provides immediate access to the control compartment, providing a service technician access to check unit operation. In addition, the draw−thru design of the outdoor section means that dirt accumulates on the outside surface of the coil. Coils can be cleaned quickly from inside using a pressure hose and detergent.

On all indoor units, service and maintenance expense is reduced due to easy−to−use cleanable filters. In addition, these cassette systems have extensive self−diagnostics to assist in troubleshooting.

BUILT − IN RELIABILITY

Ductless system indoor and outdoor units are designed to provide years of trouble−free operation.

The in−ceiling cassette units include protection against freeze−up and high evaporator temperatures on heat pumps.

The condensing units on heat pumps are protected by a three minute time delay before the compressor starts the over−current protection and the high temperature protection.

INDIVIDUAL ROOM COMFORT

Maximum comfort is provided because each space can be controlled individually based on usage pattern. The air sweep feature provided permits optimal room air mixing to eliminate hot and cold spots for occupant comfort. In addition, year−round comfort can be provided with heat pumps.

ECONOMICAL OPERATION

The ductless system design allows individual room heating or cooling when required. There is no need to run large supply−air fans or chilled water pumps to handle a few spaces with unique load patterns. In addition, because air is moved only in the space required, no energy is wasted moving air through ducts.

EASY−TO−USE CONTROLS

The in−ceiling cassette has microprocessor−based controls to provide the ultimate in comfort and efficiency. The user friendly wireless remote control provides the interface between user and the unit.

FACTORY INSTALLED CONDENSATE LIFT PUMP

Customizing these ductless systems to your application is easily accomplished. The factory installed condensate lift pump on the cassette fan coil unit provides installation flexibility.

OPTIONAL WIRED CONTROLLER

AGENCY LISTINGS

All systems are listed with AHRI (Air Conditioning, Heating & Refrigeration Institute), and ETL.

MODEL NUMBER NOMENCLATURE

INDOOR UNIT

40 MB C Q 09 – – – 3

40 = FAN COIL UNIT

MB = MODEL

INDOOR FAN COIL TYPE
C = CASSETTE

SYSTEM TYPE
Q = HEAT PUMP

NOMINAL CAPACITY
09 – 3/4 TON
12 – 1 TON
18 – 1–1/2 TONS
24 – 2 TONS
36 – 3 TONS
48 – 4 TONS

NOT USED

NOT USED

VOLTAGE
3 = 208/230–1–60

Use of the AHRI Certified TM Mark indicates a manufacturer's participation in the program For verification of certification for individual products, go to www.ahridirectory.org.

STANDARD FEATURES AND ACCESSORIES

Ease Of Installation	
Mounting Brackets	S
Low Voltage Controls	S
Comfort Features	
Microprocessor Controls	S
Wired Remote Control	A
Wireless Remote Control	S
Wi−Fi Remote Control	A
Automatic Horizontal Air Sweep	S
Air Direction Control	S
Auto Restart Function	S
Cold Blow Protection On Heat Pumps	S
Freeze Protection Mode On Heat Pumps	S
Turbo Mode	S
Silence Mode	S
Auto Changeover On Heat Pumps	S
Follow Me	S
Energy Saving Features	
Sleep Mode	S
Stop/Start Timer	S
46°F Heating Mode (Heating Setback)	S
Safety And Reliability	
Indoor Coil Freeze Protection	S
Indoor Coil High Temp Protection in Heating Mode	S
Aluminum Golden Hydrophilic pre−coated fins	S
Ease Of Service And Maintenance	
Cleanable Filters	S
Diagnostics	S
Liquid Line Pressure Taps	S
Condensate Drain Adaptor	S
Application Flexibility	
Condensate Lift Pump	S

Legend
S Standard
A Accessory

ACCESSORIES

ORDERING NO.	DESCRIPTION	FOR MODELS
KSACN0101AAA	Wired Remote Control with Timer Function	All Sizes
KSACN0501AAA	Wired Remote Control 7 day Programmable	All Sizes
40MBCQ01XXX3	Grille/Ceiling Panel 2ft x 2 ft	Sizes 09 − 18
40MBCQ02XXX3	Grille/Ceiling Panel 3ft x 3 ft	Sizes 24 − 48
KSAIF0401AAA	Wi−Fi Kit	All sizes
53DS−900−−−089	Insulated 25’ Line Set − 1/4” x 3/8”	Size 09
53DS−900−−−008	Insulated 25’ Line Set − 1/4“ x 1/2”	Sizes 12, 18

INDOOR UNIT ACCESSORIES

Grille

To maximize shipping efficiency, the grille for the in−ceiling cassette is set up as an accessory.

NOTE: Grille is required.

DIMENSIONS

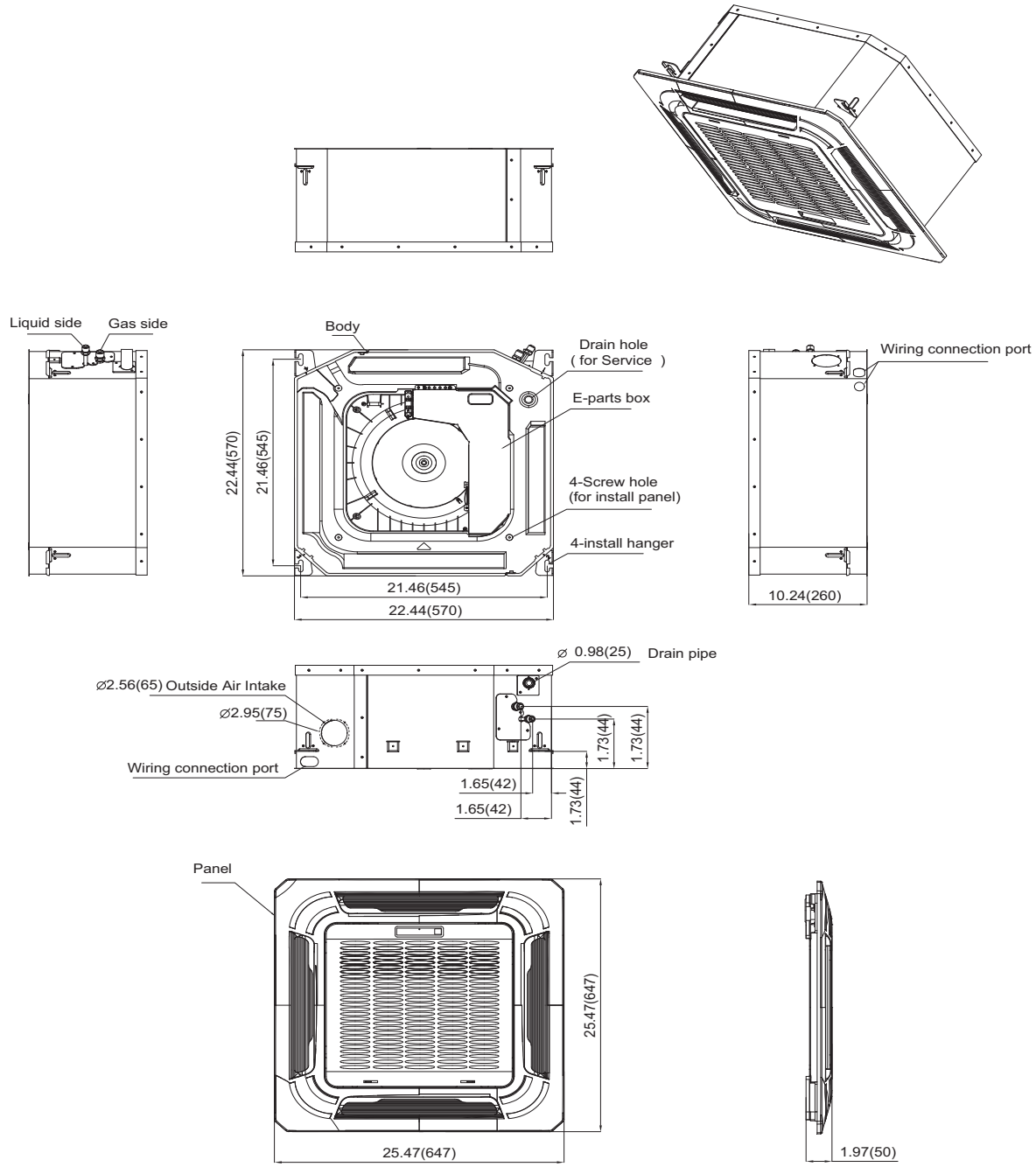
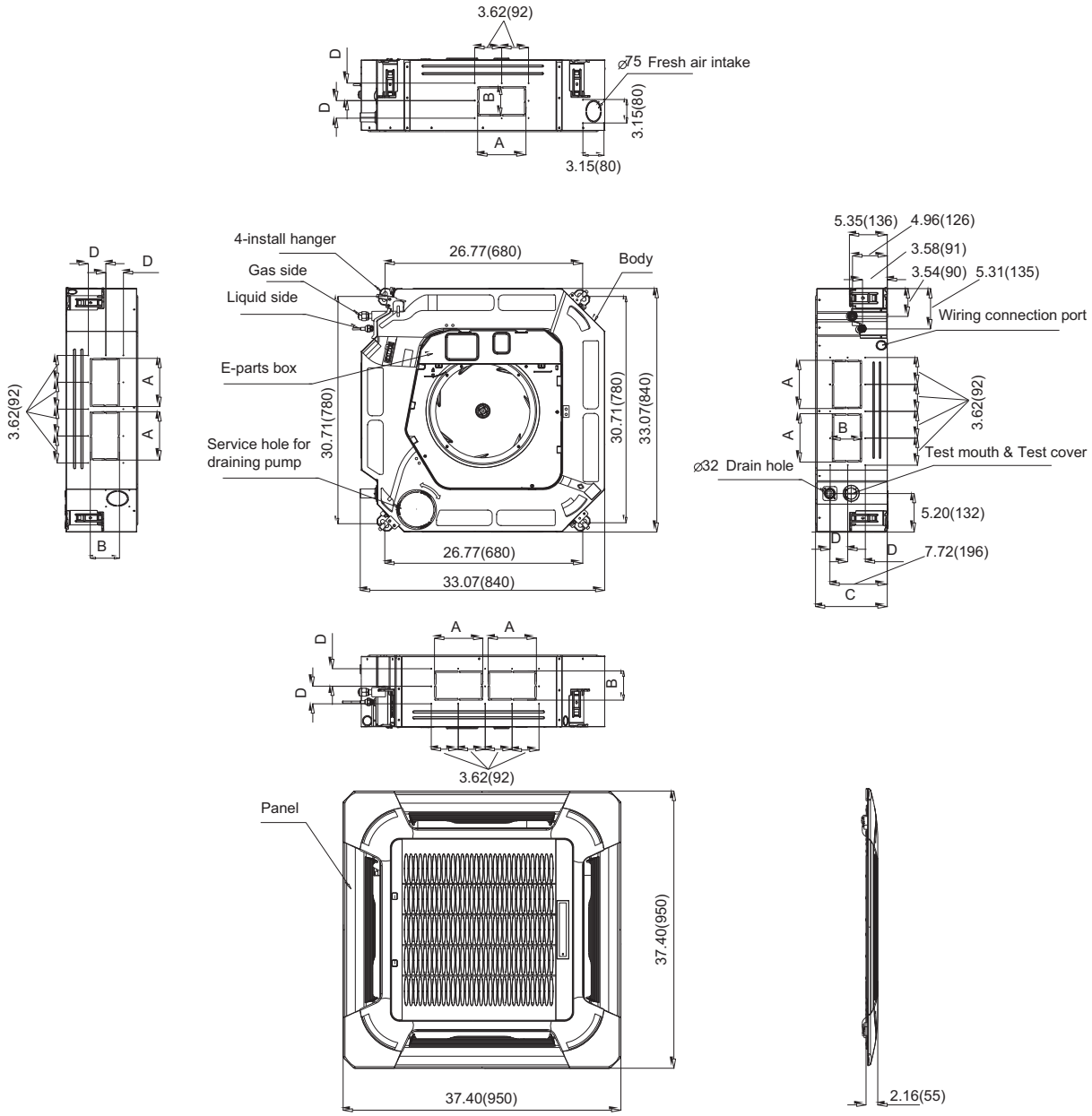


Fig. 1 – Indoor Unit (Sizes 9−18)

UNIT SIZE		9K		12K		18K		24K		36K		48K	
		Body	Panel	Body	Panel	Body	Panel	Body	Panel	Body	Panel	Body	Panel
DIMENSIONS													
Height	in (mm)	10.24 (260)	1.97 (50)	10.24 (260)	1.97 (50)	10.24 (260)	1.97 (50)	8.07 (205)	2.17 (55)	9.65 (245)	2.17 (55)	11.3 (287)	2.17 (55)
Width	In (mm)	22.44 (570)	25.47 (647)	22.44 (570)	25.47 (647)	22.44 (570)	25.47 (647)	33.07 (840)	37.4 (950)	33.07 (840)	37.4 (950)	33.07 (840)	37.4 (950)
Depth	In (mm)	22.44 (570)	25.47 (647)	22.44 (570)	25.47 (647)	22.44 (570)	25.47 (647)	33.07 (840)	37.4 (950)	33.07 (840)	37.4 (950)	33.07 (840)	37.4 (950)
PACKAGING													
Height	In (mm)	11.42 (290)	4.84 (123)	11.42 (290)	4.84 (123)	11.42 (290)	4.84 (123)	8.54 (217)	3.54 (90)	10.12 (257)	3.54 (90)	11.5 (292)	3.54 (90)
Width	In (mm)	25.79 (655)	28.15 (715)	25.79 (655)	28.15 (715)	25.79 (655)	28.15 (715)	35.43 (900)	40.75 (1035)	35.43 (900)	40.75 (1035)	35.43 (900)	40.75 (1035)
Depth	In (mm)	25.79 (655)	28.15 (715)	25.79 (655)	28.15 (715)	25.79 (655)	28.15 (715)	35.43 (900)	40.75 (1035)	35.43 (900)	40.75 (1035)	35.43 (900)	40.75 (1035)
Weight-Gross	Lbs (kg)	41.88 (19)	9.92 (4.5)	41.88 (19)	9.92 (4.5)	46.3 (21)	9.92 (4.5)	54.23 (24.6)	17.64 (8)	66.14 (30)	17.64 (8)	72.53 (32.9)	17.64 (8)
Weight-Net		35.27 (16)	5.51 (2.5)	35.27 (16)	5.51 (2.5)	39.68 (18)	5.51 (2.5)	46.3 (21)	11.02 (5)	58.2 (26.4)	11.02 (5)	63.27 (28.7)	11.02 (5)

DIMENSIONS − (CONT)



Capacity (Btu/h)		A	B	C	D
24K	mm	160	75	205	50
	inch	6.30	2.95	8.07	1.97
36K	mm	160	95	245	60
	inch	6.30	3.74	9.65	2.36
48K	mm	160	95	287	60
	inch	6.30	3.74	11.30	2.36

Fig. 2 – Indoor Unit (Sizes 24−48)

CLEARANCES

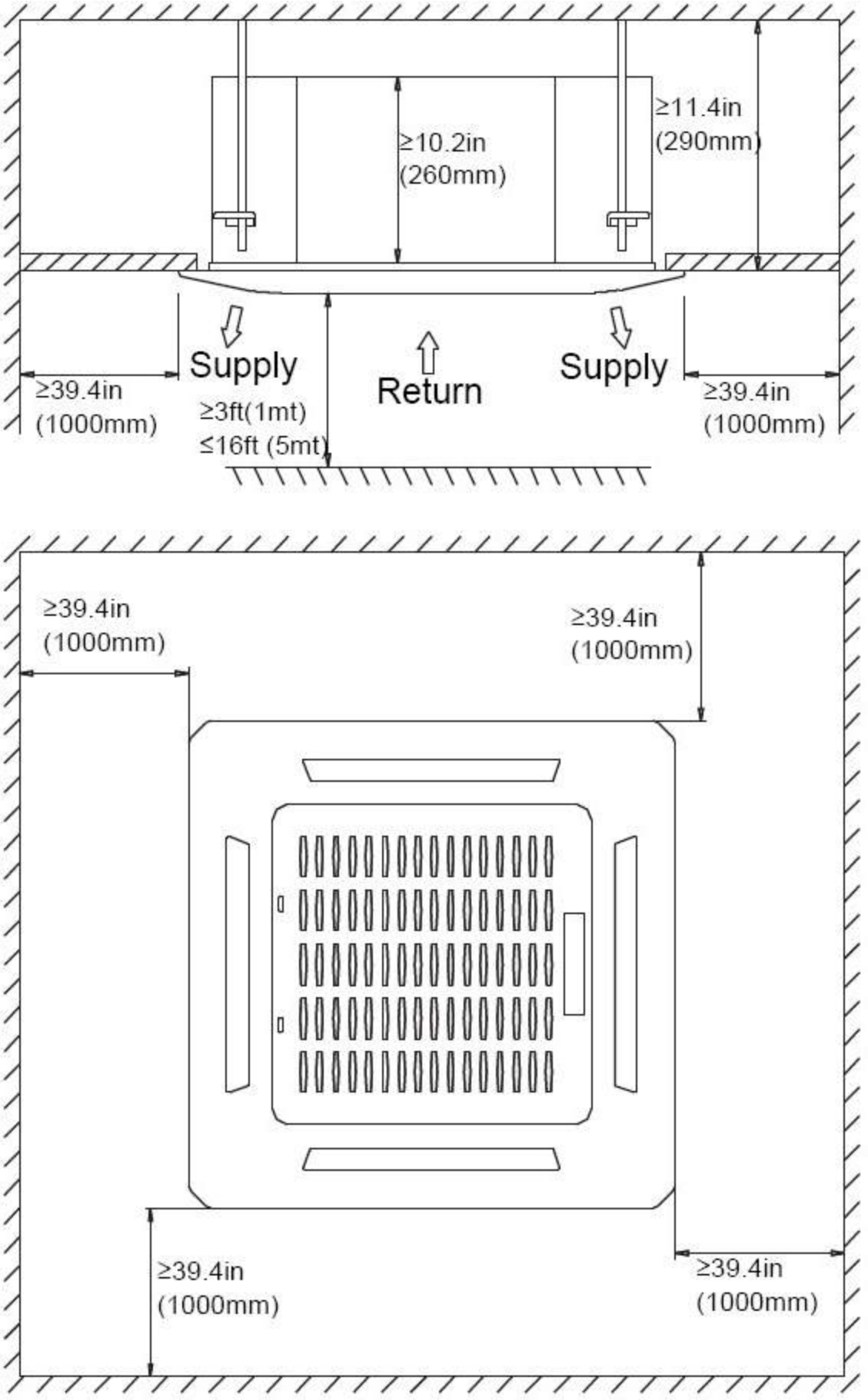


Fig. 3 – Indoor Unit Clearance

SPECIFICATIONS

Heat Pump								
System	**Size**		**9**	**12**	**18**	**24**	**36**	**48**
	Indoor Model		40MBCQ09−−−3	40MBCQ12−−−3	40MBCQ18−−−3	40MBCQ24−−−3	40MBCQ36−−−3	40MBCQ48−−−3
Electrical	Voltage, Phase, Cycle	V/Ph/Hz	208/230−1−60	208/230−1−60	208/230−1−60	208/230−1−60	208/230−1−60	208/230−1−60
	Power Supply		Indoor unit powered from outdoor unit				Indoor unit powered from outdoor unit	
	MCA	A.	0.2	0.2	0.2	0.3	0.8	1.6
Controls	Wireless Remote Controller (°F/°C Convertible)		Standard	Standard	Standard	Standard	Standard	Standard
	Wired Remote Controller (°F/°C Convertible)		Optional	Optional	Optional	Optional	Standard	Standard
Operating Range	Cooling Indoor DB Min −Max	°F (°C)	63~90 (17~32)	63~90 (17~32)	63~90 (17~32)	62~90 (17~32)	63~90 (17~32)	63~90 (17~32)
	Heating Indoor DB Min −Max	°F (°C)	32~86 (0~30)	32~86 (0~30)	32~86 (0~30)	32~86 (0~30)	32~86 (0~30)	32~86 (0~30)
Piping	Pipe Connection Size − Liquid	in (mm)	1/4 (6.35)	1/4 (6.35)	1/4 (6.35)	3/8 (9.52)	3/8 (9.52)	3/8 (9.52)
	Pipe Connection Size − Suction	in (mm)	3/8 (9.52)	1/2 (12.7)	1/2 (12.7)	5/8 (16)	5/8 (16)	5/8 (16)
Indoor Coil	Face Area	Sq. Ft.	3.1	3.1	3.1	3.6	4.6	5.2
	No. Rows		1	2	2	2	3	3
	Fins per inch		19	19	19	18	18	18
	Circuits		2	4	4	8	10	10
Indoor	Body Unit Width	in (mm)	22.44 (570)	22.44 (570)	22.44 (570)	33.07 (840)	33.07 (840)	33.07 (840)
	Body Unit Height	in (mm)	10.24 (260)	10.24 (260)	10.24 (260)	8.07 (205)	9.65 (245)	11.3 (287)
	Body Unit Depth	in (mm)	22.44 (570)	22.44 (570)	22.44 (570)	33.07 (840)	33.07 (840)	33.07 (840)
	Body Net Weight	lbs (kg)	35.27 (16)	35.27 (16)	39.68 (18)	46.3 (21)	58.2 (26.4)	63.27 (28.7)
	Panel Unit Width	in (mm)	25.47 (647)	25.47 (647)	25.47 (647)	37.4 (950)	37.4 (950)	37.4 (950)
	Panel Unit Height	in (mm)	1.97 (50)	1.97 (50)	1.97 (50)	2.17 (55)	2.17 (55)	2.17 (55)
	Panel Unit Depth	in (mm)	25.47 (647)	25.47 (647)	25.47 (647)	37.4 (950)	37.4 (950)	37.4 (950)
	Panel Net Weight	lbs (kg)	5.51 (2.5)	5.51 (2.5)	5.51 (2.5)	11.02 (5)	11.02 (5)	11.02 (5)
	Number of Fan Speeds		3	3	3	3	3	3
	Airflow (lowest to highest)	CFM	260/320/380	280/340/400	290/350/420	625/761/878	809/958/1095	853/1030/1177
	Sound Pressure (lowest to highest)	dB(A)	34/39/44	36/39/42	46/48/50	47/50/52	49/52/55	49/52/55
	Air throw Data	ft (m)	23 (7)	23 (7)	30 (9)	30 (9)	30 (9)	30 (9)
	Moisture removal	Pint/h (L/h)	1.58 (0.75)	2.88 (1.366)	4.26 (2.02)	5.22 (2.47)	8.53 (4.04)	13.5 (6.39)
	Field Drain Pipe Size O.D.	in (mm)	1 (25.4)	1 (25.4)	1 (25.4)	1 (25.4)	1 (25.4)	1 (25.4)

NOTE: Performance may vary based on the compatible outdoor units. See respective pages for performance data.

COMPATIBILITY

Indoor Unit	**40MBCQ09−−−3**	**40MBCQ12−−−3**	**40MBCQ18−−−3**	**40MBCQ24−−−3**	**40MBCQ36−−−3**	**40MBCQ48−−−3**
Outdoor Unit Single Zone	38MAQB09R−−3	38MAQB12R−−3	38MAQB18R−−3	38MAQB24R−−3	38MBRQ36A−−3	38MBRQ48A−−3
Outdoor Unit Multi−zone	38MGRQ18B−−3					
	38MGRQ24C−−3					
	38MGRQ30D−−3					
	38MGRQ36D−−3					
	38MGRQ48E−−3					

NOTE: Backward compatible with 38MAQ Single Zone and 38MGQ Multi−zone Systems.

APPLICATION DATA

UNIT SELECTION

Select equipment to either match or handle slightly less than the anticipated peak load. This provides better humidity control, fewer unit cycles, and less part−load operation.

For units used in spaces with high sensible loads, base equipment selection on the unit sensible load, not on the total anticipated load. Adjust for anticipated room wet bulb temperature to avoid undersizing the equipment.

UNIT MOUNTING (INDOOR)

Refer to unit Installation Instructions for further details.

Unit leveling − For reliable operation, units should be level in all planes. Align and level the unit by adjusting the nuts and lock−nuts on the threaded hangers.

Clearance − A minimum of 12 inches (304.8 mm) of clearance is required in the false ceiling.

Unit location − Placing the unit in the center of the room provides the best air circulation and comfort. The unit return and discharge should not be obstructed by anything which may cause unit short cycling or air recirculation.

Installation Template − Fan coil units are supplied with a cardboard template to help match the position of the hangers, refrigerant lines, condensate drain pipe and power supply cable.

UNIT MOUNTING (OUTDOOR)

Refer to the unit's Installation Instructions for further details.

Do not install the indoor or outdoor units in a location with special environmental conditions. For those applications, contact your ductless representative.

SUPPORT

Adequate support must be provided to support the weight of all fan coils. Refer to the *Physical Data* section for fan coil weights, and the base unit dimensional drawings for the location of the mounting brackets.

SYSTEM OPERATING CONDITIONS

OPERATING RANGE Min / Max °F (°C)		
	Cooling	**Heating**
Indoor DB	63 / 90 (17 / 32)	32 / 86 (0 / 30)
Indoor WB	59 / 84 (15 / 29)	

DRAIN CONNECTIONS

Install drains to meet local sanitation codes. The in−ceiling cassette is supplied with a condensate lift pump that is capable of lifting the water 29.5in (750mm) above the top of the unit. A downward sloped condensate drain pipe can be used to dispose of water.

REFRIGERANT LINES

General refrigerant line sizing:

1. The outdoor units are shipped with a full charge of R410A refrigerant.
2. Refrigerant lines should not be buried in the ground. If it is necessary to bury the lines, not more than 36−in (914 mm) should be buried. Provide a minimum 6−in (152 mm) vertical rise to the service valves to prevent refrigerant migration.
3. Both lines must be insulated. Use a minimum of 1/2−in. (12.7 mm) thick insulation. Closed−cell insulation is recommended in all long−line applications.
4. Special consideration should be given to isolating interconnecting tubing from the building structure. Isolate the tubing so that vibration or noise is not transmitted into the structure.

WIRING

All wires must be sized per NEC (National Electrical Code) or CEC (Canadian Electrical Code) and local codes. Use Electrical Data table MCA (minimum circuit amps) and MOCP (maximum over current protection) to correctly size the wires and the disconnect fuse or breakers respectively.

Recommended Connection Method for Power and Communication Wiring:

The main power is supplied to the outdoor unit. The field supplied 14/3 stranded wire with ground with a 600 volt insulation rating, power/communication wiring from the outdoor unit to indoor unit consists of four (4) wires and provides the power for the indoor unit. Two wires are line voltage AC power, one is communication wiring (S) and the other is a ground wire. Wiring between indoor and outdoor unit is polarity sensitive. The use of BX wire is NOT recommended.

If installed in a high Electromagnetic field (EMF) area and communication issues exists, a 14/2 stranded shielded wire can be used to replace L2 and (S) between outdoor unit and indoor unit landing the shield onto ground in the outdoor unit only.

⚠ CAUTION

EQUIPMENT DAMAGE HAZARD

Failure to follow this caution may result in equipment damage or improper operation.

Wires should be sized based on NEC and local codes.

⚠ CAUTION

EQUIPMENT DAMAGE HAZARD

Failure to follow this caution may result in equipment damage or improper operation.

Be sure to comply with local codes while running wire from the indoor unit to the outdoor unit.

Every wire must be connected firmly. Loose wiring may cause the terminal to overheat or result in unit malfunction. A fire hazard may also exist. Ensure all wiring is tightly connected.

No wire should touch the refrigerant tubing, compressor or any moving parts.

Disconnecting means must be provided and shall be located within sight and readily accessible from the air conditioner.

Connecting cable with conduit shall be routed through the hole in the conduit panel.

CONTROL SYSTEM

The indoor unit is equipped with a microprocessor control to perform two functions:

1. Provide safety for the system
2. Control the system and provide optimum levels of comfort and efficiency.

The main microprocessor is located on the control board of the fan coil unit (outdoor units have a microprocessor too) with thermistors located in the fan coil air inlet and on the indoor coil. Heat pump units have a thermistor on the outdoor coil. These thermistors monitor the system operation to maintain the unit within acceptable parameters and control the operating mode.

WIRELESS REMOTE CONTROL



Fig. 4 – Wireless Remote Control

1. A wireless remote control is supplied for system operation of all in−ceiling cassette units.
2. Each battery operated wireless (infrared) remote control may be used to control more than one unit.

WIRED REMOTE CONTROL (OPTIONAL)

Part Numbers (P/N):

- **KSACN0101AAA (Timer Function)**
- **KSACN0501AAA (7 Day Programmable)**

1. Optional wired remote controller used for system operation of all in−ceiling cassette units.
2. Kit includes a wired remote controller and a connecting cable.

NOTE: Extension wire available through RCD (KSACN0101AAA Part Number: 17401204001601; KSACN0501AAA Part Number: 17401204000769).

3. Connect the wire terminal between the remote controller and the indoor unit.
4. Display in °F or °C and temperature increments every 1°F or every 1°C.



Fig. 5 – KSACN0101AAA (Timer Function)



Fig. 6 – KSACN0501AAA (7 Day Programmable)

AIR FLOW DATA

SYSTEM SIZE		9K	12K	18K	24K	36K	48K
		(208/230)	(208/230)	(208/230)	(208/230)	(208/230)	(208/230)
INDOOR (CFM)	HIGH	353	350	562	878	1095	1177
	MEDIUM	306	296	485	761	958	1030
	LOW	270	253	439	625	809	853

AIR THROW DATA

UNIT CAPACITY	MAX. APROXIMATE AIR THROW ft. (m)	APROXIMATE AIR THROW RANGE ft. (m)
9K	23 (7)	11 (3.5) ~ 23 (7)
12K	23 (7)	11 (3.5) ~ 23 (7)
18K	30 (9)	13 (4) ~ 30 (9)
24K	30 (9)	13 (4) ~ 30 (9)
36K	30 (9)	13 (4) ~ 30 (9)
48K	30 (9)	13 (4) ~ 30 (9)

SOUND PRESSURE

SYSTEM SIZE		9K	12K	18K	24K	36K	48K
Cooling Operation Indoor Sound Pressure	dBa (L/M/H)	33/35/38	27/34/42	33/40/46.5	47/50/52	49/52/55	49/52/55
Heating Operation Indoor Sound Pressure	dBa (L/M/H)	31/34/37	27/34/41	32/39/45	45.7/48.8/51.2	49.5/52/54.2	49.3/52.8/55.8

SOUND PRESSURE TESTING METHOD

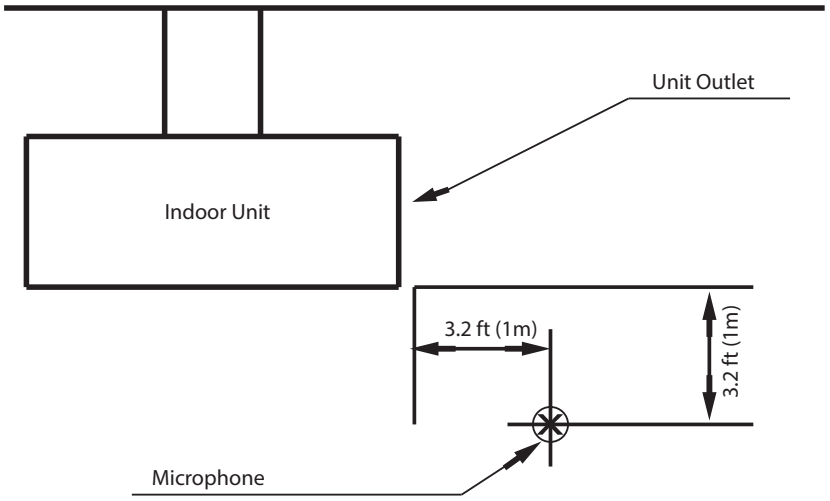


Fig. 7 – Sound Pressure Testing Method

FAN AND MOTOR SPECIFICATIONS

SYSTEM SIZE			9K	12K	18K	24K	36K	48K
Indoor Fan	Material		ABS	ABS	ABS	ABS	ABS	ABS
	Type		LX–322*147.5*12–7N	LX–322*147.5*12–7N	LX–322*147.5*12–7N	LX–460*128*12–7N	LX–476*160*12–7N	LX–476*170*12–7N
	Diameter	inch	12.7	12.7	12.7	460	476	476
	Height	inch	5.8	5.8	5.8	128	160	170
Indoor Fan Motor	Model		WZDK46–38G	WZDK46–38G	WZDK46–38G	ZKFP–42–8–1	ZKFP–124–8–2	ZKFN–170–8–1
	Volts	V	208/230	208/230	208/230	208/230	208/230	208/230
	Type		DC	DC	DC	DC	DC	DC
	Phase		3	3	3	1	1	1
	FLA		0.146	0.146	0.146	2.0	1.5	1.6
	Insulation Class		E	E	E	E	E	E
	Safe Class		IPX0	IPX0	IPX0	IPX0	IPX0	IPX0
	Input	W	45	45	45	58	141	232
	Output	W	46	46	46	42	124	170
	Range of Current	Amps	0.146±10%	0.146±10%	0.146±10%	0.332±10%	0.8±10%	1.6±10%
	Rated Current	Amps	0.146	0.146	0.146	0.332	0.8	1.6
	Capacitor	μF	N/A					
Indoor Fan Motor	Rated HP	HP	0.061	0.061	0.061	0.057	0.169	0.231
	Speed	rev/min	600/520/460	680/580/500	730/630/570	600/520/450	720/630/560	900/800/700
	Rated RPM	rev/min	960	960	960	790	910	950
	Max. Input	W	45	45	45	103	246	270

WIRING DIAGRAMS

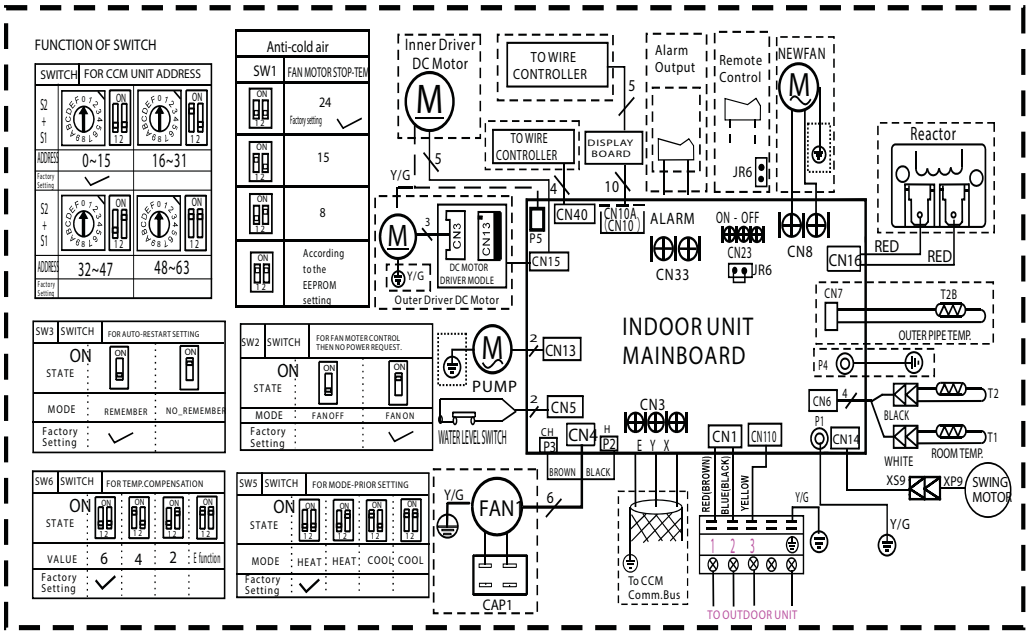


Fig. 8 – Wiring Diagram (Sizes 9K−24K)

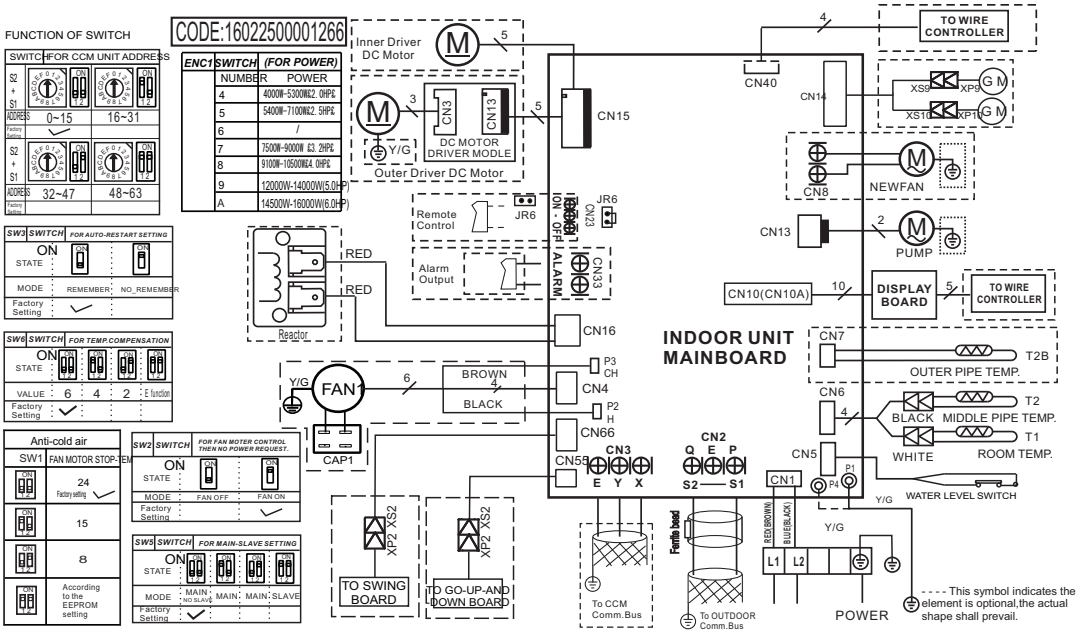


Fig. 9 – Wiring Diagram (Size 36K−48K)

INDOOR UNIT	
CODE	**PART NAME**
CN1	Input: 230VAC High voltage Connection of the terminal
CN3	Output: 0−5VDC Connection of the CCM
P1	Output: 0V Connection of the earth
CN5	Output: 1−5VDC Connection of the Water level switch
CN6	Output: 5VDC Connection of the Room and Pipe temperature
CN10A	Output: 12VDC Connection of the Display board
CN13	Output: 220VAC High voltage Connection of the Pump
CN14	Output: 12VDC Connection of the Swing motor
CN15	Output: 320VDC High voltage Connection of the DC Fan
CN16	Output: 320VDC High voltage Connection of the Reactor
CN23	Output: 1−12VDC Connection of the Remote switch
CN33	Output: 0V Connection of the Alarm
CN40	Output: 12VDC Connection of the Wire controller
CN110	Output: 24VDC between Pin2 of CN1 connection of the S signal

GUIDE SPECIFICATIONS

INDOOR IN−CEILING CASSETTE DUCTLESS UNITS

Size Range: 3/4 to 4 Ton Nominal Cooling and Heating Capacity
Model Number: 40MBCQ

PART 1 − GENERAL

1.01 System Description

Indoor, in−ceiling cassette, direct−expansion fan coils are matched with a heat pump outdoor unit.

1.02 Agency Listings

Unit are rated per AHRI Standards 210/240 and listed in the AHRI directory as a matched system.

1.03 Delivery, Storage, And Handling

Units are stored and handled per the unit manufacturer's recommendations.

1.04 Warranty (For Inclusion By Specifying Engineer)

PART 2 − PRODUCTS

2.01 Equipment

A. General:

Indoor, direct−expansion, ceiling−mounted fan coil. Unit is complete with a cooling/heating coil, fan, fan motor, piping connectors, electrical controls, microprocessor control system, and an integral temperature sensing.

B. Unit Cabinet: Cabinet is constructed of zinc−coated steel. Fully insulated discharge and inlet grilles are attractively styled, high−impact polystyrene. Grille has hinges and can be opened to obtain access to the cleanable filters, indoor fan motor and control box.

C. FANS:

1. The fan is a centrifugal direct−drive blower type with an air intake in the center of the unit and a discharge at the perimeter. An automatic, motor−driven vertical air sweep is provided standard. Automatic motor−driven louvers are provided standard and are adjustable for a 2, 3 or 4−way discharge.
2. The air sweep operation is user selectable.

D. Coil:

The coil is a copper tube with aluminum fins and galvanized steel tube sheets. Fins are bonded to the tubes by mechanical expansion and specially golden hydrophilic pre−coated for enhanced wet−ability. A drip pan under the coil has a factory installed condensate lift pump and a drain connection for a hose attachment to remove condensate.

E. Motors:

Motors are open drip−proof, permanently lubricated ball bearing with inherent overload protection. Fan motors are 7−speed.

F. Controls:

Controls consist of a microprocessor−based control system which controls the space temperature, determines the optimum fan speed, and runs self diagnostics. The temperature control range is 62°F to 86°F (17°C to 30°C) in increments of 1°F or 1°C, and has a 46°F Heating Mode (Heating Setback). The wireless remote controller, has the ability to act as the temperature sensing location for room comfort.

The unit shall have the following functions as a minimum:

1. An automatic restart after a power failure at the same operating conditions as at failure.
2. A timer function to provide a minimum 24−hour timer cycle for the system's Auto Start/Stop.
3. Temperature−sensing controls sense the return air temperature.
4. Indoor coil freeze protection.
5. Wireless infrared remote control to enter set points and operating conditions.
6. Automatic air sweep control to provide on or off activation of air sweep louvers.
7. Dehumidification mode which provides increased latent removal capability by modulating system operation and set point temperature.
8. A fan−only operation to provide room air circulation when no cooling is required.
9. Diagnostics to provide continuous checks of the unit operation and warn of possible malfunctions. Any error messages are displayed at the unit.
10. The fan speed control is user−selectable: high, medium, low, or microprocessor controlled automatic operation during all operating modes.
11. Automatic heating−to−cooling changeover in the heat pump mode. Control includes deadband to prevent rapid mode cycling between heating and cooling.
12. Indoor coil high temperature protection is provided to detect excessive indoor discharge temperature when unit is in the heat pump mode.

G. Filters:

The unit has a filter track with factory−supplied cleanable filters.

H. Electrical Requirements:

The indoor fan motor operates on 208−230V on model sizes 09−48, as specified. Power is supplied from the outdoor unit.

I. Operating Characteristics:

The 40MBCQ system has a minimum SEER (Seasonal Energy Efficiency Ratio) and HSPF at AHRI conditions, as listed on the specifications table.

J. Refrigerant Lines:

All units should have refrigerant lines that can be oriented to connect from the left, right or back of unit. Both refrigerant lines must be insulated.

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Catalog No: 40MBCQ—02PD

Manufacturer reserves the right to change, at any time, specifications and designs without notice and without obligations.

Replaces: 40MBCQ—01PD

Cassette Heat Pump Ductless System

Indoor Model: 40MBCQ09---3

Submittal Data

Job Data: | Location:

Buyer: | Buyer P.O. #: | Carrier #:

Unit Number: | Model Number:

Performance Data Certified By: | Date:





STANDARD FEATURES
Modes: Cool, Heat, Dry, Fan, Auto
Louver Control (Fixed or Swing)
Outside Air Intake
Built-in condensate Lift pump
Follow Me (senses temperature at handheld remote)
Heating Setback (46° F Heating Mode)
Quiet indoor operation
Aluminum Golden Hydrophilic pre-coated fins

Controls:
Wireless Remote Controller included with indoor unit
Optional Wired Remote Controller (Timer Function)
Optional Wired Remote Controller KSACN0501AAA (7 Day programmable)

LIMITED WARRANTY*
• 10 year limited to original purchaser on compressor and parts upon timely registration, otherwise 5 years
*For residential applications. See warranty for full details.

System	Size		9
	Indoor Model		40MBCQ09---3
Electrical	Voltage, Phase, Cycle	V/Ph/Hz	208/230-1-60
	Power Supply	Indoor unit powered by outdoor unit	
	MCA	A.	0.2
Controls	Wireless Remote Controller (°F/°C Convertible)		Standard
	Wired Remote Controller (°F/°C Convertible)		Optional
Operating Range	Cooling Indoor DB Min -Max	°F(°C)	63~90 (17~32)
	Heating Indoor DB Min -Max	°F(°C)	32~86 (0~30)
Piping	Pipe Connection Size - Liquid	in (mm)	1/4 (6.35)
	Pipe Connection Size - Suction	in (mm)	3/8 (9.52)

Indoor Coil	Face Area	Sq. Ft.	3.10
	No. Rows		1
	Fins per inch		19
	Circuits		2
Indoor	Body Unit Width	in (mm)	22.44 (570)
	Body Unit Height	in (mm)	10.24 (260)
	Body Unit Depth	in (mm)	22.44 (570)
	Body Net Weight	lbs (kg)	35.27 (16)
	Panel Unit Width	in (mm)	25.47 (647)
	Panel Unit Height	in (mm)	1.97 (50)
	Panel Unit Depth	in (mm)	25.47 (647)
	Panel Net Weight	lbs (kg)	5.51 (2.5)
	Number of Fan Speeds		3
	Airflow (low to high)	CFM	260/320/380
	Sound Pressure (lowest to highest)	dB(A)	34/39/44
	Air throw Data	ft (m)	23 (7)
	Moisture removal	Pint/h (L/h)	1.58 (0.75)
	Field Drain Pipe Size O.D.	in (mm)	1 (25.4)

For Compatibility See Product Data
Performance may vary based on the outdoor unit matched to. See compatible outdoor units pages for Performance Data.

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Edition Date: 03/2018
Catalog No: 40MBCQ-09-3-02SB

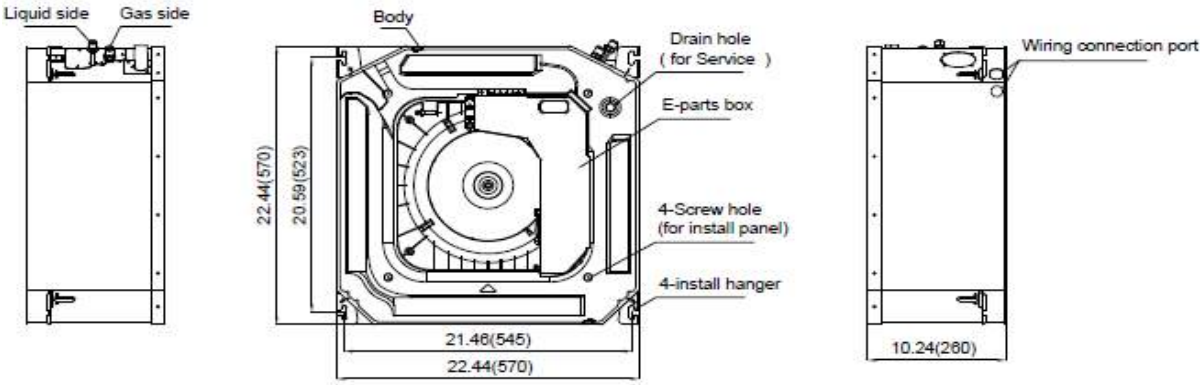
Accessories

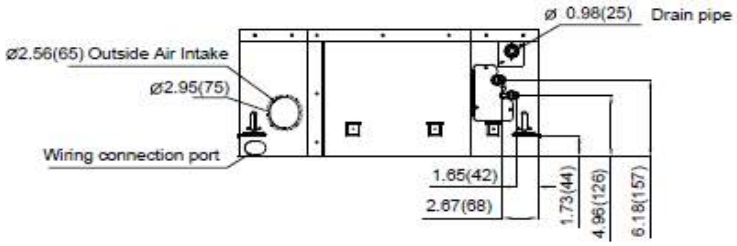
KSACN0101AAA	Wired Remote Control with Timer Function
KSACN0501AAA	Wired Remote Control 7 day Programmable
KSAIF0401AAA	Wi-Fi™ Kit
KSAIC0101230	24V Interface Kit 208/230V
40MBCQ01XXX3	Grille/Ceiling panel
53DS-900---089	Insulated 25' Line Set - 1/4" x 3/8"

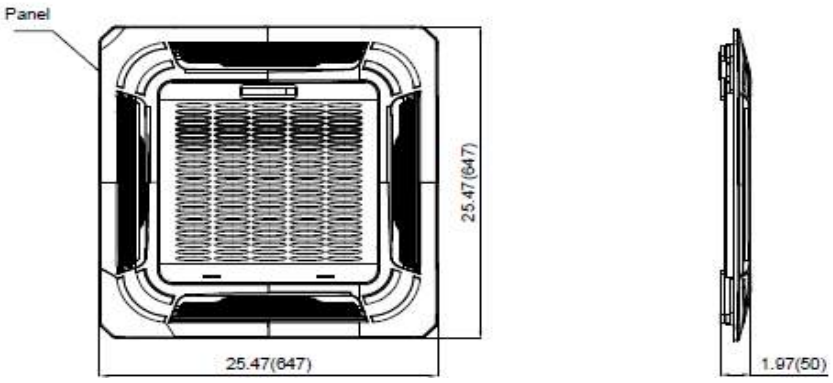
Construction View











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Edition Date: 03/2018
Catalog No: 40MBCQ-09-3-02SB

Cassette Heat Pump Ductless System

Indoor Model: 40MBCQ12---3

Submittal Data

Job Data: Location:

Buyer: Buyer P.O. #: Carrier #:

Unit Number: Model Number:

Performance Data Certified By: Date:





STANDARD FEATURES
Modes: Cool, Heat, Dry, Fan, Auto
Louver Control (Fixed or Swing)
Outside Air Intake
Built-in condensate Lift pump
Follow Me (senses temperature at handheld remote)
Heating Setback (46° F Heating Mode)
Quiet indoor operation
Aluminum Golden Hydrophilic pre-coated fins

Controls:
Wireless Remote Controller included with indoor unit
Optional Wired Remote Controller (Timer Function)
Optional Wired Remote Controller KSACN0501AAA (7 Day programmable)

LIMITED WARRANTY*
• 10 year limited to original purchaser on compressor and parts upon timely registration, otherwise 5 years
*For residential applications. See warranty for full details.

System	Size		12
	Indoor Model		40MBCQ12---3
Electrical	Voltage, Phase, Cycle	V/Ph/Hz	208/230-1-60
	Power Supply	Indoor unit powered by outdoor unit	
	MCA	A.	0.2
Controls	Wireless Remote Controller (°F/°C Convertible)		Standard
	Wired Remote Controller (°F/°C Convertible)		Optional
Operating Range	Cooling Indoor DB Min -Max	°F(°C)	63~90 (17~32)
	Heating Indoor DB Min -Max	°F(°C)	32~86 (0~30)
Piping	Pipe Connection Size - Liquid	in (mm)	1/4 (6.35)
	Pipe Connection Size - Suction	in (mm)	1/2 (12.7)

Indoor Coil	Face Area	Sq. Ft.	3.10
	No. Rows		2
	Fins per inch		19
	Circuits		4
Indoor	Body Unit Width	in (mm)	22.44 (570)
	Body Unit Height	in (mm)	10.24 (260)
	Body Unit Depth	in (mm)	22.44 (570)
	Body Net Weight	lbs (kg)	35.27 (16)
	Panel Unit Width	in (mm)	25.47 (647)
	Panel Unit Height	in (mm)	1.97 (50)
	Panel Unit Depth	in (mm)	25.47 (647)
	Panel Net Weight	lbs (kg)	5.51 (2.5)
	Number of Fan Speeds		3
	Airflow (low to high)	CFM	280/340/400
	Sound Pressure (lowest to highest)	dB(A)	36/39/42
	Air throw Data	ft (m)	23 (7)
	Moisture removal	Pint/h (L/h)	2.88 (1.366)
	Field Drain Pipe Size O.D.	in (mm)	1 (25.4)

For Compatibility See Product Data
Performance may vary based on the outdoor unit matched to. See compatible outdoor units pages for Performance Data.

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Edition Date: 03/2018
Catalog No: 40MBCQ-12-3-02SB

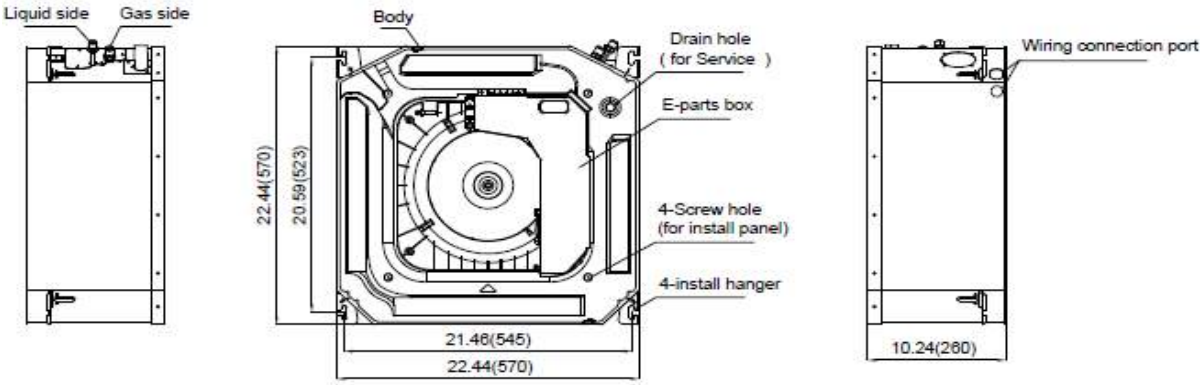
Accessories

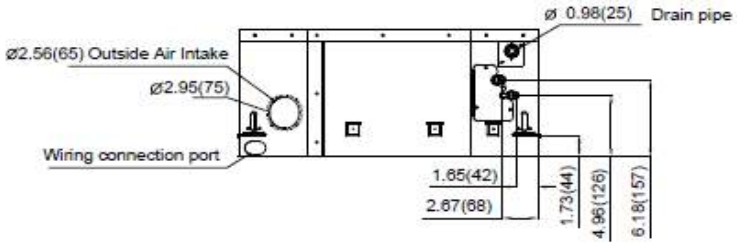
KSACN0101AAA	Wired Remote Control with Timer Function
KSACN0501AAA	Wired Remote Control 7 day Programmable
KSAIF0401AAA	Wi-Fi™ Kit
KSAIC0101230	24V Interface Kit 208/230V
40MBCQ01XXX3	Grille/Ceiling panel
53DS-900---008	Insulated 25' Line Set - 1/4" x 1/2"

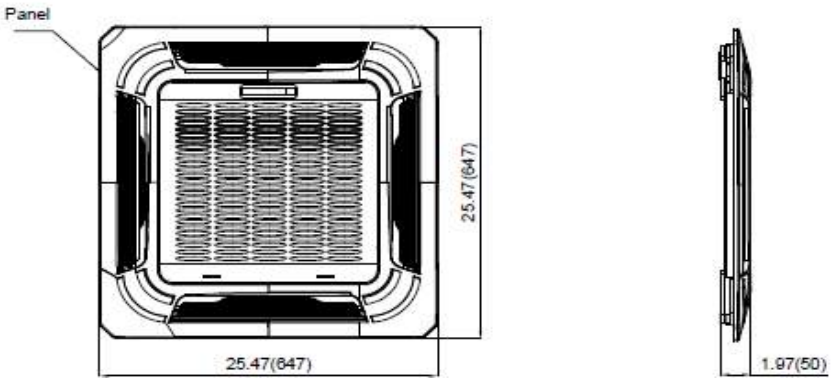
Construction View











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Cassette Heat Pump Ductless System

Indoor Model: 40MBCQ18---3

Submittal Data

Job Data: Location:

Buyer: Buyer P.O. #: Carrier #:

Unit Number: Model Number:

Performance Data Certified By: Date:





STANDARD FEATURES
Modes: Cool, Heat, Dry, Fan, Auto
Louver Control (Fixed or Swing)
Outside Air Intake
Built-in condensate Lift pump
Follow Me (senses temperature at handheld remote)
Heating Setback (46° F Heating Mode)
Quiet indoor operation
Aluminum Golden Hydrophilic pre-coated fins

Controls:
Wireless Remote Controller included with indoor unit
Optional Wired Remote Controller (Timer Function)
Optional Wired Remote Controller KSACN0501AAA (7 Day programmable)

LIMITED WARRANTY*
• 10 year limited to original purchaser on compressor and parts upon timely registration, otherwise 5 years
*For residential applications. See warranty for full details.

System	Size		18
	Indoor Model		40MBCQ18---3
Electrical	Voltage, Phase, Cycle	V/Ph/Hz	208/230-1-60
	Power Supply	Indoor unit powered by outdoor unit	
	MCA	A.	0.2
Controls	Wireless Remote Controller (°F/°C Convertible)		Standard
	Wired Remote Controller (°F/°C Convertible)		Optional
Operating Range	Cooling Indoor DB Min -Max	°F(°C)	63~90 (17~32)
	Heating Indoor DB Min -Max	°F(°C)	32~86 (0~30)
Piping	Pipe Connection Size - Liquid	in (mm)	1/4 (6.35)
	Pipe Connection Size - Suction	in (mm)	1/2 (12.7)

Indoor Coil	Face Area	Sq. Ft.	3.10
	No. Rows		2
	Fins per inch		19
	Circuits		4
Indoor	Body Unit Width	in (mm)	22.44 (570)
	Body Unit Height	in (mm)	10.24 (260)
	Body Unit Depth	in (mm)	22.44 (570)
	Body Net Weight	lbs (kg)	39.68 (18)
	Panel Unit Width	in (mm)	25.47 (647)
	Panel Unit Height	in (mm)	1.97 (50)
	Panel Unit Depth	in (mm)	25.47 (647)
	Panel Net Weight	lbs (kg)	5.51 (2.5)
	Number of Fan Speeds		3
	Airflow (low to high)	CFM	290/350/420
	Sound Pressure (lowest to highest)	dB(A)	46/48/50
	Air throw Data	ft (m)	30 (9)
	Moisture removal	Pint/h (L/h)	4.26 (2.02)
	Field Drain Pipe Size O.D.	in (mm)	1 (25.4)

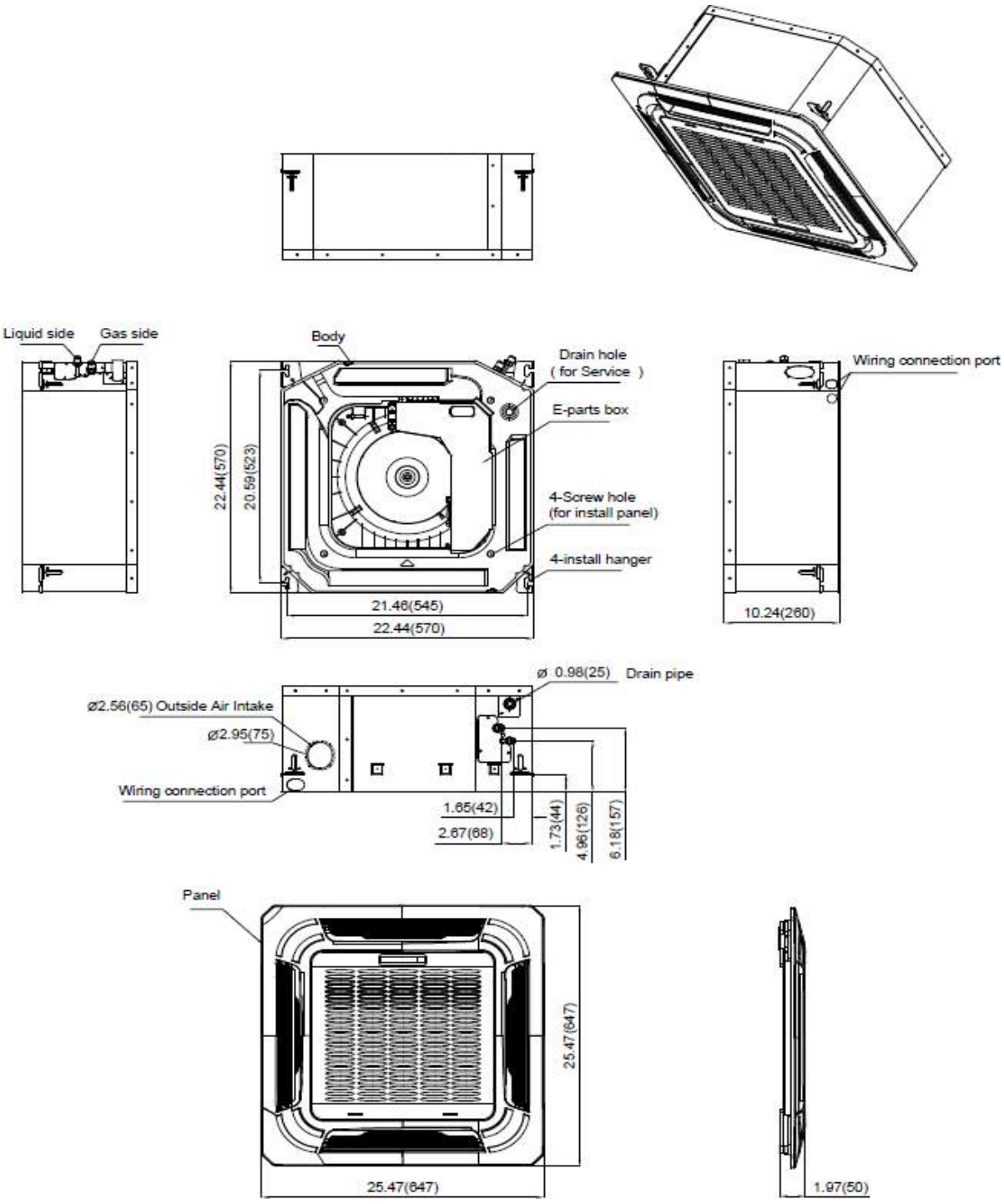
For Compatibility See Product Data
Performance may vary based on the outdoor unit matched to. See compatible outdoor units pages for Performance Data.

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Edition Date: 03/2018
Catalog No: 40MBCQ-18-3-02SB

Accessories

KSACN0101AAA	Wired Remote Control with Timer Function
KSACN0501AAA	Wired Remote Control 7 day Programmable
KSAIF0401AAA	Wi-Fi™ Kit
KSAIC0101230	24V Interface Kit 208/230V
40MBCQ01XXX3	Grille/Ceiling panel
53DS-900---008	Insulated 25' Line Set - 1/4" x 1/2"

Construction View



Cassette Heat Pump Ductless System

Indoor Model: 40MBCQ24---3

Submittal Data

Job Data: | Location:

Buyer: | Buyer P.O. #: | Carrier #:

Unit Number: | Model Number:

Performance Data Certified By: | Date:





STANDARD FEATURES
Modes: Cool, Heat, Dry, Fan, Auto
Louver Control (Fixed or Swing)
Outside Air Intake
Built-in condensate Lift pump
Follow Me (senses temperature at handheld remote)
Heating Setback (46° F Heating Mode)
Quiet indoor operation
Aluminum Golden Hydrophilic pre-coated fins

Controls:
Wireless Remote Controller included with indoor unit
Optional Wired Remote Controller (Timer Function)
Optional Wired Remote Controller KSACN0501AAA (7 Day programmable)

LIMITED WARRANTY*
• 10 year limited to original purchaser on compressor and parts upon timely registration, otherwise 5 years
*For residential applications. See warranty for full details.

System	Size		24
	Indoor Model		40MBCQ24---3
Electrical	Voltage, Phase, Cycle	V/Ph/Hz	208/230-1-60
	Power Supply	Indoor unit powered by outdoor unit	
	MCA	A.	0.332
Controls	Wireless Remote Controller (°F/°C Convertible)		Standard
	Wired Remote Controller (°F/°C Convertible)		Optional
Operating Range	Cooling Indoor DB Min -Max	°F(°C)	62~90 (17~32)
	Heating Indoor DB Min -Max	°F(°C)	32~86 (0~30)
Piping	Pipe Connection Size - Liquid	in (mm)	3/8 (9.52)
	Pipe Connection Size - Suction	in (mm)	5/8 (16)

Indoor Coil	Face Area	Sq. Ft.	3.63
	No. Rows		2
	Fins per inch		18
	Circuits		8
Indoor	Body Unit Width	in (mm)	33.07 (840)
	Body Unit Height	in (mm)	8.07 (205)
	Body Unit Depth	in (mm)	33.07 (840)
	Body Net Weight	lbs (kg)	46.3 (21)
	Panel Unit Width	in (mm)	37.4 (950)
	Panel Unit Height	in (mm)	2.17 (55)
	Panel Unit Depth	in (mm)	37.4 (950)
	Panel Net Weight	lbs (kg)	11.02 (5)
	Number of Fan Speeds		3
	Airflow (low to high)	CFM	625/761/878
	Sound Pressure (lowest to highest)	dB(A)	47/50/52
	Air throw Data	ft (m)	30 (9)
	Moisture removal	Pint/h (L/h)	5.22 (2.47)
	Field Drain Pipe Size O.D.	in (mm)	1 (25.4)

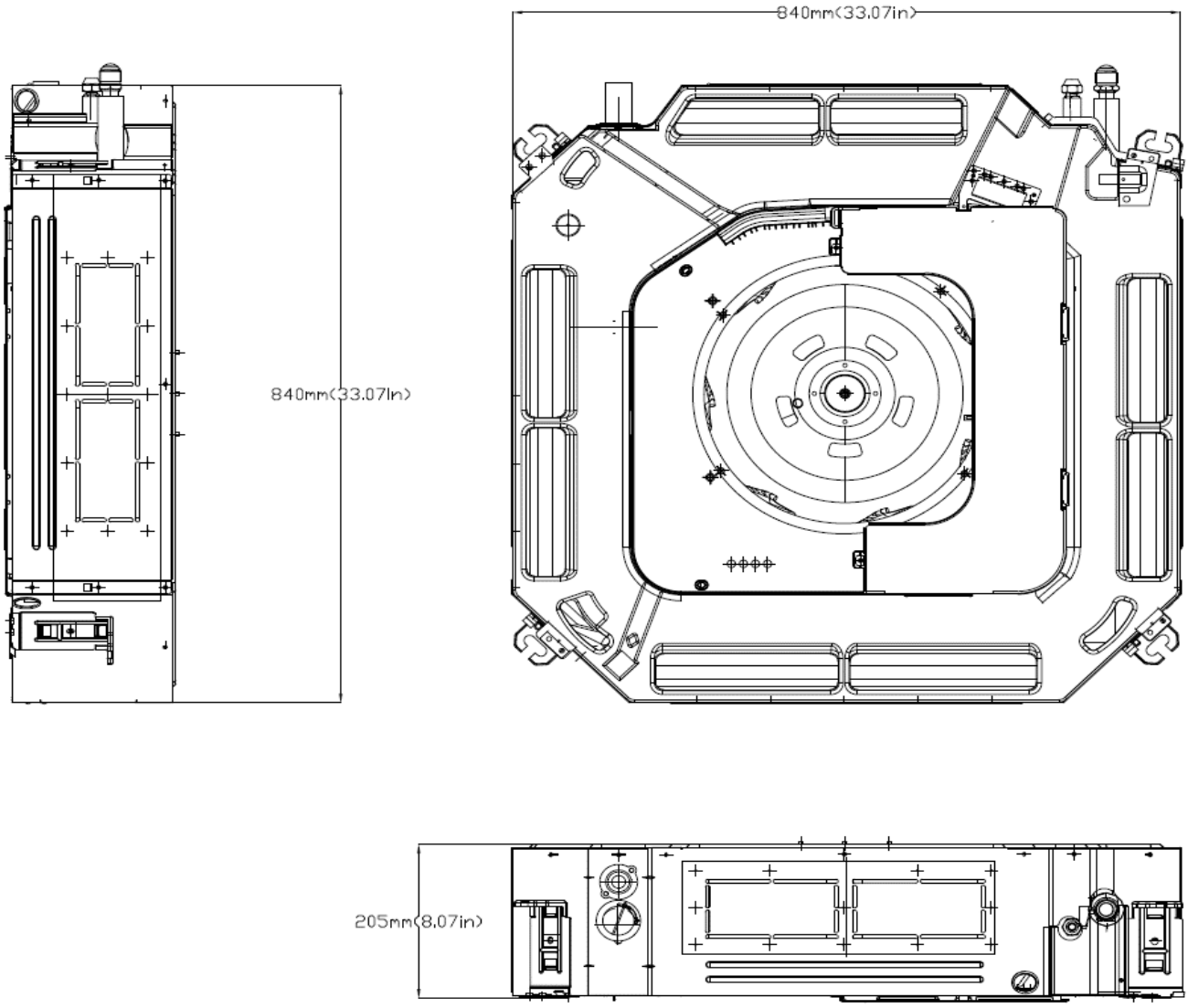
For Compatibility See Product Data
Performance may vary based on the outdoor unit matched to. See compatible outdoor units pages for Performance Data.

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Edition Date: 03/2018
Catalog No: 40MBCQ-24-3-01SB

Accessories

KSACN0101AAA	Wired Remote Control with Timer Function
KSACN0501AAA	Wired Remote Control 7 day Programmable
KSAIF0401AAA	Wi-Fi™ Kit
KSAIC0101230	24V Interface Kit 208/230V
40MBCQ02XXX3	Grille/Ceiling panel

Construction View



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Edition Date: 03/2018
Catalog No: 40MBCQ-24-3-01SB

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PHONE: (951)278-1830 FAX: (951)278-8444 www.canfab.com canfab@canfab.com

3, 4, 5 TONS

FOR: GROUP A

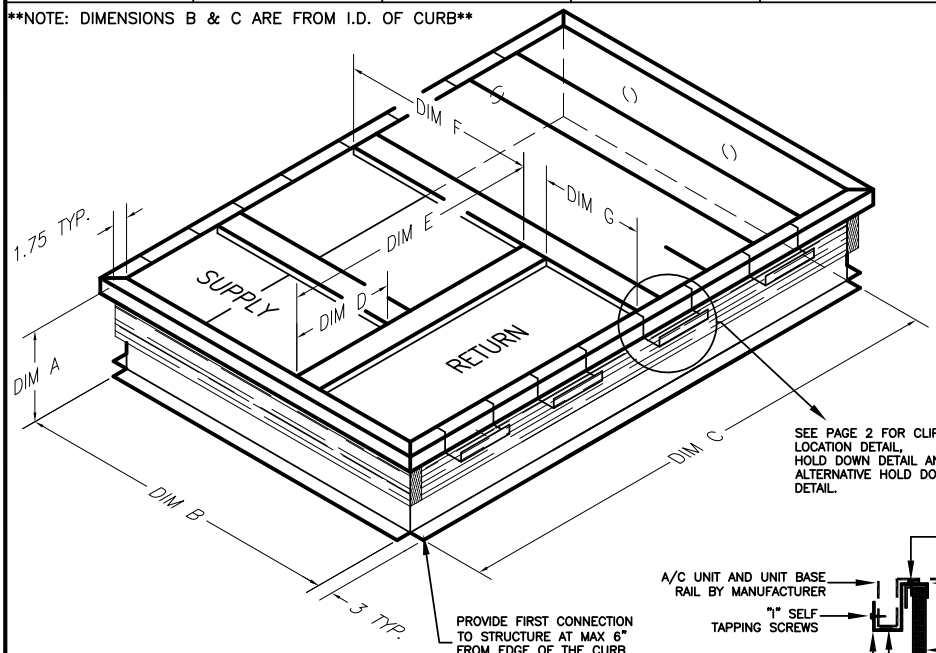
CARRIER 3 - 6-1/2 TONS

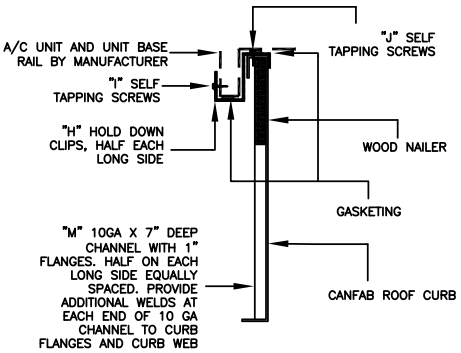
48/50HC/GC 04-06, 50HCQ 04-06, 50 KCQ 04-06, 48/50LC 04-06, 48/50TC/FC 04-07, 50TCQ 04-07, 48/50KC/FC 04-06

PART NO: 1005-CB

DIM A	DIM B	DIM C	DIM D	DIM E	DIM F	DIM G	DIM H
VARIES MAX 36" SEE TABLE 3	37.1875"	67.375"	14.1875"	32.1875"	20.25"	13.875"	N/A

NOTE: DIMENSIONS B & C ARE FROM I.D. OF CURB





14" TALL CURB
144 LBS.

ALL WORK SHALL CONFORM TO THE STANDARD OF 2018 INTERNATIONAL BUILDING CODE & 2019 CALIFORNIA BUILDING CODE.

SEISMIC DESIGN CRITERIA
-SDS = 1.5 ap = 2.5
-I = 1.5 Rp = 6.0

WIND DESIGN CRITERIA
-MAX 60 FT TALL BUILDING
-EXPOSURE C
-175 MPH, 3 SECOND GUST WIND

NOTE:
INSTALLER TO VERIFY WITH A LICENSED STRUCTURAL ENGINEER IN THE CORRESPONDING STATE THE ADEQUACY OF THE STRUCTURE FOR LOADS IMPOSED BY THE UNIT AND THE CURB IN ADDITION TO ALL OTHER LOADS.
-INSTALLER TO VERIFY WITH A LICENSED STRUCTURAL ENGINEER IN THE CORRESPONDING STATE THAT THE SEISMIC AND WIND DESIGN CRITERIA NOTED ON THIS DRAWING ARE ADEQUATE FOR THE SITE SPECIFIC VALUES. OTHERWISE, CONTACT CANNON FABRICATION FOR A SITE SPECIFIC ANALYSIS AND DRAWINGS.

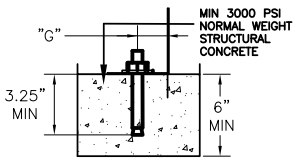
CURB CONSTRUCTION
1) ☐ WELDED
2) ☐ BOLTED
3) ☐ FINGERLOCK
-ALL WELDING CONSTRUCTION CERTIFIED TO ANSI/AWS D1.3 STRUCTURAL WELDING CODE-SHEET METAL
-SELF-DRILLING SCREW SHALL MEET ASTM C1513 SPECIFICATION AND INSTALLED PER AISI-S100
-NO GAP IS ALLOWED BETWEEN TWO METAL SHEET SURFACES WHERE SHEET METAL SCREW IS CONNECTED

CURB AND UNIT INFORMATION
"A" GAUGE GALVANIZED STEEL CURB

-SEE TABLE 3 FOR ALLOWABLE CURB AND UNIT DIMENSIONAL AND WEIGHT

-SEE TABLE 4 FOR TABULATED CURB AND ANCHORAGE INFORMATION PER VARYING CURB HEIGHT

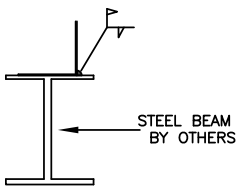
- ALPHA DESIGNATIONS "A" THRU "M", CAN BE FOUND ON TABLE 4, PAGE 3



ATTACHMENT TO STRUCTURAL CONCRETE

"B" 1/2" HILTI KWIK BOLT TZ SS 304, HALF EACH LONG SIDE.
"C" 1/2" HILTI KWIK BOLT TZ SS 304, HALF EACH SHORT SIDE.

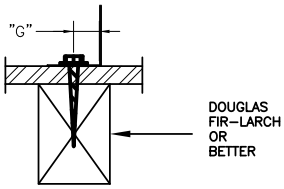
NOTE:
-MIN 5" AWAY FROM THE NEAREST CONCRETE EDGE (INSTALL PER ICC-ES ESR-1917).
-STRUCTURALLY ACCEPTABLE TO SUBSTITUTE HILTI KBTZ STAINLESS STEEL BOLTS WITH HILTI KBTZ CARBON STEEL BOLTS ONLY IF ALL THE BOLTS ARE COMPLETELY WATERPROOFED AND PROTECTED AGAINST THE WEATHER.
-BOLTS SHALL BE EQUALLY SPACED



ATTACHMENT TO STRUCTURAL STEEL

1/8" FILLET WELD, 2" LONG, "D" ON CENTER.

NOTE:
-PROVIDE MIN 2 CONNECTIONS WHERE THE CURB SIDE IS SHORTER THAN THE WELD SPACING.
-PROVIDE WELDS ON ALL SIDES



ATTACHMENT TO WOOD

"E" 3/8"x4" LAG SCREWS, HALF EACH LONG SIDE.
"F" 3/8"x4" LAG SCREWS, HALF EACH SHORT SIDE.

NOTE:
-SCREWS SHALL BE EQUALLY SPACED.

STRUCTURAL REVIEW BY:

MARTIN & associates
JOHN A. MARTIN AND ASSOCIATES
Structural Engineers
950 South Grand Ave., 4th Floor
Los Angeles, California 90015
Phone (213) 483 6490
Fax (213) 483 3084
Job No.: 19022



3/22/2019

PROJECT: IBC 2018 UPDATE/ CBC 2019 UPDATE DATE: 3.12.19

ENGINEER: LD DISTRIBUTOR:

DRAWING NUMBER: GROUP_A.DWG

CanFab
CANNON FABRICATION INC
182 GRANITE STREET, SUITE 101, CORONA, CA 92879
PHONE: (951)278-1830 FAX: (951)278-8444 www.canfab.com canfab@canfab.com

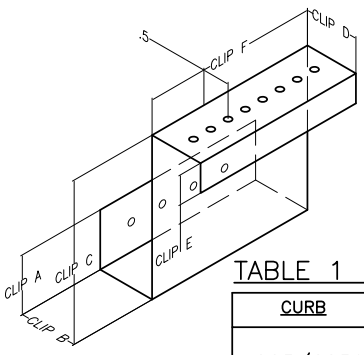
FOR: GROUP A

PART NO: SEE BELOW

STRUCTURAL REVIEW BY:

MARTIN & associates
JOHN A. MARTIN AND ASSOCIATES
Structural Engineers
950 South Grand Ave., 4th Floor
Los Angeles, California 90015
Phone (213) 483 6490
Fax (213) 483 3084
Job No.: 19022

HOLD DOWN DETAIL



NOTE:
SEE TABLE 1 FOR DESIGNATED HOLD DOWN CLIP PER CURB

TABLE 1 HOLD DOWN CLIP PER CURB

CURB	CLIP	GAUGE	CLIP A [IN]	CLIP B [IN]	CLIP C [IN]	CLIP D [IN]	CLIP E [IN]	CLIP F [IN]
1005/6059	1909-SHD8-12	12 GA	1.5	2.625	4.5625	1.875	1.0	9.0
3003	3901-SHD8-12	12 GA	1.0	4.81	3.875	2.125	1.0	9.0
4027	4901-SHD8-12	12 GA	2.0	3.0625	4.625	1.875	1.0	9.0
6037	6907-SHD8-12	12 GA	2.0	2.0	3.25	1.875	1.0	9.0

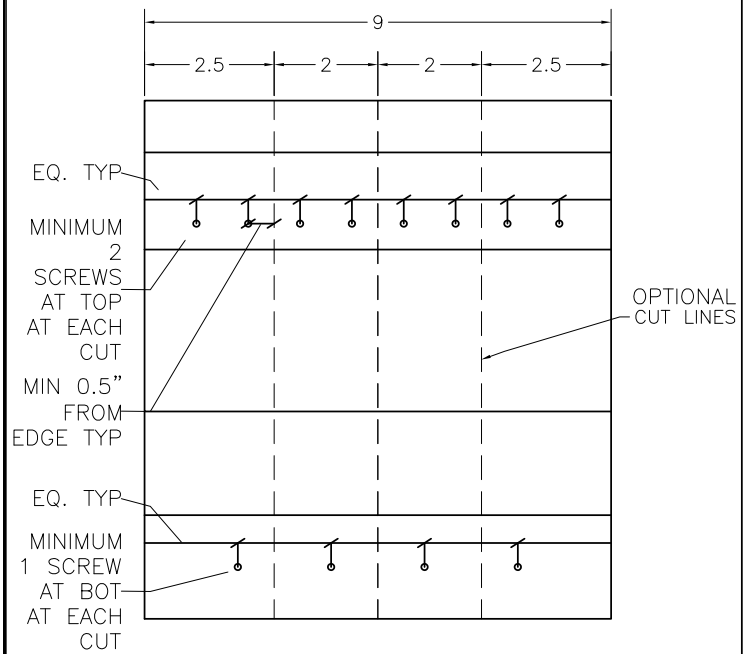


3/22/2019

ALTERNATIVE HOLD DOWN DETAIL

NOTE:
APPLICABLE ONLY FOR 9" LONG HOLD DOWN WITH (8) SCREWS AT TOP AND (4) SCREWS AT BOT EQUALLY SPACED

1. INFORMATION SHOWN ON THE STAMPED CANFAB CURB DRAWING IS THE MINIMUM REQUIREMENTS FOR THE CURB CONSTRUCTION AND INSTALLATION. NO STRUCTURAL OBJECTION TO THE USE OF LARGER SIZE SCREWS AND THICKER GAUGE SHEET METAL THAN THE INFORMATION SHOWN ON THE STAMPED CANFAB CURB DRAWING.
2. NO STRUCTURAL OBJECTION TO SHIFTING THE ATTACHMENT CLIPS ALONG THE CURB. FIRST AND LAST CLIP IN THE SERIES OF CLIPS SHALL BE LOCATED PER CLIP LOCATION DETAIL PER STAMPED CANFAB CURB DRAWING. DISTANCE SHIFTED SHALL NOT BE LARGER THAN THE LENGTH OF THE CLIP.
3. NO STRUCTURAL OBJECTION TO CUTTING THE ATTACHMENT CLIPS PER REQUIREMENTS AS SHOWN ON BELOW SKETCH.



CLIP LOCATION DETAIL

NOTE:
SEE TABLE 2 FOR CLIP LOCATION

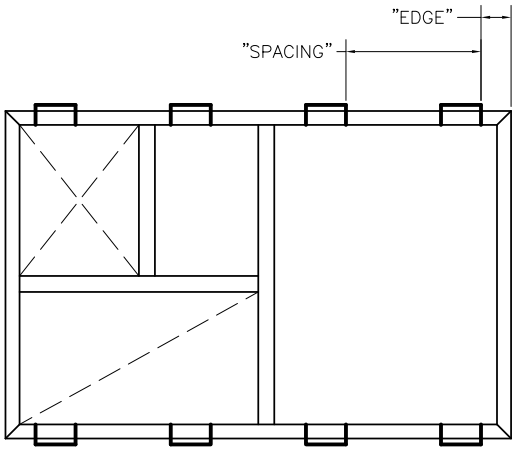


TABLE 2 CLIP LOCATION

CURB	EDGE [IN]	SPACING [IN]
1005/6059	7.75	15.46
3003	7.75	19.00
4027	7.75	18.33
6037	7.75	13.58

PROJECT: IBC 2018 UPDATE/ CBC 2019 UPDATE DATE: 3.12.19

ENGINEER: LD DISTRIBUTOR:

DRAWING NUMBER: GROUP_A.DWG

CANNON FABRICATION INC
182 GRANITE STREET, SUITE 101, CORONA, CA 92879
PHONE: (951)278-1830 FAX: (951)278-8444 www.canfab.com canfab@canfab.com

FOR: GROUP A

PART NO: SEE BELOW

STRUCTURAL REVIEW BY:

MARTIN & associates
JOHN A. MARTIN AND ASSOCIATES
Structural Engineers
950 South Grand Ave., 4th Floor
Los Angeles, California 90015
Phone (213) 483 6490
Fax (213) 483 3084
Job No.: 19022

REGISTERED PROFESSIONAL ENGINEER GREGORY LOUIS OROZCO No. 4957 STRUCTURAL STATE OF CALIFORNIA

3/22/2019

TABLE 3 ALLOWABLE CURB AND UNIT DIMENSION AND WEIGHT

RELATED CURBS	LCURB [IN]	WCURB [IN]	HCURB [IN]	WTCURB [LBS]	LUNIT [IN]	WUNIT [IN]	HUNIT [IN]	WTUNIT [LBS]	CG.LONG [IN]	CG.SHORT [IN]	CG.HEIGHT [IN]
1005	SEE PAGE 1	SEE PAGE 1	MIN 8	MIN 110	74.375	46.75	41.375	MAX 900	34.625	22.5	20.25
			11	127							
			14	144							
			18	166							
			24	262							
			MAX 36	MAX 354							
3003	SEE PAGE 1	SEE PAGE 1	MIN 8	MIN 82	82.25	44.875	32.625	MAX 900	38.6	18.75	HUNIT/2
			11	99							
			14	115							
			18	137							
			24	225							
			MAX 36	MAX 316							
4027	SEE PAGE 1	SEE PAGE 1	MIN 8	MIN 91	83.25	45	43.375	MAX 1316	47	22	HUNIT/2
			11	109							
			14	127							
			18	151							
			24	238							
			MAX 36	MAX 355							
6037	SEE PAGE 1	SEE PAGE 1	MIN 8	MIN 111	69.875	44.25	40.875	MAX 1202	44	22	HUNIT/2
			11	124							
			14	141							
			18	162							
			24	256							
			MAX 36	MAX 345							
6059	SEE PAGE 1	SEE PAGE 1	MIN 8	MIN 112	76.841	47.934	42.004	MAX 869	42	29	HUNIT/2
			11	129							
			14	146							
			18	169							
			24	265							
			MAX 36	MAX 358							

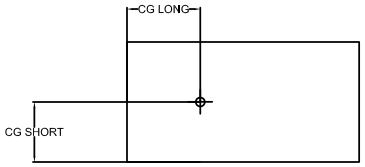


TABLE 4 TABULATED CURB AND ANCHORAGE INFORMATION PER VARYING HEIGHT

		0 < H ≤ 18"	18" < H ≤ 22"	22" < H ≤ 30"	30" < H ≤ 36"
A	CURB THICKNESS	14 GA	14 GA	12 GA	12 GA
B	EXP. ANCHOR	6	6	6	8
C	EXP. ANCHOR	4	4	4	4
D	WELD	36"	36"	36"	24"
E	SCREWS	16	18	20	22
F	SCREWS	8	8	10	12
G	DISTANCE	MAX 0.75"	MAX 0.75"	MAX 0.75"	MAX 0.75"
H	NO. OF CLIPS	8	8	8	8
I	CLIP SMS	(4) #12	(4) #12	(4) #12	(4) #12
J	CLIP SMS	(8) #12	(8) #12	(8) #12	(8) #12
K	ISO RAIL	N/A	N/A	N/A	N/A
L	NO. OF ISOLATORS	N/A	N/A	N/A	N/A
M	NO. OF STIFFENERS	N/A	N/A	N/A	(6)

PROJECT: IBC 2018 UPDATE/ CBC 2019 UPDATE DATE: 3.12.19

ENGINEER: LD DISTRIBUTOR:

DRAWING NUMBER: GROUP_A.DWG

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FOR:

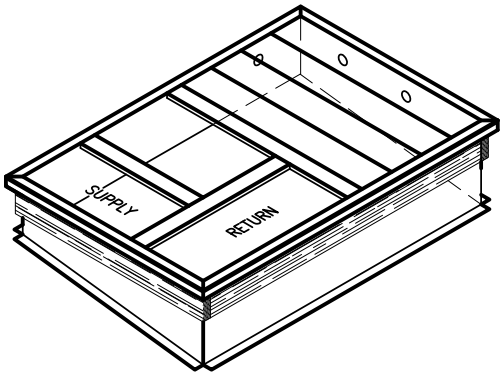
PART NO:

Pitched Roof Curb

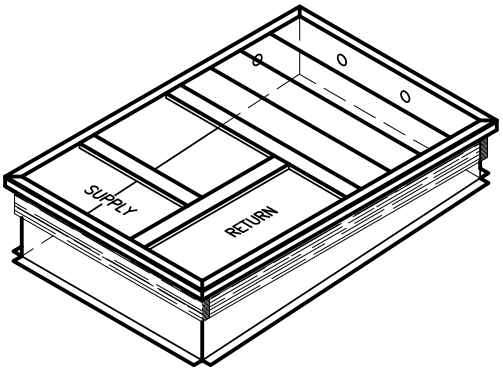
Drawing Must Accompany All Pitched Curb Orders

APPLIES TO STANDARD AND ISOLATION CURBS

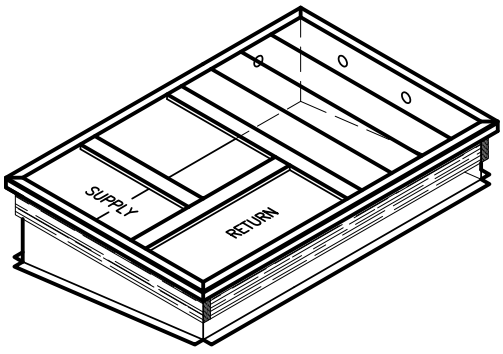
(A)



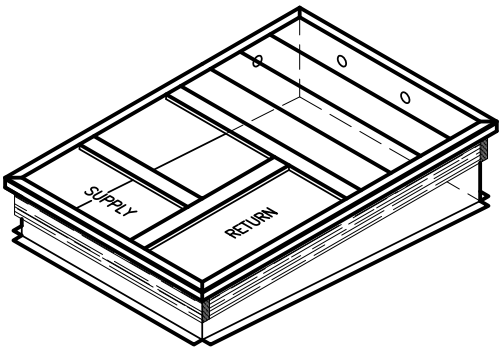
(B)



(C)



(D)



_____ On 12"

(Circle A, B, C or D To Specify Duct Placement)

PROJECT:

DATE: 01.08.19

ENGINEER:

DISTRIBUTOR:

DRAWING NUMBER:

STRUCTURAL CALCULATIONS

for

IBC 2018
Group A

NON ISOLATED CURB

1005 (Max Curb Height up to 36")

CURB AND ANCHORAGE WIND & SEISMIC DESIGN

Prepared for:

Cannon Fabrication, Inc. (CanFab)
182 Granite Street, Suite 101
Corona, California 92879
951.278.1830 (p)

Prepared by:

John A. Martin & Associates, Inc.
950 South Grand Avenue, 4th Floor
Los Angeles, California 90015
213.483.6490 (p)

JAMA Project No. J13001. 380
PO# 12751
NOV/21/2018

THE CURB HAS BEEN DESIGNED FOR SDS = 1.5G, I = 1.5 AND WIND REGION V = 175MPH. FOR HIGH SEISMIC REGIONS WITH SDS > 1.5G, I > 1.5 OR WIND REGIONS V > 175MPH, FURTHER ANALYSIS AND MODIFICATIONS TO THE CURB ARE REQUIRED PRIOR TO CONSTRUCTION

THE SUPPORTING STRUCTURE SHALL BE REVIEWED AND APPROVED BY OTHERS. BUILDING ENGINEER OF RECORD SHALL PROVIDE SUPPORT STRUCTURE AND VERIFY THE ADEQUACY OF THE STRUCTURE FOR LOADS IMPOSED ON THEM BY UNIT AS WELL AS ALL OTHER LOADS.

NO INSTALLATION SHALL TAKE PLACE UNTIL THE CURB, ANCHORAGE AND SUPPORTING STRUCTURE ARE APPROVED BY THE APPROPRIATE JURISDICTION.



11/26/2018

MARTIN & associates
JOHN A. MARTIN & ASSOCIATES, INC.
Structural Engineers

PREPARED BY LK

JOHN A. MARTIN and ASSOCIATES, INC. ☐ STRUCTURAL ENGINEERS

Architect: CANNON FABRICATION, INC. Sheet

Project: IBC 2018 Group A Job No. J13001 . 380

Date NOV/21/2018

CURB & ANCHORAGE DESIGN Engineer LK

DESIGN
for
NON ISOLATED CURB
1005 (Max Curb Height of 18")

950 S. GRAND AVENUE, 4TH FLOOR, LOS ANGELES, CALIFORNIA 90015 (213) 483-6490

JOHN A. MARTIN and ASSOCIATES, INC. ☐ STRUCTURAL ENGINEERS

Architect: CANNON FABRICATION, INC. Sheet

Project: IBC 2018 Group A Job No. J13001 . 380

Date NOV/21/2018

CURB & ANCHORAGE DESIGN Engineer LK

Design Wind Loads for Rooftop Equipment (ASCE 7-16 § Table 29.1-1)

$z := 60ft$ **Height above ground level**

$B := 60ft$ **Horizontal dimension of building measured normal to wind direction**

$Exp_{category} := "C"$ **Exposure Category per ASCE 7-16 § 26.7**

$Risk_{category} := "IV"$ **Risk Category per ASCE 7-16 Table 1.5-1**

$$V := \begin{cases} 0mph & \text{if } Risk_{category} = "I" \\ 0mph & \text{if } Risk_{category} = "II" \\ 175mph & \text{otherwise} \end{cases} = 175 \cdot mph$$

Basic Wind Speed per ASCE 7-16 Figure 26.5-1 A,B or C

$K_z = 1.14$ **Velocity Pressure Exposure Coefficient per ASCE 7-16 Table 29.10-1 [Exposure Category "C"]**

$K_{zt} := 1.0$ **Topographic Factor per ASCE 7-16 § 26.8, Figure 26.8-1**

$K_e := 1.0$ **Ground Elevation Factor per ASCE 7-16 § 26.9, Table 26.9-1**

$K_d := 0.85$ **Wind Directionality Factor per ASCE 7-16 § 26.6, Table 26.6-1 (Equipment)**

$q_z := 0.00256 K_z \cdot K_{zt} \cdot K_d \cdot K_e \cdot V^2 = 75.74 \cdot psf$ **Velocity pressure evaluated at height z above ground per ASCE 7-10 § 26.10.2; Eq. 26.10-1**

$GC_{r.lateral.max} := 1.9$ **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.9 for rooftop structures and equipment with Af less than (0.1Bh). (GCr) shall be permitted to be reduced linearly from 1.9 to 1.0 as the value of Af is increased from (0.1Bh) to (Bh)

$GC_{r.vertical.max} := 1.5$ **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.5 for rooftop structures and equipment with A_r less than (0.1*BL*). (GC_r) shall be permitted to be reduced linearly from 1.5 to 1.0 as the value of A_r is increased from (0.1*BL*) to (*BL*)

$P_{net} := q_z \cdot GC_{r.lateral.max} = 143.91 \cdot psf$ **Design Lateral Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-2**

$P_v := q_z \cdot GC_{r.vertical.max} = 113.61 \cdot psf$ **Design Vertical Uplift Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-3**

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Project: IBC 2018 Group A Job No. J13001 . 380

Date NOV/21/2018

CURB & ANCHORAGE DESIGN Engineer LK

Seismic Demands on Nonstructural Components (ASCE 7-16 § 13.3 & 13.6):

$S_{DS} := 1.5$ **Design spectral response acceleration parameter at short periods per USGS map**

$I_p := 1.5$ **Component importance factor ASCE 7-16 § 13.1.3**

$\Omega_0 := 2.0$ **Overstrength factor ASCE 7-16 Table 13.6.1**

Vibr_Isolation = "No" **Placement of Unit Vibration Isolated:**

Note: Only "F_p" at seismic concrete anchor has been increased with overstrength factor "Ω_0"

$a_p := 2.5$ $R_p = 6.0$ **Seismic coefficients a_p & R_p**
Per ASCE 7-16 Table 13.6-1 for
Mechanical & Electrical Components

$z = 60\,ft$ **Height in structure of point of attachment of component with respect to the base**

$h := 60ft$ **Average roof height of structure with respect to the base**
Where for roof top equipment:

$z \div h = 1$

F_p: Horizontal Seismic Design Force per *ASCE7-16 § 13.3.1*

F_p shall be takes as $\left(\frac{0.4 \cdot a_p \cdot S_{DS} \cdot I_p}{R_p}\right) \cdot \left(1 + 2 \cdot \frac{z}{h}\right) \cdot W_p = 112.5 \cdot \% \cdot W_p$

F_p is not required to be taken as greater than $\left(1.6 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 360 \cdot \% \cdot W_p$

F_p shall not be taken as less than $\left(0.3 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 67.5 \cdot \% \cdot W_p$

Governing F_p : Horizontal Seismic Design Force $F_p = 112.5 \cdot \% \cdot W_p$

F_v: Vertical Load per ASCE7-16 § 13.3.1.2

Concurrent Vertical Seismic Force: $F_v := 0.2 \cdot S_{DS} \cdot W_p = 30 \cdot \% \cdot W_p$

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Project: IBC 2018 Group A Job No. J13001 . 380

Date NOV/21/2018

CURB & ANCHORAGE DESIGN Engineer LK

Flat Roof Snow Loads (ASCE 7-16 § 7.3):

$Terrain_{CAT} := "C"$ **Terrain Category ASCE 7-16 § 26.7 & Table 7.3-1**

$Exp_{Roof} := "Partially\ Exposed"$ **Exposure of Roof ASCE 7-16 Table 7.3-1**

$C_e = 1$ **Exposure Factor ASCE 7-16 Table 7.3-1**

$Thermal_{condition} := "All\ structures\ except\ below"$ **Thermal Condition ASCE 7-16 Table 7.3-2**

$C_t = 1$ **Thermal Factor ASCE 7-16 Table 7.3-2**

$Risk_{category} = "IV"$ **Risk Category per ASCE 7-16 Table 1.5-1**

$I_s = 1.2$ **Snow Importance Factor ASCE 7-16 Table 1.5-2**

$p_g := 40psf$ **Ground Snow Loads ASCE 7-16 Figure 7.2-1**

$$p_f := \max\left(0.7 \cdot C_e \cdot C_t \cdot I_s \cdot p_g, \text{if}\left(p_g > 20psf, 20psf \cdot I_s, I_s \cdot p_g\right)\right) = 34 \cdot psf$$

Flat Roof Snow Loads ASCE 7-16 Equation 7.3-1 and § 7.3.4

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Date NOV/21/2018

CURB & ANCHORAGE DESIGN Engineer LK

Mechanical Unit Dimensions

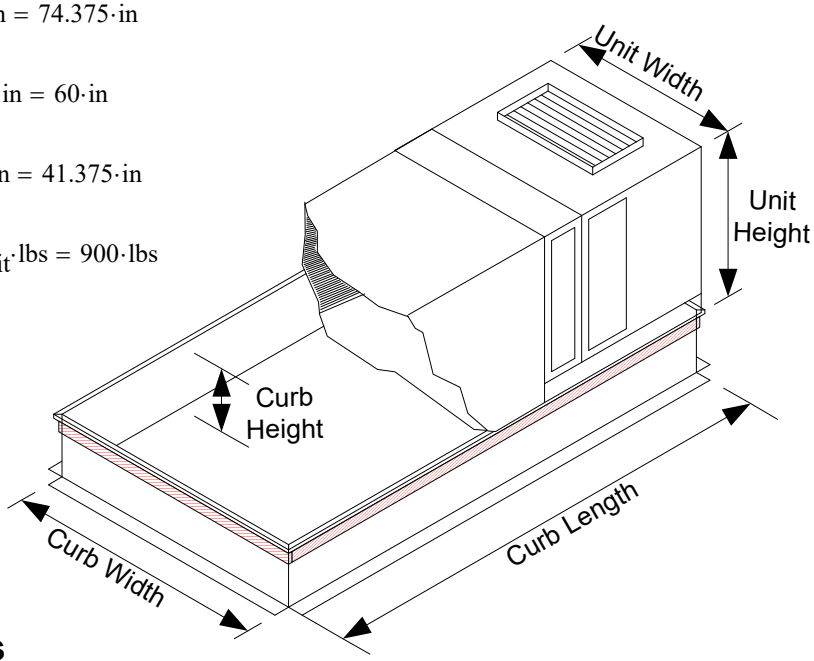
Curb = "C-1005"

Length of Unit $L_{unit} := L_{unit} \cdot in = 74.375 \cdot in$

Width of Unit $W_{unit} := W_{unit} \cdot in = 60 \cdot in$

Height of Unit $H_{unit} := H_{unit} \cdot in = 41.375 \cdot in$

Weight of Unit $Wt_{unit} := Wt_{unit} \cdot lbs = 900 \cdot lbs$



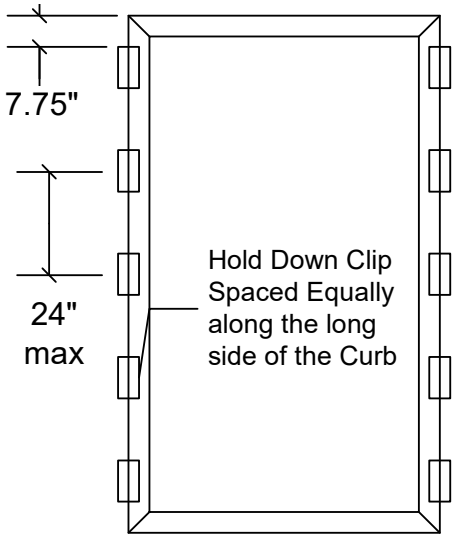
Roof Curb Dimensions

Length of Curb $L_{curb} := L_{curb} \cdot in = 67.375 \cdot in$

Width of Curb $W_{curb} := W_{curb} \cdot in = 37.188 \cdot in$

Height of Curb $H_{curb} := H_{curb} \cdot in = 18 \cdot in$

Weight of Curb $Wt_{curb} := Wt_{curb} \cdot lbs = 354 \cdot lbs$



Curb Plan

Overall System Dimensions

Total Weight

$Wt_{tot} := Wt_{unit} + Wt_{curb} = 1254 \cdot lbs$

Total height

$H_{total} := H_{unit} + H_{curb} = 59.375 \cdot in$

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Date NOV/21/2018

CURB & ANCHORAGE DESIGN Engineer LK

Seismic Loading + Snow Loading

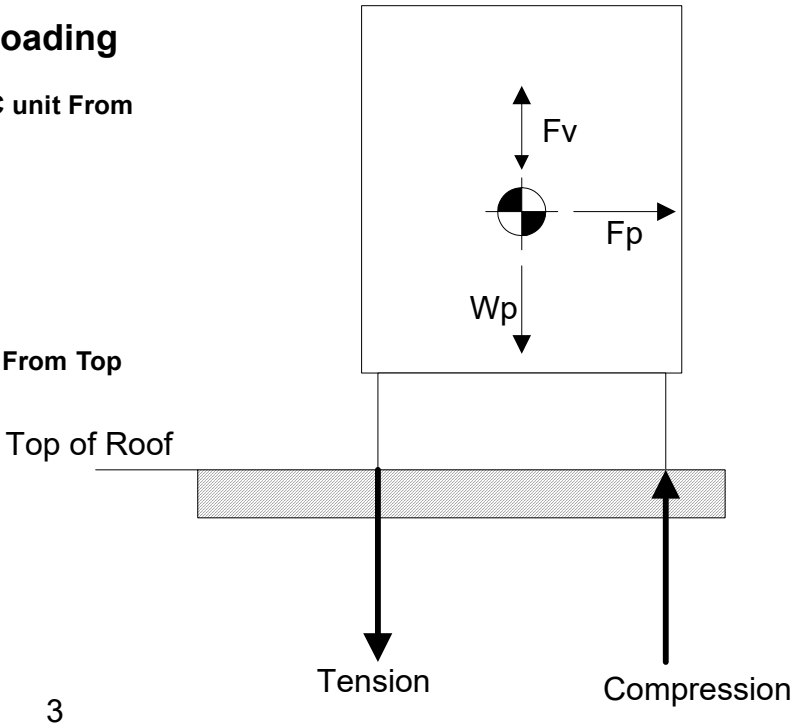
Height for Center of Gravity for HVAC unit From Top of Roof

$h_{CG.unit} := \frac{1}{2} H_{unit} = 21 \cdot in$

$h_{CG} := H_{curb} + h_{CG.unit} = 38.69 \cdot in$

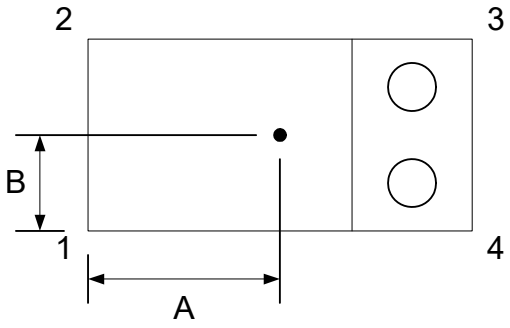
Height for Center of Gravity for Curb From Top of Roof

$h_{CG.curb} := \frac{H_{curb}}{2} = 9 \cdot in$



Max Seismic Base Shear

$V_{base.S} := F_p \cdot Wt_{tot} = 1411 \cdot lbs$



Unit C.G. distance in axis parallel to Curb Width $B_{ecc.width} := CG_{short} \cdot in = 22.5 \cdot in$

Eccentricity in axis parallel to Curb Width

$$e_{width} := \begin{cases} 0in & \text{if } B_{ecc.width} = \text{"N/A"} \\ \left| B_{ecc.width} - \frac{W_{unit}}{2} \right| & \text{otherwise} \end{cases} = 7.5 \cdot in$$

Unit C.G. distance in axis parallel to Curb Length $A_{ecc.length} := CG_{long} \cdot in = 34.625 \cdot in$

Eccentricity in axis parallel to Curb Length

$$e_{length} := \begin{cases} 0in & \text{if } A_{ecc.length} = \text{"N/A"} \\ \left| A_{ecc.length} - \frac{L_{unit}}{2} \right| & \text{otherwise} \end{cases} = 2.56 \cdot in$$

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Project: IBC 2018 Group A Job No. J13001 . 380

Date NOV/21/2018

CURB & ANCHORAGE DESIGN Engineer LK

Max Net Tension Reaction On Each Side Due To Seismic Loads

$$T_S := \begin{bmatrix} \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{W_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{W_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} \right] \\ \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{L_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{L_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} \right] \end{bmatrix} = \begin{pmatrix} -882 \\ -279 \end{pmatrix}\cdot lbs$$

Max Net Compression Reaction On Each Side Due To Seismic Loads

$$C_S := \begin{bmatrix} \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{W_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \\ \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{L_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \end{bmatrix} = \begin{pmatrix} 3513 \\ 2635 \end{pmatrix}\cdot lbs$$

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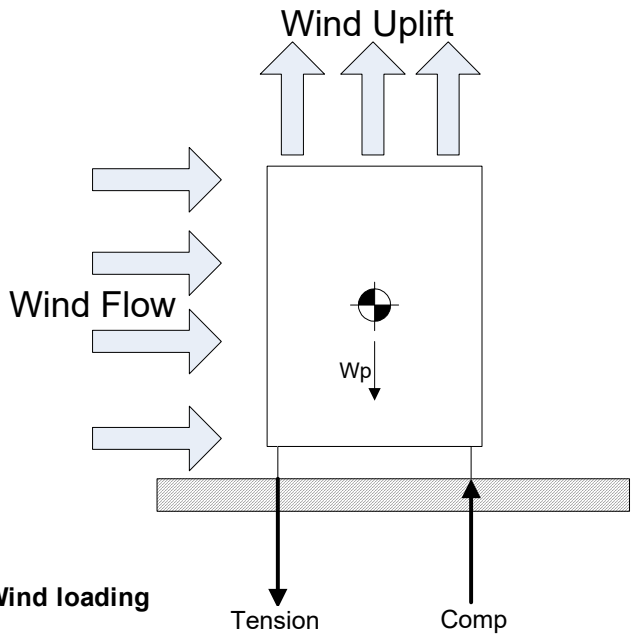
Architect: CANNON FABRICATION, INC. Sheet

Project: IBC 2018 Group A Job No. J13001 . 380

Date NOV/21/2018

CURB & ANCHORAGE DESIGN Engineer LK

Wind Loading + Snow Loading



Max Base Shear due to wind loading

$$V_{base.W} := P_{net} \cdot L_{unit} \cdot H_{total} = 4413 \cdot lbs$$

Max Uplift due to wind loading

$$L_{unit.up} := L_{unit} - 0in = 74.375 \cdot in$$

$$P_{uplift.W} := P_v \cdot L_{unit.up} \cdot W_{unit} = 3521 \cdot lbs$$

Max Net Tension Reaction On Each Side Due To Wind loading

$$T_W := \begin{pmatrix} \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} - \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \\ \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} - \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} -4883 \\ -2796 \end{pmatrix} \cdot lbs$$

Max Net Compression Reaction On Each Side Due To Wind loading

$$C_W := \begin{pmatrix} \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} + \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \\ \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} + \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} 5326 \\ 3195 \end{pmatrix} \cdot lbs$$

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Governing Loading @ Curb

Max uplift vertical load along the length of the curb

$$\omega_{x.L.vert.up} := \frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}} = 870 \cdot plf$$

Max compressive vertical load along the length of the curb

$$\omega_{x.L.vert.comp} := \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}} = 949 \cdot plf$$

Max vertical load along the length of the curb

$$\omega_{x.L.vert} := \max\left(\omega_{x.L.vert.up}, \omega_{x.L.vert.comp}\right) = 949 \cdot plf$$

Max uplift vertical load along the width of the curb

$$\omega_{x.W.vert.up} := \frac{\max\left[\left|T_{S_{(1)}}\right|, \left|T_{W_{(1)}}\right|\right]}{W_{curb}} = 902 \cdot plf$$

Max compressive vertical load along the width of the curb

$$\omega_{x.W.vert.comp} := \frac{\max\left[\left|C_{S_{(1)}}\right|, \left|C_{W_{(1)}}\right|\right]}{W_{curb}} = 1031 \cdot plf$$

Max vertical loading along the width of the curb

$$\omega_{x.W.vert} := \max\left(\omega_{x.W.vert.up}, \omega_{x.W.vert.comp}\right) = 1031 \cdot plf$$

$$\begin{pmatrix} V_{base.S} \\ V_{base.W} \end{pmatrix} = \begin{pmatrix} 1411 \\ 4413 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} \left|T_S\right| \\ \left|C_S\right| \end{pmatrix} = \begin{pmatrix} 925 \\ 4392 \end{pmatrix} \cdot lbs$$

$$\begin{pmatrix} F_v \cdot Wt_{tot} \\ P_v \cdot L_{unit} \cdot W_{unit} \end{pmatrix} = \begin{pmatrix} 376 \\ 3521 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} \left|T_W\right| \\ \left|C_W\right| \end{pmatrix} = \begin{pmatrix} 5626 \\ 6211 \end{pmatrix} \cdot lbs$$

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Anchorage To Concrete [Expansion Anchor per ACI 318-14]

Number of connection on the long side $N_B := 3 + 2$

Moment Arm for overturning (Short side) $B := W_{curb} = 37 \cdot in$

Number of Connection on the Short side. $N_L := 2 + 2$

Moment Arm for over turning (Long side) $L := L_{curb} = 67 \cdot in$

Total Number of Connections $N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 10$

Max Net Tension Reaction Due to Seismic Load, Fp

$$R_{c.EQ.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 22 \cdot lbs \qquad R_{c.EQ.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 5 \cdot lbs$$

$$R_{c.EQ} := MAX+\left[\begin{array}{l} \left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{c.EQ.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{c.EQ.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \end{array}\right] = \begin{pmatrix} 406 \\ 247 \end{pmatrix} \cdot lbs$$

Max net Tension Reaction Due to Wind Load, Pnet

$$R_{c.W} := MAX+\left[\begin{array}{l} \frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t} \end{array}\right] = \begin{pmatrix} 977 \\ 639 \end{pmatrix} \cdot lbs$$

Governing Load Case: $Govern := if\left(\left|R_{c.EQ}\right| > \left|R_{c.W}\right|, "Seismic", "Wind"\right) = "Wind"$

Governing Tension Reaction at Each anchor Point: $R_c := if\left(Govern = "Seismic", R_{c.EQ}, R_{c.W}\right) = \begin{pmatrix} 977 \\ 639 \end{pmatrix} \cdot lbs$

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Max Tension on anchor: $N_{ua} := |R_c| = 1167 \cdot lbs$

Max Shear on anchor: $V_{ua} := \frac{\max(\Omega_0 \cdot V_{base.S}, V_{base.W})}{N_t} = 441 \cdot lbs$

Hilti Kwik Bolt TZ – Carbon Steel
1/2" Anchor with min 3 1/4" embedment
Base material: 6" thick Cracked concrete w/
Compressive strength fc' = 3000 psi
Min 5" away from the concrete edge
Evaluation Report: ICC-ESR 1917

Loading Condition:	**Wind**

Design Tension Capacity [ϕN_n]:	3,500	[lbs]
Design Shear Capacity [ϕV_n]:	3,572	[lbs]

$\phi N_n := \phi N_n \cdot lbs = 3500 \cdot lbs$

$\phi V_n := \phi V_n \cdot lbs = 3572 \cdot lbs$

Utilization:

Tension Utilization: $\beta_N := \frac{N_{ua}}{\phi N_n} = 33 \cdot \%$

Shear Utilization: $\beta_V := \frac{V_{ua}}{\phi V_n} = 12 \cdot \%$

Interaction of Tensile and Shear Forces:
Per ACI 318-14 Sec. 17.6

$\beta_{NV} := \frac{(\beta_N) + (\beta_V)}{1.2} = 38 \cdot \%$

$$check\_interaction := \begin{pmatrix} if(\beta_N < 1.0, "OK", "NG") \\ if(\beta_V < 1.0, "OK", "NG") \\ if(\beta_{NV} < 1.0, "OK", "NG") \end{pmatrix} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

$$check\_interaction = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

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Anchorage To Structural Steel [Fillet Weld Conn. per AISI S100-16]

Fillet Weld 2" Long Along the Long and Short Side. Min 2 Connections per Side
Spacing: 48" O.C. for Non-Isolated Curbs; 24" for Isolated Curbs

Number of Welds on the Long Side $N_B := 2$

Moment Arm for Overturning (Short Side) $B := W_{curb} = 37 \cdot in$

Number of Welds on the Short Side. $N_L := 2$

Moment Arm for Overturning (Long Side) $L := L_{curb} = 67 \cdot in$

Total Number of Connections $N_t := \left[\left(N_B\right) + \left(N_L\right)\right] \cdot 2sides = 8$

Max Net Tension Reaction due to Seismic Load FP

$$R_{weld.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 54 \cdot lbs$$

$$R_{weld.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 10 \cdot lbs$$

$$R_{weld.EQ} := MAX+\left[\begin{bmatrix} \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{weld.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{weld.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 535 \\ 234 \end{pmatrix} \cdot lbs$$

Max Net Tension Reaction due to Wind Load Pnet

$$R_{weld.W} := MAX+\left[\begin{bmatrix} \frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 2142 \\ 1099 \end{pmatrix} \cdot lbs$$

Tension Design Force; SRSS for Loading from Each Direction $T_{u.weld} := \max\left(\left|R_{weld.EQ}\right|, \left|R_{weld.W}\right|\right) = 2408 \cdot lbs$

Shear Load at Each Weld Connection $V_{u.weld} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{N_t} = 552 \cdot lbs$

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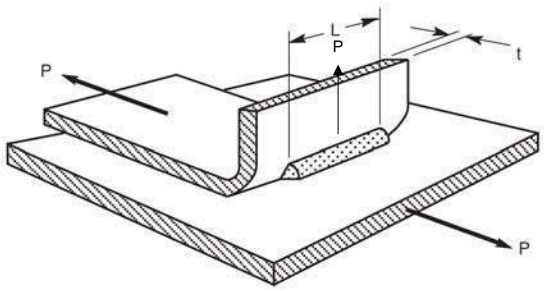
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Total Demand: SRSS of V and T

$$R_{u.weld} := \sqrt{T_{u.weld}^2 + V_{u.weld}^2} = 2470 \cdot lbs$$

Fillet Weld Design per AISI S100-16 Section J2.5

Weld Length at Each Connection Point $L_w := 2in$



Effective Throat Fillet Weld Size

$$t_w := \left(\frac{1}{8}in\right) \cdot 0.707 = 0.088 \cdot in$$

Thickness for the Thinnest Martial Being Welded
Min Curb Thickness = 16GA with Fu=65 ksi

$t_1 := thick("14GA") = 0.0785 \cdot in$

$F_u := 65ksi$

Min weld material strength

$F_{exx} := 70ksi$

For Longitudinal Loading [Parallel capacity is considered to be loading in the direction of the length of the weld] per (Eq. J2.5-1) &(Eq. J2.5-2)

$$\phi P_{long} := \begin{cases} (0.6)\left(1 - \frac{0.01 \cdot L_w}{t_1}\right) \cdot L_w \cdot t_1 \cdot F_u & \text{if } \frac{L_w}{t_1} < 25 \\ (0.5) \cdot 0.75 \cdot t_1 \cdot L_w \cdot F_u & \text{otherwise} \end{cases} = 3827 \cdot lbs$$

where $L_w \div t_1 = 25$

For Transverse Loading per (Eq. J2.5-5)

$$\phi P_{trans} := (0.65) \cdot t_1 \cdot L_w \cdot F_u = 6633 \cdot lbs$$

Strength of Weld Material per (Eq. J2.5-7)

$$\phi P_{weld} := (0.6) \cdot 0.75 \cdot t_w \cdot L_w \cdot F_{exx} = 5568 \cdot lbs$$

Design Strength of Fillet Weld

$$\phi P_n := \min\left(\phi P_{long}, \phi P_{trans}, \phi P_{weld}\right) = 3827 \cdot lbs$$

D/C Ratio for the Welded Connection

$$\beta_{NW} := \frac{R_{u.weld}}{\phi P_n} = 65 \cdot \%$$

$weld_{check} := if\left(\beta_{NW} < 1.0, "OK", "NG"\right)$

$weld_{check} = "OK"$

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Anchorage To Wood Member WITH Lag Screws [NDS-2018 LRFD Strength Design]

*** Use 3/8" Lag Screws along Each Side of the Curb**
*** Assume G=0.5 Douglas Fir-Larch**

Wood Lag Screw Capacity per NDS 2018 Section 11.3

Wet Service Factor: Cond := "DRY" **(e.g. CA = "DRY", AK = "WET")**

$$C_M := \begin{cases} 1.0 & \text{if Cond = "DRY"} \\ 0.7 & \text{if Cond = "WET"} \end{cases} = 1$$ **NDS 2018 Table 11.3.3**

Temperature Factor:
$$C_t := \begin{cases} 0.8 & \text{if Cond = "DRY"} \\ 0.7 & \text{if Cond = "WET"} \end{cases} = 0.8$$ **NDS 2018 Table 11.3.4**

Group Action Factor: $C_g := 0.97$ **NDS 2018 Table 11.3.6C**

Geometry Factor: $C_\Delta := 1.0$ **NDS 2018 Table 12.5.1A,B**

End Grain Factor: $C_{eg} := 1.0$ **NDS 2018 Sec. 12.5.2**

Diaphragm Factor: $C_{di} := 1.0$ **NDS 2018 Sec. 12.5.3**

Toe-Nail Factor: $C_{tn} := 1.0$ **NDS 2018 Sec. 12.5.4**

Format Conversion Factor: $K_F := 3.32$ **NDS 2018 Table 11.3.1**

Resistance Factor: $\phi := 0.65$ **NDS 2018 Table 11.3.1**

Time Effect Factor: $\lambda := 1.0$ **NDS 2018 App N.3.3**

Lateral Design Value: $Z := 130\text{lbs}$ **NDS 2018 Table 12K**

Withdrawal Design Value: $W := 305\text{lbs}$ **NDS 2018 Table 12.2A**

Lag Screw Diameter: $D_{lag} := \frac{3}{8}\text{in}$

Lag Screw Length: $L_{lag} := 4\text{in}$

Length of Tapered Tip: $E_{lag} := \frac{7}{32}\text{in}$

Lag Screw Penetration: $P_{lag} := 3.78125\text{in}$

Eff. Lag Screw Penetration for withdrawal: $P_{\omega.lag} := 2\text{in} + \frac{9}{32}\text{in} = 2.28\cdot\text{in}$ **NDS 2018 Appx. Table L2**

NDS 2018 Sec. 12.1.4.6

Minimum Penetration DCR <1.0: $DCR_{min.penetration} := \frac{4\cdot D_{lag}}{P_{\omega.lag}} = 0.66$ $DCR_{min.penetration} = \text{"OK"}$

Adj. Lateral Design Value: $Z' := Z\cdot C_M\cdot C_t\cdot C_g\cdot C_\Delta\cdot C_{eg}\cdot C_{di}\cdot C_{tn}\cdot K_F\cdot\phi\cdot\lambda = 218\cdot\text{lbs}$

Adj. Withdrawal Design Value: $W' := W\cdot C_M^{2}\cdot C_t\cdot C_{eg}\cdot C_{tn}\cdot K_F\cdot\phi\cdot\lambda = 527\cdot\text{lbs}$ **NDS 2018 Table 11.3.1**

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Number of Lag Screws on the Long Side $N_B := 8 + 2$

Moment Arm for Overturning (Short Side) $B := W_{curb} = 37 \cdot in$

Number of Lag Screws on the Short Side $N_L := 4 + 2$

Moment Arm for Overturning (Long Side) $L := L_{curb} = 67 \cdot in$

Total Number of Lag Screws $N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 24$

Max net Tension Reaction due to Seismic, Fp

$$R_{lag.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 11 \cdot lbs$$

$$R_{lag.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 3 \cdot lbs$$

$$R_{lag.EQ} := MAX+\left[\begin{bmatrix} \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{lag.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{lag.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 95 \\ 78 \end{pmatrix} \cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$R_{lag.W} := MAX+\left[\begin{bmatrix} \frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{L \cdot N_L \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 468 \\ 366 \end{pmatrix} \cdot lbs$$

Tension Design force; SRSS for loading from Each direction $T_{lag} := \max\left(\left|R_{lag.EQ}\right|, \left|R_{lag.W}\right|\right) = 595 \cdot lbs$

Shear load at each anchor location $V_{lag} := \frac{\max\left(V_{base.S} \cdot \sqrt{2}, V_{base.W}\right)}{N_t} = 184 \cdot lbs$

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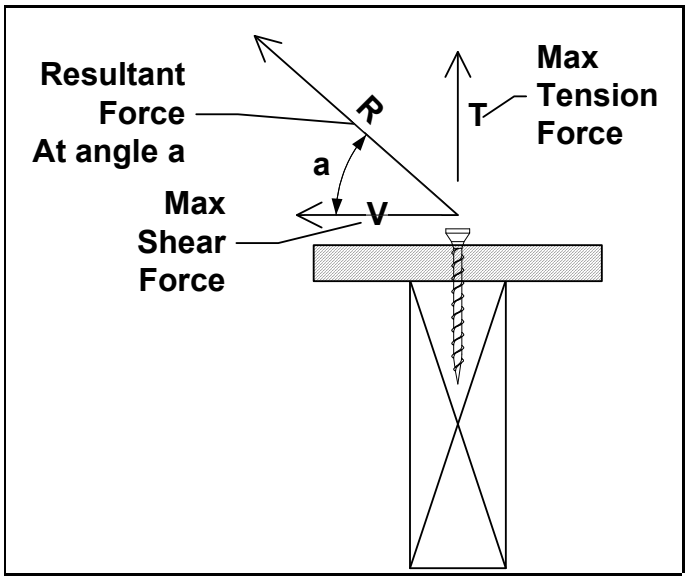
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For Lag Screws Subjected to Combined Lateral and Withdrawal Loading; Design Strength of the Lag Screw Shall Be Adjusted per Hankinson Formula as Prescribed by NDS 2018 Equation 12.4-1



Angle Between Wood Surface and Direction of Resultant Applied Load

$$(\alpha) := \operatorname{atan}\left(\frac{T_{lag}}{V_{lag}}\right) = 73\cdot deg$$

Combined Demand per Lag Screw @ Strength Level

$$R_{lag} := \sqrt{T_{lag}^{2} + V_{lag}^{2}} = 622\cdot lbs$$

Adjusted Capacity per NDS 2018 Equation 12.4-1 @ Strength Level

$$Z'_{\alpha} := \frac{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot Z'}{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot\cos(\alpha)^{2} + Z'\cdot\sin(\alpha)^{2}} = 861\cdot lbs$$

D/C Ratio for the Lag Screw connection to Wood Structure

$$\beta_{Lag} := \frac{R_{lag}}{Z'_{\alpha}} = 72\cdot\%$$

$$Lag_{Screw.Check} := \text{if}\left(\beta_{Lag} < 1.0, \text{"OK"}, \text{"NG"}\right)$$

$Lag_{Screw.Check}$ = "OK"

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Bearing and Tilting in Curb Bolted Connection AISI S100-16

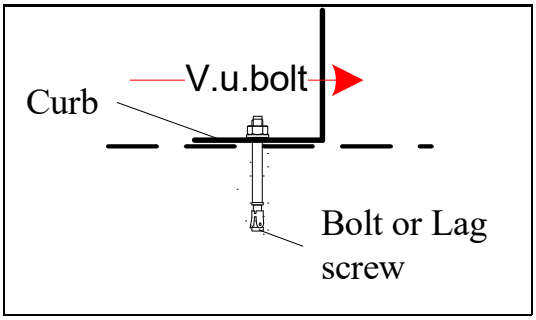
Nominal bolt diameter $d := 0.5in$

Uncoated sheet thickness $t_{curb} := thick("14GA") = 0.079 \cdot in$

Tensile strength of sheet $F_u := 65ksi$

Coefficient for conversion of units $\alpha := 1.0$

Modification Factor $m_f := 1.0$



Modification factor for type of bearing connection, per Table J3.3.1-2; For single shear connection with washers

Bearing Factor

$$C := \begin{cases} 3 \text{ if } \left(\frac{d}{t_{curb}} < 10\right) \wedge \left(0.024in < t_{curb} < 0.1875in\right) = 3 \\ "NG" \text{ if } \frac{d}{t_{curb}} > 10 \end{cases}$$

Bearing factor, which shall be determined according to Table J3.3.1-1 For d/t<10 where $d \div t_{curb} = 6$

Bearing Design Strength per AISI S100-16 Eq. J3.3.1-1

$$\phi P_{n_{(0)}} := (0.6) \cdot \left(m_f \cdot C \cdot d \cdot t_{curb} \cdot F_u\right) = 4592 \cdot lbs$$

Bolt Hole Deformation Design Strength per AISI S100-16 Eq. J3.3.2-1

$$\phi P_{n_{(1)}} := (0.65) \cdot \left[4.64 \cdot \left(\frac{\alpha}{in}\right) \cdot t_{curb} + 1.53\right] \cdot d \cdot t_{curb} \cdot F_u = 3141 \cdot lbs$$

Curb Connection Shear Capacity $\phi P_n := \min\left(\phi P_n\right) = 3141 \cdot lbs$

Loading demand at connection

$$V_{u.bolt} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{4} = 1103 \cdot lbs$$

$Curb\_Conn\_Shear := if\left(V_{u.bolt} < \phi P_n, "OK", "NG"\right)$

Curb_Conn_Shear = "OK"

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Thickness of Curb, ISO Rail and Clip

(Per AISC Table 17-10 Galvanized)

Hold Down Clip thickness

$t_{Clip} := "12GA"$ $t_{clip} := thick(t_{Clip}) = 0.1084 \cdot in$

Roof Curb thickness

$t_{Curb} := "14GA"$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

ISO RAIL thickness

$t_{Curb.iso} := "10GA"$ $t_{curb.iso} := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Note: Iso Rail thickness is only used if the curb is isolated. Not used for non-isolated curbs

Sheet Metal Screws (SMS) Equations and References

SMS properties (ESR-2196 Table 5)

$SMS_{Table} =$

"SMS"	"Diameter"	"HeadDiameter"	"Tension"	"Shear"
"Size"	"d"	"dw"	"Pts"	"Pss"
"#8"	0.164	0.335	1000	1170
"#10"	0.19	0.399	1370	1215
"#12"	0.216	0.415	2325	1880
"#14"	0.25	0.5	4580	2440

SMS Tension Eqns

$P_{not} = 0.85 \cdot t \cdot d \cdot F_u$ **(AISI S100-16 J4.4.1 & J4.4.2)**

$P_{nov} = 1.5 \cdot t \cdot d_w \cdot F_u$

$P_{nts} = 0.8 \cdot P_{ts}$

FOR THE MOST CASES, PULL-OUT CAPACITY IS THE LOWEST

SMS Shearn Eqns

$P_{vnot} = 4.2 \cdot \sqrt{(d \cdot t^3)} \cdot F_u$ **(AISI S100-16 J4.3.1)**

$P_{vnov} = 2.7 \cdot t \cdot d \cdot F_u$

$P_{vnss} = 0.8 \cdot P_{ss}$

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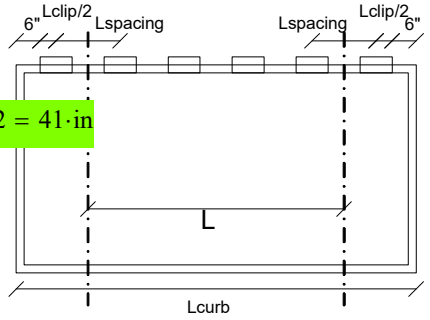
Hold Down Clip Design (Connection of the Mechanical unit to Curb)

Number of Clips on the long side $N_B := 4$

Moment Arm for over turning (Short side) $B := W_{curb} + 1.75in \cdot 2 = 41 \cdot in$

Number of Clips on the Short side $N_L := 4$

Width of Clips $L_{clip} := 9in$



Curb Centerline Spacing (Long side)

$$L_{spacing} := \frac{L_{curb} - \left(6in + \frac{L_{clip}}{2}\right) \cdot 2}{N_B - 1} = 15.458 \cdot in$$

$$L_{spacing.non.iso} := L_{spacing} = 15 \cdot in$$

Moment Arm for over turning (Long side)

$$L := L_{curb} - 2 \cdot \left[6in + \frac{L_{clip}}{2} + L_{spacing} \cdot \frac{(N_L - 2)}{4}\right] = 30.917 \cdot in$$

Total Number of Clips $N_t := (N_B) \cdot 2sides = 8$

Max net Tension Reaction due to Seismic, Fp

$$R_{clip.EQ} := MAX+\left[\begin{array}{l} \left[\frac{F_p \cdot Wt_{unit}}{B \cdot N_B} \cdot h_{CG.unit} + \frac{(0.9 - F_v) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B}\right] - \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} \\ \left[\frac{F_p \cdot Wt_{unit}}{L \cdot N_L} \cdot h_{CG.unit} + \frac{(0.9 - F_v) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L}\right] - \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} \end{array}\right] = \begin{pmatrix} 86 \\ 113 \end{pmatrix} \cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$R_{clip.W} := MAX+\left(\begin{array}{l} \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{unit}^2}{2}}{B \cdot N_B} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{unit}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{unit}^2}{2}}{L \cdot N_L} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{unit}}{N_t} \end{array}\right) = \begin{pmatrix} 767 \\ 771 \end{pmatrix} \cdot lbs$$

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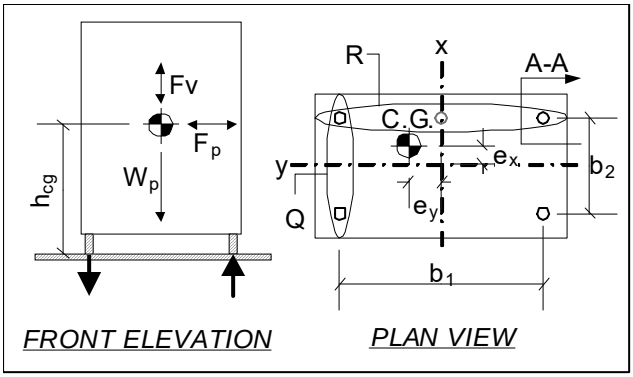
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Tensile and Shear Load calculation per ASHRAE RP-812



Eccentricity along X-X

$e_x := e_{width} = 7.5 \cdot in$

Eccentricity along Y-Y

$e_y := e_{length} = 2.562 \cdot in$

Distance between Seismic Restraints Along Y-Y

$b_1 := L_{curb} - 2 \cdot 6in = 55 \cdot in$

Distance between Seismic Restraints Along X-X

$b_2 := W_{curb} - 2 \cdot 6in = 25 \cdot in$

Moment of Inertia about X-X

$$I_{xx} := \frac{N_t \cdot (N_t + 2) \cdot (b_1)^2}{12 \cdot (N_t - 2)} = 3407 \cdot in^2$$

Moment of Inertia about Y-Y

$$I_{yy} := \frac{N_t \cdot (b_2)^2}{4} = 1269 \cdot in^2$$

Angle about Tensile Load

$$\Theta_t := \operatorname{atan}\left[\frac{I_{yy} \cdot (b_1)}{I_{xx} \cdot (b_2)}\right] = 39 \cdot deg$$

Angle about Shear Load

$$\Theta_s := \begin{cases} \operatorname{atan}\left(\frac{e_x}{e_y}\right) & \text{if } e_y \neq 0 \\ 0deg & \text{if } e_y = 0 \end{cases} = 71 \cdot deg$$

Max Net Tensile Load Due to Seismic Load, Fp

$$T_{U.EQ.pt1} := \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} - \frac{(0.9 - F_v) \cdot Wt_{unit}}{b_1 \cdot b_2} \cdot \left(\frac{b_1}{2} \cdot e_x + \frac{b_2}{2} \cdot e_y - e_x \cdot e_y\right) = -18 \cdot lbs$$

$$T_{U.EQ.pt2} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \cos(\Theta_t) \cdot \frac{0.5 \cdot b_2}{I_{yy}} = -161 \cdot lbs$$

$$T_{U.EQ.pt3} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \sin(\Theta_t) \cdot \frac{0.5 \cdot b_1}{I_{xx}} = -108 \cdot lbs$$

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$T_{U.EQ} := T_{U.EQ.pt1} + T_{U.EQ.pt2} + T_{U.EQ.pt3} = -287 \cdot lbs$

Max Net Shear Load Due to Seismic Load, Fp

$$V_{Ux.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\cos(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_2 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_1 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 86 \cdot lbs$$

$$V_{Uy.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\sin(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_1 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_2 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 144 \cdot lbs$$

$$V_{U.EQ} := \sqrt{V_{Ux.EQ}^2 + V_{Uy.EQ}^2} = 168 \cdot lbs$$

Tension Design force for Hold Down Clips

$T_{clip} := \max(R_{clip.W_0}, R_{clip.W_1}, |R_{clip.EQ}|, |T_{U.EQ}|) = 771 \cdot lbs$

Based on ASCE 7-16 Figure 29.4-1 magnitude of force coefficient,

Wind in diagonal direction to the face of equipment produces less force than that of the wind in perpendicular direction to the face of the equipment.

Therefore, wind in diagonal direction does not need to be used

$|R_{clip.EQ}| = 142 \cdot lbs$ $|T_{U.EQ}| = 287 \cdot lbs$

$|R_{clip.W}| = 1087 \cdot lbs$

$T_{clip.EQ.max} := \max(|R_{clip.EQ}|, |T_{U.EQ}|) = 287 \cdot lbs$

$T_{clip.W.max} := \max(|R_{clip.W}|) = 1087 \cdot lbs$

Shear Design force for Hold Down Clips

$$V_{clip} := \max\left(\frac{\max(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit})}{N_t}, |V_{U.EQ}|\right) = 384 \cdot lbs$$

$F_p \cdot Wt_{unit} \cdot \frac{1}{N_t} = 127 \cdot lbs$ $|V_{U.EQ}| = 168 \cdot lbs$

$P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t} = 384 \cdot lbs$

$$V_{clip.EQ.max} := \max\left[\left(F_p \cdot Wt_{unit} \cdot \frac{1}{N_t}\right), |V_{U.EQ}|\right] = 168 \cdot lbs$$

$$V_{clip.W.max} := \max\left(\left(P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t}\right)\right) = 384 \cdot lbs$$

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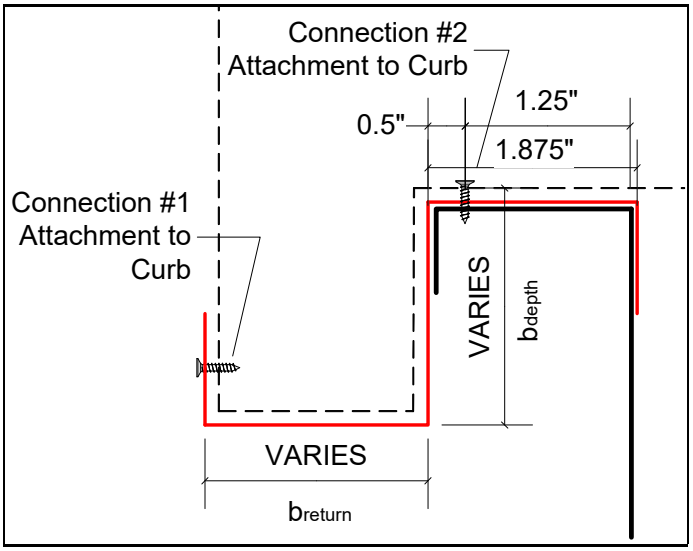
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Loading at Hold Down Clips

Due to the eccentricity of Shear and Tension forces additional moment is created in the hold down clip. These loads to be resisted in a T/C couple.

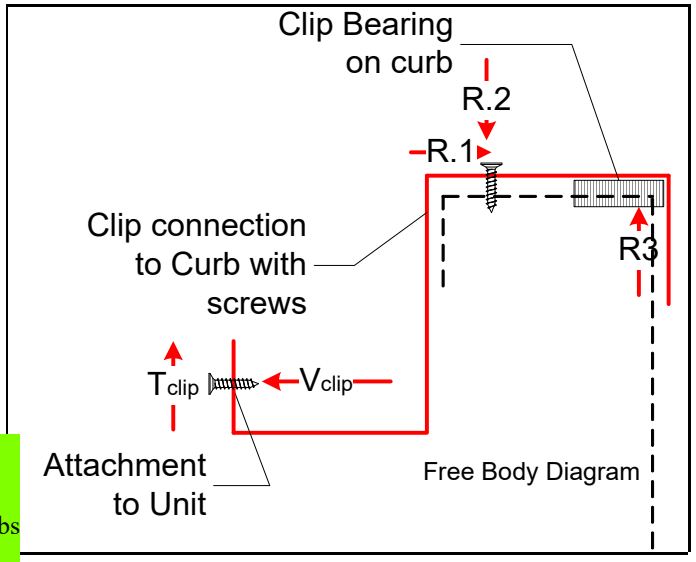


Reactions R1 & R2 to be resisted by the screws attaching the hold down clip to curb

R1 is acting as tension on the screws.

$$R_1 := V_{clip} = 384 \cdot lbs$$

R2 is acting as shear force on the connection screws
Since the loading T and V are acting in opposite directions; R2 is the maximum shear force due to either T or V



$$b_{return} := Clip_b \cdot in = 2.625 \cdot in$$

$$b_{depth} := Clip_c \, in = 4.5625 \cdot in$$

$$R_2 := \begin{bmatrix} \frac{T_{clip} \cdot (b_{return} + 1.75in - 0.5in)}{1.75in - 0.5in} \\ \frac{V_{clip} \cdot (b_{depth})}{1.75in - 0.5in} \end{bmatrix} = \begin{pmatrix} 2389 \\ 1403 \end{pmatrix} \cdot lbs$$

$$R_2 := \max(R_2) = 2389 \cdot lbs$$

Reaction R3 [compression force] is resisted by bearing of the hold down on the curb lip.

$$R_3 := R_2 - T_{clip} = 1618 \cdot lbs$$

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Design of Connection#1 Connection of Equipment to hold Down clip

Hold Down Clip thickness

$t_{Clip} = \text{"12GA"}$ $t_{clip} := thick(t_{Clip}) = 0.1084 \cdot in$

Strength Reduction for SMS Screw Connections per J.4

$\phi_{sms} = 0.5$

Ultimate SMS screw connection Strength (LRFD) Assume min thickness of the equipment housing is 16 GA [Fy = 50ksi & Fu=65ksi]

$n_{sms} := 4$ $Size_{ss} := \text{"\#12"}$

$t_{ss} := \text{"16GA"}$ $F_{u.ss} := 65ksi$

Nominal Tension Strength

$P_{nt} := n_{sms} \cdot T_s(Size_{ss}, t_{ss}, F_{u.ss}) = 3031 \cdot lbs$

$P_{not} := n_{sms} \cdot T_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 3031 \cdot lbs$

$P_{nov} := n_{sms} \cdot T_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 10277 \cdot lbs$

$P_{nts} := n_{sms} \cdot T_{nts}(Size_{ss}, t_{ss}, F_{u.ss}) = 7440 \cdot lbs$

Nominal Shear Strength

$P_{ns} := n_{sms} \cdot V_s(Size_{ss}, t_{ss}, F_{u.ss}) = 6016 \cdot lbs$

$P_{vnot} := n_{sms} \cdot V_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 8121 \cdot lbs$

$P_{vnov} := n_{sms} \cdot V_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 9629 \cdot lbs$

$P_{vnss} := n_{sms} \cdot V_{nss}(Size_{ss}, t_{ss}, F_{u.ss}) = 6016 \cdot lbs$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} V_{clip} \div (\phi_{sms} \cdot P_{nt}) \\ T_{clip} \div (\phi_{sms} \cdot P_{ns}) \end{bmatrix} = \begin{pmatrix} 25 \\ 26 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left[\begin{bmatrix} \left[\frac{T_{clip}}{P_{vnov}} + 0.71\left(\frac{V_{clip}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{T_{clip}}{P_{vnot}} + \left(\frac{V_{clip}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{T_{clip}}{P_{vnss}} + \left(\frac{V_{clip}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right] = 32 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} \text{"OK"} \\ \text{"OK"} \\ \text{"OK"} \end{pmatrix}$$

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Check Bending in Clip

There are several restraints that prevents the hold down clip for curb to have local bending at the bottom flange and transfer vertical load demand directly to the face of the curb.

- Hold down is bearing on the face of iso-rail / non-iso curb lip.
- Gasket will act as a "link" member to allow unit base rail and bottom flange to move toegther so flange can't bend unless the unit base rail bends first. However, unit base rail is not likely to bend so bottom flange won't bend

Hold Down Clip thickness

$t_{Clip} = \text{"12GA"}$ $t_{clip} := \text{thick}(t_{Clip}) = 0.1084 \cdot \text{in}$

Effective width of hold down clip

$b_c := L_{clip} = 9 \cdot \text{in}$

Yield strength of the Clip

$F_{y.c} := 50\text{ksi}$

Strength reduction for bending

$\phi_{clip} := 0.9$

Design Bending Capacity (LRFD)

$$\phi M_n := \phi_{clip} \cdot F_{y.c} \left(\frac{b_c \cdot t_{clip}^{\,2}}{6} \right) = 793 \cdot \text{in} \cdot \text{lbs}$$

Flexural bending demand

$M_{u.clip} := T_{clip} \cdot (0.5\text{in}) = 385 \cdot \text{in} \cdot \text{lbs}$

D/C Ratio for bending

$$DCR := \frac{M_{u.clip}}{\phi M_n} = 0.486$$

$Clip_{Bending} = \text{"OK"}$

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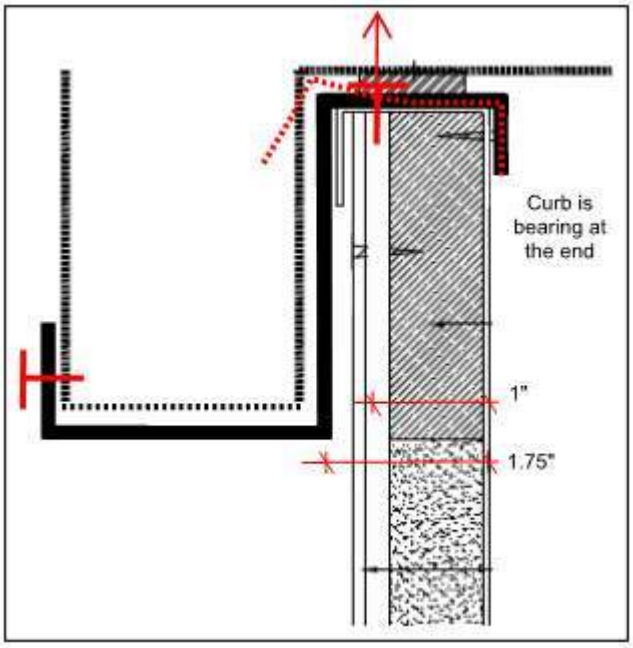
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Check Flange Bending in Curb



Roof Curb thickness

$t_{Curb} = \text{"14GA"}$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

Clip edge to edge distance

$$b_{edge2edge} := \frac{L_{curb} - \left(6in + \frac{L_{clip}}{2}\right)\cdot 2}{N_B - 1} - L_{clip} = 6.458 \cdot in$$

Effective width of Roof Curb

$b_{curb} := L_{clip} + b_{edge2edge} = 15.46 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\frac{b_{curb} \cdot (t_{curb})^2}{6} + \frac{L_{clip} \cdot (t_{clip})^2}{6}\right] = 1508 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := T_{clip} \cdot (1.75in - 0.5in) = 963 \cdot in \cdot lbs$

D/C Ratio for bending

$$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.639$$

$Curb_{Bending} = \text{"OK"}$

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Design of Connection#2 Connection of hold Down clip to Curb

Ultimate SMS screw connection Strength (LRFD) Strength based on the smallest thickness of Curb and Hold down Clip (min 16 GA) [Fy = 50ksi & Fu=65ksi]

Tension loads on SMS connection

$T_{s2} := R_2 = 2389 \cdot lbs$

Shear loads on SMS connection

$V_{s2} := R_1 = 384 \cdot lbs$

Strength Reduction for SMS Screw Connections per J.4

$n_{sms} := 8$ $Size_{ss} := "\#12"$ $\phi_{sms} = 0.5$

$t_{ss} := t_{Curb} = "14GA"$ $F_{u.ss} := 65ksi$

Nominal Tension Strength

$P_{nt} := n_{sms} \cdot T_s(Size_{ss}, t_{ss}, F_{u.ss}) = 7495 \cdot lbs$

$P_{not} := n_{sms} \cdot T_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 7495 \cdot lbs$

$P_{nov} := n_{sms} \cdot T_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 25410 \cdot lbs$

$P_{nts} := n_{sms} \cdot T_{nts}(Size_{ss}, t_{ss}, F_{u.ss}) = 14880 \cdot lbs$

Nominal Shear Strength

$P_{ns} := n_{sms} \cdot V_s(Size_{ss}, t_{ss}, F_{u.ss}) = 12032 \cdot lbs$

$P_{vnot} := n_{sms} \cdot V_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 22325 \cdot lbs$

$P_{vnov} := n_{sms} \cdot V_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 23806 \cdot lbs$

$P_{vnss} := n_{sms} \cdot V_{nss}(Size_{ss}, t_{ss}, F_{u.ss}) = 12032 \cdot lbs$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} T_{s2} \div (\phi_{sms} \cdot P_{nt}) \\ V_{s2} \div (\phi_{sms} \cdot P_{ns}) \end{bmatrix} = \begin{pmatrix} 64 \\ 6 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left[\begin{bmatrix} \left[\frac{V_{s2}}{P_{vnov}} + 0.71\left(\frac{T_{s2}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{V_{s2}}{P_{vnot}} + \left(\frac{T_{s2}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{V_{s2}}{P_{vnss}} + \left(\frac{T_{s2}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right] = 49 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

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Hold Down clip Bending and Shear Interaction

Diameter of SMS:

$$d_{sms} := \text{vlookup}\left(\text{Size}_{ss}, \text{SMS}_{Table}, 1\right)_0 \cdot \text{in} = 0.216 \cdot \text{in}$$

Depth of flat web portion

$$h_{clip.shear} := L_{clip} - n_{sms} \cdot d_{sms} = 7.27 \cdot \text{in}$$

Depth-to-Thickness Ratio:

$$\frac{h_{clip.shear}}{t_{clip}} = 67 \qquad E := 29500\text{ksi} \qquad F_y := 50\text{ksi} \qquad \mu := 0.3$$

Nominal Shear Stress:
(For unreinforced web)
AISI S100-16 G2.1

$$k_v := 5.34 \qquad \sqrt{\frac{E \cdot k_v}{F_y}} = 56 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 85$$

Area of Web Element:

$$A_w := h_{clip.shear} \cdot t_{clip} = 0.788 \cdot \text{in}^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h_{clip.shear}}{t_{clip}}\right)^2} = 31.6 \cdot \text{ksi}$$

$$V_{cr} := A_w \cdot F_{cr} \qquad V_y := 0.6 \cdot A_w \cdot F_y = 24\,\text{kip} \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.974$$

Hole Shear Reduction Factor:
(for circular holes, AISI S100-16 Eq G3-1)

$$c := \frac{h_{clip.shear}}{2} - \frac{d_{sms}}{2.83} = 3.56 \cdot \text{in}$$

$$q_s := \begin{cases} 1.0 & \text{if } \frac{c}{t_{clip}} \geq 54 \\ \frac{c}{54 \cdot t_{clip}} & \text{if } 5 \leq \frac{c}{t_{clip}} < 54 \end{cases} = 0.608$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \leq 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \leq 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 19.792 \cdot \text{kip}$$

Design Shear Capacity with holes:

$$\phi V_{n.clip} := 0.95 \cdot V_n \cdot q_s = 11.4 \cdot \text{kip}$$

D/C Ratio of V and M per AISI S100-16 Eq H2-1

$$DCR_{V.M.int.clip} := \sqrt{\left(\frac{M_{u.clip}}{\phi M_n}\right)^2 + \left(\frac{\max\left(T_{clip}, V_{clip}\right)}{\phi V_{n.clip}}\right)^2} = 0.4905$$

Demand/Capacity Ratio:

$\text{VandM}_{int.clip}$ = "OK"

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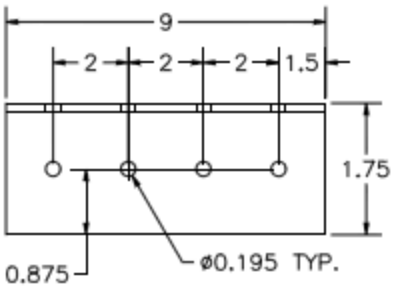
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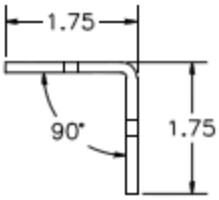
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Hold Down clip Block Shear





$b_{clip} := 1in$

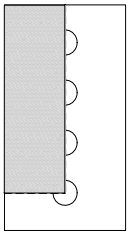
$s_{clip.sms} := 2in$

$b_{edge} := 1in$

(Figure shown as reference only)

Case 1 Block Shear Capacity: (Force in parallel direction of sms row)

CASE 1



$$A_{gv} := \left[b_{edge} + \left(n_{sms} - 1\right)\cdot s_{clip.sms}\right]\cdot t_{clip} = 1.626\cdot in^2$$

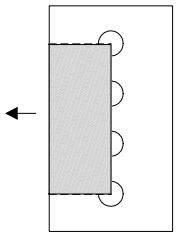
$$A_{nv} := \left[b_{edge} + \left(n_{sms} - 1\right)\cdot s_{clip.sms} - \frac{d_{sms}}{2}\right]\cdot t_{clip} = 1.614\cdot in^2$$

$$A_{nt} := t_{clip}\cdot\left(\frac{b_{clip}}{2} - \frac{d_{sms}}{2}\right) = 0.042\cdot in^2$$

$$\phi R_{n1} := 0.5\cdot\min\left(0.6\cdot F_y\cdot A_{gv} + F_u\cdot A_{nt}, 0.6\cdot F_u\cdot A_{nv} + F_u\cdot A_{nt}\right) = 26\,kip$$

Case 2 Block Shear Capacity: (Force in perpendicular direction of sms row)

CASE 2



$$A_{gv} := 2\cdot t_{clip}\cdot\frac{b_{clip}}{2} = 0.108\cdot in^2$$

$$A_{nv} := 2\cdot t_{clip}\cdot\left(\frac{b_{clip}}{2} - \frac{d_{sms}}{2}\right) = 0.085\cdot in^2$$

$$A_{nt} := t_{clip}\cdot\left[\left(n_{sms} - 1\right)\cdot s_{clip.sms} - d_{sms}\right] = 1.494\cdot in^2$$

$$\phi R_{n2} := 0.5\cdot\min\left(0.6\cdot F_y\cdot A_{gv} + F_u\cdot A_{nt}, 0.6\cdot F_u\cdot A_{nv} + F_u\cdot A_{nt}\right) = 50\,kip$$

Design Block Shear Capacity:

$$\phi R_n := \min\left(\phi R_{n1}, \phi R_{n2}\right) = 26\,kip$$

D/C Ratio of Block Shear:

$$DCR_{clip.blockshear} := \frac{\max\left(T_{clip}, V_{clip}\right)}{\phi R_n} = 0.03$$

$Blockshear_{clip}$ = "OK"

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Project: IBC 2018 Group A Job No. J13001 . 380

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Web Crippling/Compression of Non-iso CanFab Curb (AISI S100-16 G5)

Governing Compression for Non-Isolated Curb:

$$P_{web.crip.int} := \max\left[\frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}}, \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}}\right] \cdot L_{spacing.non.iso} = 1222 \cdot lbs$$

$$P_{web.crip.end} := 0.5 \cdot P_{web.crip.int} = 611 \cdot lbs$$

Yield Strength: $F_y := 50ksi$

Bearing Length: $N_{bearing} := L_{spacing.non.iso} = 15 \cdot in$

Thickness of Curb: $t_{Curb} = \text{"14GA"}$ $t := thick(t_{Curb}) = 0.0785 \cdot in$

Inside Bend Radius: $R := R_{curb} = 0.107 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web: $h := 18in - 2 \cdot (t + R) = 17.63 \cdot in$

Angle btween plane of web and bearing surface: $\theta := 90deg$

Web Crippling Limit Check (AISI Table G5-2): $\frac{R}{t} = 1$ $\frac{h}{t} = 225$ $\frac{N_{bearing}}{t} = 197$ $\frac{N_{bearing}}{h} = 0.88$

End Case Coefficient Single Web Channel (AISI Table G5-2): $C := 13$ $C_R := 0.32$ $C_N := 0.05$ $C_h := 0.04$

Reduction Factor Web Crippling Strength: $\phi_{web.end} := 0.9$ $\phi_{web.int} := 0.8$ **(For Unfastened partially Stiffened Flanges with Two-Flange Loading or Reaction.)**

Design Web Crippling Strength:

$$\phi P_{n.end} := \left(\phi_{web.end}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 1540 \cdot lbs$$

Interior Case Coefficient Single Web Channel (AISI Table G5-2): $C := 24$ $C_R := 0.52$ $C_N := 0.15$ $C_h := 0.001$

Design Web Crippling Strength:

$$\phi P_{n.interior} := \left(\phi_{web.int}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 7114 \cdot lbs$$

D/C Ratio of Shear: $DCR_{end} := \frac{P_{web.crip.end}}{2 \cdot \phi P_{n.end}} = 0.198$ $DCR_{int} := \frac{P_{web.crip.int}}{\phi P_{n.interior}} = 0.172$

Demand/Capacity Ratio: **Note: Factor of 2 for two ends connected together at the end**

$Web_{crippling} = \text{"OK"}$

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Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Length

Roof Curb thickness

$t_{Curb} = \text{"14GA"}$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

Min width of Roof Curb

$b_{curb} := L_{curb} + \frac{W_{curb}}{2} \cdot 2 + 3in \cdot 2 \cdot 2 = 116.56 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := L_{curb} + \min\left(\frac{W_{curb}}{2} \cdot 2, \frac{L_{curb}}{2}\right) = 101 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{array}{c} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{array} \right] \right] = 5387 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.L.vert.up} \cdot L_{curb}) \cdot (0.75in) = 3662 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.68$

$Curb_{BotFlangeBending} = \text{"OK"}$

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Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Width

Roof Curb thickness

$t_{Curb} = \text{"14GA"}$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

Min width of Roof Curb

$b_{curb} := W_{curb} + \frac{L_{curb}}{4} \cdot 2 + 3in \cdot 2 = 76.88 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := W_{curb} + \min\left(\frac{L_{curb}}{6} \cdot 2, W_{curb}\right) = 60 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{array}{c} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{array} \right] \right] = 3553 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.W.vert.up} \cdot W_{curb}) \cdot (0.75in) = 2097 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.59$

$Curb_{BotFlangeBending} = \text{"OK"}$

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Check CanFab Curb for Compressive Force due to T/C Coupling of Overturning

Note:
-Since the equipment is only attached to the longer sides of the CanFab Curb, most likely there will be compressive force onto the curb due to T/C coupling.
- Rectangular CanFab Curb will be considered as "Channel" to resist the compressive force.

Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Flanges*

Flat Width:

$$w := \frac{W_{curb}}{2} - R_{curb} = 18.487 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Unstiffened"}$$

Stress at the end of the Width:

$$f_2 := 50ksi \qquad f_1 := 50ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \left| \frac{f_2}{f_1} \right| = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 0.43$$

Critical Compressive Stress (Eq 1.1-4):

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w}\right)^2 = 0.21 \cdot ksi$$

Stress in Compression Element:

$$f := F_y = 50 \cdot ksi \qquad \textbf{(Assume f = Fy)}$$

Slenderness Factor (Eq 1.1-3):

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 15.55$$

Local reduction factor (Eq 1.1-2):

$$\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 0.063$$

Effective Width of the Flanges:

$$b_{eff.flange} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 1.172 \cdot in$$

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Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Web*

Flat Width:

$$w := L_{curb} - R_{curb} \cdot 2 = 67.161 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Stiffened"}$$

Stress at the end of the Width:

$$f_2 := 50ksi \qquad f_1 := 50ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \left| \frac{f_2}{f_1} \right| = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 4$$

Critical Compressive Stress (Eq 1.1-4):

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w} \right)^2 = 0.15 \cdot ksi$$

Stress in Compression Element:

$$f := F_y = 50 \cdot ksi \qquad \textbf{(Assume f = Fy)}$$

Slenderness Factor (Eq 1.1-3):

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 18.52$$

Local reduction factor (Eq 1.1-2):

$$\rho := \left(1 - \frac{0.22}{\lambda}\right) \frac{1}{\lambda} = 0.053$$

Effective Width of the Web:

$$b_{eff.web} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 3.582 \cdot in$$

Effective Area of the Member:

$$A_e := 2 \cdot \left(b_{eff.flange} \cdot t_{curb} \right) + b_{eff.web} \cdot t_{curb} = 0.465 \cdot in^2$$

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Length of the Compressive Member: $L_{curb.web} := h = 17.629 \cdot in$

Young's Modulus for Cold Form Steel: $E := 29500ksi$

Curb Shear Modulus: $G := 11300ksi$

Poisson's Ratio $\mu := 0.3$

Section Properties of the Member (From Section Properties Calculator):

$A_{half.curb} := 6.087in^2$ $r_o := 28.35in$ $I_x := 3577in^4$ $I_y := 311in^4$

$J := 0.006in^4$ $r_x := \sqrt{\frac{I_x}{A_{half.curb}}} = 24.241 \cdot in$ $r_y := \sqrt{\frac{I_y}{A_{half.curb}}} = 7.148 \cdot in$

$C_w := 209700in^6$ $r_{min} := \min(r_x, r_y) = 7.148 \cdot in$

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^2}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{(1.0 \cdot L_{curb.web})^2}\right] = 525419.037 \cdot ksi$$

$$\sigma_{e.y} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_y}\right)^2} = 47864.512 \cdot ksi \qquad \sigma_{e.x} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_x}\right)^2} = 550518.845 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2} = 47864.512 \cdot ksi$$

$$\frac{1.0 \cdot L_{curb.web}}{r_{min}} = 2.47$$

$KL_r = \text{"KL/r < 200, OK"}$

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 43868.215 \cdot ksi$$

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Nominal Compressive Stress Capacity: (Eq E2-4)

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 0.034$$

$$F_n := \begin{cases} 0.658^{\lambda_c^2} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^2}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 49.98 \cdot \text{ksi}$$

Compressive Capacity:

$$P_{n.member} := A_e \cdot F_n = 23.25 \cdot \text{kip}$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot P_{n.member} = 19.76 \cdot \text{kip}$$

Factored Max Compressive Force:

$$P_{comp.max} := \max\left(\left|C_S\right|, \left|C_W\right|\right) = 6.211 \text{ kip}$$

D/C Ratio of Compression:

$$DCR := \frac{P_{comp.max}}{\phi P_{n.member}} = 0.314$$

$$Axial_{curb.comp} := \text{if}\left(P_{comp.max} < \phi P_{n.member}, \text{"OK"}, \text{"Provide Channel from above as Web Stiffener"}\right)$$

$Axial_{curb.comp} = \text{"OK"}$

Note: No need to check for interaction since the curb is only subjected to the compressive force.

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Shear of CanFab Curb Webs without Holes (AISI S100-16 G2)

Note: Since the unit is stiffer than the curb and the curb is firmly attached to the unit and to the base structure, curbs will mainly take the lateral forces as shear and axial load rather than bending.

Thickness of Curb:

$$t := \text{thick}(t_{Curb}) = 0.079 \cdot \text{in}$$

Depth-to-Thickness Ratio:

$$\frac{h}{t} = 225$$

Curb Elastic Modulus:

$$E := 29500\text{ksi}$$

Clear distance b/w transverse stiffeners of reinforced web:

$$a := \max\left(\frac{L_{curb}}{2}, W_{curb}\right) = 37 \cdot \text{in} \qquad \frac{a}{h} = 2.11$$

$$k_v := \begin{cases} 5.34 & \text{if } a = L_{curb} \\ 4.00 + \dfrac{5.34}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \dfrac{4.00}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 6.24$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 61 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 92$$

Curb Shear Check due to Load on Longer Side

Area of Web Element:

$$A_w := W_{curb} \cdot t = 3 \cdot \text{in}^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 3.3 \cdot \text{ksi}$$

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$V_{cr} := A_w \cdot F_{cr} = 10\,kip \quad V_y := 0.6 \cdot A_w \cdot F_y = 88\,kip \quad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 3.016$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 9.628 \cdot kip$$

Number of Members within Length: $n := 2$ **(Per Curb Design)**

Design Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 18293.8 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.H} := P_{net} \cdot L_{unit} \cdot H_{total} = 4413.2 \cdot lbs$

Design Shear Demand: $V_u := \max(V_{base.S}, V_{base.W.H}) = 4413.2 \cdot lbs$

D/C Ratio of Shear: $DCR := \frac{V_u}{\phi V_n} = 0.241$

Demand/Capacity Ratio:

$Shear_{in.plane} := \text{if}(V_u < \phi V_n, \text{"OK"}, \text{"NG"})$

$Shear_{in.plane} = \text{"OK"}$

Curb Shear Check due to Load on Shorter Side

Area of Web Element: $A_w := L_{curb} \cdot t = 5 \cdot in^2$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot (1 - \mu^2) \cdot \left(\frac{h}{t}\right)^2} = 3.3 \cdot ksi$$

$V_{cr} := A_w \cdot F_{cr} = 17\,kip \quad V_y := 0.6 \cdot A_w \cdot F_y = 159\,kip \quad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 3.016$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 17.444 \cdot kip$$

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Number of Members within Length: $n := 2$ **(Per Curb Design)**

Factored Nominal Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 33144.1 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot W_{unit} \cdot H_{total} = 3560.2 \cdot lbs$

Factored Shear Demand: $V_u := \max\left(V_{base.S}, V_{base.W.L}\right) = 3560.2 \cdot lbs$

D/C Ratio of Shear: $DCR := \frac{V_u}{\phi V_n} = 0.107$

Demand/Capacity Ratio:

$Shear_{in.plane} := \text{if}\left(V_u < \phi V_n, \text{"OK"}, \text{"NG"}\right)$

$Shear_{in.plane} = \text{"OK"}$

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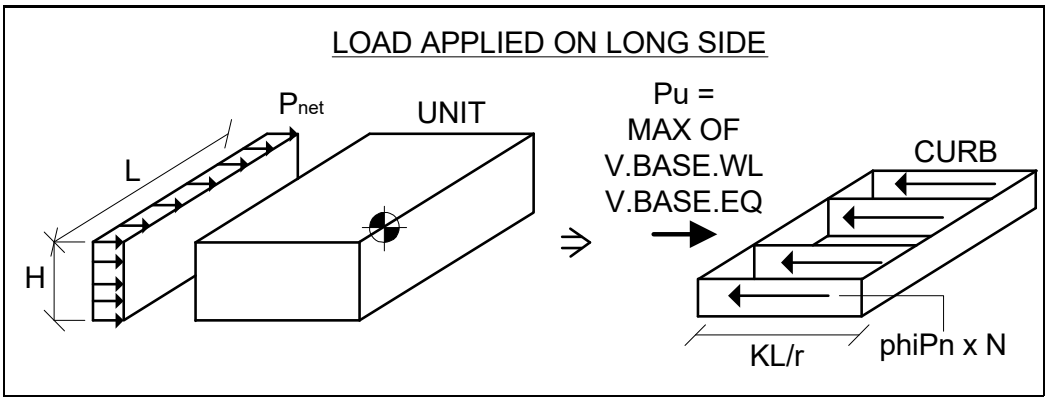
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Check CanFab Curb for In-Plane Axial due to EQ and Wind (AISI S100-16 E2)

Curb Axial Load Check due to Load on Long Side



Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot L_{unit} \cdot H_{total} = 4.4\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.L}) = 4413.21 \cdot lbs$

Member per CFS: $CFS_{member} :=$ "16GA Custom Curb 18" Tall L.b = 78in"

Max Braced Length of Member: $L_{member} := W_{curb} = 37 \cdot in$

Number of Curb in Length: $n_{curb.long} := 2$

Radius of gyration in y-axis: $r_{y.curb} := 0.675\,in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{2} = 2.21\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 55$ $KL_r =$ "KL/r < 200, OK"

Spacing: $Spacing := \frac{L_{curb}}{n_{curb.long}} = 34 \cdot in$

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 6.018 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.367$

$Axial_{short.curb} =$ "OK"

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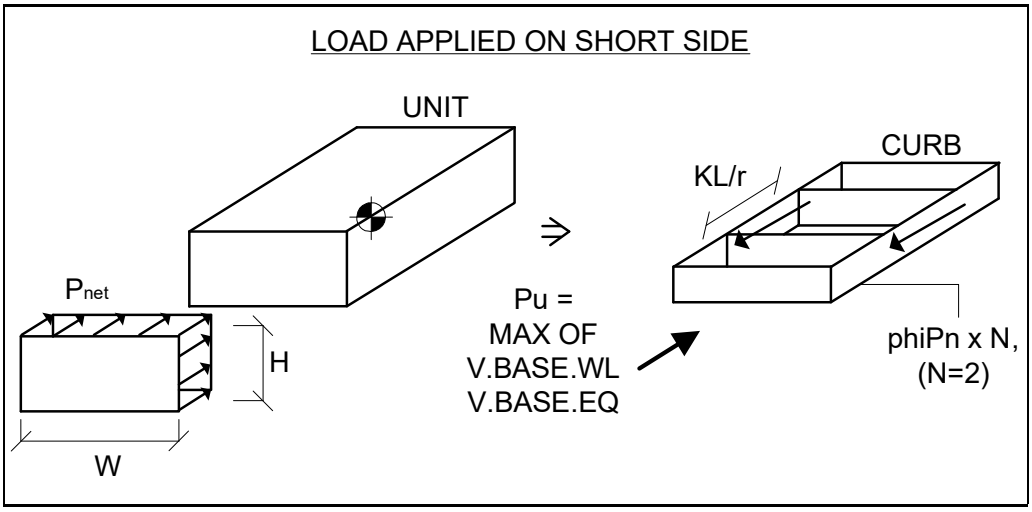
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Curb Axial Load Check due to Load on Short Side



Wind Base Shear on Short Side: $V_{base.W.H} := P_{net} \cdot W_{unit} \cdot H_{total} = 3.6\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.H}) = 3560.24 \cdot lbs$

Member per CFS: CFS_{member} = "16GA Custom Curb 18" Tall L.b = 78in"

Max Braced Length of Member: $L_{member} := \frac{L_{curb}}{n_{curb.long} - 1} = 67 \cdot in$

Number of Curb in Length: $n_{curb} := 2$

Radius of gyration in y-axis: $r_{y.curb} := 0.675\,in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{curb}} = 1.78\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 100$ KL_r = "KL/r < 200, OK"

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 6.018 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.296$

$Axial_{long.curb}$ = "OK"

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DESIGN
for
NON ISOLATED CURB
1005 (Max Curb Height of 22")

950 S. GRAND AVENUE, 4TH FLOOR, LOS ANGELES, CALIFORNIA 90015 (213) 483-6490

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Design Wind Loads for Rooftop Equipment (ASCE 7-16 § Table 29.1-1)

$z := 60ft$ **Height above ground level**

$B := 60ft$ **Horizontal dimension of building measured normal to wind direction**

$Exp_{category} := "C"$ **Exposure Category per ASCE 7-16 § 26.7**

$Risk_{category} := "IV"$ **Risk Category per ASCE 7-16 Table 1.5-1**

$V := \begin{cases} 0mph & \text{if } Risk_{category} = "I" \\ 0mph & \text{if } Risk_{category} = "II" \\ 175mph & \text{otherwise} \end{cases} = 175 \cdot mph$ **Basic Wind Speed per ASCE 7-16 Figure 26.5-1 A,B or C**

$K_z = 1.14$ **Velocity Pressure Exposure Coefficient per ASCE 7-16 Table 29.10-1 [Exposure Category "C"]**

$K_{zt} := 1.0$ **Topographic Factor per ASCE 7-16 § 26.8, Figure 26.8-1**

$K_e := 1.0$ **Ground Elevation Factor per ASCE 7-16 § 26.9, Table 26.9-1**

$K_d := 0.85$ **Wind Directionality Factor per ASCE 7-16 § 26.6, Table 26.6-1 (Equipment)**

$q_z := 0.00256 K_z \cdot K_{zt} \cdot K_d \cdot K_e \cdot V^2 = 75.74 \cdot psf$ **Velocity pressure evaluated at height z above ground per ASCE 7-10 § 26.10.2; Eq. 26.10-1**

$GC_{r.lateral.max} := 1.9$ **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.9 for rooftop structures and equipment with Af less than (0.1Bh). (GCr) shall be permitted to be reduced linearly from 1.9 to 1.0 as the value of Af is increased from (0.1Bh) to (Bh)

$GC_{r.vertical.max} := 1.5$ **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.5 for rooftop structures and equipment with A_r less than (0.1*BL*). (GC_r) shall be permitted to be reduced linearly from 1.5 to 1.0 as the value of A_r is increased from (0.1*BL*) to (*BL*)

$P_{net} := q_z \cdot GC_{r.lateral.max} = 143.91 \cdot psf$ **Design Lateral Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-2**

$P_v := q_z \cdot GC_{r.vertical.max} = 113.61 \cdot psf$ **Design Vertical Uplift Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-3**

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Seismic Demands on Nonstructural Components (ASCE 7-16 § 13.3 & 13.6):

$S_{DS} := 1.5$ **Design spectral response acceleration parameter at short periods per USGS map**

$I_p := 1.5$ **Component importance factor ASCE 7-16 § 13.1.3**

$\Omega_0 := 2.0$ **Overstrength factor ASCE 7-16 Table 13.6.1**

Vibr_Isolation = "No" **Placement of Unit Vibration Isolated:**

Note: Only "F_p" at seismic concrete anchor has been increased with overstrength factor "Ω_0"

$a_p := 2.5$ $R_p = 6.0$ **Seismic coefficients a_p & R_p**
Per ASCE 7-16 Table 13.6-1 for
Mechanical & Electrical Components

$z = 60\,ft$ **Height in structure of point of attachment of component with respect to the base**

$h := 60ft$ **Average roof height of structure with respect to the base**
Where for roof top equipment:

$z \div h = 1$

F_p: Horizontal Seismic Design Force per *ASCE7-16 § 13.3.1*

F_p shall be takes as $\left(\frac{0.4 \cdot a_p \cdot S_{DS} \cdot I_p}{R_p}\right) \cdot \left(1 + 2 \cdot \frac{z}{h}\right) \cdot W_p = 112.5 \cdot \%\cdot W_p$

F_p is not required to be taken as greater than $\left(1.6 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 360 \cdot \%\cdot W_p$

F_p shall not be taken as less than $\left(0.3 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 67.5 \cdot \%\cdot W_p$

Governing F_p : Horizontal Seismic Design Force $F_p = 112.5 \cdot \%\cdot W_p$

F_v: Vertical Load per ASCE7-16 § 13.3.1.2

Concurrent Vertical Seismic Force: $F_v := 0.2 \cdot S_{DS} \cdot W_p = 30 \cdot \%\cdot W_p$

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Flat Roof Snow Loads (ASCE 7-16 § 7.3):

$Terrain_{CAT} := "C"$ **Terrain Category ASCE 7-16 § 26.7 & Table 7.3-1**

$Exp_{Roof} := "Partially\ Exposed"$ **Exposure of Roof ASCE 7-16 Table 7.3-1**

$C_e = 1$ **Exposure Factor ASCE 7-16 Table 7.3-1**

$Thermal_{condition} := "All\ structures\ except\ below"$ **Thermal Condition ASCE 7-16 Table 7.3-2**

$C_t = 1$ **Thermal Factor ASCE 7-16 Table 7.3-2**

$Risk_{category} = "IV"$ **Risk Category per ASCE 7-16 Table 1.5-1**

$I_s = 1.2$ **Snow Importance Factor ASCE 7-16 Table 1.5-2**

$p_g := 40psf$ **Ground Snow Loads ASCE 7-16 Figure 7.2-1**

$$p_f := \max\left(0.7 \cdot C_e \cdot C_t \cdot I_s \cdot p_g, \text{if}\left(p_g > 20psf, 20psf \cdot I_s, I_s \cdot p_g\right)\right) = 34 \cdot psf$$

Flat Roof Snow Loads ASCE 7-16 Equation 7.3-1 and § 7.3.4

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Mechanical Unit Dimensions

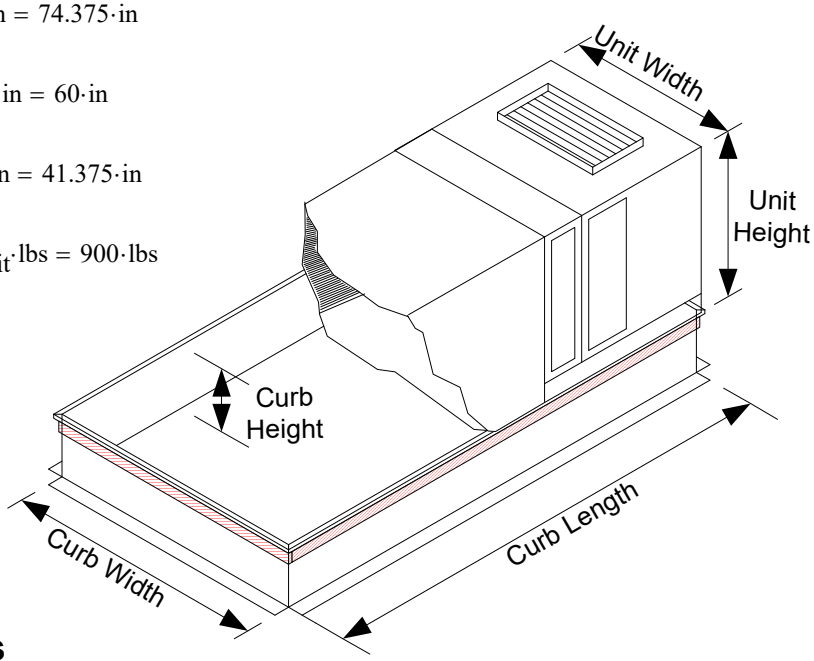
Curb = "C-1005"

Length of Unit $L_{unit} := L_{unit} \cdot in = 74.375 \cdot in$

Width of Unit $W_{unit} := W_{unit} \cdot in = 60 \cdot in$

Height of Unit $H_{unit} := H_{unit} \cdot in = 41.375 \cdot in$

Weight of Unit $Wt_{unit} := Wt_{unit} \cdot lbs = 900 \cdot lbs$



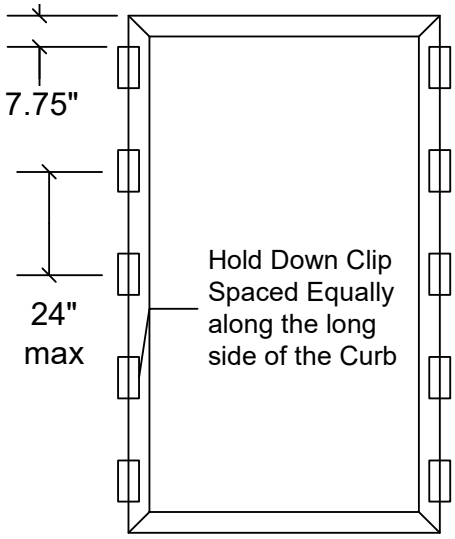
Roof Curb Dimensions

Length of Curb $L_{curb} := L_{curb} \cdot in = 67.375 \cdot in$

Width of Curb $W_{curb} := W_{curb} \cdot in = 37.188 \cdot in$

Height of Curb $H_{curb} := H_{curb} \cdot in = 22 \cdot in$

Weight of Curb $Wt_{curb} := Wt_{curb} \cdot lbs = 354 \cdot lbs$



Curb Plan

Overall System Dimensions

Total Weight

$Wt_{tot} := Wt_{unit} + Wt_{curb} = 1254 \cdot lbs$

Total height

$H_{total} := H_{unit} + H_{curb} = 63.375 \cdot in$

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Seismic Loading + Snow Loading

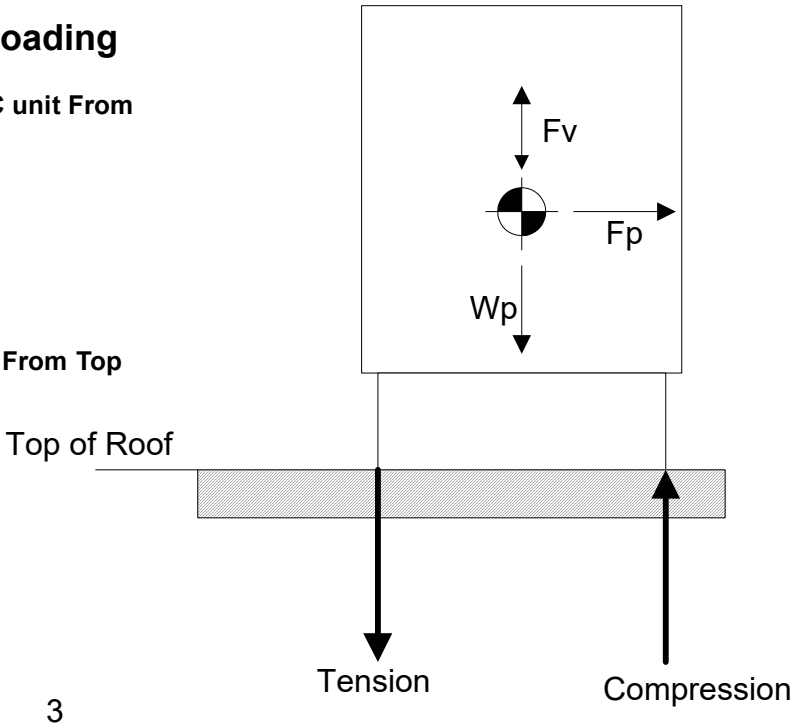
Height for Center of Gravity for HVAC unit From Top of Roof

$h_{CG.unit} := \frac{1}{2} H_{unit} = 21 \cdot in$

$h_{CG} := H_{curb} + h_{CG.unit} = 42.69 \cdot in$

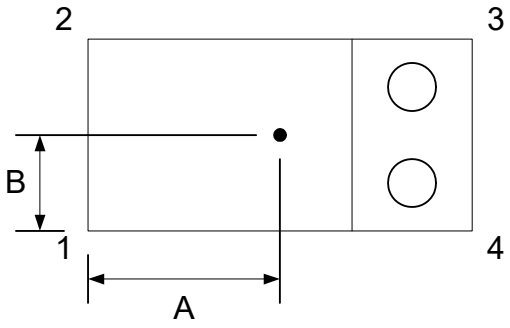
Height for Center of Gravity for Curb From Top of Roof

$h_{CG.curb} := \frac{H_{curb}}{2} = 11 \cdot in$



Max Seismic Base Shear

$V_{base.S} := F_p \cdot Wt_{tot} = 1411 \cdot lbs$



Unit C.G. distance in axis parallel to Curb Width $B_{ecc.width} := CG_{short} \cdot in = 22.5 \cdot in$

Eccentricity in axis parallel to Curb Width

$$e_{width} := \begin{cases} 0in & \text{if } B_{ecc.width} = \text{"N/A"} \\ \left| B_{ecc.width} - \frac{W_{unit}}{2} \right| & \text{otherwise} \end{cases} = 7.5 \cdot in$$

Unit C.G. distance in axis parallel to Curb Length $A_{ecc.length} := CG_{long} \cdot in = 34.625 \cdot in$

Eccentricity in axis parallel to Curb Length

$$e_{length} := \begin{cases} 0in & \text{if } A_{ecc.length} = \text{"N/A"} \\ \left| A_{ecc.length} - \frac{L_{unit}}{2} \right| & \text{otherwise} \end{cases} = 2.56 \cdot in$$

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Max Net Tension Reaction On Each Side Due To Seismic Loads

$$T_S := \begin{bmatrix} \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{W_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{W_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} \right] \\ \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{L_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{L_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} \right] \end{bmatrix} = \begin{pmatrix} -1013 \\ -351 \end{pmatrix}\cdot lbs$$

Max Net Compression Reaction On Each Side Due To Seismic Loads

$$C_S := \begin{bmatrix} \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{W_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \\ \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{L_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \end{bmatrix} = \begin{pmatrix} 3665 \\ 2719 \end{pmatrix}\cdot lbs$$

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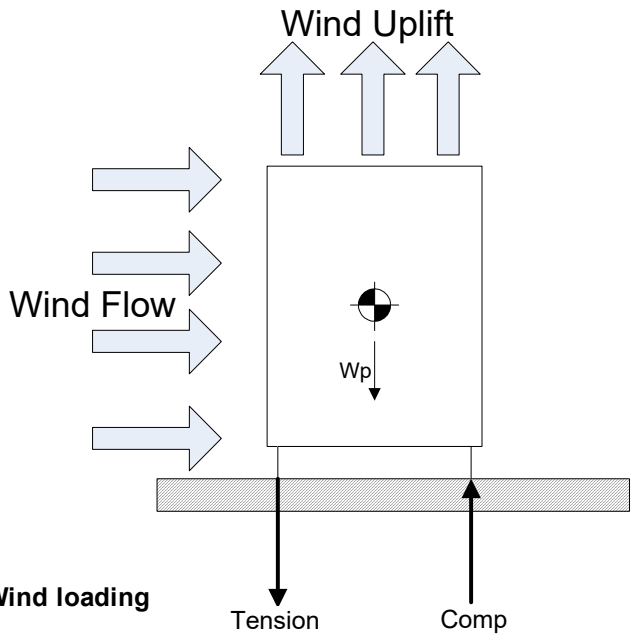
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Wind Loading + Snow Loading



Max Base Shear due to wind loading

$$V_{base.W} := P_{net} \cdot L_{unit} \cdot H_{total} = 4711 \cdot lbs$$

Max Uplift due to wind loading

$$L_{unit.up} := L_{unit} - 0in = 74.375 \cdot in$$

$$P_{uplift.W} := P_v \cdot L_{unit.up} \cdot W_{unit} = 3521 \cdot lbs$$

Max Net Tension Reaction On Each Side Due To Wind loading

$$T_W := \begin{pmatrix} \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} - \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \\ \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} - \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} -5373 \\ -3014 \end{pmatrix} \cdot lbs$$

Max Net Compression Reaction On Each Side Due To Wind loading

$$C_W := \begin{pmatrix} \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} + \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \\ \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} + \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} 5817 \\ 3414 \end{pmatrix} \cdot lbs$$

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Governing Loading @ Curb

Max uplift vertical load along the length of the curb

$$\omega_{x.L.vert.up} := \frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}} = 957 \cdot plf$$

Max compressive vertical load along the length of the curb

$$\omega_{x.L.vert.comp} := \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}} = 1036 \cdot plf$$

Max vertical load along the length of the curb

$$\omega_{x.L.vert} := \max\left(\omega_{x.L.vert.up}, \omega_{x.L.vert.comp}\right) = 1036 \cdot plf$$

Max uplift vertical load along the width of the curb

$$\omega_{x.W.vert.up} := \frac{\max\left[\left|T_{S_{(1)}}\right|, \left|T_{W_{(1)}}\right|\right]}{W_{curb}} = 973 \cdot plf$$

Max compressive vertical load along the width of the curb

$$\omega_{x.W.vert.comp} := \frac{\max\left[\left|C_{S_{(1)}}\right|, \left|C_{W_{(1)}}\right|\right]}{W_{curb}} = 1102 \cdot plf$$

Max vertical loading along the width of the curb

$$\omega_{x.W.vert} := \max\left(\omega_{x.W.vert.up}, \omega_{x.W.vert.comp}\right) = 1102 \cdot plf$$

$$\begin{pmatrix} V_{base.S} \\ V_{base.W} \end{pmatrix} = \begin{pmatrix} 1411 \\ 4711 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} \left|T_S\right| \\ \left|C_S\right| \end{pmatrix} = \begin{pmatrix} 1072 \\ 4563 \end{pmatrix} \cdot lbs$$

$$\begin{pmatrix} F_v \cdot Wt_{tot} \\ P_v \cdot L_{unit} \cdot W_{unit} \end{pmatrix} = \begin{pmatrix} 376 \\ 3521 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} \left|T_W\right| \\ \left|C_W\right| \end{pmatrix} = \begin{pmatrix} 6161 \\ 6745 \end{pmatrix} \cdot lbs$$

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Anchorage To Concrete [Expansion Anchor per ACI 318-14]

Number of connection on the long side $N_B := 3 + 2$

Moment Arm for overturning (Short side) $B := W_{curb} = 37 \cdot in$

Number of Connection on the Short side. $N_L := 2 + 2$

Moment Arm for over turning (Long side) $L := L_{curb} = 67 \cdot in$

Total Number of Connections $N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 10$

Max Net Tension Reaction Due to Seismic Load, Fp

$$R_{c.EQ.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 22 \cdot lbs \qquad R_{c.EQ.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 5 \cdot lbs$$

$$R_{c.EQ} := MAX+\left[\begin{array}{l} \left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{c.EQ.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{c.EQ.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \end{array}\right] = \begin{pmatrix} 459 \\ 283 \end{pmatrix} \cdot lbs$$

Max net Tension Reaction Due to Wind Load, Pnet

$$R_{c.W} := MAX+\left[\begin{array}{l} \frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t} \end{array}\right] = \begin{pmatrix} 1075 \\ 694 \end{pmatrix} \cdot lbs$$

Governing Load Case: $Govern := if\left(\left|R_{c.EQ}\right| > \left|R_{c.W}\right|, "Seismic", "Wind"\right) = "Wind"$

Governing Tension Reaction at Each anchor Point: $R_c := if\left(Govern = "Seismic", R_{c.EQ}, R_{c.W}\right) = \begin{pmatrix} 1075 \\ 694 \end{pmatrix} \cdot lbs$

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Max Tension on anchor: $N_{ua} := |R_c| = 1279 \cdot lbs$

Max Shear on anchor: $V_{ua} := \frac{\max(\Omega_0 \cdot V_{base.S}, V_{base.W})}{N_t} = 471 \cdot lbs$

Hilti Kwik Bolt TZ – Carbon Steel
1/2" Anchor with min 3 1/4" embedment
Base material: 6" thick Cracked concrete w/
Compressive strength fc' = 3000 psi
Min 5" away from the concrete edge
Evaluation Report: ICC-ESR 1917

Loading Condition:	**Wind**

Design Tension Capacity [ϕN_n]:	3,500	[lbs]
Design Shear Capacity [ϕV_n]:	3,572	[lbs]

$\phi N_n := \phi N_n \cdot lbs = 3500 \cdot lbs$

$\phi V_n := \phi V_n \cdot lbs = 3572 \cdot lbs$

Utilization:

Tension Utilization: $\beta_N := \frac{N_{ua}}{\phi N_n} = 37 \cdot \%$

Shear Utilization: $\beta_V := \frac{V_{ua}}{\phi V_n} = 13 \cdot \%$

Interaction of Tensile and Shear Forces:
Per ACI 318-14 Sec. 17.6

$\beta_{NV} := \frac{(\beta_N) + (\beta_V)}{1.2} = 41 \cdot \%$

$$check\_interaction := \begin{pmatrix} if(\beta_N < 1.0, "OK", "NG") \\ if(\beta_V < 1.0, "OK", "NG") \\ if(\beta_{NV} < 1.0, "OK", "NG") \end{pmatrix} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

$$check\_interaction = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

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Anchorage To Structural Steel [Fillet Weld Conn. per AISI S100-16]

Fillet Weld 2" Long Along the Long and Short Side. Min 2 Connections per Side
Spacing: 48" O.C. for Non-Isolated Curbs; 24" for Isolated Curbs

Number of Welds on the Long Side $N_B := 2$

Moment Arm for Overturning (Short Side) $B := W_{curb} = 37 \cdot in$

Number of Welds on the Short Side. $N_L := 2$

Moment Arm for Overturning (Long Side) $L := L_{curb} = 67 \cdot in$

Total Number of Connections $N_t := \left[\left(N_B\right) + \left(N_L\right)\right] \cdot 2sides = 8$

Max Net Tension Reaction due to Seismic Load FP

$$R_{weld.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 54 \cdot lbs$$

$$R_{weld.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 10 \cdot lbs$$

$$R_{weld.EQ} := MAX+\left[\begin{bmatrix} \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{weld.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{weld.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 600 \\ 269 \end{pmatrix} \cdot lbs$$

Max Net Tension Reaction due to Wind Load Pnet

$$R_{weld.W} := MAX+\left[\begin{bmatrix} \frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 2388 \\ 1208 \end{pmatrix} \cdot lbs$$

Tension Design Force; SRSS for Loading from Each Direction $T_{u.weld} := \max\left(\left|R_{weld.EQ}\right|, \left|R_{weld.W}\right|\right) = 2676 \cdot lbs$

Shear Load at Each Weld Connection $V_{u.weld} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{N_t} = 589 \cdot lbs$

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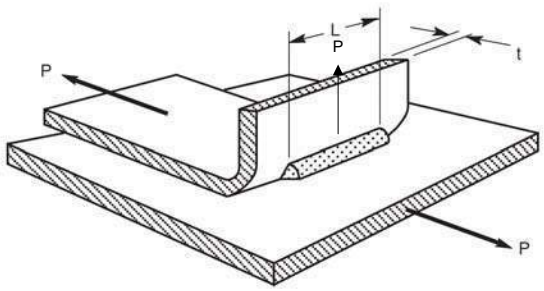
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Total Demand: SRSS of V and T

$$R_{u.weld} := \sqrt{T_{u.weld}^2 + V_{u.weld}^2} = 2740 \cdot lbs$$

Fillet Weld Design per AISI S100-16 Section J2.5

Weld Length at Each Connection Point $L_w := 2in$



Effective Throat Fillet Weld Size

$$t_w := \left(\frac{1}{8}in\right) \cdot 0.707 = 0.088 \cdot in$$

Thickness for the Thinnest Martial Being Welded
Min Curb Thickness = 16GA with Fu=65 ksi

$t_1 := thick("14GA") = 0.0785 \cdot in$

$F_u := 65ksi$

Min weld material strength

$F_{exx} := 70ksi$

For Longitudinal Loading [Parallel capacity is considered to be loading in the direction of the length of the weld] per (Eq. J2.5-1) &(Eq. J2.5-2)

$$\phi P_{long} := \begin{cases} (0.6)\left(1 - \frac{0.01 \cdot L_w}{t_1}\right) \cdot L_w \cdot t_1 \cdot F_u & \text{if } \frac{L_w}{t_1} < 25 \\ (0.5) \cdot 0.75 \cdot t_1 \cdot L_w \cdot F_u & \text{otherwise} \end{cases} = 3827 \cdot lbs$$

where $L_w \div t_1 = 25$

For Transverse Loading per (Eq. J2.5-5)

$$\phi P_{trans} := (0.65) \cdot t_1 \cdot L_w \cdot F_u = 6633 \cdot lbs$$

Strength of Weld Material per (Eq. J2.5-7)

$$\phi P_{weld} := (0.6) \cdot 0.75 \cdot t_w \cdot L_w \cdot F_{exx} = 5568 \cdot lbs$$

Design Strength of Fillet Weld

$$\phi P_n := \min\left(\phi P_{long}, \phi P_{trans}, \phi P_{weld}\right) = 3827 \cdot lbs$$

D/C Ratio for the Welded Connection

$$\beta_{NW} := \frac{R_{u.weld}}{\phi P_n} = 72 \cdot \%$$

$weld_{check} := if\left(\beta_{NW} < 1.0, "OK", "NG"\right)$

$weld_{check} = "OK"$

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Anchorage To Wood Member WITH Lag Screws [NDS-2018 LRFD Strength Design]

*** Use 3/8" Lag Screws along Each Side of the Curb**
*** Assume G=0.5 Douglas Fir-Larch**

Wood Lag Screw Capacity per NDS 2018 Section 11.3

Wet Service Factor: Cond := "DRY" **(e.g. CA = "DRY", AK = "WET")**

$C_M := \begin{cases} 1.0 & \text{if Cond = "DRY"} \\ 0.7 & \text{if Cond = "WET"} \end{cases} = 1$ **NDS 2018 Table 11.3.3**

Temperature Factor: $C_t := \begin{cases} 0.8 & \text{if Cond = "DRY"} \\ 0.7 & \text{if Cond = "WET"} \end{cases} = 0.8$ **NDS 2018 Table 11.3.4**

Group Action Factor: $C_g := 0.97$ **NDS 2018 Table 11.3.6C**

Geometry Factor: $C_\Delta := 1.0$ **NDS 2018 Table 12.5.1A,B**

End Grain Factor: $C_{eg} := 1.0$ **NDS 2018 Sec. 12.5.2**

Diaphragm Factor: $C_{di} := 1.0$ **NDS 2018 Sec. 12.5.3**

Toe-Nail Factor: $C_{tn} := 1.0$ **NDS 2018 Sec. 12.5.4**

Format Conversion Factor: $K_F := 3.32$ **NDS 2018 Table 11.3.1**

Resistance Factor: $\phi := 0.65$ **NDS 2018 Table 11.3.1**

Time Effect Factor: $\lambda := 1.0$ **NDS 2018 App N.3.3**

Lateral Design Value: $Z := 130\text{lbs}$ **NDS 2018 Table 12K**

Withdrawal Design Value: $W := 305\text{lbs}$ **NDS 2018 Table 12.2A**

Lag Screw Diameter: $D_{lag} := \frac{3}{8}\text{in}$

Lag Screw Length: $L_{lag} := 4\text{in}$

Length of Tapered Tip: $E_{lag} := \frac{7}{32}\text{in}$

Lag Screw Penetration: $P_{lag} := 3.78125\text{in}$

Eff. Lag Screw Penetration for withdrawal: $P_{\omega.lag} := 2\text{in} + \frac{9}{32}\text{in} = 2.28\cdot\text{in}$ **NDS 2018 Appx. Table L2**

NDS 2018 Sec. 12.1.4.6

Minimum Penetration DCR <1.0: $DCR_{min.penetration} := \frac{4\cdot D_{lag}}{P_{\omega.lag}} = 0.66$ $DCR_{min.penetration}$ = "OK"

Adj. Lateral Design Value: $Z' := Z\cdot C_M\cdot C_t\cdot C_g\cdot C_\Delta\cdot C_{eg}\cdot C_{di}\cdot C_{tn}\cdot K_F\cdot\phi\cdot\lambda = 218\cdot\text{lbs}$

Adj. Withdrawal Design Value: $W' := W\cdot C_M^{\,2}\cdot C_t\cdot C_{eg}\cdot C_{tn}\cdot K_F\cdot\phi\cdot\lambda = 527\cdot\text{lbs}$ **NDS 2018 Table 11.3.1**

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Number of Lag Screws on the Long Side

$N_B := 9 + 2$

Moment Arm for Overturning (Short Side)

$B := W_{curb} = 37 \cdot in$

Number of Lag Screws on the Short Side

$N_L := 4 + 2$

Moment Arm for Overturning (Long Side)

$L := L_{curb} = 67 \cdot in$

Total Number of Lag Screws

$N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 26$

Max net Tension Reaction due to Seismic, Fp

$$R_{lag.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 10 \cdot lbs$$

$$R_{lag.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 3 \cdot lbs$$

$$R_{lag.EQ} := MAX+\left[\begin{bmatrix} \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{lag.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{lag.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 97 \\ 92 \end{pmatrix} \cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$R_{lag.W} := MAX+\left[\begin{bmatrix} \frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{L \cdot N_L \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 472 \\ 395 \end{pmatrix} \cdot lbs$$

Tension Design force; SRSS for loading from Each direction

$$T_{lag} := \max\left(\left|R_{lag.EQ}\right|, \left|R_{lag.W}\right|\right) = 615 \cdot lbs$$

Shear load at each anchor location

$$V_{lag} := \frac{\max\left(V_{base.S} \cdot \sqrt{2}, V_{base.W}\right)}{N_t} = 181 \cdot lbs$$

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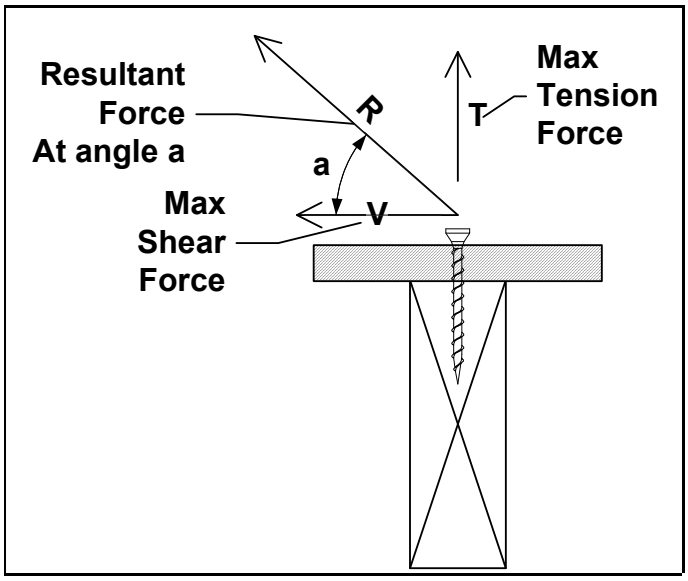
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For Lag Screws Subjected to Combined Lateral and Withdrawal Loading; Design Strength of the Lag Screw Shall Be Adjusted per Hankinson Formula as Prescribed by NDS 2018 Equation 12.4-1



Angle Between Wood Surface and Direction of Resultant Applied Load

$$(\alpha) := \operatorname{atan}\left(\frac{T_{lag}}{V_{lag}}\right) = 74\cdot\text{deg}$$

Combined Demand per Lag Screw @ Strength Level

$$R_{lag} := \sqrt{T_{lag}^{2} + V_{lag}^{2}} = 641\cdot\text{lbs}$$

Adjusted Capacity per NDS 2018 Equation 12.4-1 @ Strength Level

$$Z'_{\alpha} := \frac{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot Z'}{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot\cos(\alpha)^{2} + Z'\cdot\sin(\alpha)^{2}} = 883\cdot\text{lbs}$$

D/C Ratio for the Lag Screw connection to Wood Structure

$$\beta_{Lag} := \frac{R_{lag}}{Z'_{\alpha}} = 73\cdot\%$$

$$Lag_{Screw.Check} := \text{if}\left(\beta_{Lag} < 1.0, \text{"OK"}, \text{"NG"}\right)$$

$Lag_{Screw.Check}$ = "OK"

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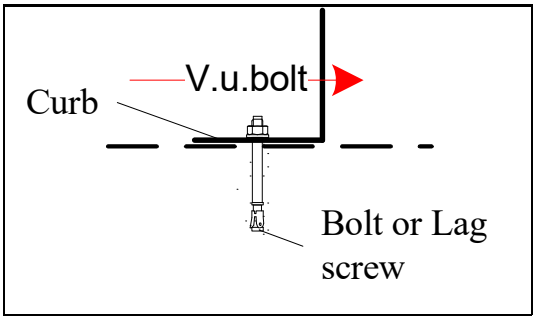
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Bearing and Tilting in Curb Bolted Connection AISI S100-16

Nominal bolt diameter $d := 0.5in$

Uncoated sheet thickness $t_{curb} := thick("14GA") = 0.079 \cdot in$



Tensile strength of sheet $F_u := 65ksi$

Coefficient for conversion of units $\alpha := 1.0$

Modification Factor $m_f := 1.0$

Modification factor for type of bearing connection, per Table J3.3.1-2; For single shear connection with washers

Bearing Factor

$$C := \begin{cases} 3 & \text{if } \left(\frac{d}{t_{curb}} < 10\right) \wedge \left(0.024in < t_{curb} < 0.1875in\right) \\ "NG" & \text{if } \frac{d}{t_{curb}} > 10 \end{cases} = 3$$

Bearing factor, which shall be determined according to Table J3.3.1-1 For d/t<10 where $d \div t_{curb} = 6$

Bearing Design Strength per AISI S100-16 Eq. J3.3.1-1

$$\phi P_{n_{(0)}} := (0.6) \cdot \left(m_f \cdot C \cdot d \cdot t_{curb} \cdot F_u\right) = 4592 \cdot lbs$$

Bolt Hole Deformation Design Strength per AISI S100-16 Eq. J3.3.2-1

$$\phi P_{n_{(1)}} := (0.65) \cdot \left[4.64 \cdot \left(\frac{\alpha}{in}\right) \cdot t_{curb} + 1.53\right] \cdot d \cdot t_{curb} \cdot F_u = 3141 \cdot lbs$$

Curb Connection Shear Capacity $\phi P_n := \min\left(\phi P_n\right) = 3141 \cdot lbs$

Loading demand at connection

$$V_{u.bolt} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{4} = 1178 \cdot lbs$$

$Curb\_Conn\_Shear := if\left(V_{u.bolt} < \phi P_n, "OK", "NG"\right)$

Curb_Conn_Shear = "OK"

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Thickness of Curb, ISO Rail and Clip

(Per AISC Table 17-10 Galvanized)

Hold Down Clip thickness $t_{Clip} := "12GA"$ $t_{clip} := thick(t_{Clip}) = 0.1084 \cdot in$

Roof Curb thickness $t_{Curb} := "14GA"$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

ISO RAIL thickness $t_{Curb.iso} := "10GA"$ $t_{curb.iso} := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Note: Iso Rail thickness is only used if the curb is isolated. Not used for non-isolated curbs

Sheet Metal Screws (SMS) Equations and References

SMS properties (ESR-2196 Table 5)

$$SMS_{Table} = \begin{pmatrix} "SMS" & "Diameter" & "HeadDiameter" & "Tension" & "Shear" \\ "Size" & "d" & "dw" & "Pts" & "Pss" \\ "\#8" & 0.164 & 0.335 & 1000 & 1170 \\ "\#10" & 0.19 & 0.399 & 1370 & 1215 \\ "\#12" & 0.216 & 0.415 & 2325 & 1880 \\ "\#14" & 0.25 & 0.5 & 4580 & 2440 \end{pmatrix}$$

SMS Tension Eqns

$P_{not} = 0.85 \cdot t \cdot d \cdot F_u$ **(AISI S100-16 J4.4.1 & J4.4.2)**

$P_{nov} = 1.5 \cdot t \cdot d_w \cdot F_u$

$P_{nts} = 0.8 \cdot P_{ts}$

FOR THE MOST CASES, PULL-OUT CAPACITY IS THE LOWEST

SMS Shearn Eqns

$P_{vnot} = 4.2 \cdot \sqrt{(d \cdot t^3)} \cdot F_u$ **(AISI S100-16 J4.3.1)**

$P_{vnov} = 2.7 \cdot t \cdot d \cdot F_u$

$P_{vnss} = 0.8 \cdot P_{ss}$

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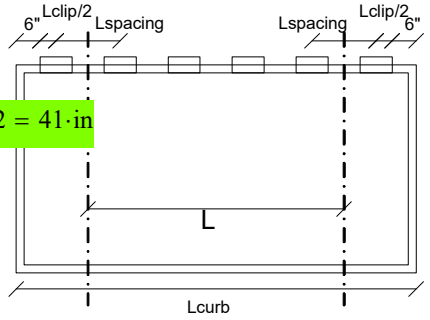
Hold Down Clip Design (Connection of the Mechanical unit to Curb)

Number of Clips on the long side $N_B := 4$

Moment Arm for over turning (Short side) $B := W_{curb} + 1.75in \cdot 2 = 41 \cdot in$

Number of Clips on the Short side $N_L := 4$

Width of Clips $L_{clip} := 9in$



Curb Centerline Spacing (Long side)

$$L_{spacing} := \frac{L_{curb} - \left(6in + \frac{L_{clip}}{2}\right) \cdot 2}{N_B - 1} = 15.458 \cdot in$$

$$L_{spacing.non.iso} := L_{spacing} = 15 \cdot in$$

Moment Arm for over turning (Long side)

$$L := L_{curb} - 2 \cdot \left[6in + \frac{L_{clip}}{2} + L_{spacing} \cdot \frac{(N_L - 2)}{4}\right] = 30.917 \cdot in$$

Total Number of Clips $N_t := (N_B) \cdot 2sides = 8$

Max net Tension Reaction due to Seismic, Fp

$$R_{clip.EQ} := MAX+\left[\begin{array}{l} \left[\frac{F_p \cdot Wt_{unit}}{B \cdot N_B} \cdot h_{CG.unit} + \frac{(0.9 - F_v) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B}\right] - \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} \\ \left[\frac{F_p \cdot Wt_{unit}}{L \cdot N_L} \cdot h_{CG.unit} + \frac{(0.9 - F_v) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L}\right] - \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} \end{array}\right] = \begin{pmatrix} 86 \\ 113 \end{pmatrix} \cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$R_{clip.W} := MAX+\left(\begin{array}{l} \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{unit}^2}{2}}{B \cdot N_B} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{unit}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{unit}^2}{2}}{L \cdot N_L} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{unit}}{N_t} \end{array}\right) = \begin{pmatrix} 767 \\ 771 \end{pmatrix} \cdot lbs$$

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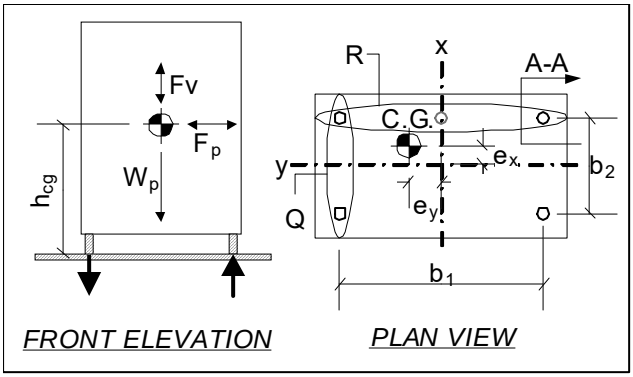
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Tensile and Shear Load calculation per ASHRAE RP-812



Eccentricity along X-X

$e_x := e_{width} = 7.5 \cdot in$

Eccentricity along Y-Y

$e_y := e_{length} = 2.562 \cdot in$

Distance between Seismic Restraints Along Y-Y

$b_1 := L_{curb} - 2 \cdot 6in = 55 \cdot in$

Distance between Seismic Restraints Along X-X

$b_2 := W_{curb} - 2 \cdot 6in = 25 \cdot in$

Moment of Inertia about X-X

$$I_{xx} := \frac{N_t \cdot (N_t + 2) \cdot (b_1)^2}{12 \cdot (N_t - 2)} = 3407 \cdot in^2$$

Moment of Inertia about Y-Y

$$I_{yy} := \frac{N_t \cdot (b_2)^2}{4} = 1269 \cdot in^2$$

Angle about Tensile Load

$$\Theta_t := \operatorname{atan}\left[\frac{I_{yy} \cdot (b_1)}{I_{xx} \cdot (b_2)}\right] = 39 \cdot deg$$

Angle about Shear Load

$$\Theta_s := \begin{cases} \operatorname{atan}\left(\frac{e_x}{e_y}\right) & \text{if } e_y \neq 0 \\ 0deg & \text{if } e_y = 0 \end{cases} = 71 \cdot deg$$

Max Net Tensile Load Due to Seismic Load, Fp

$$T_{U.EQ.pt1} := \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} - \frac{(0.9 - F_v) \cdot Wt_{unit}}{b_1 \cdot b_2} \cdot \left(\frac{b_1}{2} \cdot e_x + \frac{b_2}{2} \cdot e_y - e_x \cdot e_y\right) = -18 \cdot lbs$$

$$T_{U.EQ.pt2} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \cos(\Theta_t) \cdot \frac{0.5 \cdot b_2}{I_{yy}} = -161 \cdot lbs$$

$$T_{U.EQ.pt3} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \sin(\Theta_t) \cdot \frac{0.5 \cdot b_1}{I_{xx}} = -108 \cdot lbs$$

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$T_{U.EQ} := T_{U.EQ.pt1} + T_{U.EQ.pt2} + T_{U.EQ.pt3} = -287 \cdot lbs$

Max Net Shear Load Due to Seismic Load, Fp

$$V_{Ux.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\cos(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_2 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_1 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 86 \cdot lbs$$

$$V_{Uy.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\sin(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_1 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_2 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 144 \cdot lbs$$

$$V_{U.EQ} := \sqrt{V_{Ux.EQ}^2 + V_{Uy.EQ}^2} = 168 \cdot lbs$$

Tension Design force for Hold Down Clips

$T_{clip} := \max(R_{clip.W_0}, R_{clip.W_1}, |R_{clip.EQ}|, |T_{U.EQ}|) = 771 \cdot lbs$

$|R_{clip.EQ}| = 142 \cdot lbs$ $|T_{U.EQ}| = 287 \cdot lbs$

$|R_{clip.W}| = 1087 \cdot lbs$

$T_{clip.EQ.max} := \max(|R_{clip.EQ}|, |T_{U.EQ}|) = 287 \cdot lbs$

$T_{clip.W.max} := \max(|R_{clip.W}|) = 1087 \cdot lbs$

Based on ASCE 7-16 Figure 29.4-1 magnitude of force coefficient,

Wind in diagonal direction to the face of equipment produces less force than that of the wind in perpendicular direction to the face of the equipment.

Therefore, wind in diagonal direction does not need to be used

Shear Design force for Hold Down Clips

$$V_{clip} := \max\left(\frac{\max(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit})}{N_t}, |V_{U.EQ}|\right) = 384 \cdot lbs$$

$F_p \cdot Wt_{unit} \cdot \frac{1}{N_t} = 127 \cdot lbs$ $|V_{U.EQ}| = 168 \cdot lbs$

$P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t} = 384 \cdot lbs$

$$V_{clip.EQ.max} := \max\left[\left(F_p \cdot Wt_{unit} \cdot \frac{1}{N_t}\right), |V_{U.EQ}|\right] = 168 \cdot lbs$$

$$V_{clip.W.max} := \max\left(\left(P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t}\right)\right) = 384 \cdot lbs$$

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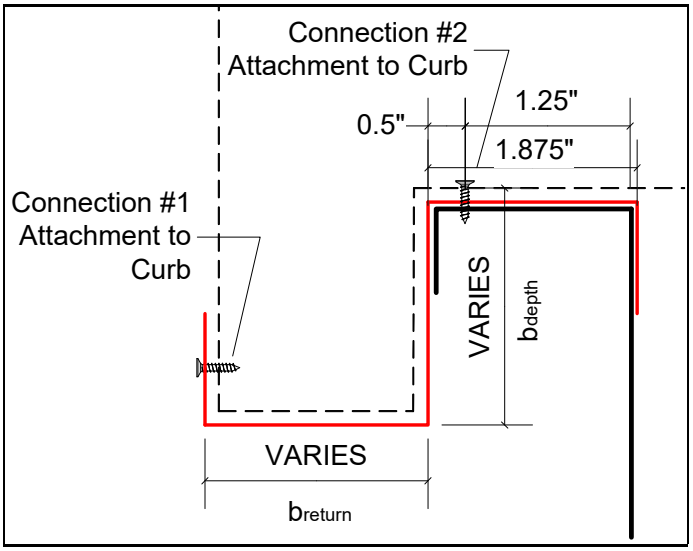
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Loading at Hold Down Clips

Due to the eccentricity of Shear and Tension forces additional moment is created in the hold down clip. These loads to be resisted in a T/C couple.

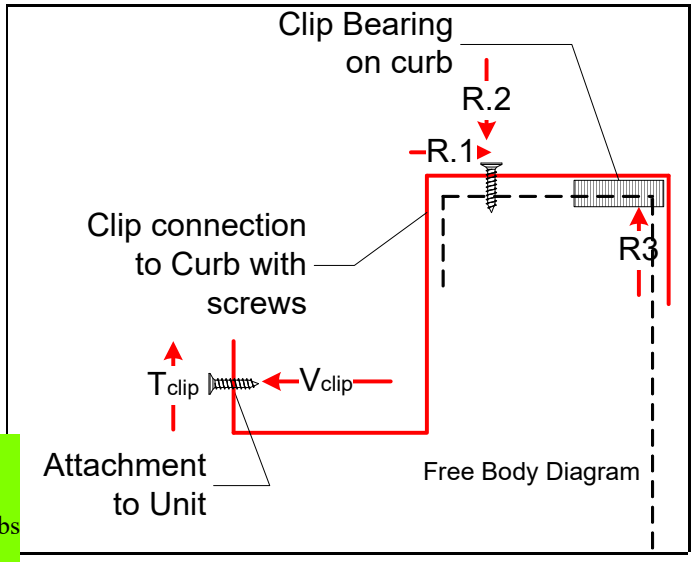


Reactions R1 & R2 to be resisted by the screws attaching the hold down clip to curb

R1 is acting as tension on the screws.

$$R_1 := V_{clip} = 384 \cdot lbs$$

R2 is acting as shear force on the connection screws
Since the loading T and V are acting in opposite directions; R2 is the maximum shear force due to either T or V



$$b_{return} := Clip_b \cdot in = 2.625 \cdot in$$

$$b_{depth} := Clip_c \, in = 4.5625 \cdot in$$

$$R_2 := \begin{bmatrix} \frac{T_{clip} \cdot (b_{return} + 1.75in - 0.5in)}{1.75in - 0.5in} \\ \frac{V_{clip} \cdot (b_{depth})}{1.75in - 0.5in} \end{bmatrix} = \begin{pmatrix} 2389 \\ 1403 \end{pmatrix} \cdot lbs$$

$$R_2 := \max(R_2) = 2389 \cdot lbs$$

Reaction R3 [compression force] is resisted by bearing of the hold down on the curb lip.

$$R_3 := R_2 - T_{clip} = 1618 \cdot lbs$$

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Design of Connection#1 Connection of Equipment to hold Down clip

Hold Down Clip thickness

$t_{Clip} = \text{"12GA"}$ $t_{clip} := thick(t_{Clip}) = 0.1084 \cdot in$

Strength Reduction for SMS Screw Connections per J.4

$\phi_{sms} = 0.5$

Ultimate SMS screw connection Strength (LRFD) Assume min thickness of the equipment housing is 16 GA [Fy = 50ksi & Fu=65ksi]

$n_{sms} := 4$ $Size_{ss} := \text{"\#12"}$

$t_{ss} := \text{"16GA"}$ $F_{u.ss} := 65ksi$

Nominal Tension Strength

$P_{nt} := n_{sms} \cdot T_s(Size_{ss}, t_{ss}, F_{u.ss}) = 3031 \cdot lbs$

$P_{not} := n_{sms} \cdot T_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 3031 \cdot lbs$

$P_{nov} := n_{sms} \cdot T_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 10277 \cdot lbs$

$P_{nts} := n_{sms} \cdot T_{nts}(Size_{ss}, t_{ss}, F_{u.ss}) = 7440 \cdot lbs$

Nominal Shear Strength

$P_{ns} := n_{sms} \cdot V_s(Size_{ss}, t_{ss}, F_{u.ss}) = 6016 \cdot lbs$

$P_{vnot} := n_{sms} \cdot V_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 8121 \cdot lbs$

$P_{vnov} := n_{sms} \cdot V_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 9629 \cdot lbs$

$P_{vnss} := n_{sms} \cdot V_{nss}(Size_{ss}, t_{ss}, F_{u.ss}) = 6016 \cdot lbs$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} V_{clip} \div (\phi_{sms} \cdot P_{nt}) \\ T_{clip} \div (\phi_{sms} \cdot P_{ns}) \end{bmatrix} = \begin{pmatrix} 25 \\ 26 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left[\begin{bmatrix} \left[\frac{T_{clip}}{P_{vnov}} + 0.71\left(\frac{V_{clip}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{T_{clip}}{P_{vnot}} + \left(\frac{V_{clip}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{T_{clip}}{P_{vnss}} + \left(\frac{V_{clip}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right] = 32 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} \text{"OK"} \\ \text{"OK"} \\ \text{"OK"} \end{pmatrix}$$

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Check Bending in Clip

There are several restraints that prevents the hold down clip for curb to have local bending at the bottom flange and transfer vertical load demand directly to the face of the curb.

- Hold down is bearing on the face of iso-rail / non-iso curb lip.
- Gasket will act as a "link" member to allow unit base rail and bottom flange to move toegther so flange can't bend unless the unit base rail bends first. However, unit base rail is not likely to bend so bottom flange won't bend

Hold Down Clip thickness

$t_{Clip} = \text{"12GA"}$ $t_{clip} := \text{thick}(t_{Clip}) = 0.1084 \cdot \text{in}$

Effective width of hold down clip

$b_c := L_{clip} = 9 \cdot \text{in}$

Yield strength of the Clip

$F_{y.c} := 50\text{ksi}$

Strength reduction for bending

$\phi_{clip} := 0.9$

Design Bending Capacity (LRFD)

$$\phi M_n := \phi_{clip} \cdot F_{y.c} \left(\frac{b_c \cdot t_{clip}^{\,2}}{6} \right) = 793 \cdot \text{in} \cdot \text{lbs}$$

Flexural bending demand

$M_{u.clip} := T_{clip} \cdot (0.5\text{in}) = 385 \cdot \text{in} \cdot \text{lbs}$

D/C Ratio for bending

$$DCR := \frac{M_{u.clip}}{\phi M_n} = 0.486$$

$Clip_{Bending} = \text{"OK"}$

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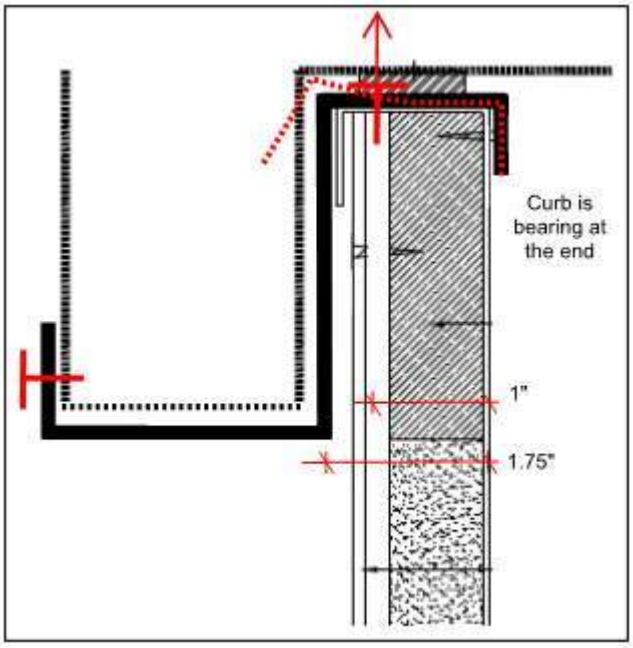
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Check Flange Bending in Curb



Roof Curb thickness

$t_{Curb} = \text{"14GA"}$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

Clip edge to edge distance

$$b_{edge2edge} := \frac{L_{curb} - \left(6in + \frac{L_{clip}}{2}\right) \cdot 2}{N_B - 1} - L_{clip} = 6.458 \cdot in$$

Effective width of Roof Curb

$b_{curb} := L_{clip} + b_{edge2edge} = 15.46 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\frac{b_{curb} \cdot (t_{curb})^2}{6} + \frac{L_{clip} \cdot (t_{clip})^2}{6} \right] = 1508 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := T_{clip} \cdot (1.75in - 0.5in) = 963 \cdot in \cdot lbs$

D/C Ratio for bending

$$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.639$$

$Curb_{Bending} = \text{"OK"}$

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Design of Connection#2 Connection of hold Down clip to Curb

Ultimate SMS screw connection Strength (LRFD) Strength based on the smallest thickness of Curb and Hold down Clip (min 16 GA) [Fy = 50ksi & Fu=65ksi]

Tension loads on SMS connection

$T_{s2} := R_2 = 2389 \cdot lbs$

Shear loads on SMS connection

$V_{s2} := R_1 = 384 \cdot lbs$

Strength Reduction for SMS Screw Connections per J.4

$n_{sms} := 8$ $Size_{ss} := "\#12"$ $\phi_{sms} = 0.5$

$t_{ss} := t_{Curb} = "14GA"$ $F_{u.ss} := 65ksi$

Nominal Tension Strength

$P_{nt} := n_{sms} \cdot T_s(Size_{ss}, t_{ss}, F_{u.ss}) = 7495 \cdot lbs$

$P_{not} := n_{sms} \cdot T_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 7495 \cdot lbs$

$P_{nov} := n_{sms} \cdot T_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 25410 \cdot lbs$

$P_{nts} := n_{sms} \cdot T_{nts}(Size_{ss}, t_{ss}, F_{u.ss}) = 14880 \cdot lbs$

Nominal Shear Strength

$P_{ns} := n_{sms} \cdot V_s(Size_{ss}, t_{ss}, F_{u.ss}) = 12032 \cdot lbs$

$P_{vnot} := n_{sms} \cdot V_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 22325 \cdot lbs$

$P_{vnov} := n_{sms} \cdot V_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 23806 \cdot lbs$

$P_{vnss} := n_{sms} \cdot V_{nss}(Size_{ss}, t_{ss}, F_{u.ss}) = 12032 \cdot lbs$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} T_{s2} \div (\phi_{sms} \cdot P_{nt}) \\ V_{s2} \div (\phi_{sms} \cdot P_{ns}) \end{bmatrix} = \begin{pmatrix} 64 \\ 6 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left[\begin{bmatrix} \left[\frac{V_{s2}}{P_{vnov}} + 0.71\left(\frac{T_{s2}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{V_{s2}}{P_{vnot}} + \left(\frac{T_{s2}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{V_{s2}}{P_{vnss}} + \left(\frac{T_{s2}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right] = 49 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

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Hold Down clip Bending and Shear Interaction

Diameter of SMS:

$$d_{sms} := vlookup\left(Size_{ss}, SMS_{Table}, 1\right)_0 \cdot in = 0.216 \cdot in$$

Depth of flat web portion

$$h_{clip.shear} := L_{clip} - n_{sms} \cdot d_{sms} = 7.27 \cdot in$$

Depth-to-Thickness Ratio:

$$\frac{h_{clip.shear}}{t_{clip}} = 67 \qquad E := 29500ksi \qquad F_y := 50ksi \qquad \mu := 0.3$$

Nominal Shear Stress:
(For unreinforced web)
AISI S100-16 G2.1

$$k_v := 5.34 \qquad \sqrt{\frac{E \cdot k_v}{F_y}} = 56 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 85$$

Area of Web Element:

$$A_w := h_{clip.shear} \cdot t_{clip} = 0.788 \cdot in^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h_{clip.shear}}{t_{clip}}\right)^2} = 31.6 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} \qquad V_y := 0.6 \cdot A_w \cdot F_y = 24\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.974$$

Hole Shear Reduction Factor:
(for circular holes, AISI S100-16 Eq G3-1)

$$c := \frac{h_{clip.shear}}{2} - \frac{d_{sms}}{2.83} = 3.56 \cdot in$$

$$q_s := \begin{cases} 1.0 & \text{if } \frac{c}{t_{clip}} \geq 54 \\ \frac{c}{54 \cdot t_{clip}} & \text{if } 5 \leq \frac{c}{t_{clip}} < 54 \end{cases} = 0.608$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \leq 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \leq 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 19.792 \cdot kip$$

Design Shear Capacity with holes:

$$\phi V_{n.clip} := 0.95 \cdot V_n \cdot q_s = 11.4 \cdot kip$$

D/C Ratio of V and M per AISI S100-16 Eq H2-1

$$DCR_{V.M.int.clip} := \sqrt{\left(\frac{M_{u.clip}}{\phi M_n}\right)^2 + \left(\frac{\max\left(T_{clip}, V_{clip}\right)}{\phi V_{n.clip}}\right)^2} = 0.4905$$

Demand/Capacity Ratio:

$VandM_{int.clip}$ = "OK"

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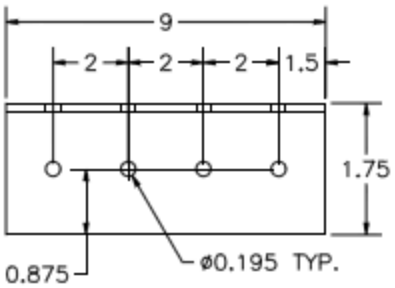
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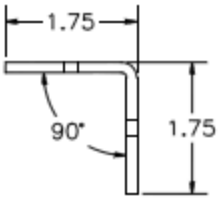
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Hold Down clip Block Shear





$b_{clip} := 1in$

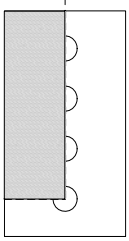
$s_{clip.sms} := 2in$

$b_{edge} := 1in$

(Figure shown as reference only)

Case 1 Block Shear Capacity: (Force in parallel direction of sms row)

CASE 1



$$A_{gv} := \left[b_{edge} + \left(n_{sms} - 1\right)\cdot s_{clip.sms}\right]\cdot t_{clip} = 1.626\cdot in^2$$

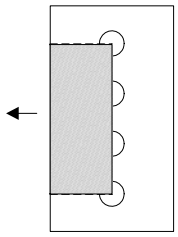
$$A_{nv} := \left[b_{edge} + \left(n_{sms} - 1\right)\cdot s_{clip.sms} - \frac{d_{sms}}{2}\right]\cdot t_{clip} = 1.614\cdot in^2$$

$$A_{nt} := t_{clip}\cdot\left(\frac{b_{clip}}{2} - \frac{d_{sms}}{2}\right) = 0.042\cdot in^2$$

$$\phi R_{n1} := 0.5\cdot\min\left(0.6\cdot F_y\cdot A_{gv} + F_u\cdot A_{nt}, 0.6\cdot F_u\cdot A_{nv} + F_u\cdot A_{nt}\right) = 26\,kip$$

Case 2 Block Shear Capacity: (Force in perpendicular direction of sms row)

CASE 2



$$A_{gv} := 2\cdot t_{clip}\cdot\frac{b_{clip}}{2} = 0.108\cdot in^2$$

$$A_{nv} := 2\cdot t_{clip}\cdot\left(\frac{b_{clip}}{2} - \frac{d_{sms}}{2}\right) = 0.085\cdot in^2$$

$$A_{nt} := t_{clip}\cdot\left[\left(n_{sms} - 1\right)\cdot s_{clip.sms} - d_{sms}\right] = 1.494\cdot in^2$$

$$\phi R_{n2} := 0.5\cdot\min\left(0.6\cdot F_y\cdot A_{gv} + F_u\cdot A_{nt}, 0.6\cdot F_u\cdot A_{nv} + F_u\cdot A_{nt}\right) = 50\,kip$$

Design Block Shear Capacity:

$$\phi R_n := \min\left(\phi R_{n1}, \phi R_{n2}\right) = 26\,kip$$

D/C Ratio of Block Shear:

$$DCR_{clip.blockshear} := \frac{\max\left(T_{clip}, V_{clip}\right)}{\phi R_n} = 0.03$$

$Blockshear_{clip}$ = "OK"

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Web Crippling/Compression of Non-iso CanFab Curb (AISI S100-16 G5)

Governing Compression for Non-Isolated Curb:

$$P_{web.crip.int} := \max\left[\frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}}, \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}}\right] \cdot L_{spacing.non.iso} = 1335 \cdot lbs$$

$$P_{web.crip.end} := 0.5 \cdot P_{web.crip.int} = 667 \cdot lbs$$

Yield Strength: $F_y := 50ksi$

Bearing Length: $N_{bearing} := L_{spacing.non.iso} = 15 \cdot in$

Thickness of Curb: $t_{Curb} = \text{"14GA"}$ $t := thick(t_{Curb}) = 0.0785 \cdot in$

Inside Bend Radius: $R := R_{curb} = 0.107 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web: $h := 22in - 2 \cdot (t + R) = 21.63 \cdot in$

Angle btween plane of web and bearing surface: $\theta := 90deg$

Web Crippling Limit Check (AISI Table G5-2): $\frac{R}{t} = 1$ $\frac{h}{t} = 276$ $\frac{N_{bearing}}{t} = 197$ $\frac{N_{bearing}}{h} = 0.71$

End Case Coefficient Single Web Channel (AISI Table G5-2): $C := 13$ $C_R := 0.32$ $C_N := 0.05$ $C_h := 0.04$

Reduction Factor Web Crippling Strength: $\phi_{web.end} := 0.9$ $\phi_{web.int} := 0.8$ **(For Unfastened partially Stiffened Flanges with Two-Flange Loading or Reaction.)**

Design Web Crippling Strength:

$$\phi P_{n.end} := \left(\phi_{web.end}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 1292 \cdot lbs$$

Interior Case Coefficient Single Web Channel (AISI Table G5-2): $C := 24$ $C_R := 0.52$ $C_N := 0.15$ $C_h := 0.001$

Design Web Crippling Strength:

$$\phi P_{n.interior} := \left(\phi_{web.int}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 7102 \cdot lbs$$

D/C Ratio of Shear: $DCR_{end} := \frac{P_{web.crip.end}}{2 \cdot \phi P_{n.end}} = 0.258$ $DCR_{int} := \frac{P_{web.crip.int}}{\phi P_{n.interior}} = 0.188$

Demand/Capacity Ratio: **Note: Factor of 2 for two ends connected together at the end**

$Web_{crippling} = \text{"OK"}$

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Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Length

Roof Curb thickness

$t_{Curb} = \text{"14GA"}$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

Min width of Roof Curb

$b_{curb} := L_{curb} + \frac{W_{curb}}{2} \cdot 2 + 3in \cdot 2 \cdot 2 = 116.56 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := L_{curb} + \min\left(\frac{W_{curb}}{2} \cdot 2, \frac{L_{curb}}{2}\right) = 101 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{array}{c} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{array} \right] \right] = 5387 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.L.vert.up} \cdot L_{curb}) \cdot (0.75in) = 4030 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.748$

$Curb_{BotFlangeBending} = \text{"OK"}$

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Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Width

Roof Curb thickness

$t_{Curb} = \text{"14GA"}$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

Min width of Roof Curb

$b_{curb} := W_{curb} + \frac{L_{curb}}{4} \cdot 2 + 3in \cdot 2 = 76.88 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := W_{curb} + \min\left(\frac{L_{curb}}{6} \cdot 2, W_{curb}\right) = 60 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{array}{c} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{array} \right] \right] = 3553 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.W.vert.up} \cdot W_{curb}) \cdot (0.75in) = 2261 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.636$

$Curb_{BotFlangeBending} = \text{"OK"}$

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Check CanFab Curb for Compressive Force due to T/C Coupling of Overturning

Note:
-Since the equipment is only attached to the longer sides of the CanFab Curb, most likely there will be compressive force onto the curb due to T/C coupling.
- Rectangular CanFab Curb will be considered as "Channel" to resist the compressive force.

Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Flanges*

Flat Width:

$$w := \frac{W_{curb}}{2} - R_{curb} = 18.487 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Unstiffened"}$$

Stress at the end of the Width:

$$f_2 := 50ksi \qquad f_1 := 50ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \left| \frac{f_2}{f_1} \right| = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 0.43$$

Critical Compressive Stress (Eq 1.1-4):

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w}\right)^2 = 0.21 \cdot ksi$$

Stress in Compression Element:

$$f := F_y = 50 \cdot ksi \qquad \textbf{(Assume f = Fy)}$$

Slenderness Factor (Eq 1.1-3):

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 15.55$$

Local reduction factor (Eq 1.1-2):

$$\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 0.063$$

Effective Width of the Flanges:

$$b_{eff.flange} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 1.172 \cdot in$$

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Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Web*

Flat Width:

$$w := L_{curb} - R_{curb} \cdot 2 = 67.161 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Stiffened"}$$

Stress at the end of the Width:

$$f_2 := 50ksi \qquad f_1 := 50ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \left| \frac{f_2}{f_1} \right| = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 4$$

Critical Compressive Stress (Eq 1.1-4):

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w} \right)^2 = 0.15 \cdot ksi$$

Stress in Compression Element:

$$f := F_y = 50 \cdot ksi \qquad \textbf{(Assume f = Fy)}$$

Slenderness Factor (Eq 1.1-3):

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 18.52$$

Local reduction factor (Eq 1.1-2):

$$\rho := \left(1 - \frac{0.22}{\lambda}\right) \frac{1}{\lambda} = 0.053$$

Effective Width of the Web:

$$b_{eff.web} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 3.582 \cdot in$$

Effective Area of the Member:

$$A_e := 2 \cdot \left(b_{eff.flange} \cdot t_{curb} \right) + b_{eff.web} \cdot t_{curb} = 0.465 \cdot in^2$$

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Length of the Compressive Member: $L_{curb.web} := h = 21.629 \cdot in$

Young's Modulus for Cold Form Steel: $E := 29500ksi$

Curb Shear Modulus: $G := 11300ksi$

Poisson's Ratio $\mu := 0.3$

Section Properties of the Member (From Section Properties Calculator):

$A_{half.curb} := 6.087in^2$ $r_o := 28.35in$ $I_x := 3577in^4$ $I_y := 311in^4$

$J := 0.006in^4$ $r_x := \sqrt{\frac{I_x}{A_{half.curb}}} = 24.241 \cdot in$ $r_y := \sqrt{\frac{I_y}{A_{half.curb}}} = 7.148 \cdot in$

$C_w := 209700in^6$ $r_{min} := \min(r_x, r_y) = 7.148 \cdot in$

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^2}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{(1.0 \cdot L_{curb.web})^2}\right] = 349052.037 \cdot ksi$$

$$\sigma_{e.y} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_y}\right)^2} = 31797.863 \cdot ksi \qquad \sigma_{e.x} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_x}\right)^2} = 365726.548 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2} = 31797.863 \cdot ksi$$

$$\frac{1.0 \cdot L_{curb.web}}{r_{min}} = 3.03$$

$KL_r = \text{"KL/r < 200, OK"}$

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 29143.001 \cdot ksi$$

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Nominal Compressive Stress Capacity: (Eq E2-4)

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 0.041$$

$$F_n := \begin{cases} 0.658^{\lambda_c^2} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^2}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 49.96 \cdot \text{ksi}$$

Compressive Capacity:

$$P_{n.member} := A_e \cdot F_n = 23.24 \cdot \text{kip}$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot P_{n.member} = 19.76 \cdot \text{kip}$$

Factored Max Compressive Force:

$$P_{comp.max} := \max\left(\left|C_S\right|, \left|C_W\right|\right) = 6.745 \text{ kip}$$

D/C Ratio of Compression:

$$DCR := \frac{P_{comp.max}}{\phi P_{n.member}} = 0.341$$

$$Axial_{curb.comp} := \text{if}\left(P_{comp.max} < \phi P_{n.member}, \text{"OK"}, \text{"Provide Channel from above as Web Stiffener"}\right)$$

$Axial_{curb.comp} = \text{"OK"}$

Note: No need to check for interaction since the curb is only subjected to the compressive force.

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Shear of CanFab Curb Webs without Holes (AISI S100-16 G2)

Note: Since the unit is stiffer than the curb and the curb is firmly attached to the unit and to the base structure, curbs will mainly take the lateral forces as shear and axial load rather than bending.

Thickness of Curb:

$$t := \text{thick}(t_{Curb}) = 0.079 \cdot \text{in}$$

Depth-to-Thickness Ratio:

$$\frac{h}{t} = 276$$

Curb Elastic Modulus:

$$E := 29500\text{ksi}$$

Clear distance b/w transverse stiffeners of reinforced web:

$$a := \max\left(\frac{L_{curb}}{2}, W_{curb}\right) = 37 \cdot \text{in} \qquad \frac{a}{h} = 1.72$$

$$k_v := \begin{cases} 5.34 & \text{if } a = L_{curb} \\ 4.00 + \dfrac{5.34}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \dfrac{4.00}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 6.69$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 63 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 95$$

Curb Shear Check due to Load on Longer Side

Area of Web Element:

$$A_w := W_{curb} \cdot t = 3 \cdot \text{in}^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 2.4 \cdot \text{ksi}$$

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$V_{cr} := A_w \cdot F_{cr} = 7\,kip$ $V_y := 0.6 \cdot A_w \cdot F_y = 88\,kip$ $\lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 3.572$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 6.862 \cdot kip$$

Number of Members within Length: $n := 2$ **(Per Curb Design)**

Design Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 13037.9 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.H} := P_{net} \cdot L_{unit} \cdot H_{total} = 4710.5 \cdot lbs$

Design Shear Demand: $V_u := \max(V_{base.S}, V_{base.W.H}) = 4710.5 \cdot lbs$

D/C Ratio of Shear: $DCR := \frac{V_u}{\phi V_n} = 0.361$

Demand/Capacity Ratio:

$Shear_{in.plane} := \text{if}(V_u < \phi V_n, \text{"OK"}, \text{"NG"})$

$Shear_{in.plane} = \text{"OK"}$

Curb Shear Check due to Load on Shorter Side

Area of Web Element: $A_w := L_{curb} \cdot t = 5 \cdot in^2$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot (1 - \mu^2) \cdot \left(\frac{h}{t}\right)^2} = 2.4 \cdot ksi$$

$V_{cr} := A_w \cdot F_{cr} = 12\,kip$ $V_y := 0.6 \cdot A_w \cdot F_y = 159\,kip$ $\lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 3.572$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 12.432 \cdot kip$$

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Number of Members within Length: $n := 2$ **(Per Curb Design)**

Factored Nominal Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 23621.7 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot W_{unit} \cdot H_{total} = 3800.1 \cdot lbs$

Factored Shear Demand: $V_u := \max(V_{base.S}, V_{base.W.L}) = 3800.1 \cdot lbs$

D/C Ratio of Shear: $DCR := \frac{V_u}{\phi V_n} = 0.161$

Demand/Capacity Ratio:

$Shear_{in.plane} := \text{if}(V_u < \phi V_n, \text{"OK"}, \text{"NG"})$

$Shear_{in.plane} = \text{"OK"}$

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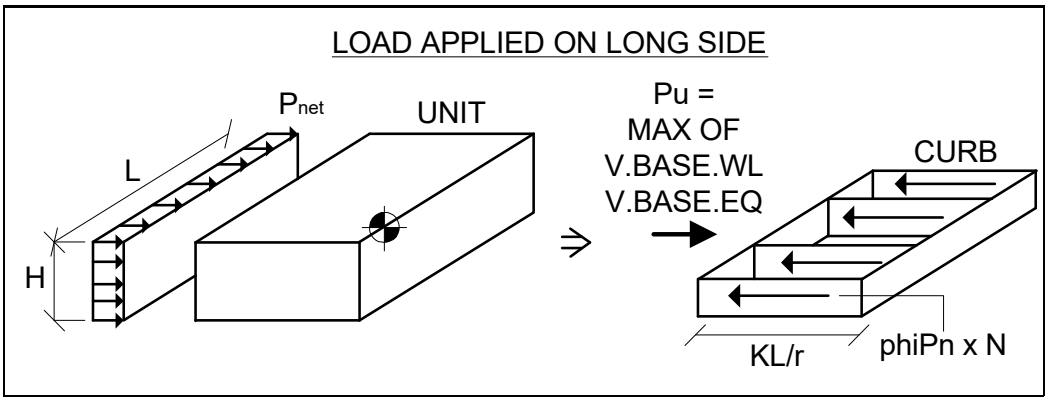
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Check CanFab Curb for In-Plane Axial due to EQ and Wind (AISI S100-16 E2)

Curb Axial Load Check due to Load on Long Side



Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot L_{unit} \cdot H_{total} = 4.7\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.L}) = 4710.52 \cdot lbs$

Member per CFS: $CFS_{member} :=$ "14GA Custom Curb 22" Tall L.b = 78in"

Max Braced Length of Member: $L_{member} := W_{curb} = 37 \cdot in$

Number of Curb in Length: $n_{curb.long} := 2$

Radius of gyration in y-axis: $r_{y.curb} := 0.630\,in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{2} = 2.36\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 59$ $KL_r =$ "KL/r < 200, OK"

Spacing: $Spacing := \frac{L_{curb}}{n_{curb.long}} = 34 \cdot in$

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 8.034 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.293$

$Axial_{short.curb} =$ "OK"

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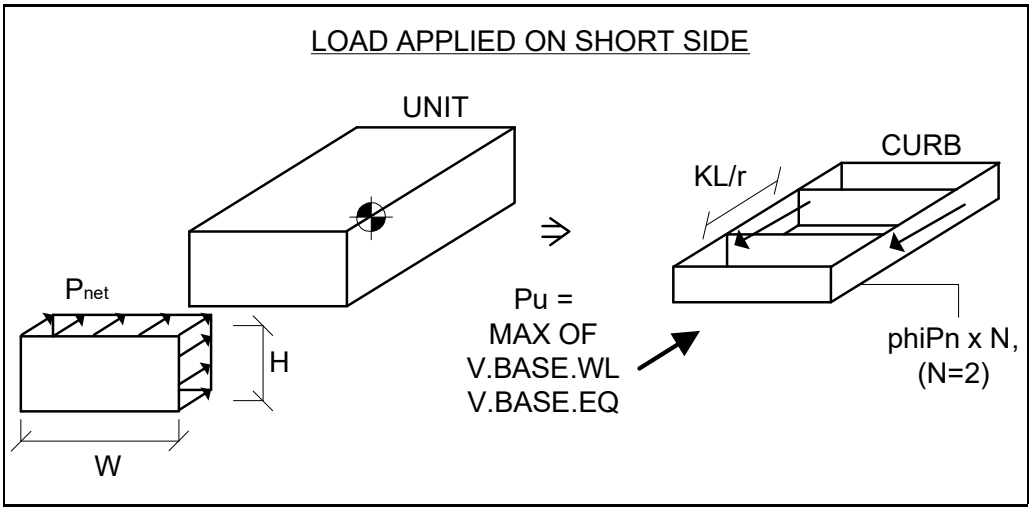
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Curb Axial Load Check due to Load on Short Side



Wind Base Shear on Short Side: $V_{base.W.H} := P_{net} \cdot W_{unit} \cdot H_{total} = 3.8\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.H}) = 3800.08 \cdot lbs$

Member per CFS: CFS_{member} = "14GA Custom Curb 22" Tall L.b = 78in"

Max Braced Length of Member: $L_{member} := \frac{L_{curb}}{n_{curb.long} - 1} = 67 \cdot in$

Number of Curb in Length: $n_{curb} := 2$

Radius of gyration in y-axis: $r_{y.curb} := 0.630\,in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{curb}} = 1.9\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 107$ KL_r = "KL/r < 200, OK"

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 8.034 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.237$

$Axial_{long.curb}$ = "OK"

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DESIGN
for
NON ISOLATED CURB
1005 (Max Curb Height of 30")

950 S. GRAND AVENUE, 4TH FLOOR, LOS ANGELES, CALIFORNIA 90015 (213) 483-6490

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Design Wind Loads for Rooftop Equipment (ASCE 7-16 § Table 29.1-1)

$z := 60ft$ **Height above ground level**

$B := 60ft$ **Horizontal dimension of building measured normal to wind direction**

$Exp_{category} := "C"$ **Exposure Category per ASCE 7-16 § 26.7**

$Risk_{category} := "IV"$ **Risk Category per ASCE 7-16 Table 1.5-1**

$V := \begin{cases} 0mph & \text{if } Risk_{category} = "I" \\ 0mph & \text{if } Risk_{category} = "II" \\ 175mph & \text{otherwise} \end{cases} = 175 \cdot mph$ **Basic Wind Speed per ASCE 7-16 Figure 26.5-1 A,B or C**

$K_z = 1.14$ **Velocity Pressure Exposure Coefficient per ASCE 7-16 Table 29.10-1 [Exposure Category "C"]**

$K_{zt} := 1.0$ **Topographic Factor per ASCE 7-16 § 26.8, Figure 26.8-1**

$K_e := 1.0$ **Ground Elevation Factor per ASCE 7-16 § 26.9, Table 26.9-1**

$K_d := 0.85$ **Wind Directionality Factor per ASCE 7-16 § 26.6, Table 26.6-1 (Equipment)**

$q_z := 0.00256 K_z \cdot K_{zt} \cdot K_d \cdot K_e \cdot V^2 = 75.74 \cdot psf$ **Velocity pressure evaluated at height z above ground per ASCE 7-10 § 26.10.2; Eq. 26.10-1**

$GC_{r.lateral.max} := 1.9$ **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.9 for rooftop structures and equipment with Af less than (0.1Bh). (GCr) shall be permitted to be reduced linearly from 1.9 to 1.0 as the value of Af is increased from (0.1Bh) to (Bh)

$GC_{r.vertical.max} := 1.5$ **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.5 for rooftop structures and equipment with A_r less than (0.1*BL*). (GC_r) shall be permitted to be reduced linearly from 1.5 to 1.0 as the value of A_r is increased from (0.1*BL*) to (*BL*)

$P_{net} := q_z \cdot GC_{r.lateral.max} = 143.91 \cdot psf$ **Design Lateral Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-2**

$P_v := q_z \cdot GC_{r.vertical.max} = 113.61 \cdot psf$ **Design Vertical Uplift Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-3**

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Seismic Demands on Nonstructural Components (ASCE 7-16 § 13.3 & 13.6):

$S_{DS} := 1.5$ **Design spectral response acceleration parameter at short periods per USGS map**

$I_p := 1.5$ **Component importance factor ASCE 7-16 § 13.1.3**

$\Omega_0 := 2.0$ **Overstrength factor ASCE 7-16 Table 13.6.1**

Vibr_Isolation = "No" **Placement of Unit Vibration Isolated:**

Note: Only "F_p" at seismic concrete anchor has been increased with overstrength factor "Ω_0"

$a_p := 2.5$ $R_p = 6.0$ **Seismic coefficients a_p & R_p**
Per ASCE 7-16 Table 13.6-1 for
Mechanical & Electrical Components

$z = 60\,ft$ **Height in structure of point of attachment of component with respect to the base**

$h := 60ft$ **Average roof height of structure with respect to the base**
Where for roof top equipment:

$z \div h = 1$

F_p: Horizontal Seismic Design Force per *ASCE7-16 § 13.3.1*

F_p shall be takes as $\left(\frac{0.4 \cdot a_p \cdot S_{DS} \cdot I_p}{R_p}\right) \cdot \left(1 + 2 \cdot \frac{z}{h}\right) \cdot W_p = 112.5 \cdot \% \cdot W_p$

F_p is not required to be taken as greater than $\left(1.6 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 360 \cdot \% \cdot W_p$

F_p shall not be taken as less than $\left(0.3 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 67.5 \cdot \% \cdot W_p$

Governing F_p : Horizontal Seismic Design Force $F_p = 112.5 \cdot \% \cdot W_p$

F_v: Vertical Load per ASCE7-16 § 13.3.1.2

Concurrent Vertical Seismic Force: $F_v := 0.2 \cdot S_{DS} \cdot W_p = 30 \cdot \% \cdot W_p$

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Flat Roof Snow Loads (ASCE 7-16 § 7.3):

$Terrain_{CAT} := "C"$ **Terrain Category ASCE 7-16 § 26.7 & Table 7.3-1**

$Exp_{Roof} := "Partially\ Exposed"$ **Exposure of Roof ASCE 7-16 Table 7.3-1**

$C_e = 1$ **Exposure Factor ASCE 7-16 Table 7.3-1**

$Thermal_{condition} := "All\ structures\ except\ below"$ **Thermal Condition ASCE 7-16 Table 7.3-2**

$C_t = 1$ **Thermal Factor ASCE 7-16 Table 7.3-2**

$Risk_{category} = "IV"$ **Risk Category per ASCE 7-16 Table 1.5-1**

$I_s = 1.2$ **Snow Importance Factor ASCE 7-16 Table 1.5-2**

$p_g := 40psf$ **Ground Snow Loads ASCE 7-16 Figure 7.2-1**

$$p_f := \max\left(0.7 \cdot C_e \cdot C_t \cdot I_s \cdot p_g, \text{if}\left(p_g > 20psf, 20psf \cdot I_s, I_s \cdot p_g\right)\right) = 34 \cdot psf$$

Flat Roof Snow Loads ASCE 7-16 Equation 7.3-1 and § 7.3.4

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Mechanical Unit Dimensions

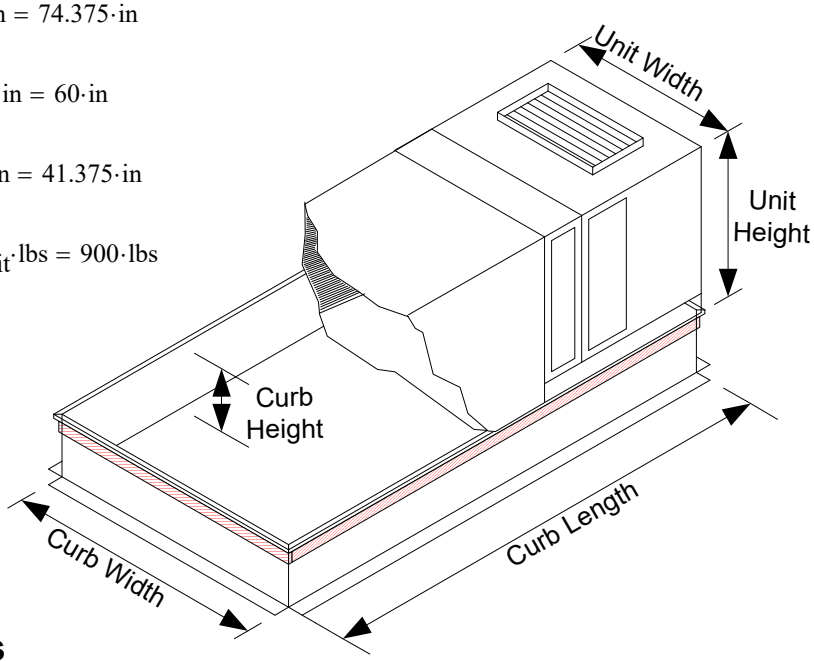
Curb = "C-1005"

Length of Unit $L_{unit} := L_{unit} \cdot in = 74.375 \cdot in$

Width of Unit $W_{unit} := W_{unit} \cdot in = 60 \cdot in$

Height of Unit $H_{unit} := H_{unit} \cdot in = 41.375 \cdot in$

Weight of Unit $Wt_{unit} := Wt_{unit} \cdot lbs = 900 \cdot lbs$



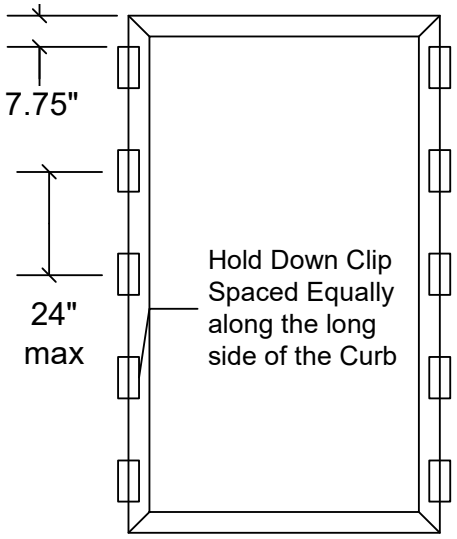
Roof Curb Dimensions

Length of Curb $L_{curb} := L_{curb} \cdot in = 67.375 \cdot in$

Width of Curb $W_{curb} := W_{curb} \cdot in = 37.188 \cdot in$

Height of Curb $H_{curb} := H_{curb} \cdot in = 30 \cdot in$

Weight of Curb $Wt_{curb} := Wt_{curb} \cdot lbs = 354 \cdot lbs$



Curb Plan

Overall System Dimensions

Total Weight

$Wt_{tot} := Wt_{unit} + Wt_{curb} = 1254 \cdot lbs$

Total height

$H_{total} := H_{unit} + H_{curb} = 71.375 \cdot in$

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Seismic Loading + Snow Loading

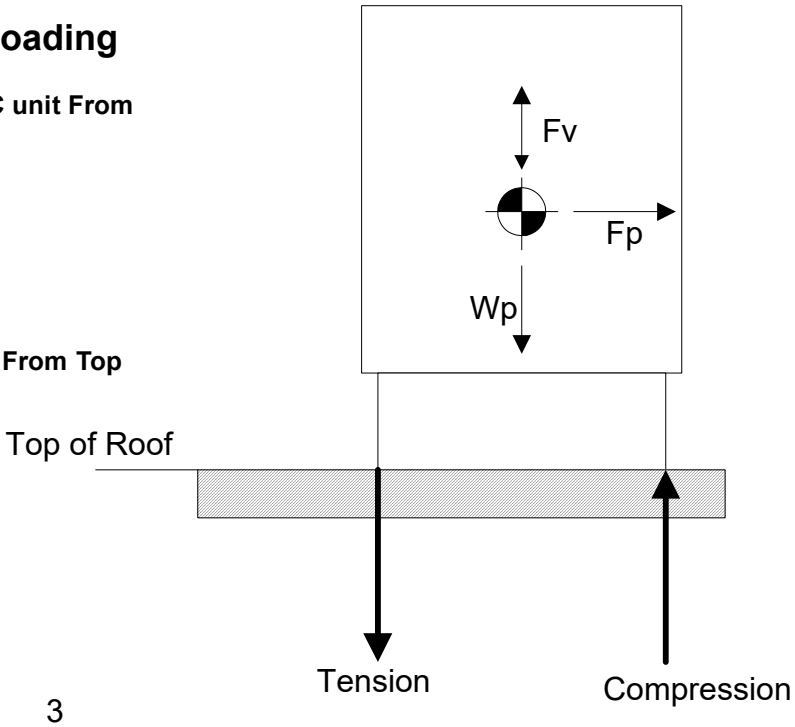
Height for Center of Gravity for HVAC unit From Top of Roof

$h_{CG.unit} := \frac{1}{2} H_{unit} = 21 \cdot in$

$h_{CG} := H_{curb} + h_{CG.unit} = 50.69 \cdot in$

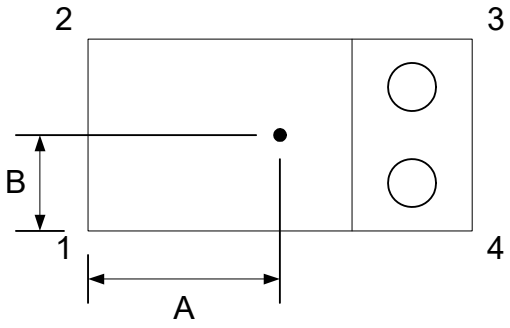
Height for Center of Gravity for Curb From Top of Roof

$h_{CG.curb} := \frac{H_{curb}}{2} = 15 \cdot in$



Max Seismic Base Shear

$V_{base.S} := F_p \cdot Wt_{tot} = 1411 \cdot lbs$



Unit C.G. distance in axis parallel to Curb Width $B_{ecc.width} := CG_{short} \cdot in = 22.5 \cdot in$

Eccentricity in axis parallel to Curb Width

$$e_{width} := \begin{cases} 0in & \text{if } B_{ecc.width} = \text{"N/A"} \\ \left| B_{ecc.width} - \frac{W_{unit}}{2} \right| & \text{otherwise} \end{cases} = 7.5 \cdot in$$

Unit C.G. distance in axis parallel to Curb Length $A_{ecc.length} := CG_{long} \cdot in = 34.625 \cdot in$

Eccentricity in axis parallel to Curb Length

$$e_{length} := \begin{cases} 0in & \text{if } A_{ecc.length} = \text{"N/A"} \\ \left| A_{ecc.length} - \frac{L_{unit}}{2} \right| & \text{otherwise} \end{cases} = 2.56 \cdot in$$

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Max Net Tension Reaction On Each Side Due To Seismic Loads

$$T_S := \begin{bmatrix} \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{W_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{W_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} \right] \\ \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{L_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{L_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} \right] \end{bmatrix} = \begin{pmatrix} -1273 \\ -495 \end{pmatrix}\cdot lbs$$

Max Net Compression Reaction On Each Side Due To Seismic Loads

$$C_S := \begin{bmatrix} \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{W_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \\ \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{L_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \end{bmatrix} = \begin{pmatrix} 3969 \\ 2886 \end{pmatrix}\cdot lbs$$

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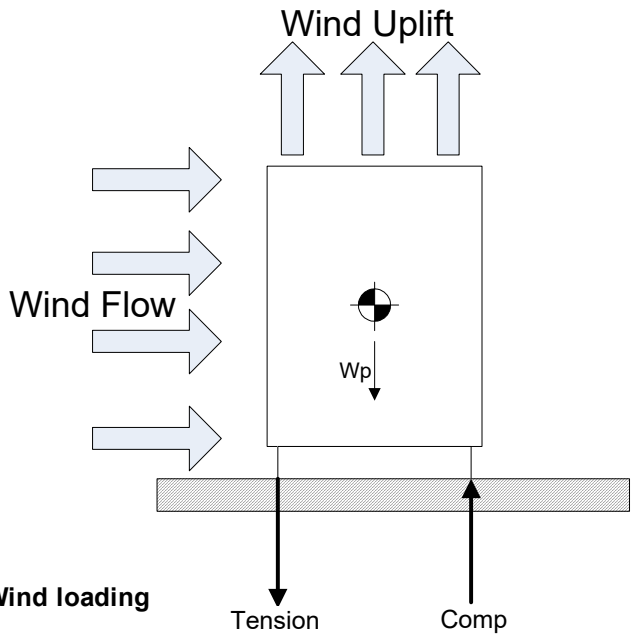
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Wind Loading + Snow Loading



Max Base Shear due to wind loading

$$V_{base.W} := P_{net} \cdot L_{unit} \cdot H_{total} = 5305 \cdot lbs$$

Max Uplift due to wind loading

$$L_{unit.up} := L_{unit} - 0in = 74.375 \cdot in$$

$$P_{uplift.W} := P_v \cdot L_{unit.up} \cdot W_{unit} = 3521 \cdot lbs$$

Max Net Tension Reaction On Each Side Due To Wind loading

$$T_W := \begin{pmatrix} \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} - \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \\ \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} - \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} -6451 \\ -3494 \end{pmatrix} \cdot lbs$$

Max Net Compression Reaction On Each Side Due To Wind loading

$$C_W := \begin{pmatrix} \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} + \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \\ \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} + \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} 6894 \\ 3893 \end{pmatrix} \cdot lbs$$

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Governing Loading @ Curb

Max uplift vertical load along the length of the curb

$$\omega_{x.L.vert.up} := \frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}} = 1149 \cdot plf$$

Max compressive vertical load along the length of the curb

$$\omega_{x.L.vert.comp} := \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}} = 1228 \cdot plf$$

Max vertical load along the length of the curb

$$\omega_{x.L.vert} := \max\left(\omega_{x.L.vert.up}, \omega_{x.L.vert.comp}\right) = 1228 \cdot plf$$

Max uplift vertical load along the width of the curb

$$\omega_{x.W.vert.up} := \frac{\max\left[\left|T_{S_{(1)}}\right|, \left|T_{W_{(1)}}\right|\right]}{W_{curb}} = 1127 \cdot plf$$

Max compressive vertical load along the width of the curb

$$\omega_{x.W.vert.comp} := \frac{\max\left[\left|C_{S_{(1)}}\right|, \left|C_{W_{(1)}}\right|\right]}{W_{curb}} = 1256 \cdot plf$$

Max vertical loading along the width of the curb

$$\omega_{x.W.vert} := \max\left(\omega_{x.W.vert.up}, \omega_{x.W.vert.comp}\right) = 1256 \cdot plf$$

$$\begin{pmatrix} V_{base.S} \\ V_{base.W} \end{pmatrix} = \begin{pmatrix} 1411 \\ 5305 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} \left|T_S\right| \\ \left|C_S\right| \end{pmatrix} = \begin{pmatrix} 1366 \\ 4907 \end{pmatrix} \cdot lbs$$

$$\begin{pmatrix} F_v \cdot Wt_{tot} \\ P_v \cdot L_{unit} \cdot W_{unit} \end{pmatrix} = \begin{pmatrix} 376 \\ 3521 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} \left|T_W\right| \\ \left|C_W\right| \end{pmatrix} = \begin{pmatrix} 7336 \\ 7918 \end{pmatrix} \cdot lbs$$

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Anchorage To Concrete [Expansion Anchor per ACI 318-14]

Number of connection on the long side $N_B := 3 + 2$

Moment Arm for overturning (Short side) $B := W_{curb} = 37 \cdot in$

Number of Connection on the Short side. $N_L := 2 + 2$

Moment Arm for over turning (Long side) $L := L_{curb} = 67 \cdot in$

Total Number of Connections $N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 10$

Max Net Tension Reaction Due to Seismic Load, Fp

$$R_{c.EQ.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 22 \cdot lbs \qquad R_{c.EQ.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 5 \cdot lbs$$

$$R_{c.EQ} := MAX+\left[\begin{array}{l} \left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{c.EQ.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{c.EQ.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \end{array}\right] = \begin{pmatrix} 563 \\ 355 \end{pmatrix} \cdot lbs$$

Max net Tension Reaction Due to Wind Load, Pnet

$$R_{c.W} := MAX+\left[\begin{array}{l} \frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t} \end{array}\right] = \begin{pmatrix} 1290 \\ 814 \end{pmatrix} \cdot lbs$$

Governing Load Case: $Govern := if\left(\left|R_{c.EQ}\right| > \left|R_{c.W}\right|, "Seismic", "Wind"\right) = "Wind"$

Governing Tension Reaction at Each anchor Point: $R_c := if\left(Govern = "Seismic", R_{c.EQ}, R_{c.W}\right) = \begin{pmatrix} 1290 \\ 814 \end{pmatrix} \cdot lbs$

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Max Tension on anchor: $N_{ua} := |R_c| = 1525 \cdot lbs$

Max Shear on anchor: $V_{ua} := \frac{\max(\Omega_0 \cdot V_{base.S}, V_{base.W})}{N_t} = 531 \cdot lbs$

Hilti Kwik Bolt TZ – Carbon Steel
1/2" Anchor with min 3 1/4" embedment
Base material: 6" thick Cracked concrete w/
Compressive strength fc' = 3000 psi
Min 5" away from the concrete edge
Evaluation Report: ICC-ESR 1917

Loading Condition:	**Wind**

Design Tension Capacity [ϕN_n]:	3,500	[lbs]
Design Shear Capacity [ϕV_n]:	3,572	[lbs]

$\phi N_n := \phi N_n \cdot lbs = 3500 \cdot lbs$

$\phi V_n := \phi V_n \cdot lbs = 3572 \cdot lbs$

Utilization:

Tension Utilization: $\beta_N := \frac{N_{ua}}{\phi N_n} = 44 \cdot \%$

Shear Utilization: $\beta_V := \frac{V_{ua}}{\phi V_n} = 15 \cdot \%$

Interaction of Tensile and Shear Forces:
Per ACI 318-14 Sec. 17.6

$\beta_{NV} := \frac{(\beta_N) + (\beta_V)}{1.2} = 49 \cdot \%$

$$check\_interaction := \begin{pmatrix} if(\beta_N < 1.0, "OK", "NG") \\ if(\beta_V < 1.0, "OK", "NG") \\ if(\beta_{NV} < 1.0, "OK", "NG") \end{pmatrix} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

$$check\_interaction = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

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Anchorage To Structural Steel [Fillet Weld Conn. per AISI S100-16]

Fillet Weld 2" Long Along the Long and Short Side. Min 2 Connections per Side
Spacing: 48" O.C. for Non-Isolated Curbs; 24" for Isolated Curbs

Number of Welds on the Long Side $N_B := 2$

Moment Arm for Overturning (Short Side) $B := W_{curb} = 37 \cdot in$

Number of Welds on the Short Side. $N_L := 2$

Moment Arm for Overturning (Long Side) $L := L_{curb} = 67 \cdot in$

Total Number of Connections $N_t := \left[\left(N_B\right) + \left(N_L\right)\right] \cdot 2sides = 8$

Max Net Tension Reaction due to Seismic Load FP

$$R_{weld.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 54 \cdot lbs$$

$$R_{weld.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 10 \cdot lbs$$

$$R_{weld.EQ} := MAX+\left[\begin{bmatrix} \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{weld.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{weld.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 731 \\ 341 \end{pmatrix} \cdot lbs$$

Max Net Tension Reaction due to Wind Load Pnet

$$R_{weld.W} := MAX+\left[\begin{bmatrix} \frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 2926 \\ 1448 \end{pmatrix} \cdot lbs$$

Tension Design Force; SRSS for Loading from Each Direction $T_{u.weld} := \max\left(\left|R_{weld.EQ}\right|, \left|R_{weld.W}\right|\right) = 3265 \cdot lbs$

Shear Load at Each Weld Connection $V_{u.weld} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{N_t} = 663 \cdot lbs$

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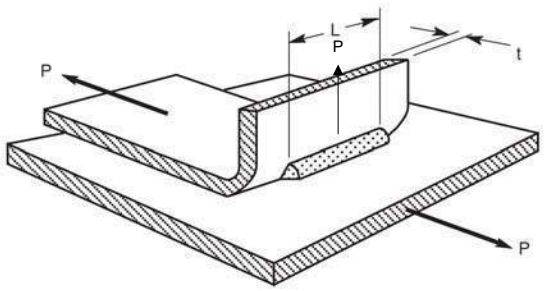
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Total Demand: SRSS of V and T

$$R_{u.weld} := \sqrt{T_{u.weld}^2 + V_{u.weld}^2} = 3332 \cdot lbs$$

Fillet Weld Design per AISI S100-16 Section J2.5

Weld Length at Each Connection Point $L_w := 2in$



Effective Throat Fillet Weld Size

$$t_w := \left(\frac{1}{8}in\right) \cdot 0.707 = 0.088 \cdot in$$

Thickness for the Thinnest Martial Being Welded
Min Curb Thickness = 16GA with Fu=65 ksi

$t_1 := thick("12GA") = 0.1084 \cdot in$

$F_u := 65ksi$

Min weld material strength

$F_{exx} := 70ksi$

For Longitudinal Loading [Parallel capacity is considered to be loading in the direction of the length of the weld] per (Eq. J2.5-1) &(Eq. J2.5-2)

$$\phi P_{long} := \begin{cases} (0.6)\left(1 - \frac{0.01 \cdot L_w}{t_1}\right) \cdot L_w \cdot t_1 \cdot F_u & \text{if } \frac{L_w}{t_1} < 25 \\ (0.5) \cdot 0.75 \cdot t_1 \cdot L_w \cdot F_u & \text{otherwise} \end{cases} = 6895 \cdot lbs$$

where $L_w \div t_1 = 18$

For Transverse Loading per (Eq. J2.5-5)

$$\phi P_{trans} := (0.65) \cdot t_1 \cdot L_w \cdot F_u = 9160 \cdot lbs$$

Strength of Weld Material per (Eq. J2.5-7)

$$\phi P_{weld} := (0.6) \cdot 0.75 \cdot t_w \cdot L_w \cdot F_{exx} = 5568 \cdot lbs$$

Design Strength of Fillet Weld

$$\phi P_n := \min\left(\phi P_{long}, \phi P_{trans}, \phi P_{weld}\right) = 5568 \cdot lbs$$

D/C Ratio for the Welded Connection

$$\beta_{NW} := \frac{R_{u.weld}}{\phi P_n} = 60 \cdot \%$$

$weld_{check} := if\left(\beta_{NW} < 1.0, "OK", "NG"\right)$

$weld_{check} = "OK"$

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Anchorage To Wood Member WITH Lag Screws [NDS-2018 LRFD Strength Design]

*** Use 3/8" Lag Screws along Each Side of the Curb**
*** Assume G=0.5 Douglas Fir-Larch**

Wood Lag Screw Capacity per NDS 2018 Section 11.3

Wet Service Factor: Cond := "DRY" **(e.g. CA = "DRY", AK = "WET")**

$C_M := \begin{cases} 1.0 & \text{if Cond = "DRY"} \\ 0.7 & \text{if Cond = "WET"} \end{cases} = 1$ **NDS 2018 Table 11.3.3**

Temperature Factor: $C_t := \begin{cases} 0.8 & \text{if Cond = "DRY"} \\ 0.7 & \text{if Cond = "WET"} \end{cases} = 0.8$ **NDS 2018 Table 11.3.4**

Group Action Factor: $C_g := 0.97$ **NDS 2018 Table 11.3.6C**

Geometry Factor: $C_\Delta := 1.0$ **NDS 2018 Table 12.5.1A,B**

End Grain Factor: $C_{eg} := 1.0$ **NDS 2018 Sec. 12.5.2**

Diaphragm Factor: $C_{di} := 1.0$ **NDS 2018 Sec. 12.5.3**

Toe-Nail Factor: $C_{tn} := 1.0$ **NDS 2018 Sec. 12.5.4**

Format Conversion Factor: $K_F := 3.32$ **NDS 2018 Table 11.3.1**

Resistance Factor: $\phi := 0.65$ **NDS 2018 Table 11.3.1**

Time Effect Factor: $\lambda := 1.0$ **NDS 2018 App N.3.3**

Lateral Design Value: $Z := 130\text{lbs}$ **NDS 2018 Table 12K**

Withdrawal Design Value: $W := 305\text{lbs}$ **NDS 2018 Table 12.2A**

Lag Screw Diameter: $D_{lag} := \frac{3}{8}\text{in}$

Lag Screw Length: $L_{lag} := 4\text{in}$

Length of Tapered Tip: $E_{lag} := \frac{7}{32}\text{in}$

Lag Screw Penetration: $P_{lag} := 3.78125\text{in}$

Eff. Lag Screw Penetration for withdrawal: $P_{\omega.lag} := 2\text{in} + \frac{9}{32}\text{in} = 2.28\cdot\text{in}$ **NDS 2018 Appx. Table L2**

NDS 2018 Sec. 12.1.4.6

Minimum Penetration DCR <1.0: $DCR_{min.penetration} := \frac{4\cdot D_{lag}}{P_{\omega.lag}} = 0.66$ $DCR_{min.penetration} = \text{"OK"}$

Adj. Lateral Design Value: $Z' := Z\cdot C_M\cdot C_t\cdot C_g\cdot C_\Delta\cdot C_{eg}\cdot C_{di}\cdot C_{tn}\cdot K_F\cdot\phi\cdot\lambda = 218\cdot\text{lbs}$

Adj. Withdrawal Design Value: $W' := W\cdot C_M^{\,2}\cdot C_t\cdot C_{eg}\cdot C_{tn}\cdot K_F\cdot\phi\cdot\lambda = 527\cdot\text{lbs}$ **NDS 2018 Table 11.3.1**

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Number of Lag Screws on the Long Side $N_B := 10 + 2$

Moment Arm for Overturning (Short Side) $B := W_{curb} = 37 \cdot in$

Number of Lag Screws on the Short Side $N_L := 5 + 2$

Moment Arm for Overturning (Long Side) $L := L_{curb} = 67 \cdot in$

Total Number of Lag Screws $N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 30$

Max net Tension Reaction due to Seismic, Fp

$$R_{lag.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 9 \cdot lbs$$

$$R_{lag.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 3 \cdot lbs$$

$$R_{lag.EQ} := MAX+\left[\begin{bmatrix} \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{lag.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{lag.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 112 \\ 99 \end{pmatrix} \cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$R_{lag.W} := MAX+\left[\begin{bmatrix} \frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{L \cdot N_L \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 518 \\ 408 \end{pmatrix} \cdot lbs$$

Tension Design force; SRSS for loading from Each direction $T_{lag} := \max\left(\left|R_{lag.EQ}\right|, \left|R_{lag.W}\right|\right) = 659 \cdot lbs$

Shear load at each anchor location $V_{lag} := \frac{\max\left(V_{base.S} \cdot \sqrt{2}, V_{base.W}\right)}{N_t} = 177 \cdot lbs$

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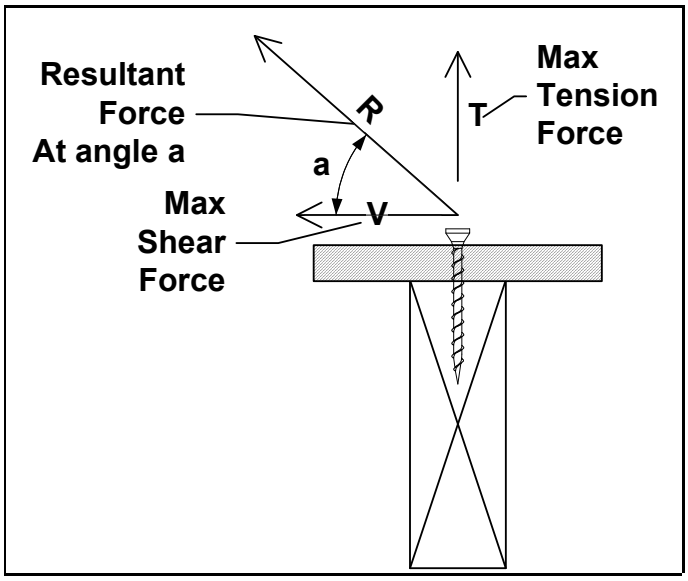
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For Lag Screws Subjected to Combined Lateral and Withdrawal Loading; Design Strength of the Lag Screw Shall Be Adjusted per Hankinson Formula as Prescribed by NDS 2018 Equation 12.4-1



Angle Between Wood Surface and Direction of Resultant Applied Load

$$(\alpha) := \operatorname{atan}\left(\frac{T_{lag}}{V_{lag}}\right) = 75\cdot deg$$

Combined Demand per Lag Screw @ Strength Level

$$R_{lag} := \sqrt{T_{lag}^{2} + V_{lag}^{2}} = 682\cdot lbs$$

Adjusted Capacity per NDS 2018 Equation 12.4-1 @ Strength Level

$$Z'_{\alpha} := \frac{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot Z'}{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot\cos(\alpha)^{2} + Z'\cdot\sin(\alpha)^{2}} = 922\cdot lbs$$

D/C Ratio for the Lag Screw connection to Wood Structure

$$\beta_{Lag} := \frac{R_{lag}}{Z'_{\alpha}} = 74\cdot\%$$

$$Lag_{Screw.Check} := \text{if}\left(\beta_{Lag} < 1.0, \text{"OK"}, \text{"NG"}\right)$$

$Lag_{Screw.Check}$ = "OK"

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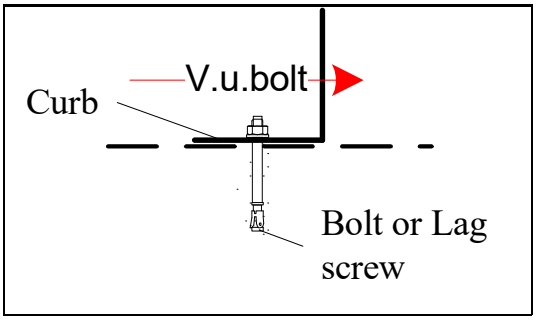
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Bearing and Tilting in Curb Bolted Connection AISI S100-16

Nominal bolt diameter $d := 0.5in$

Uncoated sheet thickness $t_{curb} := thick("12GA") = 0.108 \cdot in$



Tensile strength of sheet $F_u := 65ksi$

Coefficient for conversion of units $\alpha := 1.0$

Modification Factor $m_f := 1.0$

Modification factor for type of bearing connection, per Table J3.3.1-2; For single shear connection with washers

Bearing Factor

$$C := \begin{cases} 3 \text{ if } \left(\frac{d}{t_{curb}} < 10\right) \wedge \left(0.024in < t_{curb} < 0.1875in\right) = 3 \\ "NG" \text{ if } \frac{d}{t_{curb}} > 10 \end{cases}$$

Bearing factor, which shall be determined according to Table J3.3.1-1 For d/t<10 where $d \div t_{curb} = 5$

Bearing Design Strength per AISI S100-16 Eq. J3.3.1-1

$$\phi P_{n_{(0)}} := (0.6) \cdot \left(m_f \cdot C \cdot d \cdot t_{curb} \cdot F_u\right) = 6341 \cdot lbs$$

Bolt Hole Deformation Design Strength per AISI S100-16 Eq. J3.3.2-1

$$\phi P_{n_{(1)}} := (0.65) \cdot \left[4.64 \cdot \left(\frac{\alpha}{in}\right) \cdot t_{curb} + 1.53\right] \cdot d \cdot t_{curb} \cdot F_u = 4655 \cdot lbs$$

Curb Connection Shear Capacity $\phi P_n := \min\left(\phi P_n\right) = 4655 \cdot lbs$

Loading demand at connection

$$V_{u.bolt} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{4} = 1326 \cdot lbs$$

$Curb\_Conn\_Shear := if\left(V_{u.bolt} < \phi P_n, "OK", "NG"\right)$

Curb_Conn_Shear = "OK"

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Thickness of Curb, ISO Rail and Clip

(Per AISC Table 17-10 Galvanized)

Hold Down Clip thickness

$t_{Clip} := "12GA"$ $t_{clip} := thick(t_{Clip}) = 0.1084 \cdot in$

Roof Curb thickness

$t_{Curb} := "12GA"$ $t_{curb} := thick(t_{Curb}) = 0.1084 \cdot in$

ISO RAIL thickness

$t_{Curb.iso} := "10GA"$ $t_{curb.iso} := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Note: Iso Rail thickness is only used if the curb is isolated. Not used for non-isolated curbs

Sheet Metal Screws (SMS) Equations and References

SMS properties (ESR-2196 Table 5)

$SMS_{Table} =$

"SMS"	"Diameter"	"HeadDiameter"	"Tension"	"Shear"
"Size"	"d"	"dw"	"Pts"	"Pss"
"#8"	0.164	0.335	1000	1170
"#10"	0.19	0.399	1370	1215
"#12"	0.216	0.415	2325	1880
"#14"	0.25	0.5	4580	2440

SMS Tension Eqns

$P_{not} = 0.85 \cdot t \cdot d \cdot F_u$ **(AISI S100-16 J4.4.1 & J4.4.2)**

$P_{nov} = 1.5 \cdot t \cdot d_w \cdot F_u$ **FOR THE MOST CASES, PULL-OUT CAPACITY IS THE LOWEST**

$P_{nts} = 0.8 \cdot P_{ts}$

SMS Shearn Eqns

$P_{vnot} = 4.2 \cdot \sqrt{(d \cdot t^3)} \cdot F_u$ **(AISI S100-16 J4.3.1)**

$P_{vnov} = 2.7 \cdot t \cdot d \cdot F_u$

$P_{vnss} = 0.8 \cdot P_{ss}$

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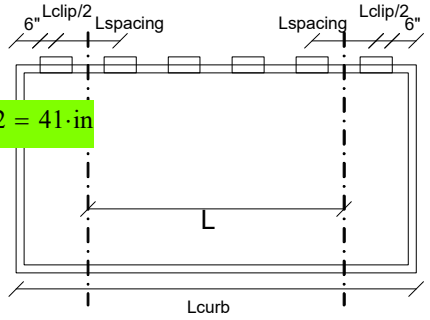
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Hold Down Clip Design (Connection of the Mechanical unit to Curb)



Number of Clips on the long side $N_B := 4$

Moment Arm for over turning (Short side) $B := W_{curb} + 1.75in \cdot 2 = 41 \cdot in$

Number of Clips on the Short side $N_L := 4$

Width of Clips $L_{clip} := 9in$

Curb Centerline Spacing (Long side)

$$L_{spacing} := \frac{L_{curb} - \left(6in + \frac{L_{clip}}{2}\right) \cdot 2}{N_B - 1} = 15.458 \cdot in$$

$$L_{spacing.non.iso} := L_{spacing} = 15 \cdot in$$

Moment Arm for over turning (Long side)

$$L := L_{curb} - 2 \cdot \left[6in + \frac{L_{clip}}{2} + L_{spacing} \cdot \frac{(N_L - 2)}{4}\right] = 30.917 \cdot in$$

Total Number of Clips

$$N_t := (N_B) \cdot 2sides = 8$$

Max net Tension Reaction due to Seismic, Fp

$$R_{clip.EQ} := MAX+\left[\begin{array}{l} \left[\frac{F_p \cdot Wt_{unit}}{B \cdot N_B} \cdot h_{CG.unit} + \frac{(0.9 - F_v) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B}\right] - \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} \\ \left[\frac{F_p \cdot Wt_{unit}}{L \cdot N_L} \cdot h_{CG.unit} + \frac{(0.9 - F_v) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L}\right] - \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} \end{array}\right] = \begin{pmatrix} 86 \\ 113 \end{pmatrix} \cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$R_{clip.W} := MAX+\left(\begin{array}{l} \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{unit}^2}{2}}{B \cdot N_B} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{unit}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{unit}^2}{2}}{L \cdot N_L} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{unit}}{N_t} \end{array}\right) = \begin{pmatrix} 767 \\ 771 \end{pmatrix} \cdot lbs$$

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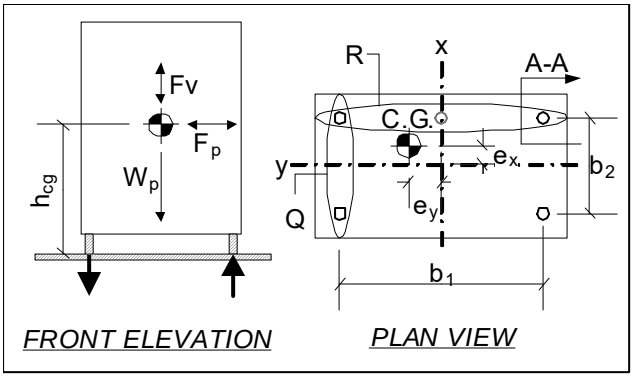
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Tensile and Shear Load calculation per ASHRAE RP-812



Eccentricity along X-X

$e_x := e_{width} = 7.5 \cdot in$

Eccentricity along Y-Y

$e_y := e_{length} = 2.562 \cdot in$

Distance between Seismic Restraints Along Y-Y

$b_1 := L_{curb} - 2 \cdot 6in = 55 \cdot in$

Distance between Seismic Restraints Along X-X

$b_2 := W_{curb} - 2 \cdot 6in = 25 \cdot in$

Moment of Inertia about X-X

$$I_{xx} := \frac{N_t \cdot (N_t + 2) \cdot (b_1)^2}{12 \cdot (N_t - 2)} = 3407 \cdot in^2$$

Moment of Inertia about Y-Y

$$I_{yy} := \frac{N_t \cdot (b_2)^2}{4} = 1269 \cdot in^2$$

Angle about Tensile Load

$$\Theta_t := \operatorname{atan}\left[\frac{I_{yy} \cdot (b_1)}{I_{xx} \cdot (b_2)}\right] = 39 \cdot deg$$

Angle about Shear Load

$$\Theta_s := \begin{cases} \operatorname{atan}\left(\frac{e_x}{e_y}\right) & \text{if } e_y \neq 0 \\ 0deg & \text{if } e_y = 0 \end{cases} = 71 \cdot deg$$

Max Net Tensile Load Due to Seismic Load, Fp

$$T_{U.EQ.pt1} := \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} - \frac{(0.9 - F_v) \cdot Wt_{unit}}{b_1 \cdot b_2} \cdot \left(\frac{b_1}{2} \cdot e_x + \frac{b_2}{2} \cdot e_y - e_x \cdot e_y\right) = -18 \cdot lbs$$

$$T_{U.EQ.pt2} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \cos(\Theta_t) \cdot \frac{0.5 \cdot b_2}{I_{yy}} = -161 \cdot lbs$$

$$T_{U.EQ.pt3} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \sin(\Theta_t) \cdot \frac{0.5 \cdot b_1}{I_{xx}} = -108 \cdot lbs$$

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$T_{U.EQ} := T_{U.EQ.pt1} + T_{U.EQ.pt2} + T_{U.EQ.pt3} = -287 \cdot lbs$

Max Net Shear Load Due to Seismic Load, Fp

$$V_{Ux.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\cos(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_2 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_1 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 86 \cdot lbs$$

$$V_{Uy.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\sin(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_1 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_2 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 144 \cdot lbs$$

$$V_{U.EQ} := \sqrt{V_{Ux.EQ}^2 + V_{Uy.EQ}^2} = 168 \cdot lbs$$

Tension Design force for Hold Down Clips

$T_{clip} := \max(R_{clip.W_0}, R_{clip.W_1}, |R_{clip.EQ}|, |T_{U.EQ}|) = 771 \cdot lbs$

$|R_{clip.EQ}| = 142 \cdot lbs$ $|T_{U.EQ}| = 287 \cdot lbs$

$|R_{clip.W}| = 1087 \cdot lbs$

$T_{clip.EQ.max} := \max(|R_{clip.EQ}|, |T_{U.EQ}|) = 287 \cdot lbs$

$T_{clip.W.max} := \max(|R_{clip.W}|) = 1087 \cdot lbs$

Based on ASCE 7-16 Figure 29.4-1 magnitude of force coefficient,

Wind in diagonal direction to the face of equipment produces less force than that of the wind in perpendicular direction to the face of the equipment.

Therefore, wind in diagonal direction does not need to be used

Shear Design force for Hold Down Clips

$$V_{clip} := \max\left(\frac{\max(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit})}{N_t}, |V_{U.EQ}|\right) = 384 \cdot lbs$$

$F_p \cdot Wt_{unit} \cdot \frac{1}{N_t} = 127 \cdot lbs$ $|V_{U.EQ}| = 168 \cdot lbs$

$P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t} = 384 \cdot lbs$

$$V_{clip.EQ.max} := \max\left[\left(F_p \cdot Wt_{unit} \cdot \frac{1}{N_t}\right), |V_{U.EQ}|\right] = 168 \cdot lbs$$

$$V_{clip.W.max} := \max\left(\left(P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t}\right)\right) = 384 \cdot lbs$$

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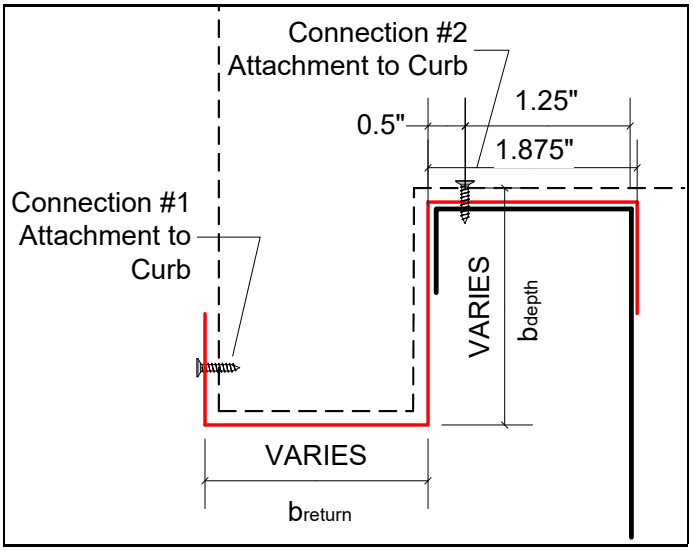
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Loading at Hold Down Clips

Due to the eccentricity of Shear and Tension forces additional moment is created in the hold down clip. These loads to be resisted in a T/C couple.



Reactions R1 & R2 to be resisted by the screws attaching the hold down clip to curb

R1 is acting as tension on the screws.

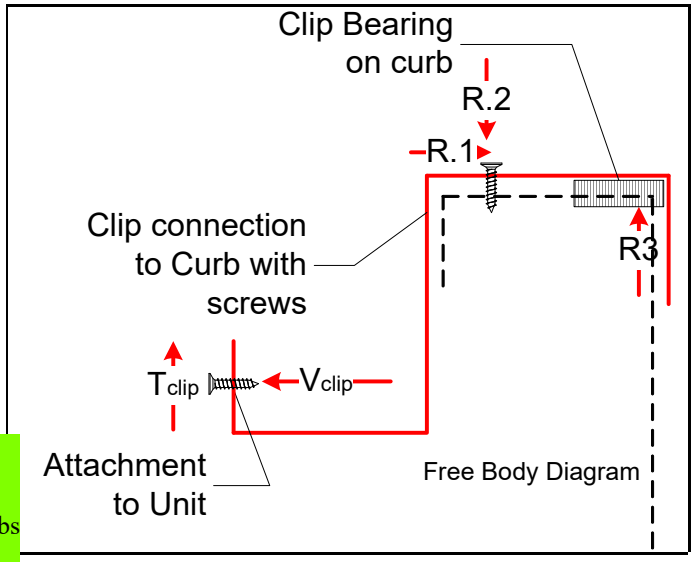
$$R_1 := V_{clip} = 384 \cdot lbs$$

R2 is acting as shear force on the connection screws
Since the loading T and V are acting in opposite directions; R2 is the maximum shear force due to either T or V

$$b_{return} := Clip_b \cdot in = 2.625 \cdot in$$

$$b_{depth} := Clip_c \, in = 4.5625 \cdot in$$

$$R_2 := \begin{bmatrix} \frac{T_{clip} \cdot (b_{return} + 1.75in - 0.5in)}{1.75in - 0.5in} \\ \frac{V_{clip} \cdot (b_{depth})}{1.75in - 0.5in} \end{bmatrix} = \begin{pmatrix} 2389 \\ 1403 \end{pmatrix} \cdot lbs$$



$$R_2 := \max(R_2) = 2389 \cdot lbs$$

Reaction R3 [compression force] is resisted by bearing of the hold down on the curb lip.

$$R_3 := R_2 - T_{clip} = 1618 \cdot lbs$$

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Design of Connection#1 Connection of Equipment to hold Down clip

Hold Down Clip thickness

$t_{Clip} = \text{"12GA"}$ $t_{clip} := thick(t_{Clip}) = 0.1084 \cdot in$

Strength Reduction for SMS Screw Connections per J.4

$\phi_{sms} = 0.5$

Ultimate SMS screw connection Strength (LRFD) Assume min thickness of the equipment housing is 16 GA [Fy = 50ksi & Fu=65ksi]

$n_{sms} := 4$ $Size_{ss} := \text{"\#12"}$

$t_{ss} := \text{"16GA"}$ $F_{u.ss} := 65ksi$

Nominal Tension Strength

$P_{nt} := n_{sms} \cdot T_s(Size_{ss}, t_{ss}, F_{u.ss}) = 3031 \cdot lbs$

$P_{not} := n_{sms} \cdot T_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 3031 \cdot lbs$

$P_{nov} := n_{sms} \cdot T_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 10277 \cdot lbs$

$P_{nts} := n_{sms} \cdot T_{nts}(Size_{ss}, t_{ss}, F_{u.ss}) = 7440 \cdot lbs$

Nominal Shear Strength

$P_{ns} := n_{sms} \cdot V_s(Size_{ss}, t_{ss}, F_{u.ss}) = 6016 \cdot lbs$

$P_{vnot} := n_{sms} \cdot V_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 8121 \cdot lbs$

$P_{vnov} := n_{sms} \cdot V_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 9629 \cdot lbs$

$P_{vnss} := n_{sms} \cdot V_{nss}(Size_{ss}, t_{ss}, F_{u.ss}) = 6016 \cdot lbs$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} V_{clip} \div (\phi_{sms} \cdot P_{nt}) \\ T_{clip} \div (\phi_{sms} \cdot P_{ns}) \end{bmatrix} = \begin{pmatrix} 25 \\ 26 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left[\begin{bmatrix} \left[\frac{T_{clip}}{P_{vnov}} + 0.71\left(\frac{V_{clip}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{T_{clip}}{P_{vnot}} + \left(\frac{V_{clip}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{T_{clip}}{P_{vnss}} + \left(\frac{V_{clip}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right] = 32 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} \text{"OK"} \\ \text{"OK"} \\ \text{"OK"} \end{pmatrix}$$

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Check Bending in Clip

There are several restraints that prevents the hold down clip for curb to have local bending at the bottom flange and transfer vertical load demand directly to the face of the curb.

- Hold down is bearing on the face of iso-rail / non-iso curb lip.
- Gasket will act as a "link" member to allow unit base rail and bottom flange to move toegther so flange can't bend unless the unit base rail bends first. However, unit base rail is not likely to bend so bottom flange won't bend

Hold Down Clip thickness

$t_{Clip} = \text{"12GA"}$ $t_{clip} := \text{thick}(t_{Clip}) = 0.1084 \cdot \text{in}$

Effective width of hold down clip

$b_c := L_{clip} = 9 \cdot \text{in}$

Yield strength of the Clip

$F_{y.c} := 50\text{ksi}$

Strength reduction for bending

$\phi_{clip} := 0.9$

Design Bending Capacity (LRFD)

$$\phi M_n := \phi_{clip} \cdot F_{y.c} \left(\frac{b_c \cdot t_{clip}^{\,2}}{6} \right) = 793 \cdot \text{in} \cdot \text{lbs}$$

Flexural bending demand

$M_{u.clip} := T_{clip} \cdot (0.5\text{in}) = 385 \cdot \text{in} \cdot \text{lbs}$

D/C Ratio for bending

$$DCR := \frac{M_{u.clip}}{\phi M_n} = 0.486$$

$Clip_{Bending} = \text{"OK"}$

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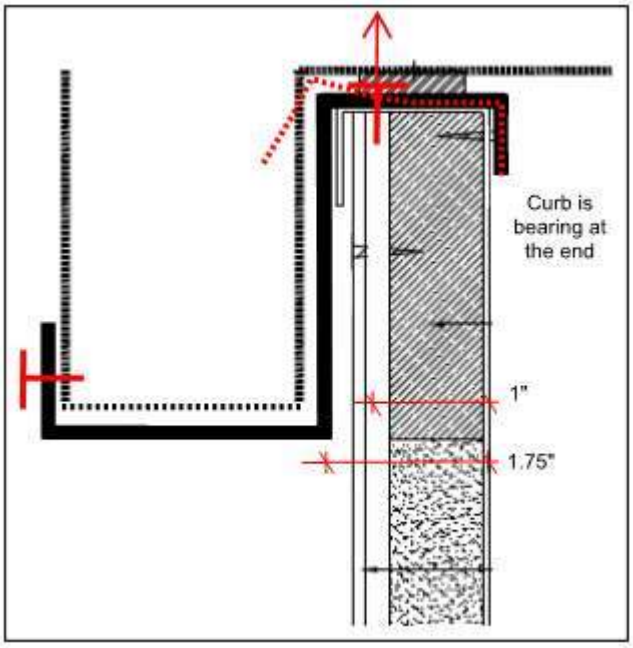
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Check Flange Bending in Curb



Roof Curb thickness

$t_{Curb} = \text{"12GA"}$ $t_{curb} := thick(t_{Curb}) = 0.1084 \cdot in$

Clip edge to edge distance

$$b_{edge2edge} := \frac{L_{curb} - \left(6in + \frac{L_{clip}}{2}\right)\cdot 2}{N_B - 1} - L_{clip} = 6.458 \cdot in$$

Effective width of Roof Curb

$b_{curb} := L_{clip} + b_{edge2edge} = 15.46 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\frac{b_{curb} \cdot (t_{curb})^2}{6} + \frac{L_{clip} \cdot (t_{clip})^2}{6}\right] = 2155 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := T_{clip} \cdot (1.75in - 0.5in) = 963 \cdot in \cdot lbs$

D/C Ratio for bending

$$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.447$$

$Curb_{Bending} = \text{"OK"}$

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Design of Connection#2 Connection of hold Down clip to Curb

Ultimate SMS screw connection Strength (LRFD) Strength based on the smallest thickness of Curb and Hold down Clip (min 16 GA) [Fy = 50ksi & Fu=65ksi]

Tension loads on SMS connection

$T_{s2} := R_2 = 2389 \cdot lbs$

Shear loads on SMS connection

$V_{s2} := R_1 = 384 \cdot lbs$

Strength Reduction for SMS Screw Connections per J.4

$n_{sms} := 8$ $Size_{ss} := "\#12"$ $\phi_{sms} = 0.5$

$t_{ss} := t_{Curb} = "12GA"$ $F_{u.ss} := 65ksi$

Nominal Tension Strength

$P_{nt} := n_{sms} \cdot T_s(Size_{ss}, t_{ss}, F_{u.ss}) = 10349 \cdot lbs$

$P_{not} := n_{sms} \cdot T_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 10349 \cdot lbs$

$P_{nov} := n_{sms} \cdot T_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 35089 \cdot lbs$

$P_{nts} := n_{sms} \cdot T_{nts}(Size_{ss}, t_{ss}, F_{u.ss}) = 14880 \cdot lbs$

Nominal Shear Strength

$P_{ns} := n_{sms} \cdot V_s(Size_{ss}, t_{ss}, F_{u.ss}) = 12032 \cdot lbs$

$P_{vnot} := n_{sms} \cdot V_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 36226 \cdot lbs$

$P_{vnov} := n_{sms} \cdot V_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 32874 \cdot lbs$

$P_{vnss} := n_{sms} \cdot V_{nss}(Size_{ss}, t_{ss}, F_{u.ss}) = 12032 \cdot lbs$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} T_{s2} \div (\phi_{sms} \cdot P_{nt}) \\ V_{s2} \div (\phi_{sms} \cdot P_{ns}) \end{bmatrix} = \begin{pmatrix} 46 \\ 6 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left[\begin{bmatrix} \left[\frac{V_{s2}}{P_{vnov}} + 0.71\left(\frac{T_{s2}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{V_{s2}}{P_{vnot}} + \left(\frac{T_{s2}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{V_{s2}}{P_{vnss}} + \left(\frac{T_{s2}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right] = 35 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

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Hold Down clip Bending and Shear Interaction

Diameter of SMS:

$$d_{sms} := vlookup\left(Size_{ss}, SMS_{Table}, 1\right)_0 \cdot in = 0.216 \cdot in$$

Depth of flat web portion

$$h_{clip.shear} := L_{clip} - n_{sms} \cdot d_{sms} = 7.27 \cdot in$$

Depth-to-Thickness Ratio:

$$\frac{h_{clip.shear}}{t_{clip}} = 67 \qquad E := 29500ksi \qquad F_y := 50ksi \qquad \mu := 0.3$$

Nominal Shear Stress:
(For unreinforced web)
AISI S100-16 G2.1

$$k_v := 5.34 \qquad \sqrt{\frac{E \cdot k_v}{F_y}} = 56 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 85$$

Area of Web Element:

$$A_w := h_{clip.shear} \cdot t_{clip} = 0.788 \cdot in^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h_{clip.shear}}{t_{clip}}\right)^2} = 31.6 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} \qquad V_y := 0.6 \cdot A_w \cdot F_y = 24\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.974$$

Hole Shear Reduction Factor:
(for circular holes, AISI S100-16 Eq G3-1)

$$c := \frac{h_{clip.shear}}{2} - \frac{d_{sms}}{2.83} = 3.56 \cdot in$$

$$q_s := \begin{cases} 1.0 & \text{if } \frac{c}{t_{clip}} \geq 54 \\ \frac{c}{54 \cdot t_{clip}} & \text{if } 5 \leq \frac{c}{t_{clip}} < 54 \end{cases} = 0.608$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \leq 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \leq 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 19.792 \cdot kip$$

Design Shear Capacity with holes:

$$\phi V_{n.clip} := 0.95 \cdot V_n \cdot q_s = 11.4 \cdot kip$$

D/C Ratio of V and M per AISI S100-16 Eq H2-1

$$DCR_{V.M.int.clip} := \sqrt{\left(\frac{M_{u.clip}}{\phi M_n}\right)^2 + \left(\frac{\max\left(T_{clip}, V_{clip}\right)}{\phi V_{n.clip}}\right)^2} = 0.4905$$

Demand/Capacity Ratio:

$VandM_{int.clip}$ = "OK"

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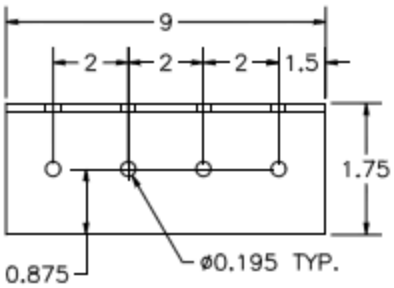
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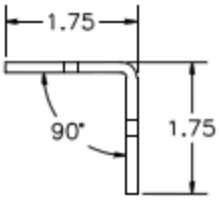
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Hold Down clip Block Shear





$b_{clip} := 1in$

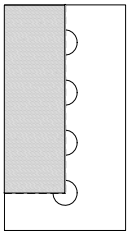
$s_{clip.sms} := 2in$

$b_{edge} := 1in$

(Figure shown as reference only)

Case 1 Block Shear Capacity: (Force in parallel direction of sms row)

CASE 1



$$A_{gv} := \left[b_{edge} + \left(n_{sms} - 1\right)\cdot s_{clip.sms}\right]\cdot t_{clip} = 1.626\cdot in^2$$

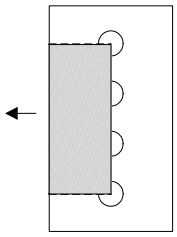
$$A_{nv} := \left[b_{edge} + \left(n_{sms} - 1\right)\cdot s_{clip.sms} - \frac{d_{sms}}{2}\right]\cdot t_{clip} = 1.614\cdot in^2$$

$$A_{nt} := t_{clip}\cdot\left(\frac{b_{clip}}{2} - \frac{d_{sms}}{2}\right) = 0.042\cdot in^2$$

$$\phi R_{n1} := 0.5\cdot\min\left(0.6\cdot F_y\cdot A_{gv} + F_u\cdot A_{nt}, 0.6\cdot F_u\cdot A_{nv} + F_u\cdot A_{nt}\right) = 26\,kip$$

Case 2 Block Shear Capacity: (Force in perpendicular direction of sms row)

CASE 2



$$A_{gv} := 2\cdot t_{clip}\cdot\frac{b_{clip}}{2} = 0.108\cdot in^2$$

$$A_{nv} := 2\cdot t_{clip}\cdot\left(\frac{b_{clip}}{2} - \frac{d_{sms}}{2}\right) = 0.085\cdot in^2$$

$$A_{nt} := t_{clip}\cdot\left[\left(n_{sms} - 1\right)\cdot s_{clip.sms} - d_{sms}\right] = 1.494\cdot in^2$$

$$\phi R_{n2} := 0.5\cdot\min\left(0.6\cdot F_y\cdot A_{gv} + F_u\cdot A_{nt}, 0.6\cdot F_u\cdot A_{nv} + F_u\cdot A_{nt}\right) = 50\,kip$$

Design Block Shear Capacity:

$$\phi R_n := \min\left(\phi R_{n1}, \phi R_{n2}\right) = 26\,kip$$

D/C Ratio of Block Shear:

$$DCR_{clip.blockshear} := \frac{\max\left(T_{clip}, V_{clip}\right)}{\phi R_n} = 0.03$$

$Blockshear_{clip}$ = "OK"

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Web Crippling/Compression of Non-iso CanFab Curb (AISI S100-16 G5)

Governing Compression for Non-Isolated Curb:

$$P_{web.crip.int} := \max\left[\frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}}, \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}}\right] \cdot L_{spacing.non.iso} = 1582 \cdot lbs$$

$$P_{web.crip.end} := 0.5 \cdot P_{web.crip.int} = 791 \cdot lbs$$

Yield Strength: $F_y := 50ksi$

Bearing Length: $N_{bearing} := L_{spacing.non.iso} = 15 \cdot in$

Thickness of Curb: $t_{Curb} = \text{"12GA"}$ $t := thick(t_{Curb}) = 0.1084 \cdot in$

Inside Bend Radius: $R := R_{curb} = 0.153 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web: $h := 30in - 2 \cdot (t + R) = 29.48 \cdot in$

Angle btween plane of web and bearing surface: $\theta := 90deg$

Web Crippling Limit Check (AISI Table G5-2): $\frac{R}{t} = 1$ $\frac{h}{t} = 272$ $\frac{N_{bearing}}{t} = 143$ $\frac{N_{bearing}}{h} = 0.52$

End Case Coefficient Single Web Channel (AISI Table G5-2): $C := 13$ $C_R := 0.32$ $C_N := 0.05$ $C_h := 0.04$

Reduction Factor Web Crippling Strength: $\phi_{web.end} := 0.9$ $\phi_{web.int} := 0.8$ **(For Unfastened partially Stiffened Flanges with Two-Flange Loading or Reaction.)**

Design Web Crippling Strength:

$$\phi P_{n.end} := \left(\phi_{web.end}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 2319 \cdot lbs$$

Interior Case Coefficient Single Web Channel (AISI Table G5-2): $C := 24$ $C_R := 0.52$ $C_N := 0.15$ $C_h := 0.001$

Design Web Crippling Strength:

$$\phi P_{n.interior} := \left(\phi_{web.int}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 11868 \cdot lbs$$

D/C Ratio of Shear: $DCR_{end} := \frac{P_{web.crip.end}}{2 \cdot \phi P_{n.end}} = 0.171$ $DCR_{int} := \frac{P_{web.crip.int}}{\phi P_{n.interior}} = 0.133$

Demand/Capacity Ratio: **Note: Factor of 2 for two ends connected together at the end**

$Web_{crippling} = \text{"OK"}$

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Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Length

Roof Curb thickness

$t_{Curb} = \text{"12GA"}$ $t_{curb} := thick(t_{Curb}) = 0.1084 \cdot in$

Min width of Roof Curb

$b_{curb} := L_{curb} + \frac{W_{curb}}{2} \cdot 2 + 3in \cdot 2 \cdot 2 = 116.56 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := L_{curb} + \min\left(\frac{W_{curb}}{2} \cdot 2, \frac{L_{curb}}{2}\right) = 101 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{array}{c} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{array} \right] \right] = 10273 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.L.vert.up} \cdot L_{curb}) \cdot (1in) = 6451 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.628$

$Curb_{BotFlangeBending} = \text{"OK"}$

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Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Width

Roof Curb thickness

$t_{Curb} = \text{"12GA"}$ $t_{curb} := thick(t_{Curb}) = 0.1084 \cdot in$

Min width of Roof Curb

$b_{curb} := W_{curb} + \frac{L_{curb}}{6} \cdot 2 + 3in \cdot 2 = 65.65 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := W_{curb} + \min\left(\frac{L_{curb}}{6} \cdot 2, W_{curb}\right) = 60 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{array}{c} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{array} \right] \right] = 5785 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.W.vert.up} \cdot W_{curb}) \cdot (1in) = 3494 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.604$

$Curb_{BotFlangeBending} = \text{"OK"}$

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Check CanFab Curb for Compressive Force due to T/C Coupling of Overturning

Note:
-Since the equipment is only attached to the longer sides of the CanFab Curb, most likely there will be compressive force onto the curb due to T/C coupling.
- Rectangular CanFab Curb will be considered as "Channel" to resist the compressive force.

Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Flanges*

Flat Width:

$$w := \frac{W_{curb}}{2} - R_{curb} = 18.441 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Unstiffened"}$$

Stress at the end of the Width:

$$f_2 := 50ksi \qquad f_1 := 50ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \left| \frac{f_2}{f_1} \right| = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 0.43$$

Critical Compressive Stress (Eq 1.1-4):

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w}\right)^2 = 0.4 \cdot ksi$$

Stress in Compression Element:

$$f := F_y = 50 \cdot ksi \qquad \textbf{(Assume f = Fy)}$$

Slenderness Factor (Eq 1.1-3):

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 11.23$$

Local reduction factor (Eq 1.1-2):

$$\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 0.087$$

Effective Width of the Flanges:

$$b_{eff.flange} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 1.609 \cdot in$$

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Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Web*

Flat Width:

$$w := L_{curb} - R_{curb} \cdot 2 = 67.07 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Stiffened"}$$

Stress at the end of the Width:

$$f_2 := 50ksi \qquad f_1 := 50ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \left| \frac{f_2}{f_1} \right| = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 4$$

Critical Compressive Stress (Eq 1.1-4):

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w} \right)^2 = 0.28 \cdot ksi$$

Stress in Compression Element:

$$f := F_y = 50 \cdot ksi \qquad \textbf{(Assume f = Fy)}$$

Slenderness Factor (Eq 1.1-3):

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 13.4$$

Local reduction factor (Eq 1.1-2):

$$\rho := \left(1 - \frac{0.22}{\lambda}\right) \frac{1}{\lambda} = 0.073$$

Effective Width of the Web:

$$b_{eff.web} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 4.924 \cdot in$$

Effective Area of the Member:

$$A_e := 2 \cdot \left(b_{eff.flange} \cdot t_{curb} \right) + b_{eff.web} \cdot t_{curb} = 0.883 \cdot in^2$$

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Length of the Compressive Member: $L_{curb.web} := h = 29.478 \cdot in$

Young's Modulus for Cold Form Steel: $E := 29500ksi$

Curb Shear Modulus: $G := 11300ksi$

Poisson's Ratio $\mu := 0.3$

Section Properties of the Member (From Section Properties Calculator):

$A_{half.curb} := 6.087in^2$ $r_o := 28.35in$ $I_x := 3577in^4$ $I_y := 311in^4$

$J := 0.006in^4$ $r_x := \sqrt{\frac{I_x}{A_{half.curb}}} = 24.241 \cdot in$ $r_y := \sqrt{\frac{I_y}{A_{half.curb}}} = 7.148 \cdot in$

$C_w := 209700in^6$ $r_{min} := \min(r_x, r_y) = 7.148 \cdot in$

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^2}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{(1.0 \cdot L_{curb.web})^2}\right] = 99039.942 \cdot ksi$$

$$\sigma_{e.y} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_y}\right)^2} = 17118.942 \cdot ksi \qquad \sigma_{e.x} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_x}\right)^2} = 196895.358 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2} = 17118.942 \cdot ksi$$

$$\frac{1.0 \cdot L_{curb.web}}{r_{min}} = 4.12$$

$KL_r = \text{"KL/r < 200, OK"}$

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 14596.034 \cdot ksi$$

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Nominal Compressive Stress Capacity: (Eq E2-4)

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 0.059$$

$$F_n := \begin{cases} 0.658^{\lambda_c^2} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^2}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 49.93 \cdot \text{ksi}$$

Compressive Capacity:

$$P_{n.member} := A_e \cdot F_n = 44.07 \cdot \text{kip}$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot P_{n.member} = 37.46 \cdot \text{kip}$$

Factored Max Compressive Force:

$$P_{comp.max} := \max\left(\left|C_S\right|, \left|C_W\right|\right) = 7.918\ \text{kip}$$

D/C Ratio of Compression:

$$DCR := \frac{P_{comp.max}}{\phi P_{n.member}} = 0.211$$

$$Axial_{curb.comp} := \text{if}\left(P_{comp.max} < \phi P_{n.member}, \text{"OK"}, \text{"Provide Channel from above as Web Stiffener"}\right)$$

$Axial_{curb.comp} = \text{"OK"}$

Note: No need to check for interaction since the curb is only subjected to the compressive force.

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Shear of CanFab Curb Webs without Holes (AISI S100-16 G2)

Note: Since the unit is stiffer than the curb and the curb is firmly attached to the unit and to the base structure, curbs will mainly take the lateral forces as shear and axial load rather than bending.

Thickness of Curb:

$$t := \text{thick}(t_{Curb}) = 0.108 \cdot \text{in}$$

Depth-to-Thickness Ratio:

$$\frac{h}{t} = 272$$

Curb Elastic Modulus:

$$E := 29500\text{ksi}$$

Clear distance b/w transverse stiffeners of reinforced web:

$$a := \max\left(\frac{L_{curb}}{2}, W_{curb}\right) = 37 \cdot \text{in} \qquad \frac{a}{h} = 1.26$$

$$k_v := \begin{cases} 5.34 & \text{if } a = L_{curb} \\ 4.00 + \dfrac{5.34}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \dfrac{4.00}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 7.85$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 68 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 103$$

Curb Shear Check due to Load on Longer Side

Area of Web Element:

$$A_w := W_{curb} \cdot t = 4 \cdot \text{in}^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 2.8 \cdot \text{ksi}$$

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$V_{cr} := A_w \cdot F_{cr} = 11\,kip \quad V_y := 0.6 \cdot A_w \cdot F_y = 121\,kip \quad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 3.255$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 11.414 \cdot kip$$

Number of Members within Length: $n := 2$ **(Per Curb Design)**

Design Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 21686.8 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.H} := P_{net} \cdot L_{unit} \cdot H_{total} = 5305.1 \cdot lbs$

Design Shear Demand: $V_u := \max(V_{base.S}, V_{base.W.H}) = 5305.1 \cdot lbs$

D/C Ratio of Shear: $DCR := \frac{V_u}{\phi V_n} = 0.245$

Demand/Capacity Ratio:

$Shear_{in.plane} := \text{if}(V_u < \phi V_n, \text{"OK"}, \text{"NG"})$

$Shear_{in.plane} = \text{"OK"}$

Curb Shear Check due to Load on Shorter Side

Area of Web Element: $A_w := L_{curb} \cdot t = 7 \cdot in^2$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot (1 - \mu^2) \cdot \left(\frac{h}{t}\right)^2} = 2.8 \cdot ksi$$

$V_{cr} := A_w \cdot F_{cr} = 21\,kip \quad V_y := 0.6 \cdot A_w \cdot F_y = 219\,kip \quad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 3.255$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 20.68 \cdot kip$$

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Number of Members within Length: $n := 2$ **(Per Curb Design)**

Factored Nominal Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 39291.4 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot W_{unit} \cdot H_{total} = 4279.8 \cdot lbs$

Factored Shear Demand: $V_u := \max\left(V_{base.S}, V_{base.W.L}\right) = 4279.8 \cdot lbs$

D/C Ratio of Shear: $DCR := \frac{V_u}{\phi V_n} = 0.109$

Demand/Capacity Ratio:

$Shear_{in.plane} := \text{if}\left(V_u < \phi V_n, \text{"OK"}, \text{"NG"}\right)$

$Shear_{in.plane} = \text{"OK"}$

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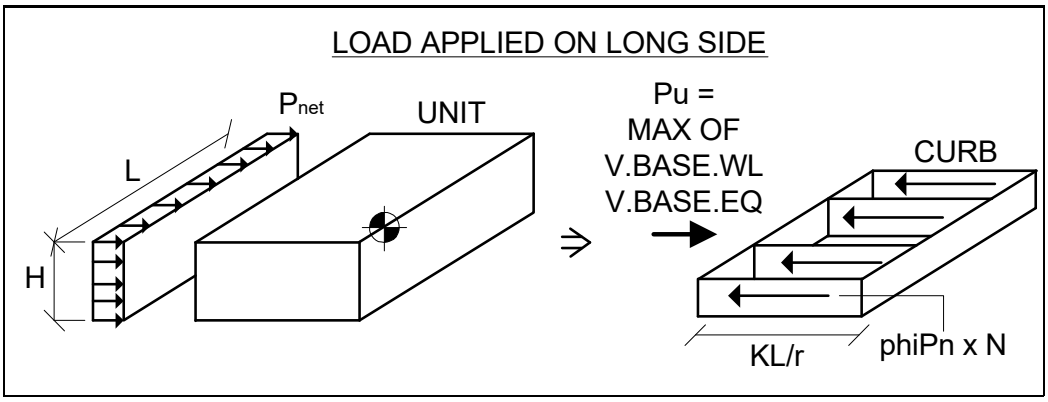
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Check CanFab Curb for In-Plane Axial due to EQ and Wind (AISI S100-16 E2)

Curb Axial Load Check due to Load on Long Side



Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot L_{unit} \cdot H_{total} = 5.3\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.L}) = 5305.14 \cdot lbs$

Member per CFS: $CFS_{member} :=$ "12GA Custom Curb 30" Tall L.b = 78in"

Max Braced Length of Member: $L_{member} := W_{curb} = 37 \cdot in$

Number of Curb in Length: $n_{curb.long} := 2$

Radius of gyration in y-axis: $r_{y.curb} := 0.558\,in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{2} = 2.65\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 67$ $KL_r =$ "KL/r < 200, OK"

Spacing: $Spacing := \frac{L_{curb}}{n_{curb.long}} = 34 \cdot in$

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 12.036 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.22$

$Axial_{short.curb} =$ "OK"

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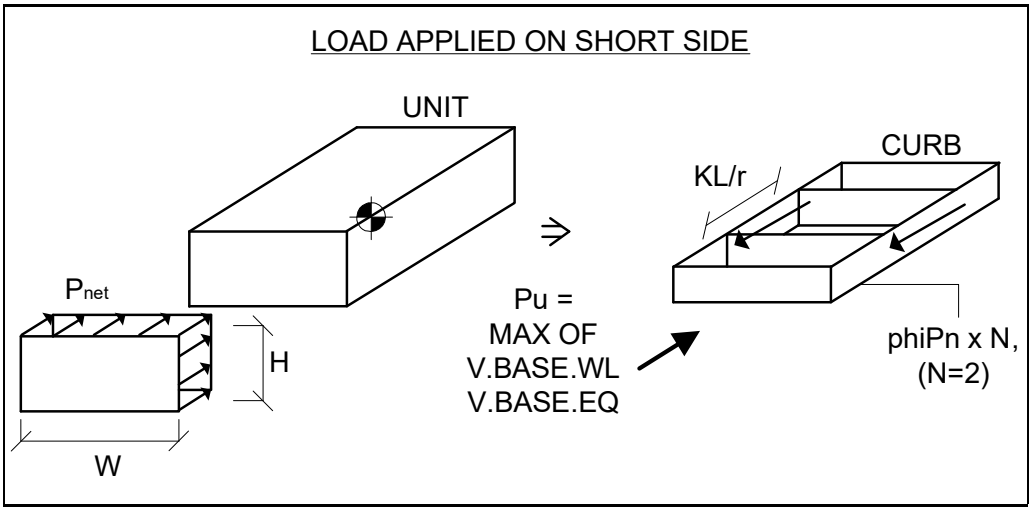
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Curb Axial Load Check due to Load on Short Side



Wind Base Shear on Short Side: $V_{base.W.H} := P_{net} \cdot W_{unit} \cdot H_{total} = 4.3\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.H}) = 4279.78 \cdot lbs$

Member per CFS: CFS_{member} = "12GA Custom Curb 30" Tall L.b = 78in"

Max Braced Length of Member: $L_{member} := \frac{L_{curb}}{n_{curb.long} - 1} = 67 \cdot in$

Number of Curb in Length: $n_{curb} := 2$

Radius of gyration in y-axis: $r_{y.curb} := 0.558\,in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{curb}} = 2.14\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 121$ KL_r = "KL/r < 200, OK"

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 12.036 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.178$

$Axial_{long.curb}$ = "OK"

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DESIGN
for
NON ISOLATED CURB
1005 (Max Curb Height of 36")

950 S. GRAND AVENUE, 4TH FLOOR, LOS ANGELES, CALIFORNIA 90015 (213) 483-6490

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Design Wind Loads for Rooftop Equipment (ASCE 7-16 § Table 29.1-1)

$z := 60ft$ **Height above ground level**

$B := 60ft$ **Horizontal dimension of building measured normal to wind direction**

$Exp_{category} := "C"$ **Exposure Category per ASCE 7-16 § 26.7**

$Risk_{category} := "IV"$ **Risk Category per ASCE 7-16 Table 1.5-1**

$$V := \begin{cases} 0mph & \text{if } Risk_{category} = "I" \\ 0mph & \text{if } Risk_{category} = "II" \\ 175mph & \text{otherwise} \end{cases} = 175 \cdot mph$$

Basic Wind Speed per ASCE 7-16 Figure 26.5-1 A,B or C

$K_z = 1.14$ **Velocity Pressure Exposure Coefficient per ASCE 7-16 Table 29.10-1 [Exposure Category "C"]**

$K_{zt} := 1.0$ **Topographic Factor per ASCE 7-16 § 26.8, Figure 26.8-1**

$K_e := 1.0$ **Ground Elevation Factor per ASCE 7-16 § 26.9, Table 26.9-1**

$K_d := 0.85$ **Wind Directionality Factor per ASCE 7-16 § 26.6, Table 26.6-1 (Equipment)**

$q_z := 0.00256 K_z \cdot K_{zt} \cdot K_d \cdot K_e \cdot V^2 = 75.74 \cdot psf$ **Velocity pressure evaluated at height z above ground per ASCE 7-10 § 26.10.2; Eq. 26.10-1**

$GC_{r.lateral.max} := 1.9$ **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.9 for rooftop structures and equipment with Af less than (0.1Bh). (GCr) shall be permitted to be reduced linearly from 1.9 to 1.0 as the value of Af is increased from (0.1Bh) to (Bh)

$GC_{r.vertical.max} := 1.5$ **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.5 for rooftop structures and equipment with A_r less than (0.1*BL*). (GC_r) shall be permitted to be reduced linearly from 1.5 to 1.0 as the value of A_r is increased from (0.1*BL*) to (*BL*)

$P_{net} := q_z \cdot GC_{r.lateral.max} = 143.91 \cdot psf$ **Design Lateral Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-2**

$P_v := q_z \cdot GC_{r.vertical.max} = 113.61 \cdot psf$ **Design Vertical Uplift Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-3**

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Seismic Demands on Nonstructural Components (ASCE 7-16 § 13.3 & 13.6):

$S_{DS} := 1.5$ **Design spectral response acceleration parameter at short periods per USGS map**

$I_p := 1.5$ **Component importance factor ASCE 7-16 § 13.1.3**

$\Omega_0 := 2.0$ **Overstrength factor ASCE 7-16 Table 13.6.1**

Vibr_Isolation = "No" **Placement of Unit Vibration Isolated:**

Note: Only "F_p" at seismic concrete anchor has been increased with overstrength factor "Ω_0"

$a_p := 2.5$ $R_p = 6.0$ **Seismic coefficients a_p & R_p**
Per ASCE 7-16 Table 13.6-1 for
Mechanical & Electrical Components

$z = 60\,ft$ **Height in structure of point of attachment of component with respect to the base**

$h := 60ft$ **Average roof height of structure with respect to the base**
Where for roof top equipment:

$z \div h = 1$

F_p: Horizontal Seismic Design Force per *ASCE7-16 § 13.3.1*

F_p shall be takes as $\left(\frac{0.4 \cdot a_p \cdot S_{DS} \cdot I_p}{R_p}\right) \cdot \left(1 + 2 \cdot \frac{z}{h}\right) \cdot W_p = 112.5 \cdot \% \cdot W_p$

F_p is not required to be taken as greater than $\left(1.6 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 360 \cdot \% \cdot W_p$

F_p shall not be taken as less than $\left(0.3 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 67.5 \cdot \% \cdot W_p$

Governing F_p : Horizontal Seismic Design Force $F_p = 112.5 \cdot \% \cdot W_p$

F_v: Vertical Load per ASCE7-16 § 13.3.1.2

Concurrent Vertical Seismic Force: $F_v := 0.2 \cdot S_{DS} \cdot W_p = 30 \cdot \% \cdot W_p$

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Flat Roof Snow Loads (ASCE 7-16 § 7.3):

$Terrain_{CAT} := "C"$ **Terrain Category ASCE 7-16 § 26.7 & Table 7.3-1**

$Exp_{Roof} := "Partially\ Exposed"$ **Exposure of Roof ASCE 7-16 Table 7.3-1**

$C_e = 1$ **Exposure Factor ASCE 7-16 Table 7.3-1**

$Thermal_{condition} := "All\ structures\ except\ below"$ **Thermal Condition ASCE 7-16 Table 7.3-2**

$C_t = 1$ **Thermal Factor ASCE 7-16 Table 7.3-2**

$Risk_{category} = "IV"$ **Risk Category per ASCE 7-16 Table 1.5-1**

$I_s = 1.2$ **Snow Importance Factor ASCE 7-16 Table 1.5-2**

$p_g := 40psf$ **Ground Snow Loads ASCE 7-16 Figure 7.2-1**

$$p_f := \max\left(0.7 \cdot C_e \cdot C_t \cdot I_s \cdot p_g, \text{if}\left(p_g > 20psf, 20psf \cdot I_s, I_s \cdot p_g\right)\right) = 34 \cdot psf$$

Flat Roof Snow Loads ASCE 7-16 Equation 7.3-1 and § 7.3.4

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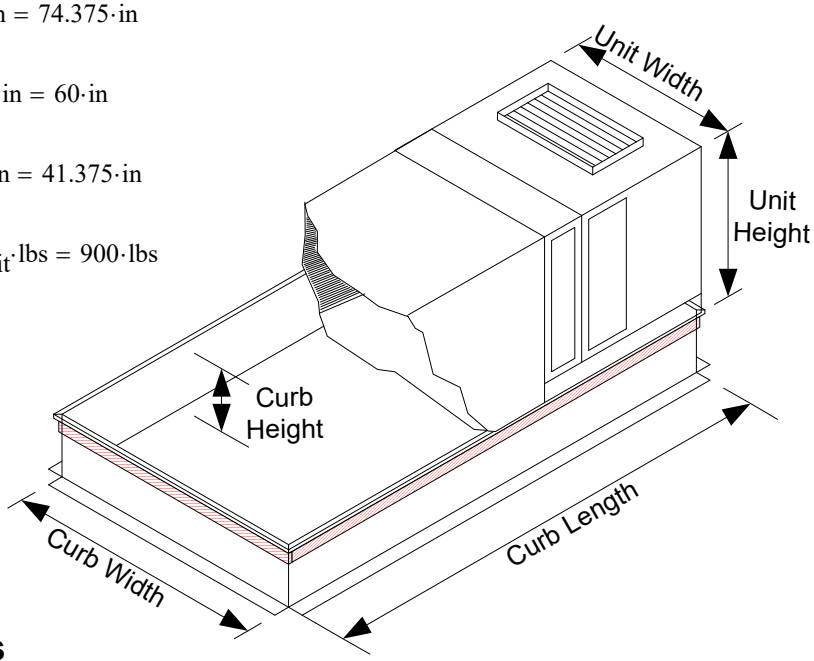
Mechanical Unit Dimensions Curb = "C-1005"

Length of Unit $L_{unit} := L_{unit} \cdot in = 74.375 \cdot in$

Width of Unit $W_{unit} := W_{unit} \cdot in = 60 \cdot in$

Height of Unit $H_{unit} := H_{unit} \cdot in = 41.375 \cdot in$

Weight of Unit $Wt_{unit} := Wt_{unit} \cdot lbs = 900 \cdot lbs$



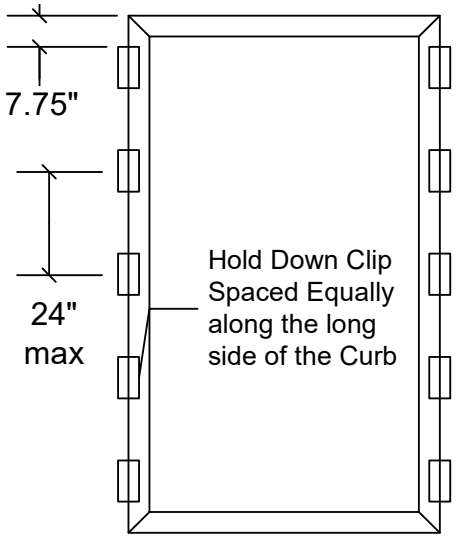
Roof Curb Dimensions

Length of Curb $L_{curb} := L_{curb} \cdot in = 67.375 \cdot in$

Width of Curb $W_{curb} := W_{curb} \cdot in = 37.188 \cdot in$

Height of Curb $H_{curb} := H_{curb} \cdot in = 36 \cdot in$

Weight of Curb $Wt_{curb} := Wt_{curb} \cdot lbs = 354 \cdot lbs$



Curb Plan

Overall System Dimensions

Total Weight

$Wt_{tot} := Wt_{unit} + Wt_{curb} = 1254 \cdot lbs$

Total height

$H_{total} := H_{unit} + H_{curb} = 77.375 \cdot in$

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Seismic Loading + Snow Loading

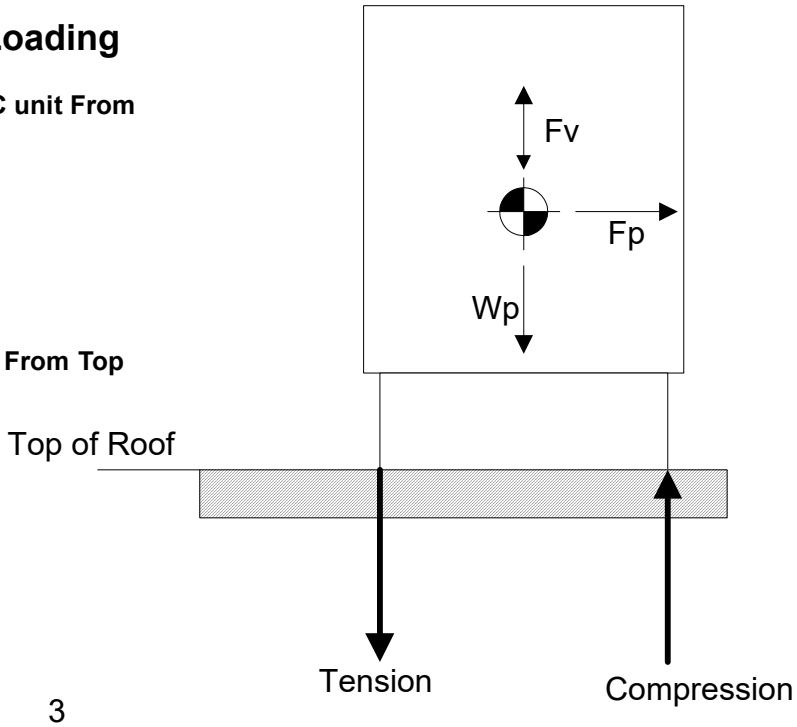
Height for Center of Gravity for HVAC unit From Top of Roof

$h_{CG.unit} := \frac{1}{2} H_{unit} = 21 \cdot in$

$h_{CG} := H_{curb} + h_{CG.unit} = 56.69 \cdot in$

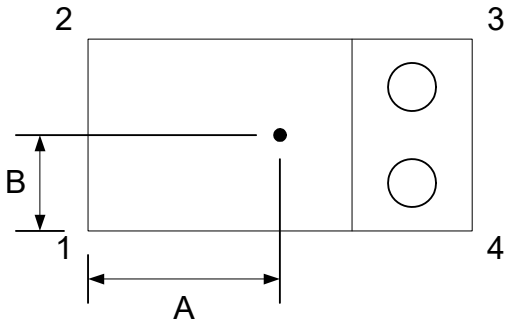
Height for Center of Gravity for Curb From Top of Roof

$h_{CG.curb} := \frac{H_{curb}}{2} = 18 \cdot in$



Max Seismic Base Shear

$V_{base.S} := F_p \cdot Wt_{tot} = 1411 \cdot lbs$



Unit C.G. distance in axis parallel to Curb Width $B_{ecc.width} := CG_{short} \cdot in = 22.5 \cdot in$

Eccentricity in axis parallel to Curb Width

$$e_{width} := \begin{cases} 0in & \text{if } B_{ecc.width} = \text{"N/A"} \\ \left| B_{ecc.width} - \frac{W_{unit}}{2} \right| & \text{otherwise} \end{cases} = 7.5 \cdot in$$

Unit C.G. distance in axis parallel to Curb Length $A_{ecc.length} := CG_{long} \cdot in = 34.625 \cdot in$

Eccentricity in axis parallel to Curb Length

$$e_{length} := \begin{cases} 0in & \text{if } A_{ecc.length} = \text{"N/A"} \\ \left| A_{ecc.length} - \frac{L_{unit}}{2} \right| & \text{otherwise} \end{cases} = 2.56 \cdot in$$

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Max Net Tension Reaction On Each Side Due To Seismic Loads

$$T_S := \begin{bmatrix} \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{W_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{W_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} \right] \\ \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{L_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{L_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} \right] \end{bmatrix} = \begin{pmatrix} -1469 \\ -603 \end{pmatrix}\cdot lbs$$

Max Net Compression Reaction On Each Side Due To Seismic Loads

$$C_S := \begin{bmatrix} \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{W_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \\ \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{L_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \end{bmatrix} = \begin{pmatrix} 4196 \\ 3012 \end{pmatrix}\cdot lbs$$

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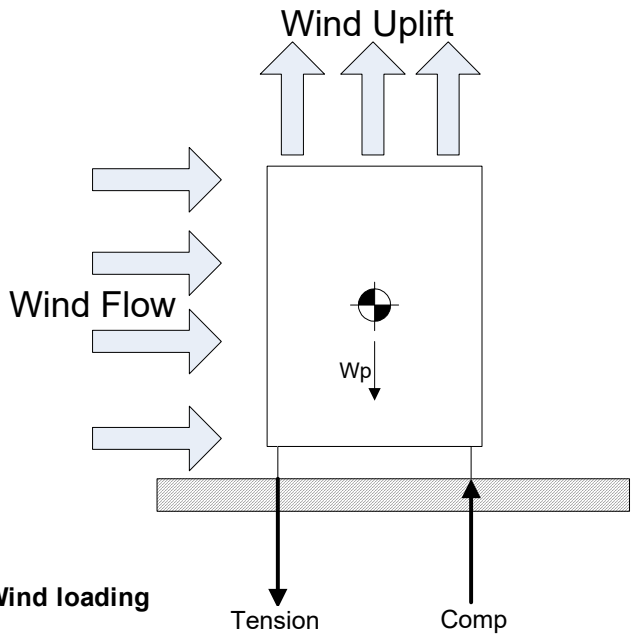
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Wind Loading + Snow Loading



Max Base Shear due to wind loading

$$V_{base.W} := P_{net} \cdot L_{unit} \cdot H_{total} = 5751 \cdot lbs$$

Max Uplift due to wind loading

$$L_{unit.up} := L_{unit} - 0in = 74.375 \cdot in$$

$$P_{uplift.W} := P_v \cdot L_{unit.up} \cdot W_{unit} = 3521 \cdot lbs$$

Max Net Tension Reaction On Each Side Due To Wind loading

$$T_W := \begin{pmatrix} \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} - \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \\ \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} - \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} -7343 \\ -3891 \end{pmatrix} \cdot lbs$$

Max Net Compression Reaction On Each Side Due To Wind loading

$$C_W := \begin{pmatrix} \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} + \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \\ \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} + \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} 7786 \\ 4291 \end{pmatrix} \cdot lbs$$

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Governing Loading @ Curb

Max uplift vertical load along the length of the curb

$$\omega_{x.L.vert.up} := \frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}} = 1308 \cdot plf$$

Max compressive vertical load along the length of the curb

$$\omega_{x.L.vert.comp} := \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}} = 1387 \cdot plf$$

Max vertical load along the length of the curb

$$\omega_{x.L.vert} := \max\left(\omega_{x.L.vert.up}, \omega_{x.L.vert.comp}\right) = 1387 \cdot plf$$

Max uplift vertical load along the width of the curb

$$\omega_{x.W.vert.up} := \frac{\max\left[\left|T_{S_{(1)}}\right|, \left|T_{W_{(1)}}\right|\right]}{W_{curb}} = 1256 \cdot plf$$

Max compressive vertical load along the width of the curb

$$\omega_{x.W.vert.comp} := \frac{\max\left[\left|C_{S_{(1)}}\right|, \left|C_{W_{(1)}}\right|\right]}{W_{curb}} = 1385 \cdot plf$$

Max vertical loading along the width of the curb

$$\omega_{x.W.vert} := \max\left(\omega_{x.W.vert.up}, \omega_{x.W.vert.comp}\right) = 1385 \cdot plf$$

$$\begin{pmatrix} V_{base.S} \\ V_{base.W} \end{pmatrix} = \begin{pmatrix} 1411 \\ 5751 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} \left|T_S\right| \\ \left|C_S\right| \end{pmatrix} = \begin{pmatrix} 1588 \\ 5165 \end{pmatrix} \cdot lbs$$

$$\begin{pmatrix} F_v \cdot Wt_{tot} \\ P_v \cdot L_{unit} \cdot W_{unit} \end{pmatrix} = \begin{pmatrix} 376 \\ 3521 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} \left|T_W\right| \\ \left|C_W\right| \end{pmatrix} = \begin{pmatrix} 8310 \\ 8890 \end{pmatrix} \cdot lbs$$

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Anchorage To Concrete [Expansion Anchor per ACI 318-14]

Number of connection on the long side $N_B := 4 + 2$

Moment Arm for overturning (Short side) $B := W_{curb} = 37 \cdot in$

Number of Connection on the Short side. $N_L := 2 + 2$

Moment Arm for over turning (Long side) $L := L_{curb} = 67 \cdot in$

Total Number of Connections $N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 12$

Max Net Tension Reaction Due to Seismic Load, Fp

$$R_{c.EQ.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 18 \cdot lbs \qquad R_{c.EQ.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 5 \cdot lbs$$

$$R_{c.EQ} := MAX+\left[\begin{array}{l} \left[\left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{c.EQ.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t}\right] \\ \left[\left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{c.EQ.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t}\right] \end{array}\right] = \begin{pmatrix} 534 \\ 422 \end{pmatrix} \cdot lbs$$

Max net Tension Reaction Due to Wind Load, Pnet

$$R_{c.W} := MAX+\left[\begin{array}{l} \frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t} \end{array}\right] = \begin{pmatrix} 1224 \\ 873 \end{pmatrix} \cdot lbs$$

Governing Load Case: $Govern := if\left(\left|R_{c.EQ}\right| > \left|R_{c.W}\right|, "Seismic", "Wind"\right) = "Wind"$

Governing Tension Reaction at Each anchor Point: $R_c := if\left(Govern = "Seismic", R_{c.EQ}, R_{c.W}\right) = \begin{pmatrix} 1224 \\ 873 \end{pmatrix} \cdot lbs$

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Max Tension on anchor: $N_{ua} := |R_c| = 1503 \cdot lbs$

Max Shear on anchor: $V_{ua} := \frac{\max(\Omega_0 \cdot V_{base.S}, V_{base.W})}{N_t} = 479 \cdot lbs$

Hilti Kwik Bolt TZ – Carbon Steel
1/2" Anchor with min 3 1/4" embedment
Base material: 6" thick Cracked concrete w/
Compressive strength fc' = 3000 psi
Min 5" away from the concrete edge
Evaluation Report: ICC-ESR 1917

Loading Condition:	**Wind**

Design Tension Capacity [ϕN_n]:	3,500	[lbs]
Design Shear Capacity [ϕV_n]:	3,572	[lbs]

$\phi N_n := \phi N_n \cdot lbs = 3500 \cdot lbs$

$\phi V_n := \phi V_n \cdot lbs = 3572 \cdot lbs$

Utilization:

Tension Utilization: $\beta_N := \frac{N_{ua}}{\phi N_n} = 43 \cdot \%$

Shear Utilization: $\beta_V := \frac{V_{ua}}{\phi V_n} = 13 \cdot \%$

Interaction of Tensile and Shear Forces:
Per ACI 318-14 Sec. 17.6

$\beta_{NV} := \frac{(\beta_N) + (\beta_V)}{1.2} = 47 \cdot \%$

$$check\_interaction := \begin{pmatrix} \text{if}(\beta_N < 1.0, \text{"OK"}, \text{"NG"}) \\ \text{if}(\beta_V < 1.0, \text{"OK"}, \text{"NG"}) \\ \text{if}(\beta_{NV} < 1.0, \text{"OK"}, \text{"NG"}) \end{pmatrix} = \begin{pmatrix} \text{"OK"} \\ \text{"OK"} \\ \text{"OK"} \end{pmatrix}$$

$$check\_interaction = \begin{pmatrix} \text{"OK"} \\ \text{"OK"} \\ \text{"OK"} \end{pmatrix}$$

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Anchorage To Structural Steel [Fillet Weld Conn. per AISI S100-16]

Fillet Weld 2" Long Along the Long and Short Side. Min 2 Connections per Side
Spacing: 48" O.C. for Non-Isolated Curbs; 24" for Isolated Curbs

Number of Welds on the Long Side $N_B := 3$

Moment Arm for Overturning (Short Side) $B := W_{curb} = 37 \cdot in$

Number of Welds on the Short Side. $N_L := 2$

Moment Arm for Overturning (Long Side) $L := L_{curb} = 67 \cdot in$

Total Number of Connections $N_t := \left[\left(N_B\right) + \left(N_L\right)\right] \cdot 2sides = 10$

Max Net Tension Reaction due to Seismic Load FP

$$R_{weld.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 36 \cdot lbs$$

$$R_{weld.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 10 \cdot lbs$$

$$R_{weld.EQ} := MAX+\left[\left[\begin{array}{l} \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{weld.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{weld.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \end{array}\right]\right] = \begin{pmatrix} 540 \\ 414 \end{pmatrix} \cdot lbs$$

Max Net Tension Reaction due to Wind Load Pnet

$$R_{weld.W} := MAX+\left[\left[\begin{array}{l} \frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t} \end{array}\right]\right] = \begin{pmatrix} 2288 \\ 1587 \end{pmatrix} \cdot lbs$$

Tension Design Force; SRSS for Loading from Each Direction $T_{u.weld} := \max\left(\left|R_{weld.EQ}\right|, \left|R_{weld.W}\right|\right) = 2784 \cdot lbs$

Shear Load at Each Weld Connection $V_{u.weld} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{N_t} = 575 \cdot lbs$

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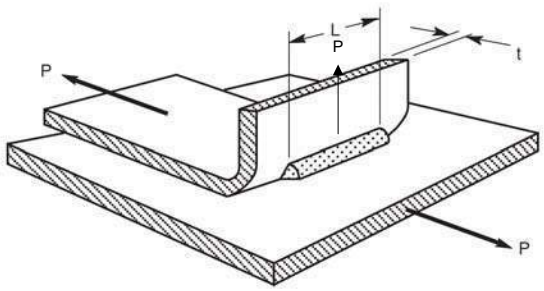
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Total Demand: SRSS of V and T

$$R_{u.weld} := \sqrt{T_{u.weld}^2 + V_{u.weld}^2} = 2843 \cdot lbs$$

Fillet Weld Design per AISI S100-16 Section J2.5

Weld Length at Each Connection Point $L_w := 2in$



Effective Throat Fillet Weld Size

$$t_w := \left(\frac{1}{8}in\right) \cdot 0.707 = 0.088 \cdot in$$

Thickness for the Thinnest Martial Being Welded
Min Curb Thickness = 16GA with Fu=65 ksi

$t_1 := thick("12GA") = 0.1084 \cdot in$

$F_u := 65ksi$

Min weld material strength

$F_{exx} := 70ksi$

For Longitudinal Loading [Parallel capacity is considered to be loading in the direction of the length of the weld] per (Eq. J2.5-1) &(Eq. J2.5-2)

$$\phi P_{long} := \begin{cases} (0.6)\left(1 - \frac{0.01 \cdot L_w}{t_1}\right) \cdot L_w \cdot t_1 \cdot F_u & \text{if } \frac{L_w}{t_1} < 25 \\ (0.5) \cdot 0.75 \cdot t_1 \cdot L_w \cdot F_u & \text{otherwise} \end{cases} = 6895 \cdot lbs$$

where $L_w \div t_1 = 18$

For Transverse Loading per (Eq. J2.5-5)

$$\phi P_{trans} := (0.65) \cdot t_1 \cdot L_w \cdot F_u = 9160 \cdot lbs$$

Strength of Weld Material per (Eq. J2.5-7)

$$\phi P_{weld} := (0.6) \cdot 0.75 \cdot t_w \cdot L_w \cdot F_{exx} = 5568 \cdot lbs$$

Design Strength of Fillet Weld

$$\phi P_n := \min\left(\phi P_{long}, \phi P_{trans}, \phi P_{weld}\right) = 5568 \cdot lbs$$

D/C Ratio for the Welded Connection

$$\beta_{NW} := \frac{R_{u.weld}}{\phi P_n} = 51 \cdot \%$$

$weld_{check} := if\left(\beta_{NW} < 1.0, "OK", "NG"\right)$

$weld_{check} = "OK"$

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Anchorage To Wood Member WITH Lag Screws [NDS-2018 LRFD Strength Design]

*** Use 3/8" Lag Screws along Each Side of the Curb**
*** Assume G=0.5 Douglas Fir-Larch**

Wood Lag Screw Capacity per NDS 2018 Section 11.3

Wet Service Factor: Cond := "DRY" **(e.g. CA = "DRY", AK = "WET")**

$C_M := \begin{cases} 1.0 & \text{if Cond = "DRY"} \\ 0.7 & \text{if Cond = "WET"} \end{cases} = 1$ **NDS 2018 Table 11.3.3**

Temperature Factor: $C_t := \begin{cases} 0.8 & \text{if Cond = "DRY"} \\ 0.7 & \text{if Cond = "WET"} \end{cases} = 0.8$ **NDS 2018 Table 11.3.4**

Group Action Factor: $C_g := 0.97$ **NDS 2018 Table 11.3.6C**

Geometry Factor: $C_\Delta := 1.0$ **NDS 2018 Table 12.5.1A,B**

End Grain Factor: $C_{eg} := 1.0$ **NDS 2018 Sec. 12.5.2**

Diaphragm Factor: $C_{di} := 1.0$ **NDS 2018 Sec. 12.5.3**

Toe-Nail Factor: $C_{tn} := 1.0$ **NDS 2018 Sec. 12.5.4**

Format Conversion Factor: $K_F := 3.32$ **NDS 2018 Table 11.3.1**

Resistance Factor: $\phi := 0.65$ **NDS 2018 Table 11.3.1**

Time Effect Factor: $\lambda := 1.0$ **NDS 2018 App N.3.3**

Lateral Design Value: $Z := 130\text{lbs}$ **NDS 2018 Table 12K**

Withdrawal Design Value: $W := 305\text{lbs}$ **NDS 2018 Table 12.2A**

Lag Screw Diameter: $D_{lag} := \frac{3}{8}\text{in}$

Lag Screw Length: $L_{lag} := 4\text{in}$

Length of Tapered Tip: $E_{lag} := \frac{7}{32}\text{in}$

Lag Screw Penetration: $P_{lag} := 3.78125\text{in}$

Eff. Lag Screw Penetration for withdrawal: $P_{\omega.lag} := 2\text{in} + \frac{9}{32}\text{in} = 2.28\cdot\text{in}$ **NDS 2018 Appx. Table L2**

NDS 2018 Sec. 12.1.4.6

Minimum Penetration DCR <1.0: $DCR_{min.penetration} := \frac{4\cdot D_{lag}}{P_{\omega.lag}} = 0.66$ $DCR_{min.penetration}$ = "OK"

Adj. Lateral Design Value: $Z' := Z\cdot C_M\cdot C_t\cdot C_g\cdot C_\Delta\cdot C_{eg}\cdot C_{di}\cdot C_{tn}\cdot K_F\cdot\phi\cdot\lambda = 218\cdot\text{lbs}$

Adj. Withdrawal Design Value: $W' := W\cdot C_M^{\,2}\cdot C_t\cdot C_{eg}\cdot C_{tn}\cdot K_F\cdot\phi\cdot\lambda = 527\cdot\text{lbs}$ **NDS 2018 Table 11.3.1**

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Number of Lag Screws on the Long Side $N_B := 11 + 2$

Moment Arm for Overturning (Short Side) $B := W_{curb} = 37 \cdot in$

Number of Lag Screws on the Short Side $N_L := 6 + 2$

Moment Arm for Overturning (Long Side) $L := L_{curb} = 67 \cdot in$

Total Number of Lag Screws $N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 34$

Max net Tension Reaction due to Seismic, Fp

$$R_{lag.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 8 \cdot lbs$$

$$R_{lag.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 3 \cdot lbs$$

$$R_{lag.EQ} := MAX+\left[\begin{bmatrix} \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{lag.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{lag.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 120 \\ 100 \end{pmatrix} \cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$R_{lag.W} := MAX+\left[\begin{bmatrix} \frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{L \cdot N_L \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 543 \\ 407 \end{pmatrix} \cdot lbs$$

Tension Design force; SRSS for loading from Each direction $T_{lag} := \max\left(\left|R_{lag.EQ}\right|, \left|R_{lag.W}\right|\right) = 679 \cdot lbs$

Shear load at each anchor location $V_{lag} := \frac{\max\left(V_{base.S} \cdot \sqrt{2}, V_{base.W}\right)}{N_t} = 169 \cdot lbs$

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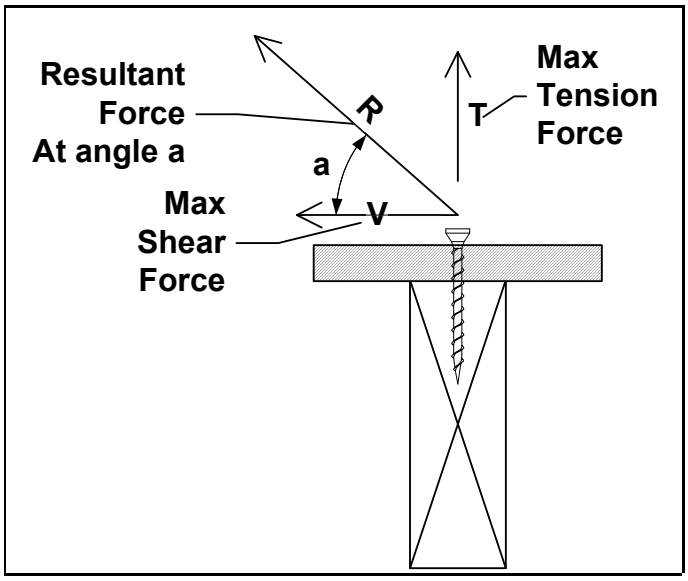
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For Lag Screws Subjected to Combined Lateral and Withdrawal Loading; Design Strength of the Lag Screw Shall Be Adjusted per Hankinson Formula as Prescribed by NDS 2018 Equation 12.4-1



Angle Between Wood Surface and Direction of Resultant Applied Load

$$(\alpha) := \operatorname{atan}\left(\frac{T_{lag}}{V_{lag}}\right) = 76\cdot\text{deg}$$

Combined Demand per Lag Screw @ Strength Level

$$R_{lag} := \sqrt{T_{lag}^{2} + V_{lag}^{2}} = 700\cdot\text{lbs}$$

Adjusted Capacity per NDS 2018 Equation 12.4-1 @ Strength Level

$$Z'_{\alpha} := \frac{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot Z'}{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot\cos(\alpha)^{2} + Z'\cdot\sin(\alpha)^{2}} = 950\cdot\text{lbs}$$

D/C Ratio for the Lag Screw connection to Wood Structure

$$\beta_{Lag} := \frac{R_{lag}}{Z'_{\alpha}} = 74\cdot\%$$

$$\text{Lag}_{Screw.Check} := \text{if}\left(\beta_{Lag} < 1.0, \text{"OK"}, \text{"NG"}\right)$$

$\text{Lag}_{Screw.Check} = \text{"OK"}$

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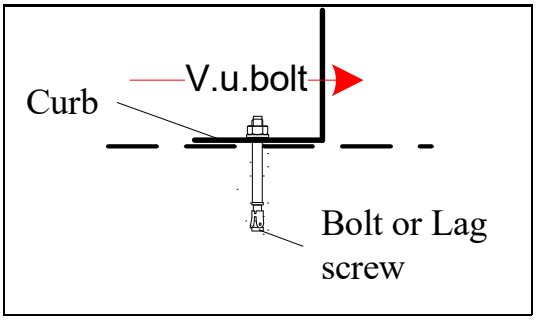
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Bearing and Tilting in Curb Bolted Connection AISI S100-16

Nominal bolt diameter $d := 0.5in$

Uncoated sheet thickness $t_{curb} := thick("12GA") = 0.108 \cdot in$



Tensile strength of sheet $F_u := 65ksi$

Coefficient for conversion of units $\alpha := 1.0$

Modification Factor $m_f := 1.0$

Modification factor for type of bearing connection, per Table J3.3.1-2; For single shear connection with washers

Bearing Factor

$$C := \begin{cases} 3 & \text{if } \left(\frac{d}{t_{curb}} < 10\right) \wedge \left(0.024in < t_{curb} < 0.1875in\right) \\ "NG" & \text{if } \frac{d}{t_{curb}} > 10 \end{cases} = 3$$

Bearing factor, which shall be determined according to Table J3.3.1-1 For d/t<10 where $d \div t_{curb} = 5$

Bearing Design Strength per AISI S100-16 Eq. J3.3.1-1

$$\phi P_{n_{(0)}} := (0.6) \cdot \left(m_f \cdot C \cdot d \cdot t_{curb} \cdot F_u\right) = 6341 \cdot lbs$$

Bolt Hole Deformation Design Strength per AISI S100-16 Eq. J3.3.2-1

$$\phi P_{n_{(1)}} := (0.65) \cdot \left[4.64 \cdot \left(\frac{\alpha}{in}\right) \cdot t_{curb} + 1.53\right] \cdot d \cdot t_{curb} \cdot F_u = 4655 \cdot lbs$$

Curb Connection Shear Capacity $\phi P_n := \min\left(\phi P_n\right) = 4655 \cdot lbs$

Loading demand at connection

$$V_{u.bolt} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{4} = 1438 \cdot lbs$$

$Curb\_Conn\_Shear := if\left(V_{u.bolt} < \phi P_n, "OK", "NG"\right)$

Curb_Conn_Shear = "OK"

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Thickness of Curb, ISO Rail and Clip

(Per AISC Table 17-10 Galvanized)

Hold Down Clip thickness

$t_{Clip} := "12GA"$ $t_{clip} := thick(t_{Clip}) = 0.1084 \cdot in$

Roof Curb thickness

$t_{Curb} := "12GA"$ $t_{curb} := thick(t_{Curb}) = 0.1084 \cdot in$

ISO RAIL thickness

$t_{Curb.iso} := "10GA"$ $t_{curb.iso} := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Note: Iso Rail thickness is only used if the curb is isolated. Not used for non-isolated curbs

Sheet Metal Screws (SMS) Equations and References

SMS properties (ESR-2196 Table 5)

$SMS_{Table} =$

"SMS"	"Diameter"	"HeadDiameter"	"Tension"	"Shear"
"Size"	"d"	"dw"	"Pts"	"Pss"
"#8"	0.164	0.335	1000	1170
"#10"	0.19	0.399	1370	1215
"#12"	0.216	0.415	2325	1880
"#14"	0.25	0.5	4580	2440

SMS Tension Eqns

$P_{not} = 0.85 \cdot t \cdot d \cdot F_u$ **(AISI S100-16 J4.4.1 & J4.4.2)**

$P_{nov} = 1.5 \cdot t \cdot d_w \cdot F_u$ **FOR THE MOST CASES, PULL-OUT CAPACITY IS THE LOWEST**

$P_{nts} = 0.8 \cdot P_{ts}$

SMS Shearn Eqns

$P_{vnot} = 4.2 \cdot \sqrt{(d \cdot t^3)} \cdot F_u$ **(AISI S100-16 J4.3.1)**

$P_{vnov} = 2.7 \cdot t \cdot d \cdot F_u$

$P_{vnss} = 0.8 \cdot P_{ss}$

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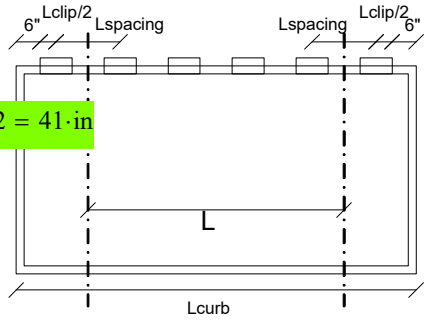
Hold Down Clip Design (Connection of the Mechanical unit to Curb)

Number of Clips on the long side $N_B := 4$

Moment Arm for over turning (Short side) $B := W_{curb} + 1.75in \cdot 2 = 41 \cdot in$

Number of Clips on the Short side $N_L := 4$

Width of Clips $L_{clip} := 9in$



Curb Centerline Spacing (Long side)

$$L_{spacing} := \frac{L_{curb} - \left(6in + \frac{L_{clip}}{2}\right) \cdot 2}{N_B - 1} = 15.458 \cdot in$$

$$L_{spacing.non.iso} := L_{spacing} = 15 \cdot in$$

Moment Arm for over turning (Long side)

$$L := L_{curb} - 2 \cdot \left[6in + \frac{L_{clip}}{2} + L_{spacing} \cdot \frac{(N_L - 2)}{4}\right] = 30.917 \cdot in$$

Total Number of Clips $N_t := (N_B) \cdot 2sides = 8$

Max net Tension Reaction due to Seismic, Fp

$$R_{clip.EQ} := MAX+\left[\begin{array}{l} \left[\frac{F_p \cdot Wt_{unit}}{B \cdot N_B} \cdot h_{CG.unit} + \frac{(0.9 - F_v) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B}\right] - \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} \\ \left[\frac{F_p \cdot Wt_{unit}}{L \cdot N_L} \cdot h_{CG.unit} + \frac{(0.9 - F_v) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L}\right] - \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} \end{array}\right] = \begin{pmatrix} 86 \\ 113 \end{pmatrix} \cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$R_{clip.W} := MAX+\left(\begin{array}{l} \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{unit}^2}{2}}{B \cdot N_B} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{unit}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{unit}^2}{2}}{L \cdot N_L} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{unit}}{N_t} \end{array}\right) = \begin{pmatrix} 767 \\ 771 \end{pmatrix} \cdot lbs$$

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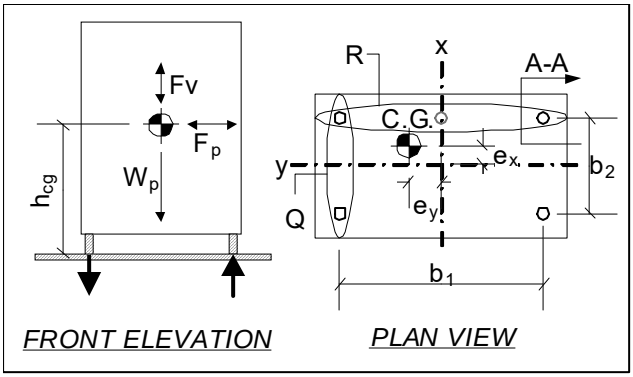
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Tensile and Shear Load calculation per ASHRAE RP-812



Eccentricity along X-X

$e_x := e_{width} = 7.5 \cdot in$

Eccentricity along Y-Y

$e_y := e_{length} = 2.562 \cdot in$

Distance between Seismic Restraints Along Y-Y

$b_1 := L_{curb} - 2 \cdot 6in = 55 \cdot in$

Distance between Seismic Restraints Along X-X

$b_2 := W_{curb} - 2 \cdot 6in = 25 \cdot in$

Moment of Inertia about X-X

$$I_{xx} := \frac{N_t \cdot (N_t + 2) \cdot (b_1)^2}{12 \cdot (N_t - 2)} = 3407 \cdot in^2$$

Moment of Inertia about Y-Y

$$I_{yy} := \frac{N_t \cdot (b_2)^2}{4} = 1269 \cdot in^2$$

Angle about Tensile Load

$$\Theta_t := \operatorname{atan}\left[\frac{I_{yy} \cdot (b_1)}{I_{xx} \cdot (b_2)}\right] = 39 \cdot deg$$

Angle about Shear Load

$$\Theta_s := \begin{cases} \operatorname{atan}\left(\frac{e_x}{e_y}\right) & \text{if } e_y \neq 0 \\ 0deg & \text{if } e_y = 0 \end{cases} = 71 \cdot deg$$

Max Net Tensile Load Due to Seismic Load, Fp

$$T_{U.EQ.pt1} := \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} - \frac{(0.9 - F_v) \cdot Wt_{unit}}{b_1 \cdot b_2} \cdot \left(\frac{b_1}{2} \cdot e_x + \frac{b_2}{2} \cdot e_y - e_x \cdot e_y\right) = -18 \cdot lbs$$

$$T_{U.EQ.pt2} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \cos(\Theta_t) \cdot \frac{0.5 \cdot b_2}{I_{yy}} = -161 \cdot lbs$$

$$T_{U.EQ.pt3} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \sin(\Theta_t) \cdot \frac{0.5 \cdot b_1}{I_{xx}} = -108 \cdot lbs$$

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$T_{U.EQ} := T_{U.EQ.pt1} + T_{U.EQ.pt2} + T_{U.EQ.pt3} = -287 \cdot lbs$

Max Net Shear Load Due to Seismic Load, Fp

$$V_{Ux.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\cos(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_2 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_1 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 86 \cdot lbs$$

$$V_{Uy.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\sin(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_1 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_2 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 144 \cdot lbs$$

$$V_{U.EQ} := \sqrt{V_{Ux.EQ}^2 + V_{Uy.EQ}^2} = 168 \cdot lbs$$

Tension Design force for Hold Down Clips

$T_{clip} := \max(R_{clip.W_0}, R_{clip.W_1}, |R_{clip.EQ}|, |T_{U.EQ}|) = 771 \cdot lbs$

$|R_{clip.EQ}| = 142 \cdot lbs$ $|T_{U.EQ}| = 287 \cdot lbs$

$|R_{clip.W}| = 1087 \cdot lbs$

$T_{clip.EQ.max} := \max(|R_{clip.EQ}|, |T_{U.EQ}|) = 287 \cdot lbs$

$T_{clip.W.max} := \max(|R_{clip.W}|) = 1087 \cdot lbs$

Based on ASCE 7-16 Figure 29.4-1 magnitude of force coefficient,

Wind in diagonal direction to the face of equipment produces less force than that of the wind in perpendicular direction to the face of the equipment.

Therefore, wind in diagonal direction does not need to be used

Shear Design force for Hold Down Clips

$$V_{clip} := \max\left(\frac{\max(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit})}{N_t}, |V_{U.EQ}|\right) = 384 \cdot lbs$$

$F_p \cdot Wt_{unit} \cdot \frac{1}{N_t} = 127 \cdot lbs$ $|V_{U.EQ}| = 168 \cdot lbs$

$P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t} = 384 \cdot lbs$

$$V_{clip.EQ.max} := \max\left[\left(F_p \cdot Wt_{unit} \cdot \frac{1}{N_t}\right), |V_{U.EQ}|\right] = 168 \cdot lbs$$

$$V_{clip.W.max} := \max\left(\left(P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t}\right)\right) = 384 \cdot lbs$$

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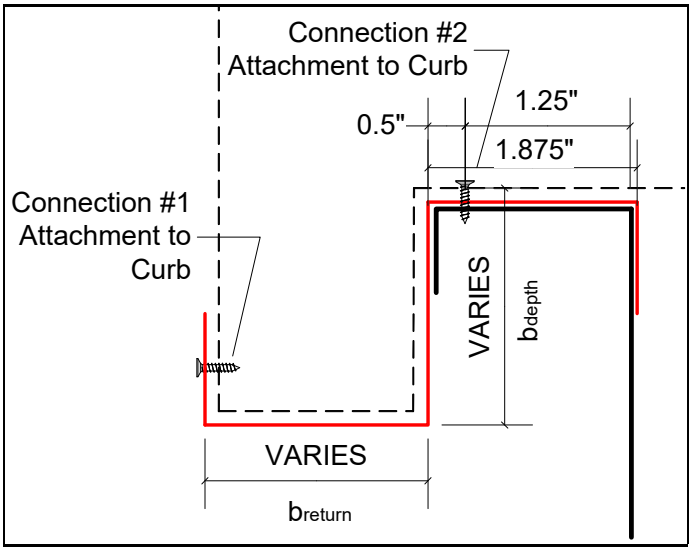
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Loading at Hold Down Clips

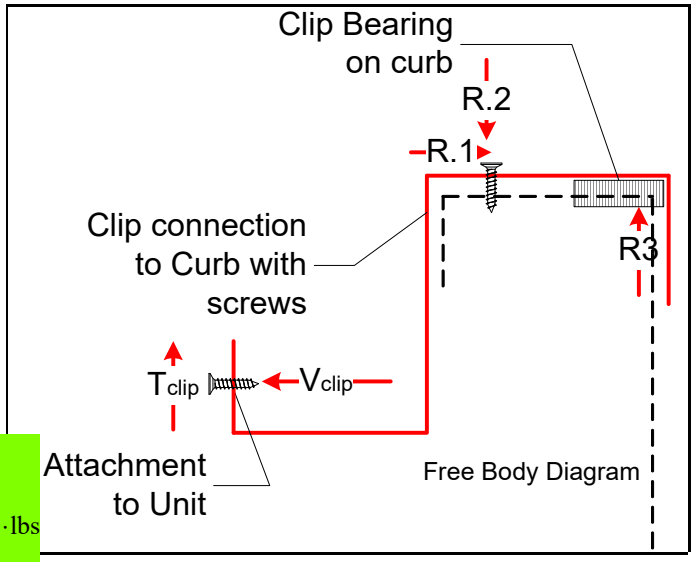


Due to the eccentricity of Shear and Tension forces additional moment is created in the hold down clip. These loads to be resisted in a T/C couple.

Reactions R1 & R2 to be resisted by the screws attaching the hold down clip to curb

R1 is acting as tension on the screws.

$$R_1 := V_{clip} = 384 \cdot lbs$$



R2 is acting as shear force on the connection screws
Since the loading T and V are acting in opposite directions; R2 is the maximum shear force due to either T or V

$$b_{return} := Clip_b \cdot in = 2.625 \cdot in$$

$$b_{depth} := Clip_c \, in = 4.5625 \cdot in$$

$$R_2 := \begin{bmatrix} \frac{T_{clip} \cdot \left[b_{return} + (1.75in - 0.5in) \right]}{1.75in - 0.5in} \\ \frac{V_{clip} \cdot \left(b_{depth} \right)}{1.75in - 0.5in} \end{bmatrix} = \begin{pmatrix} 2389 \\ 1403 \end{pmatrix} \cdot lbs$$

$$R_2 := \max\left(R_2\right) = 2389 \cdot lbs$$

Reaction R3 [compression force] is resisted by bearing of the hold down on the curb lip.

$$R_3 := R_2 - T_{clip} = 1618 \cdot lbs$$

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Design of Connection#1 Connection of Equipment to hold Down clip

Hold Down Clip thickness

$t_{Clip} = \text{"12GA"}$ $t_{clip} := thick(t_{Clip}) = 0.1084 \cdot in$

Strength Reduction for SMS Screw Connections per J.4

$\phi_{sms} = 0.5$

Ultimate SMS screw connection Strength (LRFD) Assume min thickness of the equipment housing is 16 GA [Fy = 50ksi & Fu=65ksi]

$n_{sms} := 4$ $Size_{ss} := \text{"\#12"}$

$t_{ss} := \text{"16GA"}$ $F_{u.ss} := 65ksi$

Nominal Tension Strength

$P_{nt} := n_{sms} \cdot T_s(Size_{ss}, t_{ss}, F_{u.ss}) = 3031 \cdot lbs$

$P_{not} := n_{sms} \cdot T_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 3031 \cdot lbs$

$P_{nov} := n_{sms} \cdot T_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 10277 \cdot lbs$

$P_{nts} := n_{sms} \cdot T_{nts}(Size_{ss}, t_{ss}, F_{u.ss}) = 7440 \cdot lbs$

Nominal Shear Strength

$P_{ns} := n_{sms} \cdot V_s(Size_{ss}, t_{ss}, F_{u.ss}) = 6016 \cdot lbs$

$P_{vnot} := n_{sms} \cdot V_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 8121 \cdot lbs$

$P_{vnov} := n_{sms} \cdot V_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 9629 \cdot lbs$

$P_{vnss} := n_{sms} \cdot V_{nss}(Size_{ss}, t_{ss}, F_{u.ss}) = 6016 \cdot lbs$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} V_{clip} \div (\phi_{sms} \cdot P_{nt}) \\ T_{clip} \div (\phi_{sms} \cdot P_{ns}) \end{bmatrix} = \begin{pmatrix} 25 \\ 26 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left[\begin{bmatrix} \left[\frac{T_{clip}}{P_{vnov}} + 0.71\left(\frac{V_{clip}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{T_{clip}}{P_{vnot}} + \left(\frac{V_{clip}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{T_{clip}}{P_{vnss}} + \left(\frac{V_{clip}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right] = 32 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} \text{"OK"} \\ \text{"OK"} \\ \text{"OK"} \end{pmatrix}$$

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Check Bending in Clip

There are several restraints that prevents the hold down clip for curb to have local bending at the bottom flange and transfer vertical load demand directly to the face of the curb.

- Hold down is bearing on the face of iso-rail / non-iso curb lip.
- Gasket will act as a "link" member to allow unit base rail and bottom flange to move toegther so flange can't bend unless the unit base rail bends first. However, unit base rail is not likely to bend so bottom flange won't bend

Hold Down Clip thickness

$t_{Clip} = \text{"12GA"}$ $t_{clip} := \text{thick}(t_{Clip}) = 0.1084 \cdot \text{in}$

Effective width of hold down clip

$b_c := L_{clip} = 9 \cdot \text{in}$

Yield strength of the Clip

$F_{y.c} := 50\text{ksi}$

Strength reduction for bending

$\phi_{clip} := 0.9$

Design Bending Capacity (LRFD)

$$\phi M_n := \phi_{clip} \cdot F_{y.c} \left(\frac{b_c \cdot t_{clip}^{\,2}}{6} \right) = 793 \cdot \text{in} \cdot \text{lbs}$$

Flexural bending demand

$M_{u.clip} := T_{clip} \cdot (0.5\text{in}) = 385 \cdot \text{in} \cdot \text{lbs}$

D/C Ratio for bending

$$DCR := \frac{M_{u.clip}}{\phi M_n} = 0.486$$

$Clip_{Bending} = \text{"OK"}$

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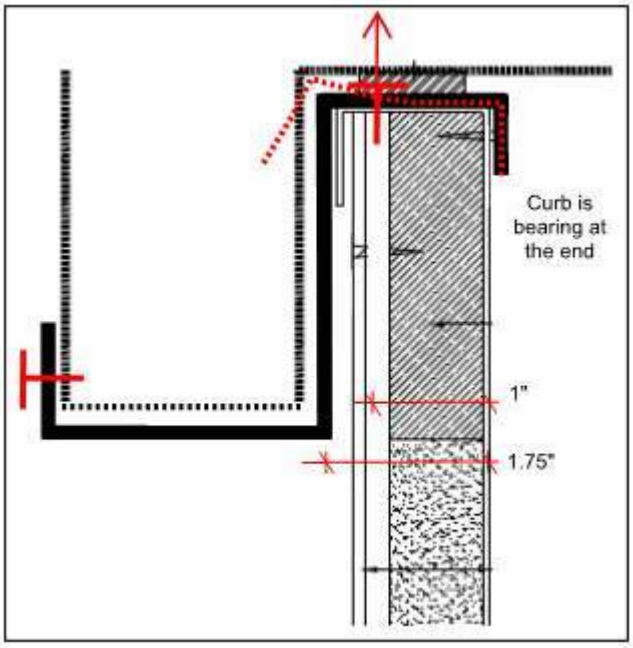
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Check Flange Bending in Curb



Roof Curb thickness

$t_{Curb} = \text{"12GA"}$ $t_{curb} := thick(t_{Curb}) = 0.1084 \cdot in$

Clip edge to edge distance

$$b_{edge2edge} := \frac{L_{curb} - \left(6in + \frac{L_{clip}}{2}\right)\cdot 2}{N_B - 1} - L_{clip} = 6.458 \cdot in$$

Effective width of Roof Curb

$b_{curb} := L_{clip} + b_{edge2edge} = 15.46 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\frac{b_{curb}\cdot(t_{curb})^2}{6} + \frac{L_{clip}\cdot(t_{clip})^2}{6}\right] = 2155 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := T_{clip} \cdot (1.75in - 0.5in) = 963 \cdot in \cdot lbs$

D/C Ratio for bending

$$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.447$$

$Curb_{Bending} = \text{"OK"}$

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Design of Connection#2 Connection of hold Down clip to Curb

Ultimate SMS screw connection Strength (LRFD) Strength based on the smallest thickness of Curb and Hold down Clip (min 16 GA) [Fy = 50ksi & Fu=65ksi]

Tension loads on SMS connection

$T_{s2} := R_2 = 2389 \cdot lbs$

Shear loads on SMS connection

$V_{s2} := R_1 = 384 \cdot lbs$

Strength Reduction for SMS Screw Connections per J.4

$n_{sms} := 8$ $Size_{ss} := "\#12"$ $\phi_{sms} = 0.5$

$t_{ss} := t_{Curb} = "12GA"$ $F_{u.ss} := 65ksi$

Nominal Tension Strength

$P_{nt} := n_{sms} \cdot T_s(Size_{ss}, t_{ss}, F_{u.ss}) = 10349 \cdot lbs$

$P_{not} := n_{sms} \cdot T_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 10349 \cdot lbs$

$P_{nov} := n_{sms} \cdot T_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 35089 \cdot lbs$

$P_{nts} := n_{sms} \cdot T_{nts}(Size_{ss}, t_{ss}, F_{u.ss}) = 14880 \cdot lbs$

Nominal Shear Strength

$P_{ns} := n_{sms} \cdot V_s(Size_{ss}, t_{ss}, F_{u.ss}) = 12032 \cdot lbs$

$P_{vnot} := n_{sms} \cdot V_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 36226 \cdot lbs$

$P_{vnov} := n_{sms} \cdot V_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 32874 \cdot lbs$

$P_{vnss} := n_{sms} \cdot V_{nss}(Size_{ss}, t_{ss}, F_{u.ss}) = 12032 \cdot lbs$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} T_{s2} \div (\phi_{sms} \cdot P_{nt}) \\ V_{s2} \div (\phi_{sms} \cdot P_{ns}) \end{bmatrix} = \begin{pmatrix} 46 \\ 6 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left[\begin{bmatrix} \left[\frac{V_{s2}}{P_{vnov}} + 0.71\left(\frac{T_{s2}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{V_{s2}}{P_{vnot}} + \left(\frac{T_{s2}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{V_{s2}}{P_{vnss}} + \left(\frac{T_{s2}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right] = 35 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

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Hold Down clip Bending and Shear Interaction

Diameter of SMS:

$$d_{sms} := vlookup\left(Size_{ss}, SMS_{Table}, 1\right)_0 \cdot in = 0.216 \cdot in$$

Depth of flat web portion

$$h_{clip.shear} := L_{clip} - n_{sms} \cdot d_{sms} = 7.27 \cdot in$$

Depth-to-Thickness Ratio:

$$\frac{h_{clip.shear}}{t_{clip}} = 67 \qquad E := 29500ksi \qquad F_y := 50ksi \qquad \mu := 0.3$$

Nominal Shear Stress:
(For unreinforced web)
AISI S100-16 G2.1

$$k_v := 5.34 \qquad \sqrt{\frac{E \cdot k_v}{F_y}} = 56 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 85$$

Area of Web Element:

$$A_w := h_{clip.shear} \cdot t_{clip} = 0.788 \cdot in^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h_{clip.shear}}{t_{clip}}\right)^2} = 31.6 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} \qquad V_y := 0.6 \cdot A_w \cdot F_y = 24\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.974$$

Hole Shear Reduction Factor:
(for circular holes, AISI S100-16 Eq G3-1)

$$c := \frac{h_{clip.shear}}{2} - \frac{d_{sms}}{2.83} = 3.56 \cdot in$$

$$q_s := \begin{cases} 1.0 & \text{if } \frac{c}{t_{clip}} \geq 54 \\ \frac{c}{54 \cdot t_{clip}} & \text{if } 5 \leq \frac{c}{t_{clip}} < 54 \end{cases} = 0.608$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \leq 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \leq 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 19.792 \cdot kip$$

Design Shear Capacity with holes:

$$\phi V_{n.clip} := 0.95 \cdot V_n \cdot q_s = 11.4 \cdot kip$$

D/C Ratio of V and M per AISI S100-16 Eq H2-1

$$DCR_{V.M.int.clip} := \sqrt{\left(\frac{M_{u.clip}}{\phi M_n}\right)^2 + \left(\frac{\max\left(T_{clip}, V_{clip}\right)}{\phi V_{n.clip}}\right)^2} = 0.4905$$

Demand/Capacity Ratio:

$VandM_{int.clip} = "OK"$

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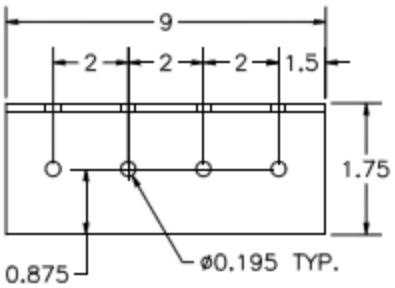
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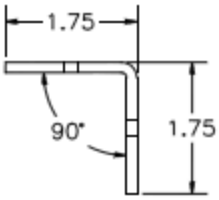
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Hold Down clip Block Shear





$b_{clip} := 1in$

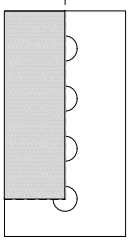
$s_{clip.sms} := 2in$

$b_{edge} := 1in$

(Figure shown as reference only)

Case 1 Block Shear Capacity: (Force in parallel direction of sms row)

CASE 1



$$A_{gv} := \left[b_{edge} + \left(n_{sms} - 1\right)\cdot s_{clip.sms}\right]\cdot t_{clip} = 1.626\cdot in^2$$

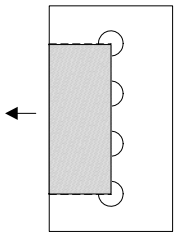
$$A_{nv} := \left[b_{edge} + \left(n_{sms} - 1\right)\cdot s_{clip.sms} - \frac{d_{sms}}{2}\right]\cdot t_{clip} = 1.614\cdot in^2$$

$$A_{nt} := t_{clip}\cdot\left(\frac{b_{clip}}{2} - \frac{d_{sms}}{2}\right) = 0.042\cdot in^2$$

$$\phi R_{n1} := 0.5\cdot\min\left(0.6\cdot F_y\cdot A_{gv} + F_u\cdot A_{nt}, 0.6\cdot F_u\cdot A_{nv} + F_u\cdot A_{nt}\right) = 26\,kip$$

Case 2 Block Shear Capacity: (Force in perpendicular direction of sms row)

CASE 2



$$A_{gv} := 2\cdot t_{clip}\cdot\frac{b_{clip}}{2} = 0.108\cdot in^2$$

$$A_{nv} := 2\cdot t_{clip}\cdot\left(\frac{b_{clip}}{2} - \frac{d_{sms}}{2}\right) = 0.085\cdot in^2$$

$$A_{nt} := t_{clip}\cdot\left[\left(n_{sms} - 1\right)\cdot s_{clip.sms} - d_{sms}\right] = 1.494\cdot in^2$$

$$\phi R_{n2} := 0.5\cdot\min\left(0.6\cdot F_y\cdot A_{gv} + F_u\cdot A_{nt}, 0.6\cdot F_u\cdot A_{nv} + F_u\cdot A_{nt}\right) = 50\,kip$$

Design Block Shear Capacity:

$$\phi R_n := \min\left(\phi R_{n1}, \phi R_{n2}\right) = 26\,kip$$

D/C Ratio of Block Shear:

$$DCR_{clip.blockshear} := \frac{\max\left(T_{clip}, V_{clip}\right)}{\phi R_n} = 0.03$$

$Blockshear_{clip}$ = "OK"

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Project: IBC 2018 Group A Job No. J13001 . 380

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CURB & ANCHORAGE DESIGN Engineer LK

Web Crippling/Compression of Non-iso CanFab Curb (AISI S100-16 G5)

Governing Compression for Non-Isolated Curb:

$$P_{web.crip.int} := \max\left[\frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}}, \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}}\right] \cdot L_{spacing.non.iso} = 1786 \cdot lbs$$

$$P_{web.crip.end} := 0.5 \cdot P_{web.crip.int} = 893 \cdot lbs$$

Yield Strength: $F_y := 50ksi$

Bearing Length: $N_{bearing} := L_{spacing.non.iso} = 15 \cdot in$

Thickness of Curb: $t_{Curb} = "12GA"$ $t := thick(t_{Curb}) = 0.1084 \cdot in$

Inside Bend Radius: $R := R_{curb} = 0.153 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web: $h := 36in - 2 \cdot (t + R) = 35.48 \cdot in$

Angle btween plane of web and bearing surface: $\theta := 90deg$

Web Crippling Limit Check (AISI Table G5-2): $\frac{R}{t} = 1$ $\frac{h}{t} = 327$ $\frac{N_{bearing}}{t} = 143$ $\frac{N_{bearing}}{h} = 0.44$

End Case Coefficient Single Web Channel (AISI Table G5-2): $C := 13$ $C_R := 0.32$ $C_N := 0.05$ $C_h := 0.04$

Reduction Factor Web Crippling Strength: $\phi_{web.end} := 0.9$ $\phi_{web.int} := 0.8$ **(For Unfastened partially Stiffened Flanges with Two-Flange Loading or Reaction.)**

Design Web Crippling Strength:

$$\phi P_{n.end} := \left(\phi_{web.end}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 1882 \cdot lbs$$

Interior Case Coefficient Single Web Channel (AISI Table G5-2): $C := 24$ $C_R := 0.52$ $C_N := 0.15$ $C_h := 0.001$

Design Web Crippling Strength:

$$\phi P_{n.interior} := \left(\phi_{web.int}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 11848 \cdot lbs$$

D/C Ratio of Shear: $DCR_{end} := \frac{P_{web.crip.end}}{2 \cdot \phi P_{n.end}} = 0.237$ $DCR_{int} := \frac{P_{web.crip.int}}{\phi P_{n.interior}} = 0.151$

Demand/Capacity Ratio: **Note: Factor of 2 for two ends connected together at the end**

$Web_{crippling} = "OK"$

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Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Length

Roof Curb thickness

$t_{Curb} = \text{"12GA"}$ $t_{curb} := thick(t_{Curb}) = 0.1084 \cdot in$

Min width of Roof Curb

$b_{curb} := L_{curb} + \frac{W_{curb}}{2} \cdot 2 + 3in \cdot 2 \cdot 2 = 116.56 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := L_{curb} + \min\left(\frac{W_{curb}}{2} \cdot 2, \frac{L_{curb}}{2}\right) = 101 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{array}{c} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{array} \right] \right] = 10273 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.L.vert.up} \cdot L_{curb}) \cdot (0.75in) = 5507 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.536$

$Curb_{BotFlangeBending} = \text{"OK"}$

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Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Width

Roof Curb thickness

$t_{Curb} = \text{"12GA"}$ $t_{curb} := thick(t_{Curb}) = 0.1084 \cdot in$

Min width of Roof Curb

$b_{curb} := W_{curb} + \frac{L_{curb}}{6} \cdot 2 + 3in \cdot 2 = 65.65 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := W_{curb} + \min\left(\frac{L_{curb}}{6} \cdot 2, W_{curb}\right) = 60 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{array}{c} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{array} \right] \right] = 5785 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.W.vert.up} \cdot W_{curb}) \cdot (0.75in) = 2918 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.504$

$Curb_{BotFlangeBending} = \text{"OK"}$

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Web Crippling/Compression of Iso CanFab Curb (AISI S100-16 G5)

Note: Curb stiffeners directly transfer the compressive load from isolator to the base. Therefore, curb web crippling is prevented.

Curb Web with Reinforcement

Max Compression: $Comp_{maxtot} := \max(|C_S|, |C_W|) = 8890.19 \cdot lbs$

Reinforcement per CFS: $CFS_{reinf} :=$ "Single Stiffener 10GA 1"x7"x1" Fy=50ksi 36" Tall on min. 16GA "

Note: min. of 10 GA channel and min. 16 GA curb web

Number of Reinforcement in Length: $n_{reinf} := 3$

Max Compression per Reinf: $Comp_{per.reinf} := \frac{Comp_{maxtot}}{n_{reinf}} = 2.963\ kip$

Spacing: $Spacing := \frac{L_{curb}}{n_{reinf}} = 22 \cdot in$ $KL_r := \frac{1.0 \cdot 3ft}{0.2339in} = 154$

Factored Nominal Comp. Capacity per reinforcement: $\phi P_{n.reinf} = 9.719 \cdot kip$ **(See attached CFS)**

Total Factored nominal Comp Capacity: $\phi P_{n.tot} := n_{reinf} \cdot \phi P_{n.reinf} = 29 \cdot kip$

D/C Ratio of Compression: $DCR := \frac{Comp_{maxtot}}{\phi P_{n.tot}} = 0.3$

$Comp_{reinf} := if(Comp_{maxtot} < \phi P_{n.tot}, "OK", "NG")$ $Comp_{reinf} = "OK"$

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Check CanFab Curb for Compressive Force due to T/C Coupling of Overturning

Note:
-Since the equipment is only attached to the longer sides of the CanFab Curb, most likely there will be compressive force onto the curb due to T/C coupling.
- Rectangular CanFab Curb will be considered as "Channel" to resist the compressive force.

Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Flanges*

Flat Width:

$$w := \frac{W_{curb}}{2} - R_{curb} = 18.441 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Unstiffened"}$$

Stress at the end of the Width:

$$f_2 := 50ksi \qquad f_1 := 50ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \left| \frac{f_2}{f_1} \right| = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 0.43$$

Critical Compressive Stress (Eq 1.1-4):

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w}\right)^2 = 0.4 \cdot ksi$$

Stress in Compression Element:

$$f := F_y = 50 \cdot ksi \qquad \textbf{(Assume f = Fy)}$$

Slenderness Factor (Eq 1.1-3):

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 11.23$$

Local reduction factor (Eq 1.1-2):

$$\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 0.087$$

Effective Width of the Flanges:

$$b_{eff.flange} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 1.609 \cdot in$$

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Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Web*

Flat Width: $w := L_{curb} - R_{curb} \cdot 2 = 67.07 \cdot in$

Stiffened Web Check: $Stiffened_{check} := \text{"Stiffened"}$

Stress at the end of the Width: $f_2 := 50ksi \qquad f_1 := 50ksi$

Compressive Stress Ratio (Eq. 1.1.2-1): $\Psi := \left| \frac{f_2}{f_1} \right| = 1$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 4$$

Critical Compressive Stress (Eq 1.1-4): $F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w} \right)^2 = 0.28 \cdot ksi$

Stress in Compression Element: $f := F_y = 50 \cdot ksi$ **(Assume f = Fy)**

Slenderness Factor (Eq 1.1-3): $\lambda := \sqrt{\frac{f}{F_{cr}}} = 13.4$

Local reduction factor (Eq 1.1-2): $\rho := \left(1 - \frac{0.22}{\lambda}\right) \frac{1}{\lambda} = 0.073$

Effective Width of the Web:

$$b_{eff.web} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 4.924 \cdot in$$

Effective Area of the Member: $A_e := 2 \cdot \left(b_{eff.flange} \cdot t_{curb} \right) + b_{eff.web} \cdot t_{curb} = 0.883 \cdot in^2$

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Length of the Compressive Member: $L_{curb.web} := h = 35.478 \cdot in$

Young's Modulus for Cold Form Steel: $E := 29500ksi$

Curb Shear Modulus: $G := 11300ksi$

Poisson's Ratio $\mu := 0.3$

Section Properties of the Member (From Section Properties Calculator):

$A_{half.curb} := 6.087in^2$ $r_o := 28.35in$ $I_x := 3577in^4$ $I_y := 311in^4$

$J := 0.006in^4$ $r_x := \sqrt{\frac{I_x}{A_{half.curb}}} = 24.241 \cdot in$ $r_y := \sqrt{\frac{I_y}{A_{half.curb}}} = 7.148 \cdot in$

$C_w := 209700in^6$ $r_{min} := \min(r_x, r_y) = 7.148 \cdot in$

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^2}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{(1.0 \cdot L_{curb.web})^2}\right] = 68373.739 \cdot ksi$$

$$\sigma_{e.y} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_y}\right)^2} = 11818.319 \cdot ksi \qquad \sigma_{e.x} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_x}\right)^2} = 135929.664 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2} = 11818.319 \cdot ksi$$

$$\frac{1.0 \cdot L_{curb.web}}{r_{min}} = 4.96$$

$KL_r = \text{"KL/r < 200, OK"}$

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 10076.592 \cdot ksi$$

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Nominal Compressive Stress Capacity: (Eq E2-4)

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 0.07$$

$$F_n := \begin{cases} 0.658^{\lambda_c^2} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^2}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 49.9 \cdot ksi$$

Compressive Capacity:

$$P_{n.member} := A_e \cdot F_n = 44.04 \cdot kip$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot P_{n.member} = 37.44 \cdot kip$$

Factored Max Compressive Force:

$$P_{comp.max} := \max\left(\left|C_S\right|, \left|C_W\right|\right) = 8.89\,kip$$

D/C Ratio of Compression:

$$DCR := \frac{P_{comp.max}}{\phi P_{n.member}} = 0.237$$

$$Axial_{curb.comp} := \text{if}\left(P_{comp.max} < \phi P_{n.member}, \text{"OK"}, \text{"Provide Channel from above as Web Stiffener"}\right)$$

$Axial_{curb.comp}$ = "OK"

Note: No need to check for interaction since the curb is only subjected to the compressive force.

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Shear of CanFab Curb Webs without Holes (AISI S100-16 G2)

Note: Since the unit is stiffer than the curb and the curb is firmly attached to the unit and to the base structure, curbs will mainly take the lateral forces as shear and axial load rather than bending.

Thickness of Curb:

$$t := \text{thick}(t_{Curb}) = 0.108 \cdot \text{in}$$

Depth-to-Thickness Ratio:

$$\frac{h}{t} = 327$$

Curb Elastic Modulus:

$$E := 29500\text{ksi}$$

Clear distance b/w transverse stiffeners of reinforced web:

$$a := \max\left(\frac{L_{curb}}{2}, W_{curb}\right) = 37 \cdot \text{in} \qquad \frac{a}{h} = 1.05$$

$$k_v := \begin{cases} 5.34 & \text{if } a = L_{curb} \\ 4.00 + \dfrac{5.34}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \dfrac{4.00}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 8.98$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 73 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 110$$

Curb Shear Check due to Load on Longer Side

Area of Web Element:

$$A_w := W_{curb} \cdot t = 4 \cdot \text{in}^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 2.2 \cdot \text{ksi}$$

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$V_{cr} := A_w \cdot F_{cr} = 9\,kip$ $V_y := 0.6 \cdot A_w \cdot F_y = 121\,kip$ $\lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 3.663$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 9.011 \cdot kip$$

Number of Members within Length: $n := 2$ **(Per Curb Design)**

Design Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 17120.9 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.H} := P_{net} \cdot L_{unit} \cdot H_{total} = 5751.1 \cdot lbs$

Design Shear Demand: $V_u := \max(V_{base.S}, V_{base.W.H}) = 5751.1 \cdot lbs$

D/C Ratio of Shear: $DCR := \frac{V_u}{\phi V_n} = 0.336$

Demand/Capacity Ratio:

$Shear_{in.plane} := \text{if}(V_u < \phi V_n, \text{"OK"}, \text{"NG"})$

$Shear_{in.plane} = \text{"OK"}$

Curb Shear Check due to Load on Shorter Side

Area of Web Element: $A_w := L_{curb} \cdot t = 7 \cdot in^2$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot (1 - \mu^2) \cdot \left(\frac{h}{t}\right)^2} = 2.2 \cdot ksi$$

$V_{cr} := A_w \cdot F_{cr} = 16\,kip$ $V_y := 0.6 \cdot A_w \cdot F_y = 219\,kip$ $\lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 3.663$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 16.326 \cdot kip$$

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Number of Members within Length: $n := 2$ **(Per Curb Design)**

Factored Nominal Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 31019 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot W_{unit} \cdot H_{total} = 4639.6 \cdot lbs$

Factored Shear Demand: $V_u := \max\left(V_{base.S}, V_{base.W.L}\right) = 4639.6 \cdot lbs$

D/C Ratio of Shear: $DCR := \dfrac{V_u}{\phi V_n} = 0.15$

Demand/Capacity Ratio:

$Shear_{in.plane} := \text{if}\left(V_u < \phi V_n, \text{"OK"}, \text{"NG"}\right)$

$Shear_{in.plane} = \text{"OK"}$

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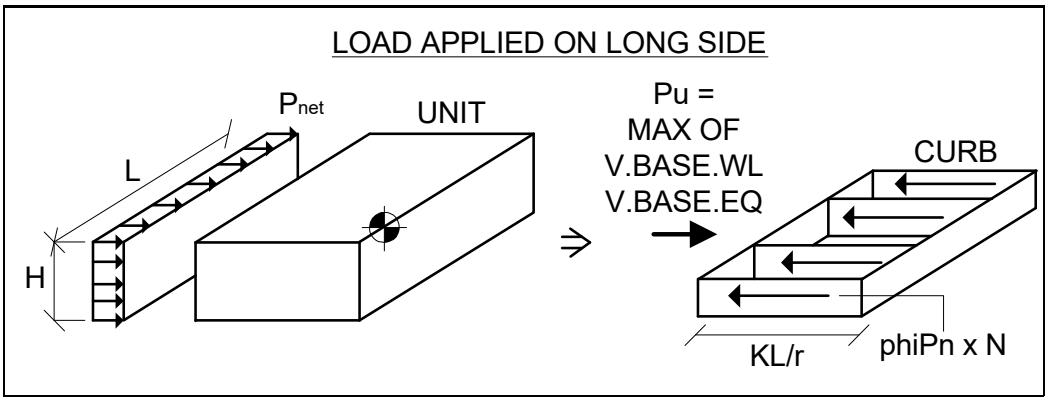
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Check CanFab Curb for In-Plane Axial due to EQ and Wind (AISI S100-16 E2)

Curb Axial Load Check due to Load on Long Side



Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot L_{unit} \cdot H_{total} = 5.8\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.L}) = 5751.11 \cdot lbs$

Member per CFS: $CFS_{member} :=$ "12GA Custom Curb 36" Tall L.b = 78in"

Max Braced Length of Member: $L_{member} := W_{curb} = 37 \cdot in$

Number of Curb in Length: $n_{curb.long} := 2$

Radius of gyration in y-axis: $r_{y.curb} := 0.521\,in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{2} = 2.88\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 71$ $KL_r =$ "KL/r < 200, OK"

Spacing: $Spacing := \frac{L_{curb}}{n_{curb.long}} = 34 \cdot in$

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 9.846 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.292$

$Axial_{short.curb} =$ "OK"

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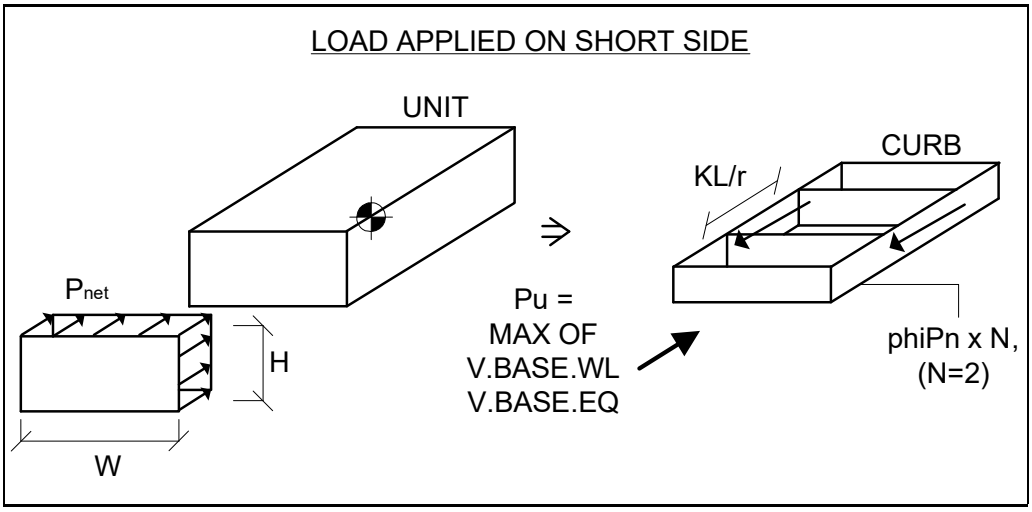
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Curb Axial Load Check due to Load on Short Side



Wind Base Shear on Short Side: $V_{base.W.H} := P_{net} \cdot W_{unit} \cdot H_{total} = 4.6\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.H}) = 4639.55 \cdot lbs$

Member per CFS: CFS_{member} = "12GA Custom Curb 36" Tall L.b = 78in"

Max Braced Length of Member: $L_{member} := \frac{L_{curb}}{n_{curb.long} - 1} = 67 \cdot in$

Number of Curb in Length: $n_{curb} := 2$

Radius of gyration in y-axis: $r_{y.curb} := 0.521\,in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{curb}} = 2.32\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 129$ KL_r = "KL/r < 200, OK"

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 9.846 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.236$

$Axial_{long.curb}$ = "OK"

A162

JOHN A. MARTIN and ASSOCIATES, INC. ☐ STRUCTURAL ENGINEERS

Architect: CANNON FABRICATION, INC. Sheet

Project: IBC 2018 Group A Job No. J13001 . 380

Date NOV/21/2018

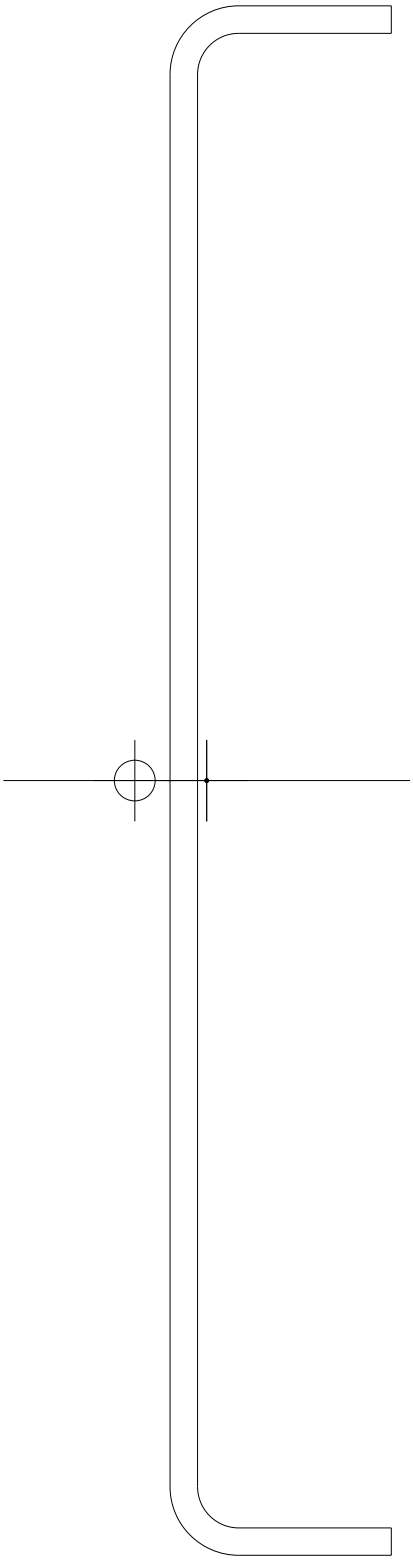
CURB & ANCHORAGE DESIGN Engineer LK

REFERENCE

CFS Version 10.0.0
Section: Section 2.cfss
Channel 7x1-10 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 11/18/2018 9:00:07 PM
By: Leonard Kim
Printed: 11/18/2018 9:05:49 PM



CFS Version 10.0.0

Section: Section 2.cfss
Channel 7x1-10 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 11/18/2018 9:00:07 PM
By: Leonard Kim
Printed: 11/18/2018 9:05:50 PM

Section Inputs

```
Material: A653 SS Grade 33
No strength increase from cold work of forming.
Modulus of Elasticity, E           29500 ksi
Yield Strength, Fy                    33 ksi
Tensile Strength, Fu                  45 ksi
Warping Constant Override, Cw          0 in^6
Torsion Constant Override, J           0 in^4

Channel, Thickness 0.1242 in (10 Gage)
Placement of Part from Origin:
X to center of gravity           0 in
Y to center of gravity           0 in
Outside dimensions, Open shape
        Length      Angle     Radius  Web      k    Hole Size   Distance
          (in)      (deg)       (in)         Coef.       (in)       (in)
  1     1.0000    180.000    0.18630 Single  0.000     0.0000     0.5000
  2     7.0000     90.000    0.18630 Cee     0.000     0.0000     3.5000
  3     1.0000      0.000    0.18630 Single  0.000     0.0000     0.5000
```

Member Check - 2016 North American Specification - US (LRFD)

```
Material Type: A653 SS Grade 33, Fy=33 ksi
Design Parameters:
Lx        1.5000 ft     Ly        1.5000 ft     Lt        1.5000 ft
Kx        1.0000        Ky        1.0000        Kt        1.0000
Cbx       1.0000        Cby       1.0000        ex        0.0000 in
Cmx       1.0000        Cmy       1.0000        ey        0.0000 in
Braced Flange: None     kϕ             0 k
Red. Factor, R: 0       Lm        1.5000 ft

Loads:           P         Mx         Vy         My         Vx
                (k)     (k-in)        (k)     (k-in)        (k)
Entered       0.000      0.000      0.000      0.000      0.000
Applied       0.000      0.000      0.000      0.000      0.000
Strength     21.066     49.218     14.903      2.066      3.222

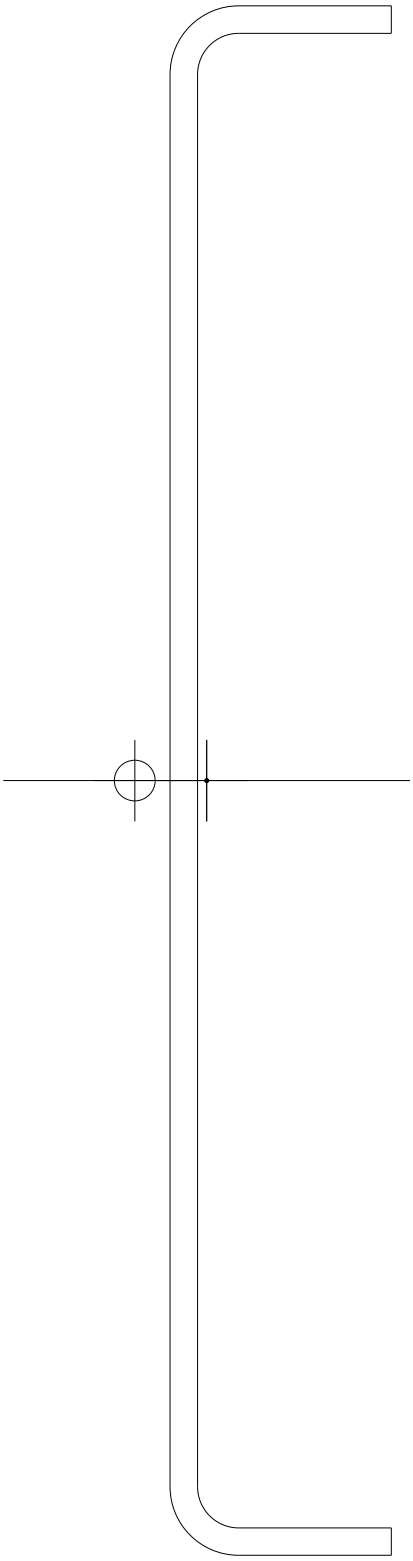
Effective section properties at applied loads:
Ae       1.06047 in^2   Ixe       5.8000 in^4   Iye       0.0580 in^4
                        Sxe(t)    1.6572 in^3   Sye(l)    0.3499 in^3
                        Sxe(b)    1.6572 in^3   Sye(r)    0.0696 in^3

Interaction Equations
NAS Eq. H1.2-1    (P, Mx, My)  0.000 + 0.000 + 0.000 = 0.000 <= 1.0
NAS Eq. H2-1         (Mx, Vy)     Sqrt(0.000 + 0.000)= 0.000 <= 1.0
NAS Eq. H2-1         (My, Vx)     Sqrt(0.000 + 0.000)= 0.000 <= 1.0
```

CFS Version 10.0.0
Section: Section 2.cfss
Channel 7x1-10 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 11/18/2018 9:00:07 PM
By: Leonard Kim
Printed: 11/18/2018 9:05:19 PM



CFS Version 10.0.0

Section: Section 2.cfss
Channel 7x1-10 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 11/18/2018 9:00:07 PM
By: Leonard Kim
Printed: 11/18/2018 9:05:19 PM

Section Inputs

```
Material: A653 SS Grade 33
No strength increase from cold work of forming.
Modulus of Elasticity, E           29500 ksi
Yield Strength, Fy                    33 ksi
Tensile Strength, Fu                  45 ksi
Warping Constant Override, Cw          0 in^6
Torsion Constant Override, J           0 in^4

Channel, Thickness 0.1242 in (10 Gage)
Placement of Part from Origin:
X to center of gravity           0 in
Y to center of gravity           0 in
Outside dimensions, Open shape
        Length      Angle     Radius  Web      k    Hole Size   Distance
          (in)      (deg)       (in)         Coef.       (in)       (in)
  1     1.0000    180.000    0.18630 Single  0.000     0.0000     0.5000
  2     7.0000     90.000    0.18630 Cee     0.000     0.0000     3.5000
  3     1.0000      0.000    0.18630 Single  0.000     0.0000     0.5000
```

Member Check - 2016 North American Specification - US (LRFD)

```
Material Type: A653 SS Grade 33, Fy=33 ksi
Design Parameters:
Lx        1.8333 ft     Ly        1.8333 ft     Lt        1.8333 ft
Kx        1.0000        Ky        1.0000        Kt        1.0000
Cbx       1.0000        Cby       1.0000        ex        0.0000 in
Cmx       1.0000        Cmy       1.0000        ey        0.0000 in
Braced Flange: None     kϕ             0 k
Red. Factor, R: 0       Lm        1.8333 ft

Loads:           P         Mx         Vy         My         Vx
                (k)     (k-in)        (k)     (k-in)        (k)
Entered       0.000      0.000      0.000      0.000      0.000
Applied       0.000      0.000      0.000      0.000      0.000
Strength     18.898     47.330     14.903      2.066      3.222

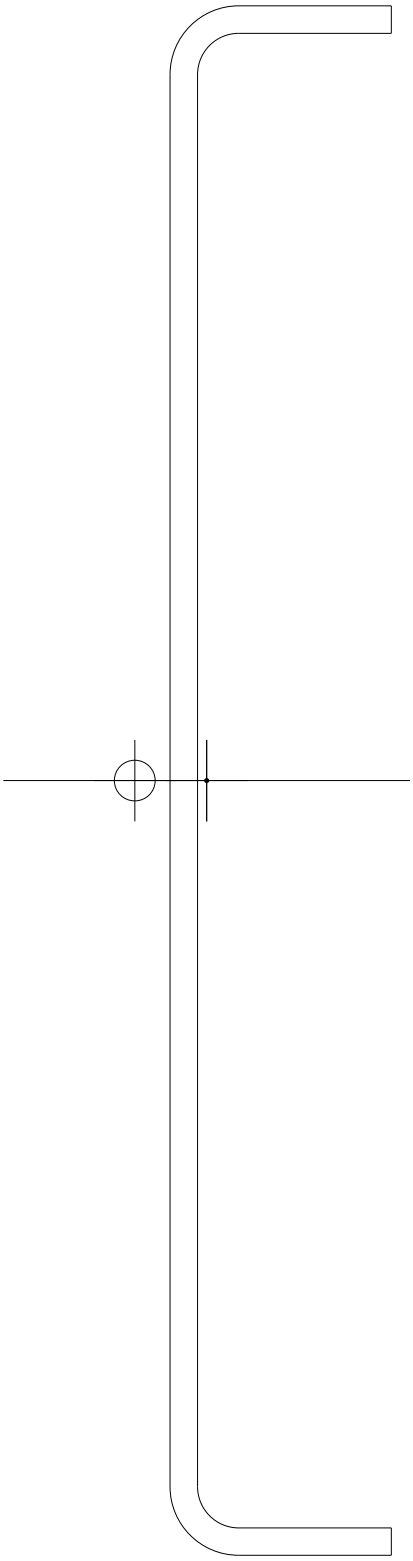
Effective section properties at applied loads:
Ae       1.06047 in^2   Ixe       5.8000 in^4   Iye       0.0580 in^4
                        Sxe(t)    1.6572 in^3   Sye(l)    0.3499 in^3
                        Sxe(b)    1.6572 in^3   Sye(r)    0.0696 in^3

Interaction Equations
NAS Eq. H1.2-1    (P, Mx, My)  0.000 + 0.000 + 0.000 = 0.000 <= 1.0
NAS Eq. H2-1         (Mx, Vy)     Sqrt(0.000 + 0.000)= 0.000 <= 1.0
NAS Eq. H2-1         (My, Vx)     Sqrt(0.000 + 0.000)= 0.000 <= 1.0
```

CFS Version 10.0.0
Section: Section 2.cfss
Channel 7x1-10 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 11/18/2018 9:00:07 PM
By: Leonard Kim
Printed: 11/18/2018 9:06:38 PM



CFS Version 10.0.0

Section: Section 2.cfss
Channel 7x1-10 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 11/18/2018 9:00:07 PM
By: Leonard Kim
Printed: 11/18/2018 9:06:38 PM

Section Inputs

```
Material: A653 SS Grade 33
No strength increase from cold work of forming.
Modulus of Elasticity, E           29500 ksi
Yield Strength, Fy                    33 ksi
Tensile Strength, Fu                  45 ksi
Warping Constant Override, Cw          0 in^6
Torsion Constant Override, J           0 in^4

Channel, Thickness 0.1242 in (10 Gage)
Placement of Part from Origin:
X to center of gravity           0 in
Y to center of gravity           0 in
Outside dimensions, Open shape
        Length      Angle     Radius  Web      k    Hole Size   Distance
          (in)      (deg)       (in)         Coef.       (in)       (in)
  1     1.0000    180.000    0.18630 Single  0.000     0.0000     0.5000
  2     7.0000     90.000    0.18630 Cee     0.000     0.0000     3.5000
  3     1.0000      0.000    0.18630 Single  0.000     0.0000     0.5000
```

Member Check - 2016 North American Specification - US (LRFD)

```
Material Type: A653 SS Grade 33, Fy=33 ksi
Design Parameters:
Lx        2.5000 ft     Ly        2.5000 ft     Lt        2.5000 ft
Kx        1.0000        Ky        1.0000        Kt        1.0000
Cbx       1.0000        Cby       1.0000        ex        0.0000 in
Cmx       1.0000        Cmy       1.0000        ey        0.0000 in
Braced Flange: None     kϕ             0 k
Red. Factor, R: 0       Lm        2.5000 ft

Loads:           P         Mx         Vy         My         Vx
                (k)     (k-in)       (k)     (k-in)       (k)
Entered       0.000      0.000      0.000      0.000      0.000
Applied       0.000      0.000      0.000      0.000      0.000
Strength     13.633     41.902     14.903      2.066      3.222

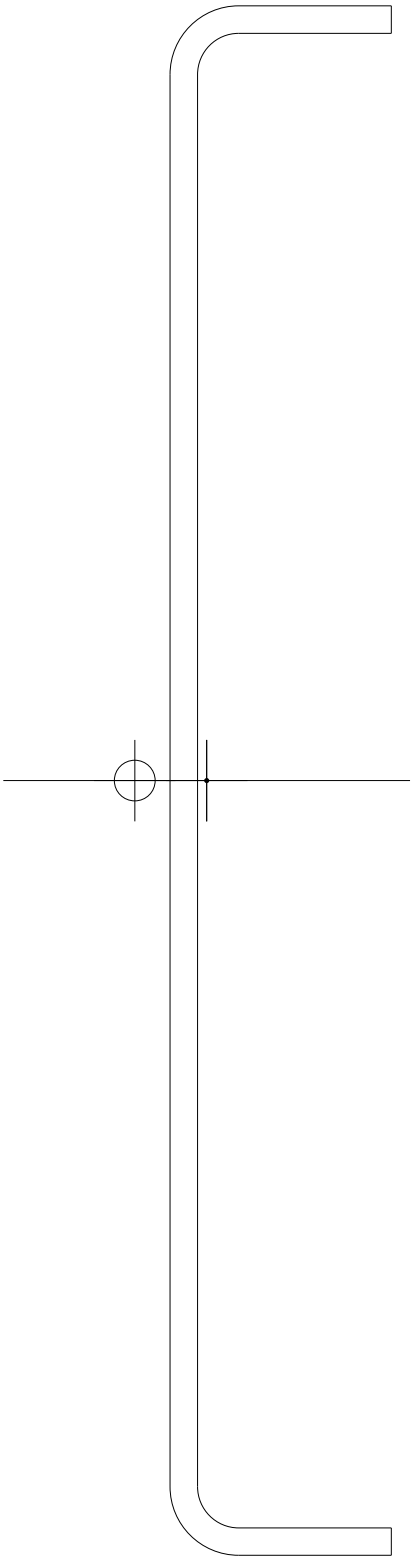
Effective section properties at applied loads:
Ae       1.06047 in^2   Ixe       5.8000 in^4   Iye       0.0580 in^4
                        Sxe(t)    1.6572 in^3   Sye(l)    0.3499 in^3
                        Sxe(b)    1.6572 in^3   Sye(r)    0.0696 in^3

Interaction Equations
NAS Eq. H1.2-1    (P, Mx, My)  0.000 + 0.000 + 0.000 = 0.000 <= 1.0
NAS Eq. H2-1         (Mx, Vy)     Sqrt(0.000 + 0.000)= 0.000 <= 1.0
NAS Eq. H2-1         (My, Vx)     Sqrt(0.000 + 0.000)= 0.000 <= 1.0
```

CFS Version 10.0.0
Section: Section 2.cfss
Channel 7x1-10 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 11/18/2018 9:00:07 PM
By: Leonard Kim
Printed: 11/18/2018 9:04:05 PM



CFS Version 10.0.0

Section: Section 2.cfss
Channel 7x1-10 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 11/18/2018 9:00:07 PM
By: Leonard Kim
Printed: 11/18/2018 9:04:06 PM

Section Inputs

```
Material: A653 SS Grade 33
No strength increase from cold work of forming.
Modulus of Elasticity, E           29500 ksi
Yield Strength, Fy                    33 ksi
Tensile Strength, Fu                  45 ksi
Warping Constant Override, Cw          0 in^6
Torsion Constant Override, J           0 in^4

Channel, Thickness 0.1242 in (10 Gage)
Placement of Part from Origin:
X to center of gravity           0 in
Y to center of gravity           0 in
Outside dimensions, Open shape
        Length      Angle     Radius  Web      k    Hole Size   Distance
          (in)      (deg)       (in)         Coef.       (in)       (in)
  1     1.0000    180.000    0.18630 Single  0.000     0.0000     0.5000
  2     7.0000     90.000    0.18630 Cee     0.000     0.0000     3.5000
  3     1.0000      0.000    0.18630 Single  0.000     0.0000     0.5000
```

Full Section Properties

```
Area      1.0605 in^2   Wt.    0.0036056 k/ft   Width     8.5384 in

Ix        5.8000 in^4   rx        2.3387 in     Ixy       0.0000 in^4
Sx(t)     1.6572 in^3   y(t)      3.5000 in     α          0.000 deg
Sx(b)     1.6572 in^3   y(b)      3.5000 in
                       Height    7.0000 in
Iy        0.0580 in^4   ry        0.2339 in     xo       -0.3251 in
Sy(l)     0.3499 in^3   x(l)      0.1658 in     yo        0.0000 in
Sy(r)     0.0696 in^3   x(r)      0.8342 in     jx        6.5817 in
                       Width     1.0000 in     jy        0.0000 in
I1        5.8000 in^4   r1        2.3387 in
I2        0.0580 in^4   r2        0.2339 in
Ic        5.8581 in^4   rc        2.3503 in     Cw       0.50479 in^6
Io        5.9701 in^4   ro        2.3727 in     J      0.0054528 in^4
```

Member Check - 2016 North American Specification - US (LRFD)

```
Material Type: A653 SS Grade 33, Fy=33 ksi
Design Parameters:
Lx        3.0000 ft     Ly        3.0000 ft     Lt        3.0000 ft
Kx        1.0000        Ky        1.0000        Kt        1.0000
Cbx       1.0000        Cby       1.0000        ex        0.0000 in
Cmx       1.0000        Cmy       1.0000        ey        0.0000 in
Braced Flange: None     kϕ             0 k
Red. Factor, R: 0       Lm        3.0000 ft

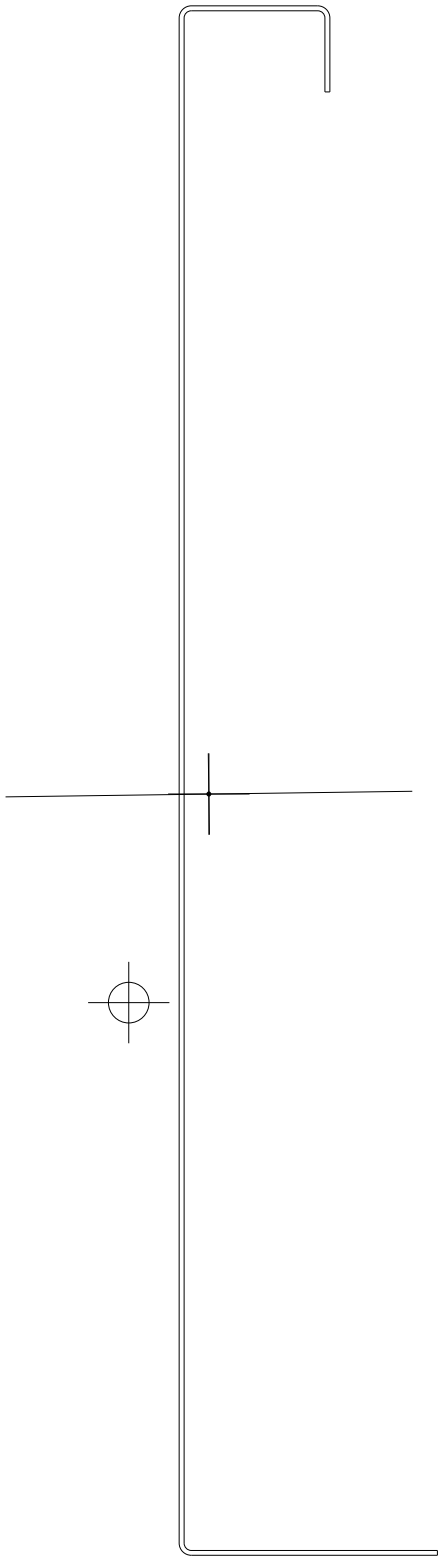
Loads:           P         Mx         Vy         My         Vx
                (k)     (k-in)        (k)     (k-in)        (k)
Entered       0.000      0.000      0.000      0.000      0.000
Applied       0.000      0.000      0.000      0.000      0.000
Strength      9.719     37.295     14.903      2.066      3.222
```

CFS Version 10.0.0

Section: Section 1.cfss
Channel 18x3x1-16 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 11/11/2018 9:08:33 PM
By: Leonard Kim
Printed: 11/11/2018 9:10:06 PM



CFS Version 10.0.0
Section: Section 1.cfss
Channel 18x3x1-16 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 11/11/2018 9:08:33 PM
By: Leonard Kim
Printed: 11/11/2018 9:10:06 PM

Section Inputs

```
Material: A653 SS Grade 50/1
No strength increase from cold work of forming.
Modulus of Elasticity, E           29500 ksi
Yield Strength, Fy                    50 ksi
Tensile Strength, Fu                  65 ksi
Warping Constant Override, Cw          0 in^6
Torsion Constant Override, J           0 in^4

Stiffened Channel, Thickness 0.0566 in (16 Gage)
Placement of Part from Origin:
X to center of gravity           0 in
Y to center of gravity           0 in
Outside dimensions, Open shape
        Length      Angle     Radius  Web      k    Hole Size   Distance
          (in)      (deg)       (in)         Coef.       (in)       (in)
  1      3.000    180.000   0.084900 Single  0.000      0.000      1.500
  2     18.000     90.000   0.084900 Cee     0.000      0.000      9.000
  3      1.750      0.000   0.084900 Single  0.000      0.000      0.875
  4      1.000    -90.000   0.084900 None    0.000      0.000      0.500
```

Full Section Properties

```
Area      1.3264 in^2   Wt.    0.0045097 k/ft   Width     23.434 in

Ix        51.769 in^4   rx         6.247 in     Ixy       -0.700 in^4
Sx(t)     5.6540 in^3   y(t)       9.156 in     α          0.784 deg
Sx(b)     5.8536 in^3   y(b)       8.844 in
                       Height    18.000 in
Iy         0.604 in^4   ry         0.675 in     xo        -0.931 in
Sy(l)     1.7526 in^3   x(l)       0.345 in     yo        -2.422 in
Sy(r)     0.2275 in^3   x(r)       2.655 in     jx        15.454 in
                       Width      3.000 in     jy         2.638 in
I1        51.778 in^4   r1         6.248 in
I2         0.594 in^4   r2         0.669 in
Ic        52.373 in^4   rc         6.284 in     Cw        34.519 in^6
Io        61.306 in^4   ro         6.799 in     J      0.0014164 in^4
```

Member Check - 2016 North American Specification - US (LRFD)

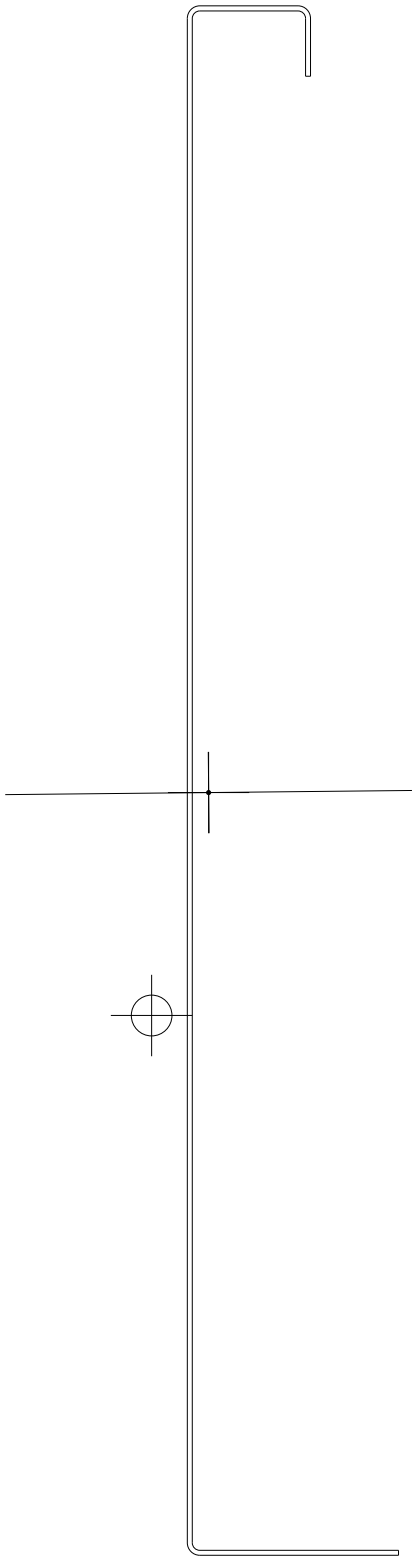
```
Material Type: A653 SS Grade 50/1, Fy=50 ksi
Design Parameters:
Lx        6.5000 ft     Ly        6.5000 ft     Lt        6.5000 ft
Kx        1.0000        Ky        1.0000        Kt        1.0000
Cbx       1.0000        Cby       1.0000        ex        0.0000 in
Cmx       1.0000        Cmy       1.0000        ey        0.0000 in
Braced Flange: None     kϕ             0 k
Red. Factor, R: 0       Lm        6.5000 ft

Loads:           P         Mx         Vy         My         Vx
                (k)     (k-in)        (k)     (k-in)        (k)
Entered      0.0000      0.000     0.0000      0.000     0.0000
Applied      0.0000      0.000     0.0000      0.000     0.0000
Strength     6.0182     86.821     1.1657      6.189     6.9775
```

CFS Version 10.0.0
Section: Section 2.cfss
Channel 22x3x1-14 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 11/11/2018 10:04:20 PM
By: Leonard Kim
Printed: 11/11/2018 10:05:35 PM



CFS Version 10.0.0
Section: Section 2.cfss
Channel 22x3x1-14 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 11/11/2018 10:04:20 PM
By: Leonard Kim
Printed: 11/11/2018 10:05:35 PM

Section Inputs

```
Material: A653 SS Grade 50/1
No strength increase from cold work of forming.
Modulus of Elasticity, E           29500 ksi
Yield Strength, Fy                    50 ksi
Tensile Strength, Fu                  65 ksi
Warping Constant Override, Cw          0 in^6
Torsion Constant Override, J           0 in^4

Stiffened Channel, Thickness 0.0713 in (14 Gage)
Placement of Part from Origin:
X to center of gravity           0 in
Y to center of gravity           0 in
Outside dimensions, Open shape
        Length      Angle     Radius  Web      k    Hole Size   Distance
          (in)      (deg)       (in)         Coef.       (in)       (in)
  1      3.000    180.000    0.10690 Single  0.000      0.000      1.500
  2     22.000     90.000    0.10690 Cee     0.000      0.000     11.000
  3      1.750      0.000    0.10690 Single  0.000      0.000      0.875
  4      1.000    -90.000    0.10690 None    0.000      0.000      0.500
```

Full Section Properties

```
Area      1.9502 in^2   Wt.    0.0066308 k/ft   Width     27.353 in

Ix        108.38 in^4   rx         7.455 in     Ixy        -1.12 in^4
Sx(t)      9.702 in^3   y(t)      11.170 in     α          0.594 deg
Sx(b)     10.007 in^3   y(b)      10.830 in
                       Height    22.000 in
Iy          0.77 in^4   ry         0.630 in     xo        -0.810 in
Sy(l)      2.552 in^3   x(l)       0.303 in     yo        -3.165 in
Sy(r)      0.287 in^3   x(r)       2.697 in     jx        22.700 in
                       Width      3.000 in     jy         3.415 in
I1        108.39 in^4   r1         7.455 in
I2          0.76 in^4   r2         0.625 in
Ic        109.15 in^4   rc         7.481 in     Cw        66.606 in^6
Io        129.97 in^4   ro         8.163 in     J      0.0033048 in^4
```

Member Check - 2016 North American Specification - US (LRFD)

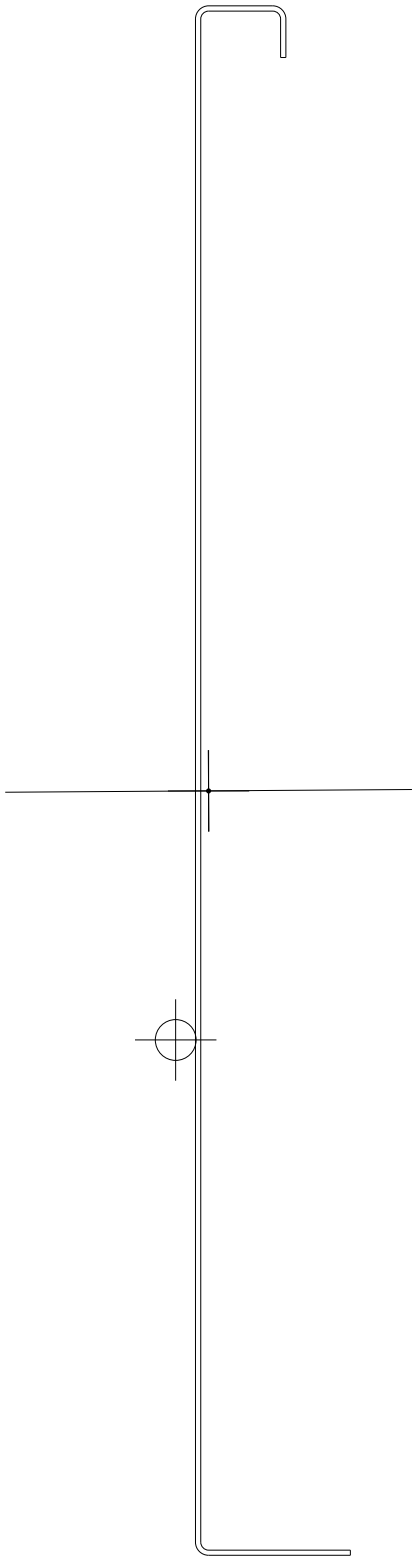
```
Material Type: A653 SS Grade 50/1, Fy=50 ksi
Design Parameters:
Lx        6.5000 ft     Ly        6.5000 ft     Lt        6.5000 ft
Kx        1.0000        Ky        1.0000        Kt        1.0000
Cbx       1.0000        Cby       1.0000        ex        0.0000 in
Cmx       1.0000        Cmy       1.0000        ey        0.0000 in
Braced Flange: None     kϕ             0 k
Red. Factor, R: 0       Lm        6.5000 ft

Loads:           P         Mx         Vy         My         Vx
                (k)     (k-in)        (k)     (k-in)        (k)
Entered      0.0000       0.00     0.0000       0.00     0.0000
Applied      0.0000       0.00     0.0000       0.00     0.0000
Strength     8.0434     134.22     1.9075       8.85     8.5659
```

CFS Version 10.0.0
Section: Section 1 30IN TALL 12 GA.cfss
Channel 30x3x1-12 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 11/11/2018 10:09:49 PM
By: Leonard Kim
Printed: 11/11/2018 10:10:48 PM



CFS Version 10.0.0
Section: Section 1 30IN TALL 12 GA.cfss Leonard Kim
Channel 30x3x1-12 Gage John A. Martin & Associates

Rev. Date: 11/11/2018 10:09:49 PM
By: Leonard Kim
Printed: 11/11/2018 10:10:49 PM

Section Inputs

```
Material: A653 SS Grade 50/1
No strength increase from cold work of forming.
Modulus of Elasticity, E           29500 ksi
Yield Strength, Fy                    50 ksi
Tensile Strength, Fu                  65 ksi
Warping Constant Override, Cw          0 in^6
Torsion Constant Override, J           0 in^4

Stiffened Channel, Thickness 0.1017 in (12 Gage)
Placement of Part from Origin:
X to center of gravity           0 in
Y to center of gravity           0 in
Outside dimensions, Open shape
        Length      Angle     Radius  Web      k    Hole Size   Distance
          (in)      (deg)       (in)         Coef.       (in)       (in)
  1      3.000    180.000    0.15250 Single  0.000      0.000      1.500
  2     30.000     90.000    0.15250 Cee     0.000      0.000     15.000
  3      1.750      0.000    0.15250 Single  0.000      0.000      0.875
  4      1.000    -90.000    0.15250 None    0.000      0.000      0.500
```

Full Section Properties

```
Area      3.5781 in^2   Wt.     0.012166 k/ft   Width     35.183 in

Ix        345.11 in^4   rx         9.821 in     Ixy        -2.32 in^4
Sx(t)     22.706 in^3   y(t)      15.199 in     α          0.387 deg
Sx(b)     23.318 in^3   y(b)      14.801 in
                       Height    30.000 in
Iy          1.11 in^4   ry         0.558 in     xo        -0.637 in
Sy(l)      4.397 in^3   x(l)       0.254 in     yo        -4.823 in
Sy(r)      0.406 in^3   x(r)       2.747 in     jx        41.980 in
                       Width      3.000 in     jy         5.132 in
I1        345.13 in^4   r1         9.821 in
I2          1.10 in^4   r2         0.554 in
Ic        346.23 in^4   rc         9.837 in     Cw        180.01 in^6
Io        430.90 in^4   ro        10.974 in     J       0.012336 in^4
```

Member Check - 2016 North American Specification - US (LRFD)

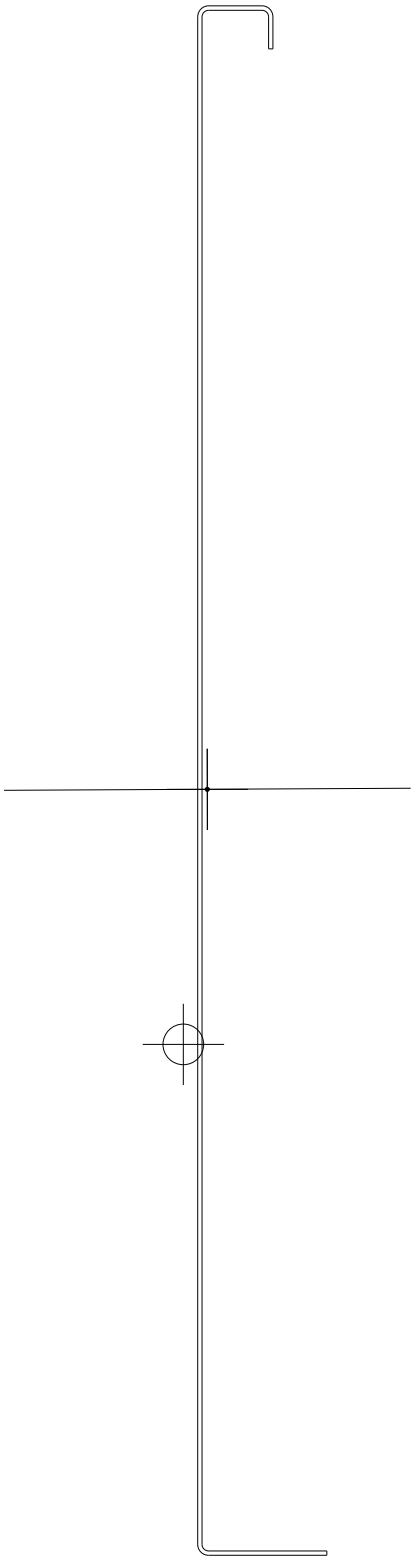
```
Material Type: A653 SS Grade 50/1, Fy=50 ksi
Design Parameters:
Lx        6.5000 ft     Ly        6.5000 ft     Lt        6.5000 ft
Kx        1.0000        Ky        1.0000        Kt        1.0000
Cbx       1.0000        Cby       1.0000        ex        0.0000 in
Cmx       1.0000        Cmy       1.0000        ey        0.0000 in
Braced Flange: None     kϕ             0 k
Red. Factor, R: 0       Lm        6.5000 ft

Loads:           P         Mx         Vy         My         Vx
                (k)     (k-in)        (k)     (k-in)        (k)
Entered       0.000       0.00      0.000       0.00      0.000
Applied       0.000       0.00      0.000       0.00      0.000
Strength     12.036     260.52      4.063      12.80     11.557
```

CFS Version 10.0.0
Section: Section 5.cfss
Channel 36x3x1-12 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 11/11/2018 10:23:02 PM
By: Leonard Kim
Printed: 11/11/2018 10:23:52 PM



CFS Version 10.0.0
Section: Section 5.cfss
Channel 36x3x1-12 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 11/11/2018 10:23:02 PM
By: Leonard Kim
Printed: 11/11/2018 10:23:53 PM

Section Inputs

```
Material: A653 SS Grade 50/1
No strength increase from cold work of forming.
Modulus of Elasticity, E           29500 ksi
Yield Strength, Fy                    50 ksi
Tensile Strength, Fu                  65 ksi
Warping Constant Override, Cw          0 in^6
Torsion Constant Override, J           0 in^4

Stiffened Channel, Thickness 0.1017 in (12 Gage)
Placement of Part from Origin:
X to center of gravity           0 in
Y to center of gravity           0 in
Outside dimensions, Open shape
        Length      Angle     Radius  Web      k    Hole Size   Distance
          (in)      (deg)       (in)         Coef.       (in)       (in)
  1      3.000    180.000    0.15250 Single  0.000      0.000      1.500
  2     36.000     90.000    0.15250 Cee     0.000      0.000     18.000
  3      1.750      0.000    0.15250 Single  0.000      0.000      0.875
  4      1.000    -90.000    0.15250 None    0.000      0.000      0.500
```

Full Section Properties

```
Area      4.1883 in^2   Wt.     0.014240 k/ft   Width     41.183 in

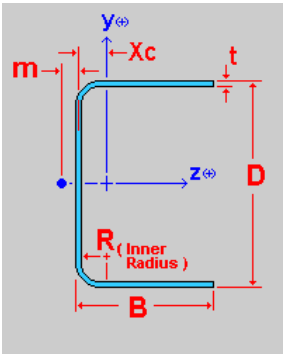
Ix        563.41 in^4   rx        11.598 in     Ixy        -2.80 in^4
Sx(t)     30.953 in^3   y(t)      18.202 in     α          0.285 deg
Sx(b)     31.657 in^3   y(b)      17.798 in
                       Height    36.000 in
Iy          1.14 in^4   ry         0.521 in     xo        -0.556 in
Sy(l)      5.074 in^3   x(l)       0.224 in     yo        -5.928 in
Sy(r)      0.409 in^3   x(r)       2.776 in     jx        60.364 in
                       Width      3.000 in     jy         6.254 in
I1        563.43 in^4   r1        11.598 in
I2          1.12 in^4   r2         0.518 in
Ic        564.55 in^4   rc        11.610 in     Cw        269.37 in^6
Io        713.01 in^4   ro        13.048 in     J       0.014440 in^4
```

Member Check - 2016 North American Specification - US (LRFD)

```
Material Type: A653 SS Grade 50/1, Fy=50 ksi
Design Parameters:
Lx        6.5000 ft     Ly        6.5000 ft     Lt        6.5000 ft
Kx        1.0000        Ky        1.0000        Kt        1.0000
Cbx       1.0000        Cby       1.0000        ex        0.0000 in
Cmx       1.0000        Cmy       1.0000        ey        0.0000 in
Braced Flange: None     kϕ             0 k
Red. Factor, R: 0       Lm        6.5000 ft

Loads:           P         Mx         Vy         My         Vx
                (k)     (k-in)        (k)     (k-in)        (k)
Entered       0.000       0.00      0.000       0.00      0.000
Applied       0.000       0.00      0.000       0.00      0.000
Strength      9.846     294.38      3.376      12.87     11.557
```

Shape Name : **Canfab Group A**
Database : **AISI Custom**
Shape Type : **CU**
Material : **Cold Formed**



D	:	61.75	in	J	:	.006	in^4
B	:	23	in	Cw	:	209700	in^6
t	:	.057	in	ro	:	28.35	in
R	:	.085	in	Xc	:	4.907	in
Area	:	6.087	in^2	m	:	7.934	in
Iyy	:	310.801	in^4	j	:	34.444	in
Izz	:	3577.482	in^4				

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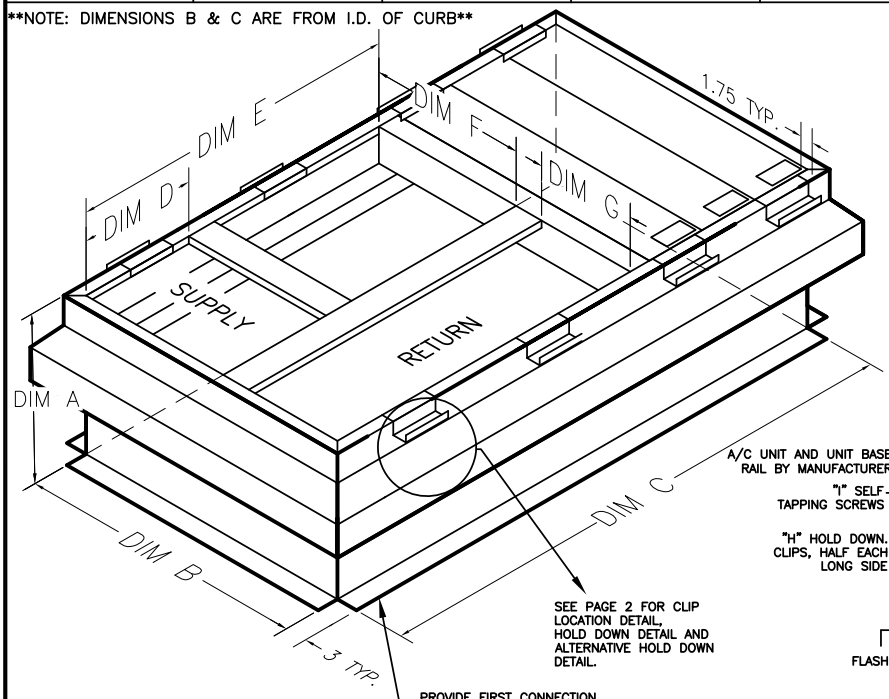
6 Ton

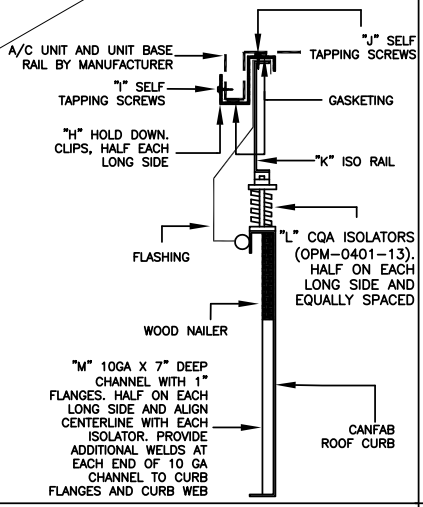
FOR: GROUP A ISO
CARRIER 3 - 6-1/2 TONS
48/50HC/GC 04-06, 50HCQ 04-06, 50 KCQ 04-06, 48/50LC 04-06, 48/50TC/FC 04-07, 50TCQ 04-07, 48/50KC/FC 04-06

PART NO: 1006-IC

DIM A	DIM B	DIM C	DIM D	DIM E	DIM F	DIM G	DIM H
VARIES MAX 36" SEE TABLE 3	37.1875"	67.375"	14.1875"	32.1875"	20.25"	13.875"	N/A

NOTE: DIMENSIONS B & C ARE FROM I.D. OF CURB





6 TON (FC TYPE)
14" TALL
346 LBS.

NOTE: FINISH CURB HEIGHT IS 13.5" TALLER THAN DIMENSION A.

ALL WORK SHALL CONFORM TO THE STANDARD OF 2018 INTERNATIONAL BUILDING CODE & 2019 CALIFORNIA BUILDING CODE.

SEISMIC DESIGN CRITERIA
-SDS = 1.5 ap = 2.5
-I = 1.5 Rp = 2.0

WIND DESIGN CRITERIA
-MAX 60 FT TALL BUILDING
-EXPOSURE C
-175 MPH, 3 SECOND GUST WIND

NOTE:
INSTALLER TO VERIFY WITH A LICENSED STRUCTURAL ENGINEER IN THE CORRESPONDING STATE THE ADEQUACY OF THE STRUCTURE FOR LOADS IMPOSED BY THE UNIT AND THE CURB IN ADDITION TO ALL OTHER LOADS.
-INSTALLER TO VERIFY WITH A LICENSED STRUCTURAL ENGINEER IN THE CORRESPONDING STATE THAT THE SEISMIC AND WIND DESIGN CRITERIA NOTED ON THIS DRAWING ARE ADEQUATE FOR THE SITE SPECIFIC VALUES. OTHERWISE, CONTACT CANNON FABRICATION FOR A SITE SPECIFIC ANALYSIS AND DRAWINGS.

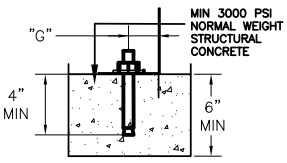
CURB CONSTRUCTION
1) ☐ WELDED
2) ☐ BOLTED
3) ☐ FINGERLOCK
-ALL WELDING CONSTRUCTION CERTIFIED TO ANSI/AWS D1.3 STRUCTURAL WELDING CODE-SHEET METAL
-SELF-DRILLING SCREW SHALL MEET ASTM C1513 SPECIFICATION AND INSTALLED PER AISI-S100
-NO GAP IS ALLOWED BETWEEN TWO METAL SHEET SURFACES WHERE SHEET METAL SCREW IS CONNECTED

CURB AND UNIT INFORMATION
"A" GAUGE GALVANIZED STEEL CURB

-SEE TABLE 3 FOR ALLOWABLE CURB AND UNIT DIMENSIONAL AND WEIGHT

-SEE TABLE 4 FOR TABULATED CURB AND ANCHORAGE INFORMATION PER VARYING CURB HEIGHT

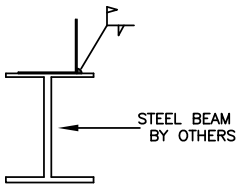
- ALPHA DESIGNATIONS "A" THRU "M", CAN BE FOUND ON TABLE 4, PAGE 3



ATTACHMENT TO STRUCTURAL CONCRETE

"B" 5/8" HILTI KWIK BOLT TZ SS 304, HALF EACH LONG SIDE.
"C" 5/8" HILTI KWIK BOLT TZ SS 304, HALF EACH SHORT SIDE.

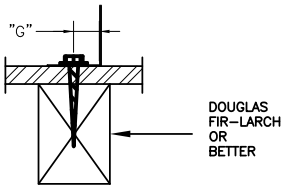
NOTE:
-MIN 5" AWAY FROM THE NEAREST CONCRETE EDGE (INSTALL PER ICC-ES ESR-1917).
-STRUCTURALLY ACCEPTABLE TO SUBSTITUTE HILTI KBTZ STAINLESS STEEL BOLTS WITH HILTI KBTZ CARBON STEEL BOLTS ONLY IF ALL THE BOLTS ARE COMPLETELY WATERPROOFED AND PROTECTED AGAINST THE WEATHER.
-BOLTS SHALL BE EQUALLY SPACED



ATTACHMENT TO STRUCTURAL STEEL

1/8" FILLET WELD, 2" LONG, "D" ON CENTER.

NOTE:
-PROVIDE MIN 2 CONNECTIONS WHERE THE CURB SIDE IS SHORTER THAN THE WELD SPACING.
-PROVIDE WELDS ON ALL SIDES



ATTACHMENT TO WOOD

"E" 3/8"x4" LAG SCREWS, HALF EACH LONG SIDE.
"F" 3/8"x4" LAG SCREWS, HALF EACH SHORT SIDE.

NOTE:
-SCREWS SHALL BE EQUALLY SPACED.

STRUCTURAL REVIEW BY:
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JOHN A. MARTIN AND ASSOCIATES
Structural Engineers
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Los Angeles, California 90015
Phone (213) 483 6490
Fax (213) 483 3084
Job No.: 19022

REGISTERED PROFESSIONAL ENGINEER
GREGORY LOUIS OROZCO
No. 4957
STRUCTURAL
STATE OF CALIFORNIA

3/22/2019

PROJECT: IBC 2018 UPDATE/ CBC 2019 UPDATE DATE: 3.12.19

ENGINEER: LD DISTRIBUTOR:

DRAWING NUMBER: GROUP_A_ISO.DWG

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182 GRANITE STREET, SUITE 101, CORONA, CA 92879
PHONE: (951)278-1830 FAX: (951)278-8444 www.canfab.com canfab@canfab.com

FOR: GROUP A ISO

PART NO: SEE BELOW

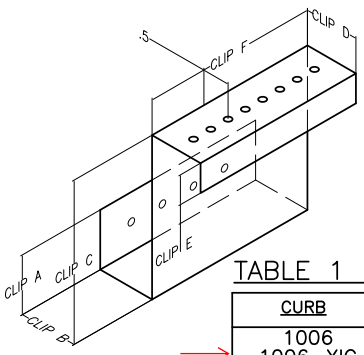
STRUCTURAL REVIEW BY:

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No. 4957
STRUCTURAL
STATE OF CALIFORNIA

3/22/2019

HOLD DOWN DETAIL



NOTE:
SEE TABLE 1 FOR DESIGNATED HOLD DOWN CLIP PER CURB

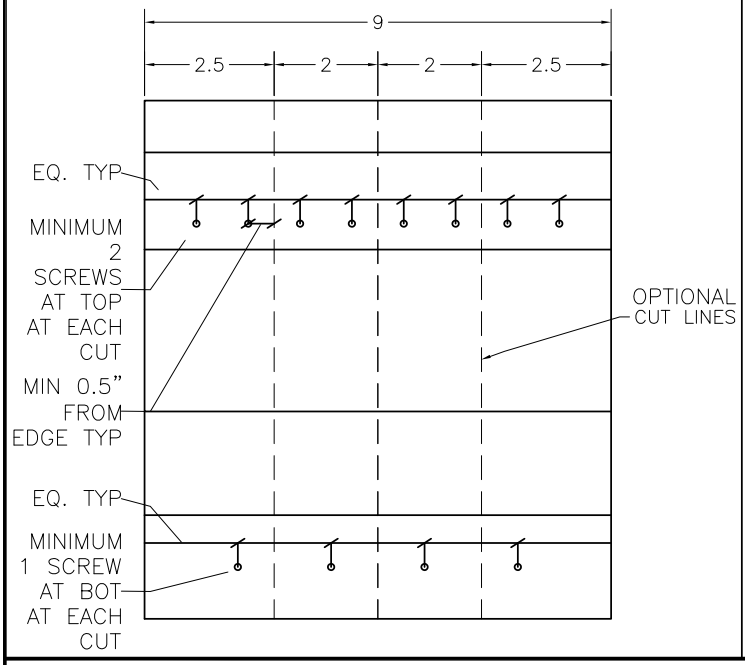
TABLE 1 HOLD DOWN CLIP PER CURB

CURB	CLIP	GAUGE	CLIP A [IN]	CLIP B [IN]	CLIP C [IN]	CLIP D [IN]	CLIP E [IN]	CLIP F [IN]
1006 1006-XIC 6060	1909-SHD8-12	12 GA	1.5	2.625	4.5625	1.875	1.0	9.0
3004	3901-SHD8-12	12 GA	1.0	4.81	3.875	2.125	1.0	9.0
4028	4901-SHD8-12	12 GA	2.0	3.0625	4.625	1.875	1.0	9.0
6038	6907-SHD8-12	12 GA	2.0	2.0	3.25	1.875	1.0	9.0

ALTERNATIVE HOLD DOWN DETAIL

NOTE:
APPLICABLE ONLY FOR 9" LONG HOLD DOWN WITH (8) SCREWS AT TOP AND (4) SCREWS AT BOT EQUALLY SPACED

1. INFORMATION SHOWN ON THE STAMPED CANFAB CURB DRAWING IS THE MINIMUM REQUIREMENTS FOR THE CURB CONSTRUCTION AND INSTALLATION. NO STRUCTURAL OBJECTION TO THE USE OF LARGER SIZE SCREWS AND THICKER GAUGE SHEET METAL THAN THE INFORMATION SHOWN ON THE STAMPED CANFAB CURB DRAWING.
2. NO STRUCTURAL OBJECTION TO SHIFTING THE ATTACHMENT CLIPS ALONG THE CURB. FIRST AND LAST CLIP IN THE SERIES OF CLIPS SHALL BE LOCATED PER CLIP LOCATION DETAIL PER STAMPED CANFAB CURB DRAWING. DISTANCE SHIFTED SHALL NOT BE LARGER THAN THE LENGTH OF THE CLIP.
3. NO STRUCTURAL OBJECTION TO CUTTING THE ATTACHMENT CLIPS PER REQUIREMENTS AS SHOWN ON BELOW SKETCH.



CLIP LOCATION DETAIL

NOTE:
SEE TABLE 2 FOR CLIP LOCATION

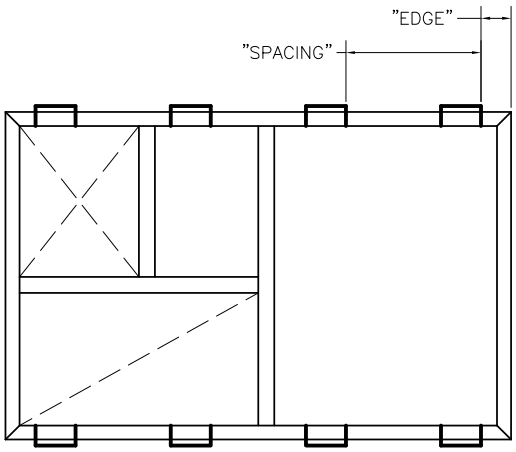


TABLE 2 CLIP LOCATION

CURB	EDGE [IN]	SPACING [IN]
1006, 1006-XIC, 6060	7.75	15.46
3004	7.75	19.00
4028	7.75	18.33
6038	7.75	16.58

PROJECT: IBC 2018 UPDATE/ CBC 2019 UPDATE DATE: 3.12.19

ENGINEER: LD DISTRIBUTOR:

DRAWING NUMBER: GROUP_A_ISO.DWG

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FOR: GROUP A ISO

PART NO: SEE BELOW

STRUCTURAL REVIEW BY:

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Fax (213) 483 3084
Job No.: 19022

REGISTERED PROFESSIONAL ENGINEER GREGORY LOUIS OROZCO No. 4957 STRUCTURAL STATE OF CALIFORNIA

3/22/2019

TABLE 3 ALLOWABLE CURB AND UNIT DIMENSION AND WEIGHT

RELATED CURBS	LCURB [IN]	WCURB [IN]	HCURB [IN]	WTCURB [LBS]	LUNIT [IN]	WUNIT [IN]	HUNIT [IN]	WTUNIT [LBS]	CG.LONG [IN]	CG.SHORT [IN]	CG.HEIGHT [IN]
1006 1006-XIC	SEE PAGE 1	SEE PAGE 1	MIN 8	MIN 298,301	74.375	46.75	41.375	MAX 900 FOR 1006 MAX 1100 FOR 1006-XIC	34.625	22.5	20.25
			11	321, 324							
			14	343, 346							
			18	372, 375							
			24	479, 482							
			MAX 36	MAX 592,595							
3004	SEE PAGE 1	SEE PAGE 1	MIN 8	MIN 266	82.25	44.875	32.625	MAX 900	38.6	18.75	HUNIT/2
			11	294							
			14	322							
			18	358							
			24	469							
			MAX 36	MAX 604							
4028	SEE PAGE 1	SEE PAGE 1	MIN 8	MIN 352	83.25	45	43.375	MAX 1316	47	22	HUNIT/2
			11	381							
			14	408							
			18	445							
			24	551							
			MAX 36	MAX 706							
6038	SEE PAGE 1	SEE PAGE 1	MIN 8	MIN 292	69.875	44.25	40.875	MAX 1202	44	22	HUNIT/2
			11	314							
			14	341							
			18	375							
			24	488							
			MAX 36	MAX 614							
6060	SEE PAGE 1	SEE PAGE 1	MIN 8	MIN 300	76.841	47.934	42.004	MAX 869	42	29	HUNIT/2
			11	323							
			14	345							
			18	375							
			24	482							
			MAX 36	MAX 596							

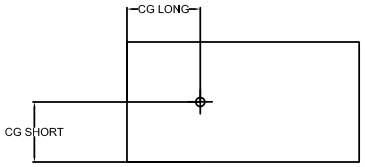


TABLE 4 TABULATED CURB AND ANCHORAGE INFORMATION PER VARYING HEIGHT

		0 < H ≤ 18"	18" < H ≤ 22"	22" < H ≤ 30"	30" < H ≤ 36"
A	CURB THICKNESS	14 GA	14 GA	12 GA	12 GA
B	EXP. ANCHOR	6	6	8	8
C	EXP. ANCHOR	4	4	6	6
D	WELD	24"	24"	24"	18"
E	SCREWS	24	26	28	32
F	SCREWS	12	14	14	14
G	DISTANCE	MAX 0.75"	MAX 0.75"	MAX 0.75"	MAX 0.75"
H	NO. OF CLIPS	8	8	8	8
I	CLIP SMS	(4) #14	(4) #14	(4) #14	(4) #14
J	CLIP SMS	(8) #14	(8) #14	(8) #14	(8) #14
K	ISO RAIL	10 GA 7.5" DEEP X 1" FLANGES			
L	NO. OF ISOLATORS	6 FOR 1006, 3004 AND 6060, 7 FOR 1006 XIC, 8 FOR 4028 AND 6038			
M	NO. OF STIFFENERS	6 FOR 1006, 3004 AND 6060, 7 FOR 1006 XIC, 8 FOR 4028 AND 6038			

PROJECT: IBC 2018 UPDATE/ CBC 2019 UPDATE DATE: 3.12.19

ENGINEER: LD DISTRIBUTOR:

DRAWING NUMBER: GROUP_A_ISO.DWG

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FOR:

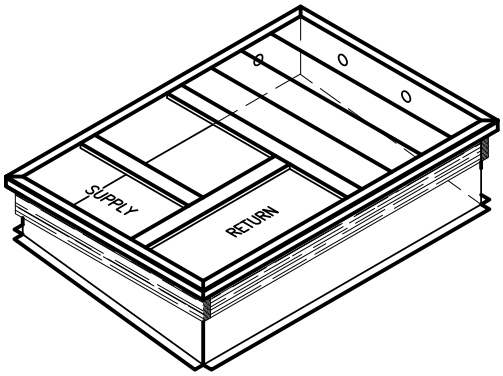
PART NO:

Pitched Roof Curb

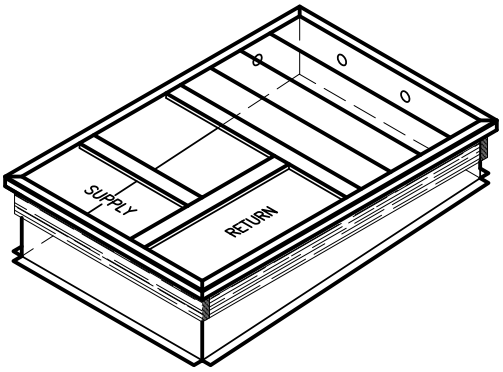
Drawing Must Accompany All Pitched Curb Orders

APPLIES TO STANDARD AND ISOLATION CURBS

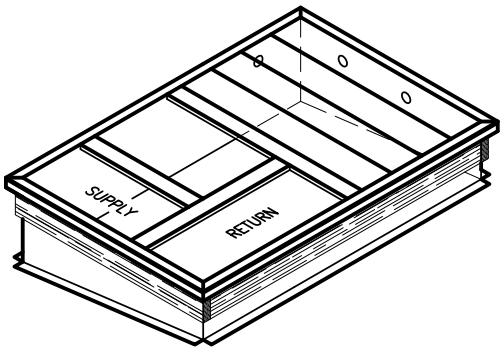
(A)



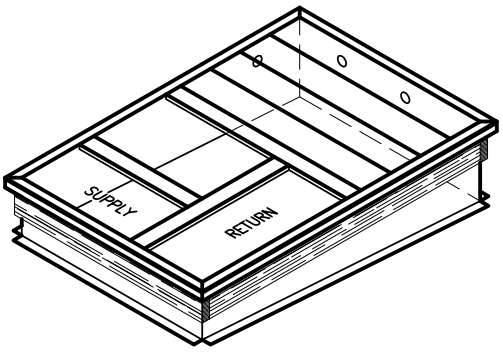
(B)



(C)



(D)



_____ On 12"

(Circle A, B, C or D To Specify Duct Placement)

PROJECT:

DATE: 01.08.19

ENGINEER:

DISTRIBUTOR:

DRAWING NUMBER:

STRUCTURAL CALCULATIONS

for

IBC 2018
Group A

ISOLATED CURB

1006 XIC (Max Curb Height up to 36")

CURB AND ANCHORAGE WIND & SEISMIC DESIGN

Prepared for:

Cannon Fabrication, Inc. (CanFab)
182 Granite Street, Suite 101
Corona, California 92879
951.278.1830 (p)

Prepared by:

John A. Martin & Associates, Inc.
950 South Grand Avenue, 4th Floor
Los Angeles, California 90015
213.483.6490 (p)

JAMA Project No. J13001. 380
PO# 12751
NOV/21/2018

THE CURB HAS BEEN DESIGNED FOR SDS = 1.5G, I = 1.5 AND WIND REGION V = 175MPH. FOR HIGH SEISMIC REGIONS WITH SDS > 1.5G, I > 1.5 OR WIND REGIONS V > 175MPH, FURTHER ANALYSIS AND MODIFICATIONS TO THE CURB ARE REQUIRED PRIOR TO CONSTRUCTION

THE SUPPORTING STRUCTURE SHALL BE REVIEWED AND APPROVED BY OTHERS. BUILDING ENGINEER OF RECORD SHALL PROVIDE SUPPORT STRUCTURE AND VERIFY THE ADEQUACY OF THE STRUCTURE FOR LOADS IMPOSED ON THEM BY UNIT AS WELL AS ALL OTHER LOADS.

NO INSTALLATION SHALL TAKE PLACE UNTIL THE CURB, ANCHORAGE AND SUPPORTING STRUCTURE ARE APPROVED BY THE APPROPRIATE JURISDICTION.



11/26/2018

JOHN A. MARTIN & ASSOCIATES, INC.
Structural Engineers

PREPARED BY LK

DESIGN
for
ISOLATED CURB
1006 XIC (Max Curb Height of 18")

Design Wind Loads for Rooftop Equipment (ASCE 7-16 § Table 29.1-1)

$z := 60ft$ — **Height above ground level**

$B := 60ft$ — **Horizontal dimension of building measured normal to wind direction**

$Exp_{category} := "C"$ — **Exposure Category per ASCE 7-16 § 26.7**

$Risk_{category} := "IV"$ — **Risk Category per ASCE 7-16 Table 1.5-1**

$$V := \begin{cases} 0mph & \text{if } Risk_{category} = "I" \\ 0mph & \text{if } Risk_{category} = "II" \\ 175mph & \text{otherwise} \end{cases} = 175 \cdot mph$$

Basic Wind Speed per ASCE 7-16 Figure 26.5-1 A,B or C

$K_z = 1.14$ — **Velocity Pressure Exposure Coefficient per ASCE 7-16 Table 29.10-1 [Exposure Category "C"]**

$K_{zt} := 1.0$ — **Topographic Factor per ASCE 7-16 § 26.8, Figure 26.8-1**

$K_e := 1.0$ — **Ground Elevation Factor per ASCE 7-16 § 26.9, Table 26.9-1**

$K_d := 0.85$ — **Wind Directionality Factor per ASCE 7-16 § 26.6, Table 26.6-1 (Equipment)**

$q_z := 0.00256 K_z \cdot K_{zt} \cdot K_d \cdot K_e \cdot V^2 = 75.74 \cdot psf$ — **Velocity pressure evaluated at height z above ground per ASCE 7-10 § 26.10.2; Eq. 26.10-1**

$GC_{r.lateral.max} := 1.9$ — **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.9 for rooftop structures and equipment with Af less than (0.1Bh). (GCr) shall be permitted to be reduced linearly from 1.9 to 1.0 as the value of Af is increased from (0.1Bh) to (Bh)

$GC_{r.vertical.max} := 1.5$ — **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.5 for rooftop structures and equipment with A_r less than (0.1*BL*). (GC_r) shall be permitted to be reduced linearly from 1.5 to 1.0 as the value of A_r is increased from (0.1*BL*) to (*BL*)

$P_{net} := q_z \cdot GC_{r.lateral.max} = 143.91 \cdot psf$ — **Design Lateral Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-2**

$P_v := q_z \cdot GC_{r.vertical.max} = 113.61 \cdot psf$ — **Design Vertical Uplift Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-3**

Seismic Demands on Nonstructural Components (ASCE 7-16 § 13.3 & 13.6):

$S_{DS} := 1.5$ — **Design spectral response acceleration parameter at short periods per USGS map**

$I_p := 1.5$ — **Component importance factor ASCE 7-16 § 13.1.3**

$\Omega_0 := 2.0$ — **Overstrength factor ASCE 7-16 Table 13.6.1**

Vibr_Isolation = "Yes" — **Placement of Unit Vibration Isolated:**

Note: Only "F_p" at seismic concrete anchor has been increased with overstrength factor "Ω_0"

$a_p := 2.5$ $R_p = 2.0$ — **Seismic coefficients a_p & R_p**
Per ASCE 7-16 Table 13.6-1 for
Mechanical & Electrical Components

$z = 60\,ft$ — **Height in structure of point of attachment of component with respect to the base**

$h := 60ft$ — **Average roof height of structure with respect to the base**
Where for roof top equipment:

$z \div h = 1$

F_p: Horizontal Seismic Design Force per *ASCE7-16 § 13.3.1*

F_p shall be takes as $\left(\frac{0.4 \cdot a_p \cdot S_{DS} \cdot I_p}{R_p}\right) \cdot \left(1 + 2 \cdot \frac{z}{h}\right) \cdot W_p = 337.5 \cdot \%_{\cdot} W_p$

F_p is not required to be taken as greater than $\left(1.6 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 360 \cdot \%_{\cdot} W_p$

F_p shall not be taken as less than $\left(0.3 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 67.5 \cdot \%_{\cdot} W_p$

Governing F_p : Horizontal Seismic Design Force $F_p = 337.5 \cdot \%_{\cdot} W_p$

F_v: Vertical Load per ASCE7-16 § 13.3.1.2

Concurrent Vertical Seismic Force: $F_v := 0.2 \cdot S_{DS} \cdot W_p = 30 \cdot \%_{\cdot} W_p$

Flat Roof Snow Loads (ASCE 7-16 § 7.3):

$Terrain_{CAT} := "C"$ — **Terrain Category ASCE 7-16 § 26.7 & Table 7.3-1**

$Exp_{Roof} := "Partially\ Exposed"$ — **Exposure of Roof ASCE 7-16 Table 7.3-1**

$C_e = 1$ — **Exposure Factor ASCE 7-16 Table 7.3-1**

$Thermal_{condition} := "All\ structures\ except\ below"$ — **Thermal Condition ASCE 7-16 Table 7.3-2**

$C_t = 1$ — **Thermal Factor ASCE 7-16 Table 7.3-2**

$Risk_{category} = "IV"$ — **Risk Category per ASCE 7-16 Table 1.5-1**

$I_s = 1.2$ — **Snow Importance Factor ASCE 7-16 Table 1.5-2**

$p_g := 40psf$ — **Ground Snow Loads ASCE 7-16 Figure 7.2-1**

$$p_f := \max\left(0.7 \cdot C_e \cdot C_t \cdot I_s \cdot p_g, \text{if}\left(p_g > 20psf, 20psf \cdot I_s, I_s \cdot p_g\right)\right) = 34 \cdot psf$$

Flat Roof Snow Loads ASCE 7-16 Equation 7.3-1 and § 7.3.4

Mechanical Unit Dimensions

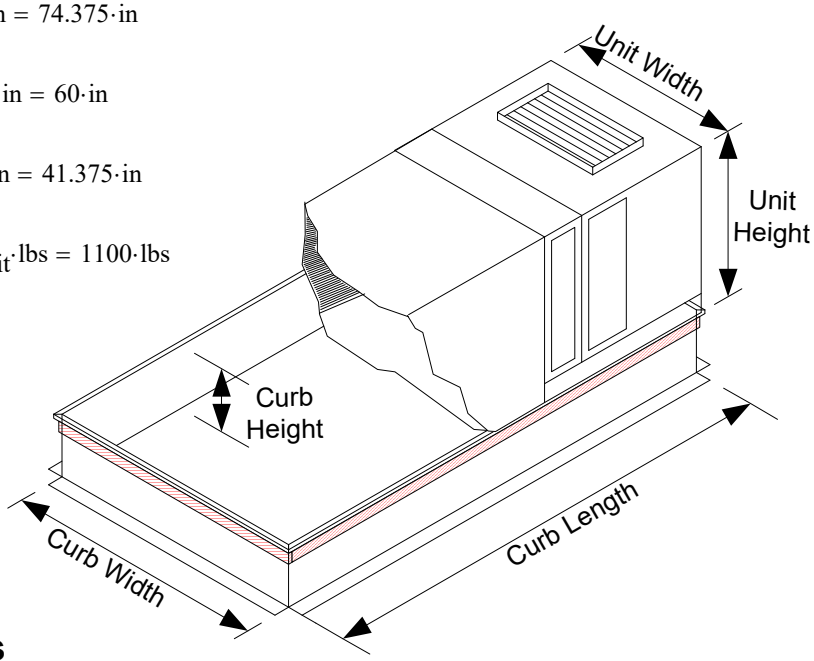
Curb = "C-1006 XIC"

Length of Unit $L_{unit} := L_{unit} \cdot in = 74.375 \cdot in$

Width of Unit $W_{unit} := W_{unit} \cdot in = 60 \cdot in$

Height of Unit $H_{unit} := H_{unit} \cdot in = 41.375 \cdot in$

Weight of Unit $Wt_{unit} := Wt_{unit} \cdot lbs = 1100 \cdot lbs$



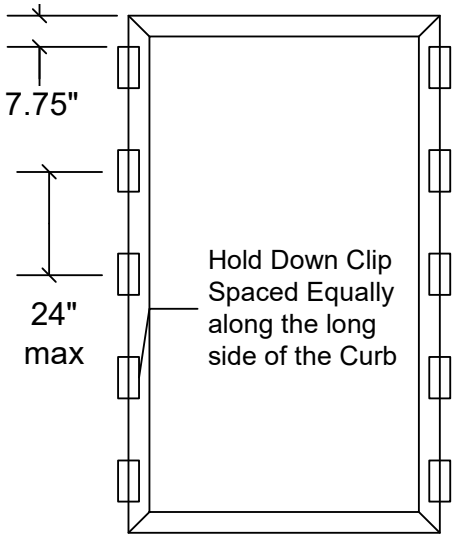
Roof Curb Dimensions

Length of Curb $L_{curb} := L_{curb} \cdot in = 67.375 \cdot in$

Width of Curb $W_{curb} := W_{curb} \cdot in = 37.188 \cdot in$

Height of Curb $H_{curb} := H_{curb} \cdot in = 30.5 \cdot in$

Weight of Curb $Wt_{curb} := Wt_{curb} \cdot lbs = 595 \cdot lbs$



Curb Plan

Overall System Dimensions

Total Weight

$Wt_{tot} := Wt_{unit} + Wt_{curb} = 1695 \cdot lbs$

Total height

$H_{total} := H_{unit} + H_{curb} = 71.875 \cdot in$

Seismic Loading + Snow Loading

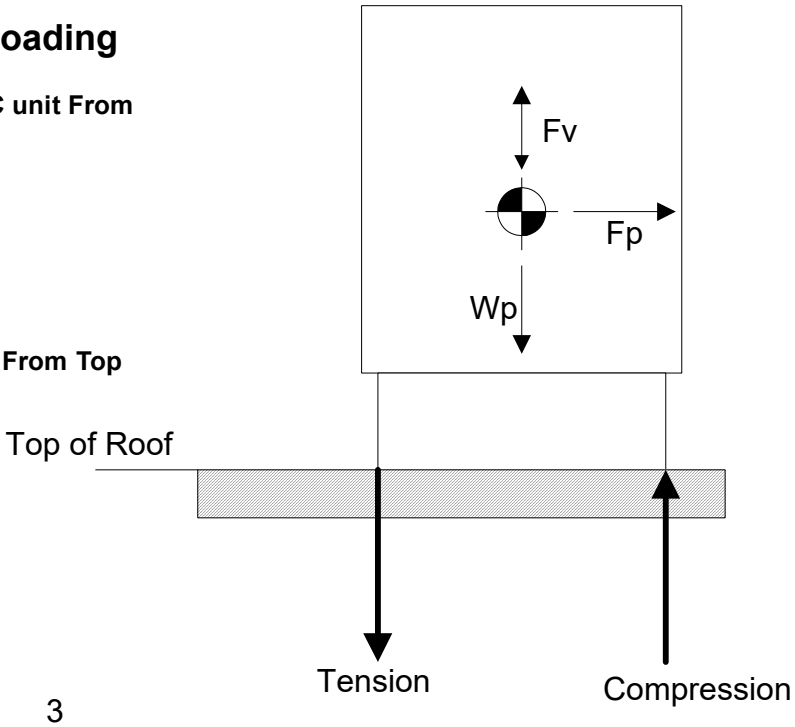
Height for Center of Gravity for HVAC unit From Top of Roof

$h_{CG.unit} := \frac{1}{2} H_{unit} = 21 \cdot in$

$h_{CG} := H_{curb} + h_{CG.unit} = 51.19 \cdot in$

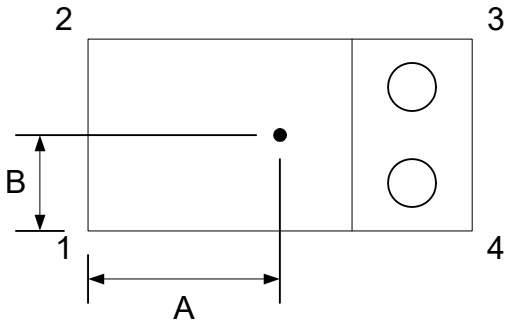
Height for Center of Gravity for Curb From Top of Roof

$h_{CG.curb} := \frac{H_{curb}}{2} = 15.25 \cdot in$



Max Seismic Base Shear

$V_{base.S} := F_p \cdot Wt_{tot} = 5721 \cdot lbs$



Unit C.G. distance in axis parallel to Curb Width $B_{ecc.width} := CG_{short} \cdot in = 22.5 \cdot in$

Eccentricity in axis parallel to Curb Width

$$e_{width} := \begin{cases} 0in & \text{if } B_{ecc.width} = \text{"N/A"} \\ \left| B_{ecc.width} - \frac{W_{unit}}{2} \right| & \text{otherwise} \end{cases} = 7.5 \cdot in$$

Unit C.G. distance in axis parallel to Curb Length $A_{ecc.length} := CG_{long} \cdot in = 34.625 \cdot in$

Eccentricity in axis parallel to Curb Length

$$e_{length} := \begin{cases} 0in & \text{if } A_{ecc.length} = \text{"N/A"} \\ \left| A_{ecc.length} - \frac{L_{unit}}{2} \right| & \text{otherwise} \end{cases} = 2.56 \cdot in$$

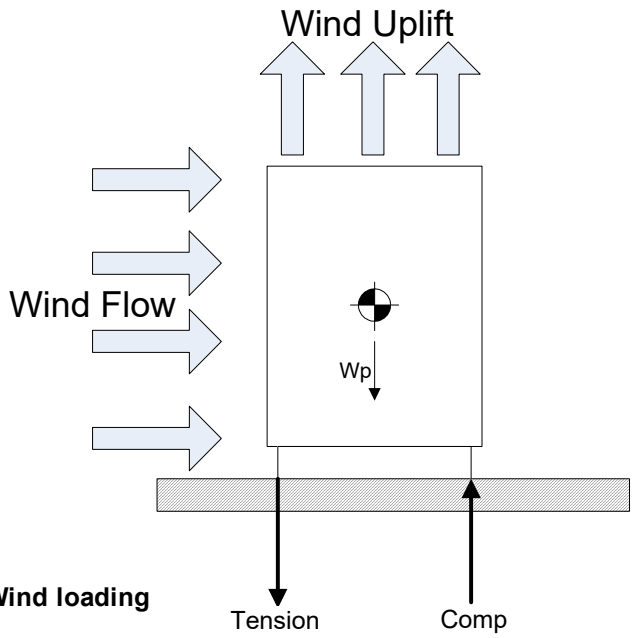
Max Net Tension Reaction On Each Side Due To Seismic Loads

$$T_S := \begin{bmatrix} \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{W_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{W_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} \right] \\ \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{L_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{L_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} \right] \end{bmatrix} = \begin{pmatrix} -5558 \\ -2792 \end{pmatrix}\cdot lbs$$

Max Net Compression Reaction On Each Side Due To Seismic Loads

$$C_S := \begin{bmatrix} \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{W_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \\ \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{L_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \end{bmatrix} = \begin{pmatrix} 10311 \\ 6513 \end{pmatrix}\cdot lbs$$

Wind Loading + Snow Loading



Max Base Shear due to wind loading

$V_{base.W} := P_{net} \cdot L_{unit} \cdot H_{total} = 5342 \cdot lbs$

Max Uplift due to wind loading

$L_{unit.up} := L_{unit} - 0in = 74.375 \cdot in$

$P_{uplift.W} := P_v \cdot L_{unit.up} \cdot W_{unit} = 3521 \cdot lbs$

Max Net Tension Reaction On Each Side Due To Wind loading

$$T_W := \begin{pmatrix} \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} - \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \\ \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} - \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} -6360 \\ -3334 \end{pmatrix} \cdot lbs$$

Max Net Compression Reaction On Each Side Due To Wind loading

$$C_W := \begin{pmatrix} \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} + \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \\ \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} + \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} 7279 \\ 4199 \end{pmatrix} \cdot lbs$$

Governing Loading @ Curb

Max uplift vertical load along the length of the curb

$$\omega_{x.L.vert.up} := \frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}} = 1133 \cdot plf$$

Max compressive vertical load along the length of the curb

$$\omega_{x.L.vert.comp} := \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}} = 1837 \cdot plf$$

Max vertical load along the length of the curb

$$\omega_{x.L.vert} := \max\left(\omega_{x.L.vert.up}, \omega_{x.L.vert.comp}\right) = 1837 \cdot plf$$

Max uplift vertical load along the width of the curb

$$\omega_{x.W.vert.up} := \frac{\max\left[\left|T_{S_{(1)}}\right|, \left|T_{W_{(1)}}\right|\right]}{W_{curb}} = 1076 \cdot plf$$

Max compressive vertical load along the width of the curb

$$\omega_{x.W.vert.comp} := \frac{\max\left[\left|C_{S_{(1)}}\right|, \left|C_{W_{(1)}}\right|\right]}{W_{curb}} = 2102 \cdot plf$$

Max vertical loading along the width of the curb

$$\omega_{x.W.vert} := \max\left(\omega_{x.W.vert.up}, \omega_{x.W.vert.comp}\right) = 2102 \cdot plf$$

$$\begin{pmatrix} V_{base.S} \\ V_{base.W} \end{pmatrix} = \begin{pmatrix} 5721 \\ 5342 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} \left|T_S\right| \\ \left|C_S\right| \end{pmatrix} = \begin{pmatrix} 6220 \\ 12196 \end{pmatrix} \cdot lbs$$

$$\begin{pmatrix} F_v \cdot Wt_{tot} \\ P_v \cdot L_{unit} \cdot W_{unit} \end{pmatrix} = \begin{pmatrix} 509 \\ 3521 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} \left|T_W\right| \\ \left|C_W\right| \end{pmatrix} = \begin{pmatrix} 7181 \\ 8403 \end{pmatrix} \cdot lbs$$

Anchorage To Concrete [Expansion Anchor per ACI 318-14]

Number of connection on the long side

$N_B := 3 + 2$

Moment Arm for overturning (Short side)

$B := W_{curb} + 3in \cdot 2 = 43 \cdot in$

Number of Connection on the Short side.

$N_L := 2 + 2$

Moment Arm for over turning (Long side)

$L := L_{curb} + 3in \cdot 2 = 73 \cdot in$

Total Number of Connections

$N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 10$

Max Net Tension Reaction Due to Seismic Load, Fp

$$R_{c.EQ.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 23 \cdot lbs \qquad R_{c.EQ.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 6 \cdot lbs$$

$$R_{c.EQ} := MAX+\left[\begin{bmatrix}\left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{c.EQ.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{c.EQ.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}1965 \\ 1408\end{pmatrix} \cdot lbs$$

Max net Tension Reaction Due to Wind Load, Pnet

$$R_{c.W} := MAX+\left[\begin{bmatrix}\frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}1123 \\ 736\end{pmatrix} \cdot lbs$$

Governing Load Case:

$Govern := if\left(\left|R_{c.EQ}\right| > \left|R_{c.W}\right|, "Seismic", "Wind"\right) = "Seismic"$

Governing Tension Reaction at Each anchor Point:

$R_c := if\left(Govern = "Seismic", R_{c.EQ}, R_{c.W}\right) = \begin{pmatrix}1965 \\ 1408\end{pmatrix} \cdot lbs$

Max Tension on anchor: $N_{ua} := |R_c| = 2417 \cdot lbs$

Max Shear on anchor: $V_{ua} := \frac{\max(\Omega_0 \cdot V_{base.S}, V_{base.W})}{N_t} = 1144 \cdot lbs$

Hilti Kwik Bolt TZ – Carbon Steel
5/8" Anchor with min 4" embedment
Base material: 6" thick Cracked concrete w/
Compressive strength fc' = 3000 psi
Min 6" away from the concrete edge
Evaluation Report: ICC-ESR 1917

Loading Condition:	**Seismic**

Design Tension Capacity [ϕN_n]:	3,631	[lbs]
Design Shear Capacity [ϕV_n]:	4,940	[lbs]

$\phi N_n := \phi N_n \cdot lbs = 3631 \cdot lbs$

$\phi V_n := \phi V_n \cdot lbs = 4940 \cdot lbs$

Utilization:

Tension Utilization: $\beta_N := \frac{N_{ua}}{\phi N_n} = 67 \cdot \%$

Shear Utilization: $\beta_V := \frac{V_{ua}}{\phi V_n} = 23 \cdot \%$

Interaction of Tensile and Shear Forces:
Per ACI 318-14 Sec. 17.6

$\beta_{NV} := \frac{(\beta_N) + (\beta_V)}{1.2} = 75 \cdot \%$

$$check\_interaction := \begin{pmatrix} if(\beta_N < 1.0, "OK", "NG") \\ if(\beta_V < 1.0, "OK", "NG") \\ if(\beta_{NV} < 1.0, "OK", "NG") \end{pmatrix} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

$$check\_interaction = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

Anchorage To Structural Steel [Fillet Weld Conn. per AISI S100-16]

Fillet Weld 2" Long Along the Long and Short Side. Min 2 Connections per Side
Spacing: 48" O.C. for Non-Isolated Curbs; 24" for Isolated Curbs

Number of Welds on the Long Side $N_B := 3$

Moment Arm for Overturning (Short Side) $B := W_{curb} = 37 \cdot in$

Number of Welds on the Short Side. $N_L := 2$

Moment Arm for Overturning (Long Side) $L := L_{curb} = 67 \cdot in$

Total Number of Connections $N_t := \left[\left(N_B\right) + \left(N_L\right)\right] \cdot 2sides = 10$

Max Net Tension Reaction due to Seismic Load FP

$$R_{weld.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 44 \cdot lbs$$

$$R_{weld.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 13 \cdot lbs$$

$$R_{weld.EQ} := MAX+\left[\begin{bmatrix}\left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{weld.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{weld.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}1921 \\ 1548\end{pmatrix} \cdot lbs$$

Max Net Tension Reaction due to Wind Load Pnet

$$R_{weld.W} := MAX+\left[\begin{bmatrix}\frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}1987 \\ 1368\end{pmatrix} \cdot lbs$$

Tension Design Force; SRSS for Loading from Each Direction $T_{u.weld} := \max\left(\left|R_{weld.EQ}\right|, \left|R_{weld.W}\right|\right) = 2467 \cdot lbs$

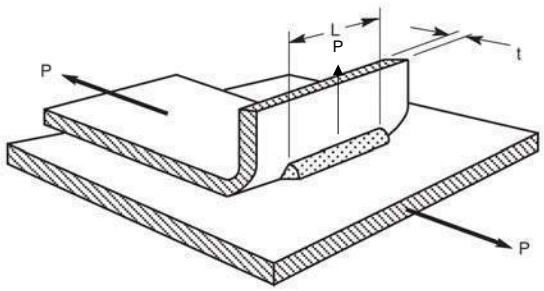
Shear Load at Each Weld Connection $V_{u.weld} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{N_t} = 572 \cdot lbs$

Total Demand: SRSS of V and T

$$R_{u.weld} := \sqrt{T_{u.weld}^2 + V_{u.weld}^2} = 2532 \cdot lbs$$

Fillet Weld Design per AISI S100-16 Section J2.5

Weld Length at Each Connection Point $L_w := 2in$



Effective Throat Fillet Weld Size

$$t_w := \left(\frac{1}{8}in\right) \cdot 0.707 = 0.088 \cdot in$$

Thickness for the Thinnest Martial Being Welded
Min Curb Thickness = 16GA with Fu=65 ksi

$t_1 := thick("14GA") = 0.0785 \cdot in$

$F_u := 65ksi$

Min weld material strength

$F_{exx} := 70ksi$

For Longitudinal Loading [Parallel capacity is considered to be loading in the direction of the length of the weld] per (Eq. J2.5-1) &(Eq. J2.5-2)

$$\phi P_{long} := \begin{cases} (0.6)\left(1 - \frac{0.01 \cdot L_w}{t_1}\right) \cdot L_w \cdot t_1 \cdot F_u & \text{if } \frac{L_w}{t_1} < 25 \\ (0.5) \cdot 0.75 \cdot t_1 \cdot L_w \cdot F_u & \text{otherwise} \end{cases} = 3827 \cdot lbs$$

where $L_w \div t_1 = 25$

For Transverse Loading per (Eq. J2.5-5)

$$\phi P_{trans} := (0.65) \cdot t_1 \cdot L_w \cdot F_u = 6633 \cdot lbs$$

Strength of Weld Material per (Eq. J2.5-7)

$$\phi P_{weld} := (0.6) \cdot 0.75 \cdot t_w \cdot L_w \cdot F_{exx} = 5568 \cdot lbs$$

Design Strength of Fillet Weld

$$\phi P_n := \min\left(\phi P_{long}, \phi P_{trans}, \phi P_{weld}\right) = 3827 \cdot lbs$$

D/C Ratio for the Welded Connection

$$\beta_{NW} := \frac{R_{u.weld}}{\phi P_n} = 66 \cdot \%$$

$weld_{check} := if\left(\beta_{NW} < 1.0, "OK", "NG"\right)$

$weld_{check} = "OK"$

Anchorage To Wood Member WITH Lag Screws [NDS-2018 LRFD Strength Design]

*** Use 3/8" Lag Screws along Each Side of the Curb**
*** Assume G=0.5 Douglas Fir-Larch**

Wood Lag Screw Capacity per NDS 2018 Section 11.3

Wet Service Factor: $Cond := "DRY"$ **(e.g. CA = "DRY", AK = "WET")**

$$C_M := \begin{cases} 1.0 & \text{if } Cond = "DRY" \\ 0.7 & \text{if } Cond = "WET" \end{cases} = 1$$ **NDS 2018 Table 11.3.3**

Temperature Factor:
$$C_t := \begin{cases} 0.8 & \text{if } Cond = "DRY" \\ 0.7 & \text{if } Cond = "WET" \end{cases} = 0.8$$ **NDS 2018 Table 11.3.4**

Group Action Factor: $C_g := 0.97$ **NDS 2018 Table 11.3.6C**

Geometry Factor: $C_\Delta := 1.0$ **NDS 2018 Table 12.5.1A,B**

End Grain Factor: $C_{eg} := 1.0$ **NDS 2018 Sec. 12.5.2**

Diaphragm Factor: $C_{di} := 1.0$ **NDS 2018 Sec. 12.5.3**

Toe-Nail Factor: $C_{tn} := 1.0$ **NDS 2018 Sec. 12.5.4**

Format Conversion Factor: $K_F := 3.32$ **NDS 2018 Table 11.3.1**

Resistance Factor: $\phi := 0.65$ **NDS 2018 Table 11.3.1**

Time Effect Factor: $\lambda := 1.0$ **NDS 2018 App N.3.3**

Lateral Design Value: $Z := 130lbs$ **NDS 2018 Table 12K**

Withdrawal Design Value: $W := 305lbs$ **NDS 2018 Table 12.2A**

Lag Screw Diameter: $D_{lag} := \frac{3}{8}in$

Lag Screw Length: $L_{lag} := 4in$

Length of Tapered Tip: $E_{lag} := \frac{7}{32}in$

Lag Screw Penetration: $P_{lag} := 3.78125in$

Eff. Lag Screw Penetration for withdrawal: $P_{\omega.lag} := 2in + \frac{9}{32}in = 2.28 \cdot in$ **NDS 2018 Appx. Table L2**

NDS 2018 Sec. 12.1.4.6

Minimum Penetration DCR <1.0: $DCR_{min.penetration} := \frac{4 \cdot D_{lag}}{P_{\omega.lag}} = 0.66$ $DCR_{min.penetration} = "OK"$

Adj. Lateral Design Value: $Z' := Z \cdot C_M \cdot C_t \cdot C_g \cdot C_\Delta \cdot C_{eg} \cdot C_{di} \cdot C_{tn} \cdot K_F \cdot \phi \cdot \lambda = 218 \cdot lbs$

Adj. Withdrawal Design Value: $W' := W \cdot C_M^{\,2} \cdot C_t \cdot C_{eg} \cdot C_{tn} \cdot K_F \cdot \phi \cdot \lambda = 527 \cdot lbs$ **NDS 2018 Table 11.3.1**

Number of Lag Screws on the Long Side $N_B := 12 + 2$

Moment Arm for Overturning (Short Side) $B := W_{curb} = 37 \cdot in$

Number of Lag Screws on the Short Side $N_L := 6 + 2$

Moment Arm for Overturning (Long Side) $L := L_{curb} = 67 \cdot in$

Total Number of Lag Screws $N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 36$

Max net Tension Reaction due to Seismic, Fp

$$R_{lag.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 10 \cdot lbs$$

$$R_{lag.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 3 \cdot lbs$$

$$R_{lag.EQ} := MAX+\left[\begin{bmatrix} \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{lag.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{lag.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 405 \\ 384 \end{pmatrix} \cdot lbs$$

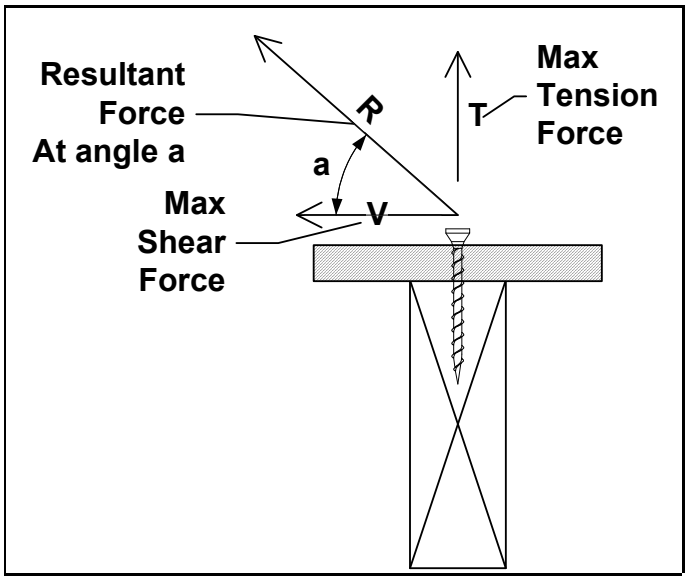
Max net Tension Reaction due to Wind load, Pnet

$$R_{lag.W} := MAX+\left[\begin{bmatrix} \frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{L \cdot N_L \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 438 \\ 347 \end{pmatrix} \cdot lbs$$

Tension Design force; SRSS for loading from Each direction $T_{lag} := \max\left(\left|R_{lag.EQ}\right|, \left|R_{lag.W}\right|\right) = 559 \cdot lbs$

Shear load at each anchor location $V_{lag} := \frac{\max\left(V_{base.S} \cdot \sqrt{2}, V_{base.W}\right)}{N_t} = 225 \cdot lbs$

For Lag Screws Subjected to Combined Lateral and Withdrawal Loading; Design Strength of the Lag Screw Shall Be Adjusted per Hankinson Formula as Prescribed by NDS 2018 Equation 12.4-1



Angle Between Wood Surface and Direction of Resultant Applied Load

$$(\alpha) := \operatorname{atan}\left(\frac{T_{lag}}{V_{lag}}\right) = 68\cdot deg$$

Combined Demand per Lag Screw @ Strength Level

$$R_{lag} := \sqrt{T_{lag}^{2} + V_{lag}^{2}} = 603\cdot lbs$$

Adjusted Capacity per NDS 2018 Equation 12.4-1 @ Strength Level

$$Z'_{\alpha} := \frac{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot Z'}{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot\cos(\alpha)^{2} + Z'\cdot\sin(\alpha)^{2}} = 738\cdot lbs$$

D/C Ratio for the Lag Screw connection to Wood Structure

$$\beta_{Lag} := \frac{R_{lag}}{Z'_{\alpha}} = 82\cdot\%$$

$$Lag_{Screw.Check} := \text{if}\left(\beta_{Lag} < 1.0, \text{"OK"}, \text{"NG"}\right)$$

$Lag_{Screw.Check}$ = "OK"

Bearing and Tilting in Curb Bolted Connection AISI S100-16

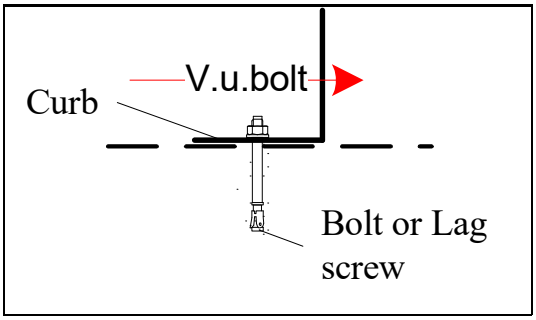
Nominal bolt diameter $d := 0.5in$

Uncoated sheet thickness $t_{curb} := thick("14GA") = 0.079 \cdot in$

Tensile strength of sheet $F_u := 65ksi$

Coefficient for conversion of units $\alpha := 1.0$

Modification Factor $m_f := 1.0$



Modification factor for type of bearing connection, per Table J3.3.1-2; For single shear connection with washers

Bearing Factor

$$C := \begin{cases} 3 \text{ if } \left(\frac{d}{t_{curb}} < 10\right) \wedge \left(0.024in < t_{curb} < 0.1875in\right) = 3 \\ "NG" \text{ if } \frac{d}{t_{curb}} > 10 \end{cases}$$

Bearing factor, which shall be determined according to Table J3.3.1-1 For d/t<10 where $d \div t_{curb} = 6$

Bearing Design Strength per AISI S100-16 Eq. J3.3.1-1

$$\phi P_{n_{(0)}} := (0.6) \cdot \left(m_f \cdot C \cdot d \cdot t_{curb} \cdot F_u\right) = 4592 \cdot lbs$$

Bolt Hole Deformation Design Strength per AISI S100-16 Eq. J3.3.2-1

$$\phi P_{n_{(1)}} := (0.65) \cdot \left[4.64 \cdot \left(\frac{\alpha}{in}\right) \cdot t_{curb} + 1.53\right] \cdot d \cdot t_{curb} \cdot F_u = 3141 \cdot lbs$$

Curb Connection Shear Capacity $\phi P_n := \min\left(\phi P_n\right) = 3141 \cdot lbs$

Loading demand at connection

$$V_{u.bolt} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{4} = 1430 \cdot lbs$$

$Curb\_Conn\_Shear := if\left(V_{u.bolt} < \phi P_n, "OK", "NG"\right)$ Curb_Conn_Shear = "OK"

Thickness of Curb, ISO Rail and Clip

(Per AISC Table 17-10 Galvanized)

Hold Down Clip thickness

$t_{Clip} := "12GA"$ $t_{clip} := thick(t_{Clip}) = 0.1084 \cdot in$

Roof Curb thickness

$t_{Curb} := "14GA"$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

ISO RAIL thickness

$t_{Curb.iso} := "10GA"$ $t_{curb.iso} := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Note: Iso Rail thickness is only used if the curb is isolated. Not used for non-isolated curbs

Sheet Metal Screws (SMS) Equations and References

SMS properties (ESR-2196 Table 5)

$SMS_{Table} =$

"SMS"	"Diameter"	"HeadDiameter"	"Tension"	"Shear"
"Size"	"d"	"dw"	"Pts"	"Pss"
"#8"	0.164	0.335	1000	1170
"#10"	0.19	0.399	1370	1215
"#12"	0.216	0.415	2325	1880
"#14"	0.25	0.5	4580	2440

SMS Tension Eqns

$P_{not} = 0.85 \cdot t \cdot d \cdot F_u$

$P_{nov} = 1.5 \cdot t \cdot d_w \cdot F_u$

$P_{nts} = 0.8 \cdot P_{ts}$

(AISI S100-16 J4.4.1 & J4.4.2)

FOR THE MOST CASES, PULL-OUT CAPACITY IS THE LOWEST

SMS Shearn Eqns

$P_{vnot} = 4.2 \cdot \sqrt{(d \cdot t^3)} \cdot F_u$

$P_{vnov} = 2.7 \cdot t \cdot d \cdot F_u$

$P_{vnss} = 0.8 \cdot P_{ss}$

(AISI S100-16 J4.3.1)

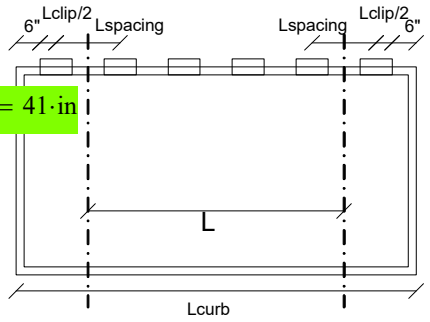
Hold Down Clip Design (Connection of the Mechanical unit to Curb)

Number of Clips on the long side $N_B := 4$

Moment Arm for overturning (Short side) $B := W_{curb} + 1.75in \cdot 2 = 41 \cdot in$

Number of Clips on the Short side. $N_L := 4$

Width of Clips $L_{clip} := 9in$



Curb Centerline Spacing (Long side)

$$L_{spacing} := \frac{L_{curb} - \left(6in + \frac{L_{clip}}{2}\right) \cdot 2}{N_B - 1} = 15.458 \cdot in$$

Moment Arm for overturning (Long side)

$$L := L_{curb} - 2 \cdot \left[6in + \frac{L_{clip}}{2} + L_{spacing} \cdot \frac{(N_L - 2)}{4}\right] = 30.917 \cdot in$$

Total Number of Clips

$$N_t := (N_B) \cdot 2sides = 8$$

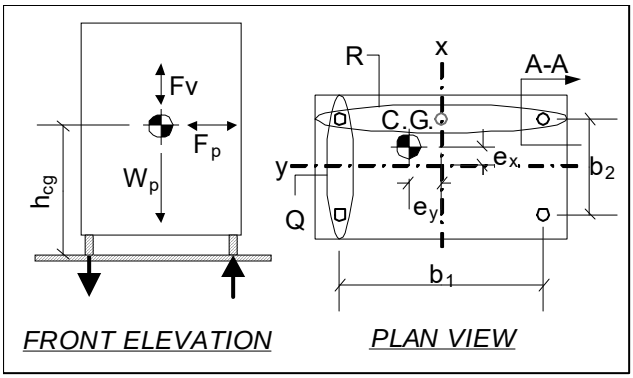
Max net Tension Reaction due to Seismic, Fp

$$R_{clip.EQ} := MAX+\left[\begin{array}{l} \left[\frac{F_p \cdot Wt_{unit}}{B \cdot N_B} \cdot h_{CG.unit} + \frac{(0.9 - F_v) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B}\right] - \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} \\ \left[\frac{F_p \cdot Wt_{unit}}{L \cdot N_L} \cdot h_{CG.unit} + \frac{(0.9 - F_v) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L}\right] - \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} \end{array}\right] = \begin{pmatrix} 420 \\ 552 \end{pmatrix} \cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$R_{clip.W} := MAX+\left(\begin{array}{l} \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{unit}^2}{2}}{B \cdot N_B} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{unit}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{unit}^2}{2}}{L \cdot N_L} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{unit}}{N_t} \end{array}\right) = \begin{pmatrix} 753 \\ 752 \end{pmatrix} \cdot lbs$$

Tensile and Shear Load calculation per ASHRAE RP-812



Eccentricity along X-X

$e_x := e_{width} = 7.5 \cdot in$

Eccentricity along Y-Y

$e_y := e_{length} = 2.562 \cdot in$

Distance between Seismic Restraints Along Y-Y

$b_1 := L_{curb} - 2 \cdot 6in = 55 \cdot in$

Distance between Seismic Restraints Along X-X

$b_2 := W_{curb} = 37 \cdot in$

Moment of Inertia about X-X

$$I_{xx} := \frac{N_t \cdot (N_t + 2) \cdot (b_1)^2}{12 \cdot (N_t - 2)} = 3407 \cdot in^2$$

Moment of Inertia about Y-Y

$$I_{yy} := \frac{N_t \cdot (b_2)^2}{4} = 2766 \cdot in^2$$

Angle about Tensile Load

$$\Theta_t := \operatorname{atan}\left[\frac{I_{yy} \cdot (b_1)}{I_{xx} \cdot (b_2)}\right] = 50 \cdot deg$$

Angle about Shear Load

$$\Theta_s := \begin{cases} \operatorname{atan}\left(\frac{e_x}{e_y}\right) & \text{if } e_y \neq 0 \\ 0deg & \text{if } e_y = 0 \end{cases} = 71 \cdot deg$$

Max Net Tensile Load Due to Seismic Load, Fp

$$T_{U.EQ.pt1} := \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} - \frac{(0.9 - F_v) \cdot Wt_{unit}}{b_1 \cdot b_2} \cdot \left(\frac{b_1}{2} \cdot e_x + \frac{b_2}{2} \cdot e_y - e_x \cdot e_y\right) = 7 \cdot lbs$$

$$T_{U.EQ.pt2} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \cos(\Theta_t) \cdot \frac{0.5 \cdot b_2}{I_{yy}} = -329 \cdot lbs$$

$$T_{U.EQ.pt3} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \sin(\Theta_t) \cdot \frac{0.5 \cdot b_1}{I_{xx}} = -481 \cdot lbs$$

$$T_{U.EQ} := T_{U.EQ.pt1} + T_{U.EQ.pt2} + T_{U.EQ.pt3} = -803 \cdot lbs$$

Max Net Shear Load Due to Seismic Load, Fp

$$V_{Ux.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\cos(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_2 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_1 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 277 \cdot lbs$$

$$V_{Uy.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\sin(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_1 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_2 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 532 \cdot lbs$$

$$V_{U.EQ} := \sqrt{V_{Ux.EQ}^2 + V_{Uy.EQ}^2} = 600 \cdot lbs$$

Tension Design force for Hold Down Clips

$$T_{clip} := \max\left(R_{clip.W_0}, R_{clip.W_1}, \left|R_{clip.EQ}\right|, \left|T_{U.EQ}\right|\right) = 803 \cdot lbs$$

Based on ASCE 7-16 Figure 29.4-1 magnitude of force coefficient,

Wind in diagonal direction to the face of equipment produces less force than that of the wind in perpendicular direction to the face of the equipment. Therefore, wind in diagonal direction does not need to be used

$$\left|R_{clip.EQ}\right| = 694 \cdot lbs \qquad \left|T_{U.EQ}\right| = 803 \cdot lbs$$

$$\left|R_{clip.W}\right| = 1064 \cdot lbs$$

$$T_{clip.EQ.max} := \max\left(\left|R_{clip.EQ}\right|, \left|T_{U.EQ}\right|\right) = 803 \cdot lbs$$

$$T_{clip.W.max} := \max\left(\left|R_{clip.W}\right|\right) = 1064 \cdot lbs$$

Shear Design force for Hold Down Clips

$$V_{clip} := \max\left(\frac{\max\left(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit}\right)}{N_t}, \left|V_{U.EQ}\right|\right) = 600 \cdot lbs$$

$$F_p \cdot Wt_{unit} \cdot \frac{1}{N_t} = 464 \cdot lbs \qquad \left|V_{U.EQ}\right| = 600 \cdot lbs$$

$$P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t} = 384 \cdot lbs$$

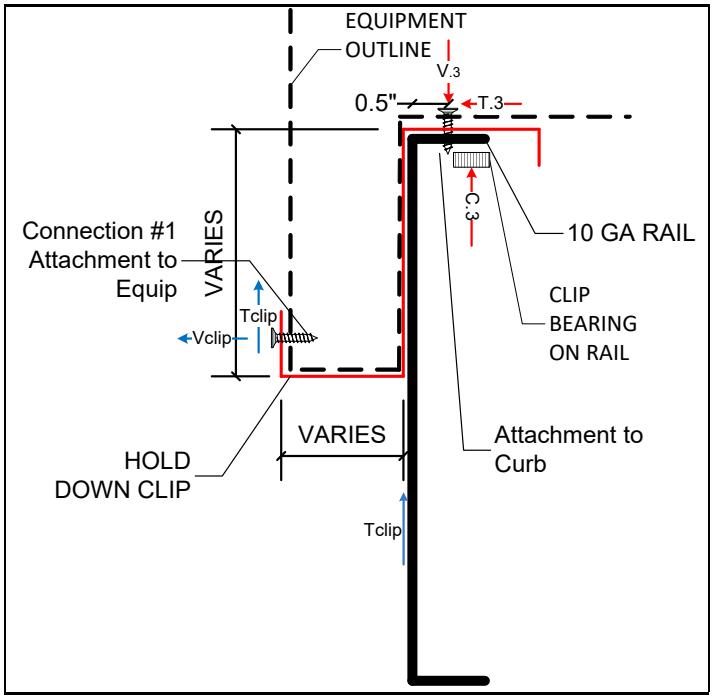
$$V_{clip.EQ.max} := \max\left[\left(F_p \cdot Wt_{unit} \cdot \frac{1}{N_t}\right), \left|V_{U.EQ}\right|\right] = 600 \cdot lbs$$

$$V_{clip.W.max} := \max\left(\left(P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t}\right)\right) = 384 \cdot lbs$$

Loading at Hold Down Clips @ Isolator Curb

$b_{return.iso} := Clip_b \cdot in = 2.625 \cdot in$

$b_{depth.iso} := Clip_c \cdot in = 4.563 \cdot in$



*For Reference Only

Mu Bending moment in the hold down

$M_u := T_{clip} \cdot b_{return.iso} = 2108 \cdot in \cdot lbs$

Resolve bending moment a T/C couple
Assume 0.5" bearing length
Moment Arm for T/C couple

$d_{T/C} := 1in - 0.5in = 0.5 \cdot in$

V3 is acting as shear on the screws. due to eccentricity of Tension force T

$$V_3 := \frac{T_{clip} \cdot \left[b_{return.iso} + (0) \right]}{d_{T/C}} = 4217 \cdot lbs$$

Additional load from Direct Shear acting out of plane (SRSS)

$$V_3 := \sqrt{V_3^{\,2} + V_{clip}^{\,2}} = 4259 \cdot lbs$$

Reaction C3 [compression force] is resisted by bearing of the hold down on the curb lip. Assume 0.5" bearing length

$C_3 := V_3 - T_{clip} = 3456 \cdot lbs$

T3 Load due to the shear acting out of plane tension on the screws.

$$T_3 := \left(\max\left(\frac{T_{clip} \cdot b_{return.iso}}{b_{depth.iso}}, V_{clip} \right) \right) = 600 \cdot lbs$$

Check Bending in Clip @ Isolator Curb

There are several restraints that prevents the hold down clip for iso-curb to have local bending at the bottom and transfer vertical load demand directly to the face of the curb.

- Hold down is bearing on the face of iso-rail / non-iso curb lip.
- Gasket will act as a "link" member to allow unit base rail and bottom flange to move totegther so flange can't bend unless the unit base rail bends first. However, unit base rail is not likely to bend so bottom flange won't bend

Hold Down Clip thickness

$t_{Clip} = \text{"12GA"}$ $t_{clip} := \text{thick}(t_{Clip}) = 0.1084 \cdot in$

Effective width of hold down clip

$b_c := L_{clip} = 9 \cdot in$

Yield strength of the Clip

$F_{y.c} := 50ksi$

Strength reduction for bending

$\phi_{clip} := 0.9$

Design Bending Capacity (LRFD)

$$\phi M_n := \phi_{clip} \cdot F_{y.c} \left(\frac{b_c \cdot t_{clip}^{\,2}}{6} \right) = 793 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.clip} := T_{clip} \cdot 0.5in = 402 \cdot in \cdot lbs$

D/C Ratio for bending

$$DCR := \frac{M_{u.clip}}{\phi M_n} = 0.506$$

$Clip_{Bending} = \text{"OK"}$

Check Flange Bending in Clip @ Isolator Curb

Note:
- **If the curb flange is welded to the 10GA channel and 10GA channel is welded back to the base of the curb, then both tension and compression due to equipment overturning will be taken care by the 10GA channel.**
- **Since the curb will be reinforced with 10GA channel under each isolator, it can be assumed that the loads will trasnferred down to the base structure through the channels. Therefore, flange downward bending at curb due to compressive load does not need to be checked.**

Roof Curb thickness

$t_{Curb} = \text{"14GA"}$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

Clip edge to edge distance

$$b_{edge2edge} := \frac{L_{curb} - \left(6in + \frac{L_{clip}}{2}\right) \cdot 2}{N_B - 1} - L_{clip} = 6.458 \cdot in$$

Effective width of Roof Curb

$b_{curb} := L_{clip} + b_{edge2edge} = 15.46 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\frac{b_{curb} \cdot (t_{curb})^2}{6}\right] = 714 \cdot in \cdot lbs$$

Width of Isolator

$w_{JQ.iso} := 2in$ **2 in. for CQAs**

Flexural bending demand

$$M_{u.Curb} := T_{clip} \cdot \left(\max\left(\frac{1.75in}{2} - 0.5in, \frac{w_{JQ.iso}}{2} - 1in\right)\right) = 301 \cdot in \cdot lbs$$

D/C Ratio for bending

$$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.422$$

$Curb_{Bending} = \text{"OK, Weld 10GA channel ends to curb flange"}$

Design of Connection#1 Connection of Equipment to hold Down clip

Ultimate SMS screw connection Strength (LRFD)
Strength based on the smallest thickness of Curb and Equipment Housing (min 16 GA) [Fy = 50ksi & Fu=65ksi]

$n_{sms} := 4$ $\quad Size_{ss} := "\#14"$

$t_{ss} := "16GA"$ $\quad F_{u.ss} := 65ksi$

Nominal Tension Strength

$$P_{nt} := n_{sms} \cdot T_s\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 3508 \cdot lbs$$

$$P_{not} := n_{sms} \cdot T_{not}\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 3508 \cdot lbs$$

$$P_{nov} := n_{sms} \cdot T_{nov}\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 12383 \cdot lbs$$

$$P_{nts} := n_{sms} \cdot T_{nts}\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 14656 \cdot lbs$$

Nominal Shear Strength

$$P_{ns} := n_{sms} \cdot V_s\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 7808 \cdot lbs$$

$$P_{vnot} := n_{sms} \cdot V_{not}\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 8737 \cdot lbs$$

$$P_{vnov} := n_{sms} \cdot V_{nov}\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 11144 \cdot lbs$$

$$P_{vnss} := n_{sms} \cdot V_{nss}\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 7808 \cdot lbs$$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} V_{clip} \div \left(\phi_{sms} \cdot P_{nt}\right) \\ T_{clip} \div \left(\phi_{sms} \cdot P_{ns}\right) \end{bmatrix} = \begin{pmatrix} 34 \\ 21 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left(\begin{bmatrix} \left[\frac{T_{clip}}{P_{vnov}} + 0.71\left(\frac{V_{clip}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{T_{clip}}{P_{vnot}} + \left(\frac{V_{clip}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{T_{clip}}{P_{vnss}} + \left(\frac{V_{clip}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right) = 38 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

Design of Connection#2 Connection of hold Down clip to Curb

Tension loads on SMS connection

$T_{s2} := V_3 = 4259 \cdot lbs$

Shear loads on SMS connection

$V_{s2} := T_3 = 600 \cdot lbs$

Ultimate SMS screw connection Strength (LRFD)
Strength based on the smallest thickness of Curb and Equipment Housing (min 16 GA) [Fy = 50ksi & Fu=65ksi]

$n_{sms} := 8$ $Size_{ss} := "\#14"$

$t_{ss} := (t_{Curb.iso}) = "10GA"$ $F_{u.ss} := 65ksi$

Nominal Tension Strength

$P_{nt} := n_{sms} \cdot T_s(Size_{ss}, t_{ss}, F_{u.ss}) = 15271 \cdot lbs$

Note:
SMS is getting pulled up so the thicker curb iso rail is engaged for SMS capacity , rather than just the clip itself.

$P_{not} := n_{sms} \cdot T_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 15271 \cdot lbs$

$P_{nov} := n_{sms} \cdot T_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 53898 \cdot lbs$

$P_{nts} := n_{sms} \cdot T_{nts}(Size_{ss}, t_{ss}, F_{u.ss}) = 29312 \cdot lbs$

Nominal Shear Strength

$P_{ns} := n_{sms} \cdot V_s(Size_{ss}, t_{ss}, F_{u.ss}) = 15616 \cdot lbs$

$P_{vnot} := n_{sms} \cdot V_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 56103 \cdot lbs$

$P_{vnov} := n_{sms} \cdot V_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 48508 \cdot lbs$

$P_{vnss} := n_{sms} \cdot V_{nss}(Size_{ss}, t_{ss}, F_{u.ss}) = 15616 \cdot lbs$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} T_{s2} \div (\phi_{sms} \cdot P_{nt}) \\ V_{s2} \div (\phi_{sms} \cdot P_{ns}) \end{bmatrix} = \begin{pmatrix} 56 \\ 8 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left[\begin{bmatrix} \left[\frac{V_{s2}}{P_{vnov}} + 0.71\left(\frac{T_{s2}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{V_{s2}}{P_{vnot}} + \left(\frac{T_{s2}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{V_{s2}}{P_{vnss}} + \left(\frac{T_{s2}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right] = 42 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

Hold Down clip Bending and Shear Interaction

Diameter of SMS:

$d_{sms} := vlookup(Size_{ss}, SMS_{Table}, 1)_0 \cdot in = 0.25 \cdot in$

Depth of flat web portion

$h_{clip.shear} := L_{clip} - n_{sms} \cdot d_{sms} = 7 \cdot in$

Depth-to-Thickness Ratio:

$\frac{h_{clip.shear}}{t_{clip}} = 65 \qquad E := 29500ksi \qquad F_y := 50ksi \qquad \mu := 0.3$

Nominal Shear Stress:
(For unreinforced web)
AISI S100-16 G2.1

$k_v := 5.34 \qquad \sqrt{\frac{E \cdot k_v}{F_y}} = 56 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 85$

Area of Web Element:

$A_w := h_{clip.shear} \cdot t_{clip} = 0.759 \cdot in^2$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h_{clip.shear}}{t_{clip}}\right)^2} = 34.1 \cdot ksi$$

$V_{cr} := A_w \cdot F_{cr} \qquad V_y := 0.6 \cdot A_w \cdot F_y = 23\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.937$

Hole Shear Reduction Factor:
(for circular holes, AISI S100-16 Eq G3-1)

$c := \frac{h_{clip.shear}}{2} - \frac{d_{sms}}{2.83} = 3.41 \cdot in$

$$q_s := \begin{cases} 1.0 & \text{if } \frac{c}{t_{clip}} \geq 54 \\ \frac{c}{54 \cdot t_{clip}} & \text{if } 5 \leq \frac{c}{t_{clip}} < 54 \end{cases} = 0.583$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \leq 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \leq 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 19.792 \cdot kip$$

Design Shear Capacity with holes:

$\phi V_{n.clip} := 0.95 \cdot V_n \cdot q_s = 11 \cdot kip$

D/C Ratio of V and M per AISI S100-16 Eq H2-1

$$DCR_{V.M.int.clip} := \sqrt{\left(\frac{M_{u.clip}}{\phi M_n}\right)^2 + \left(\frac{\max(T_{clip}, V_{clip})}{\phi V_{n.clip}}\right)^2} = 0.5116$$

Demand/Capacity Ratio:

$VandM_{int.clip} = \text{"OK"}$

ISOLATOR DESIGN [PER OPM-0401-13]

OPM-0401-13 is based on allowable stress design

Number of isolators on the long side

$N_B := 3.5$ $N_{iso.long} := N_B = 4$

Moment Arm for overturning (Short side)

$B := W_{curb} + \frac{1.75in}{2} \cdot 2 = 39 \cdot in$

Number of isolators on the Short side.

$N_L := 2$

Isolator Centerline Spacing (Long side)

$L_{spacing.iso} := \frac{L_{curb} - (6in) \cdot 2}{N_B - 1} = 22.15 \cdot in$

Moment Arm for overturning (Long side)

$L := L_{curb} - 2 \cdot 6in - 2 \cdot L_{spacing.iso} \cdot \frac{(N_L - 2)}{4} = 55 \cdot in$

Total Number of isolators

$N_t := (N_B) \cdot 2sides = 7$

Max net Tension Reaction due to Seismic, Fp

$EQ_{ASD} := \left[0.6 - (0.7 \cdot F_v)\right] \cdot Wt_{unit} = 0.429\ kip$

$$R_{iso.EQ} := MAX+\left[\begin{bmatrix}\left[\frac{(0.7F_p) \cdot Wt_{unit}}{B \cdot N_B} \cdot (h_{CG.unit} + 0in) + \frac{EQ_{ASD} \cdot e_{width}}{B \cdot N_B}\right] - \frac{EQ_{ASD}}{N_t} \\ \left[\frac{(0.7F_p) \cdot Wt_{unit}}{L \cdot N_L} \cdot (h_{CG.unit} + 0in) + \frac{EQ_{ASD} \cdot e_{length}}{L \cdot N_L}\right] - \frac{EQ_{ASD}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}357 \\ 434\end{pmatrix} \cdot lbs$$

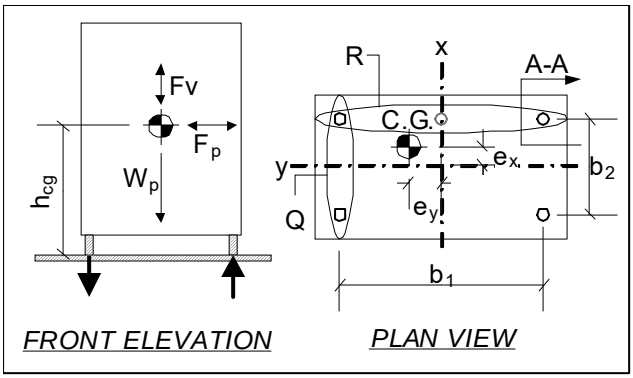
Max net Tension Reaction due to Wind load, Pnet

$$F_{wind.B} := \frac{P_{net} \cdot L_{unit} \cdot (H_{unit} + 0in)}{B \cdot N_B} \cdot \left(\frac{1}{2} \cdot H_{unit} + 0in\right) = 467 \cdot lbs$$

$$F_{wind.L} := \frac{P_{net} \cdot W_{unit} \cdot (H_{unit} + 0in)}{L \cdot N_L} \cdot \left(\frac{1}{2} \cdot H_{unit} + 0in\right) = 463 \cdot lbs$$

$$R_{iso.W} := (0.6) \cdot MAX+\left(\begin{pmatrix}F_{wind.B} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{Wt_{unit}}{N_t} \\ F_{wind.L} + \frac{P_v \cdot L_{unit.up} W_{unit}}{N_t} + \frac{Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{Wt_{unit}}{N_t}\end{pmatrix}\right) = \begin{pmatrix}524 \\ 501\end{pmatrix} \cdot lbs$$

Tensile and Shear Load calculation per ASHRAE RP-812



Eccentricity along X-X

$e_x := e_{width} = 7.5 \cdot in$

Eccentricity along Y-Y

$e_y := e_{length} = 2.56 \cdot in$

Distance between Seismic Restraints Along Y-Y

$b_1 := L_{curb} - 2 \cdot 6in = 55 \cdot in$

Distance between Seismic Restraints Along X-X

$b_2 := W_{curb} + 2 \cdot \frac{1.75in}{2} = 39 \cdot in$

Moment of Inertia about X-X

$I_{xx} := \frac{N_t \cdot (N_t + 2) \cdot (b_1)^2}{12 \cdot (N_t - 2)} = 3220 \cdot in^2$

Moment of Inertia about Y-Y

$I_{yy} := \frac{N_t \cdot (b_2)^2}{4} = 2653 \cdot in^2$

Angle about Tensile Load

$\Theta_t := \operatorname{atan}\left[\frac{I_{yy} \cdot (b_1)}{I_{xx} \cdot (b_2)}\right] = 50 \cdot deg$

Angle about Shear Load

$\Theta_s := \begin{cases} \operatorname{atan}\left(\frac{e_x}{e_y}\right) & \text{if } e_y \neq 0 \\ 0deg & \text{if } e_y = 0 \end{cases} = 71 \cdot deg$

Max Net Tensile Load Due to Seismic Load, Fp

$T_{U.EQ.pt1} := \frac{(0.6 - 0.7 \cdot F_v) \cdot Wt_{unit}}{N_t} - \frac{(0.6 - 0.7 \cdot F_v) \cdot Wt_{unit}}{b_1 \cdot b_2} \cdot \left(\frac{b_1}{2} \cdot e_x + \frac{b_2}{2} \cdot e_y - e_x \cdot e_y\right) = 14 \cdot lbs$

$T_{U.EQ.pt2} := -0.7 \cdot (F_p \cdot Wt_{unit}) \cdot (h_{CG.unit} + 0in) \cdot \cos(\Theta_t) \cdot \frac{0.5 \cdot b_2}{I_{yy}} = -256 \cdot lbs$

$T_{U.EQ.pt3} := -0.7 \cdot (F_p \cdot Wt_{unit}) \cdot (h_{CG.unit} + 0in) \cdot \sin(\Theta_t) \cdot \frac{0.5 \cdot b_1}{I_{xx}} = -352 \cdot lbs$

$T_{U.EQ} := T_{U.EQ.pt1} + T_{U.EQ.pt2} + T_{U.EQ.pt3} = -594 \cdot lbs$

Max Net Shear Load Due to Seismic Load, Fp

$$V_{Ux.EQ} := 0.7 \cdot F_p \cdot Wt_{unit} \cdot \frac{\cos(\Theta_s)}{N_t} + \frac{0.7 \cdot F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_2 \cdot e_y + 0.7 \cdot F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_1 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 214 \cdot lbs$$

$$V_{Uy.EQ} := 0.7 \cdot F_p \cdot Wt_{unit} \cdot \frac{\sin(\Theta_s)}{N_t} + \frac{0.7 \cdot F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_1 \cdot e_y + 0.7 \cdot F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_2 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 423 \cdot lbs$$

$$V_{U.EQ} := \sqrt{V_{Ux.EQ}^2 + V_{Uy.EQ}^2} = 474 \cdot lbs$$

Tension Design force SRSS for loading from Each direction

$R_{iso.EQ.1.RP812} := \left| T_{U.EQ.pt1} + T_{U.EQ.pt3} \right| = 338 \cdot lbs$

$R_{iso.EQ.0.RP812} := \left| T_{U.EQ.pt1} + T_{U.EQ.pt2} \right| = 242 \cdot lbs$

$$R_{iso.EQ.max_1} := \max\left[\left(R_{iso.EQ.1.RP812} + 0 \cdot R_{iso.EQ.0.RP812}\right), \left(R_{iso.EQ_1} + 0 \cdot R_{iso.EQ_0}\right)\right] = 434 \cdot lbs$$

$$R_{iso.EQ.max_0} := \max\left[\left(R_{iso.EQ.0.RP812} + 0 \cdot R_{iso.EQ.1.RP812}\right), \left(R_{iso.EQ_0} + 0 \cdot R_{iso.EQ_1}\right)\right] = 357 \cdot lbs$$

For the plot:

$R_{iso.EQ.max_1} = 434 \cdot lbs$ $R_{iso.W_1} = 501 \cdot lbs$

$R_{iso.EQ.max_0} = 357 \cdot lbs$ $R_{iso.W_0} = 524 \cdot lbs$

Shear load at each anchor location

For the plot:

$$V_{iso.E} := \max\left[\left[\begin{array}{c} 1.0 \cdot V_{Ux.EQ} + 0 \cdot V_{Uy.EQ} \\ 0.3 \cdot V_{Ux.EQ} + 0 \cdot V_{Uy.EQ} \\ \left[\left(0.7F_p\right) \cdot Wt_{unit} \cdot \frac{1}{N_t}\right] \end{array}\right]\right] = 371 \cdot lbs \qquad V_{iso.W} := 0.6P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t} = 264 \cdot lbs$$

Isolator Capacity:

$ID_{Iso} := "CQA"$

$T_{n.\Omega} := 2117lbs$ **(ASD)**

$V_{n.\Omega} := 775lbs$ **(ASD)**

Isolator Demand:

$R_{iso.max} := \max\left[\left(R_{iso.EQ.max_1}\right), \left(R_{iso.EQ.max_0}\right), \left(R_{iso.W_1}\right), \left(R_{iso.W_0}\right)\right] = 524 \cdot lbs$

$V_{iso.max} := \max\left(V_{iso.E}, V_{iso.W}\right) = 371 \cdot lbs$

D/C Ratio of Tension Only.:

$$DCR_{tension} := \frac{R_{iso.max}}{T_{n.\Omega}} = 0.247$$

$DCR_{tension} = "OK"$

D/C Ratio of Shear Only.:

$$DCR_{shear} := \frac{V_{iso.max}}{V_{n.\Omega}} = 0.479$$

$DCR_{shear} = "OK"$

D/C Ratio of Tension Only.:

$$DCR_{Int} := \frac{V_{iso.max}}{V_{n.\Omega}} + \frac{R_{iso.max}}{T_{n.\Omega}} = 0.727$$

$DCR_{Int} = "OK"$

ISOLATOR "SPRING" DESIGN [PER OPM-0401-13]

Factor of Safety of Spring

$FS_{spring} := 0.75$

Compressive Strength of Spring

$$C_{spring.\Omega} := \begin{cases} \left(FS_{spring} \cdot 300lbs\right) & \text{if } ID_{Iso} = "CQA" \\ \left(FS_{spring} \cdot 918lbs\right) & \text{if } ID_{Iso} = "CQB" \\ \left(FS_{spring} \cdot 918lbs\right) & \text{if } ID_{Iso} = "CQBX" \end{cases} = 225 \cdot lbs$$

Rated Load per unit self-weight

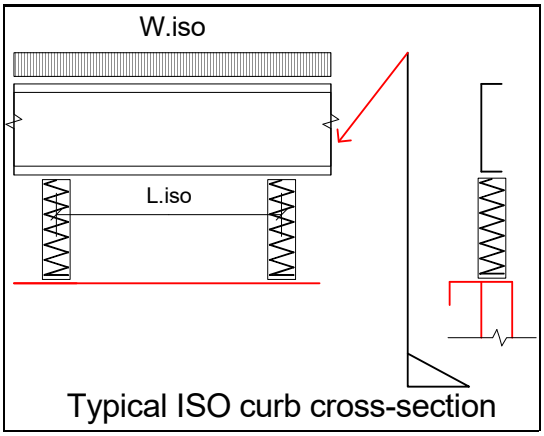
$$C_{unit.rated.load} := \frac{Wt_{unit}}{N_t} = 157 \cdot lbs$$

D/C Ratio of Spring Compression:

$$DCR := \frac{C_{unit.rated.load}}{C_{spring.\Omega}} = 0.698$$

$IsoSpring_{compression} = "OK"$

Check ISO Rail for Bending about Strong and Weak Axis (AISI S100-16 F2.1)



Typical ISO curb cross-section

Thickness of Curb:

$t_{Curb.iso}$ = "10GA" $t := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Inside Bend Radius:

$R := R_{iso} = 0.186 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web:

$h := 7.5in - 2 \cdot (t + R) = 6.85 \cdot in$

Width of Flange:

$h_w := 1in$

Check Curb Bending of Long Side (Strong axis)

Member per CFS: $CFS_{member} :=$ "10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"

Number of Isolators on each Long Side: $N_{iso.long} = 4$

Center-to-Center Spacing of Isolators $L_{iso} := \frac{L_{curb}}{N_{iso.long} - 1} = 27 \cdot in$

Distributed Load $\omega_{iso} := \omega_{x.L.vert} = 1.837\,klf$

Moment Demand on Iso Rail $M_{cx} := \frac{\omega_{iso} \cdot L_{iso}^2}{8} = 13.894 \cdot kip \cdot in$

Curb Elastic Modulus / Yield Stress: $E := 29500ksi$ $F_y := 50ksi$

Curb Shear Modulus: $G := 11300ksi$

Poisson's Ratio $\mu := 0.3$

Section Properties from CFS: $r_x = 2.4893 \cdot in$ $r_o = 2.519 \cdot in$ $C_w = 0.595 \cdot in^6$ $S_x = 1.855 \cdot in^3$

$r_y = 0.2288 \cdot in$ $J = 0.0058 \cdot in^4$ $S_y = 0.3669 \cdot in^3$

$r_{min} := \min(r_x, r_y) = 0.2288 \cdot in$

Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Flanges*

Flat Width: $w := h_w - R_{curb} = 0.893 \cdot in$

Stiffened Web Check: $Stiffened_{check} := "Unstiffened"$

Stress at the end of the Width: $f_2 := 11.407ksi$ $f_1 := 11.407ksi$

Compressive Stress Ratio (Eq. 1.1.2-1): $\Psi := \frac{f_2}{f_1} = 1$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = "Stiffened" \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = "Unstiffened" \end{cases} = 0.43$$

Critical Compressive Stress: $F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot (1 - \mu^2)} \cdot \left(\frac{t}{w}\right)^2 = 274.53 \cdot ksi$

Stress in Compression Element: $f := 18ksi$

Note: Use f from "Elastive Flexural Buckling Stress" on "Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI E2)"

Slenderness Factor: $\lambda := \sqrt{\frac{f}{F_{cr}}} = 0.26$

Local reduction factor: $\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 0.55$

Effective Width of the Flanges:

$$b_{eff.flange} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 0.893 \cdot in$$

Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Web*

Flat Width: $w := h = 6.851 \cdot in$

Stiffened Web Check: $Stiffened_{check} := "Stiffened"$

Stress at the end of the Width: $f_2 := 11.407ksi$ $f_1 := 11.407ksi$

Compressive Stress Ratio (Eq. 1.1.2-1): $\Psi := \frac{f_2}{f_1} = 1$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = "Stiffened" \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = "Unstiffened" \end{cases} = 4$$

Critical Compressive Stress: $F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t}{w}\right)^2 = 43.4 \cdot ksi$

Stress in Compression Element: $f := 18ksi$

Note: Use f from "Elastive Flexural Buckling Stress" on "Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI E2)"

Slenderness Factor: $\lambda := \sqrt{\frac{f}{F_{cr}}} = 0.64$

Local reduction factor: $\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 1.022$

Effective Width of the Web:

$$b_{eff.web} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 6.851 \cdot in$$

Effective Area of the Member: $A_e := 2 \cdot \left(b_{eff.flange} \cdot t\right) + b_{eff.web} \cdot t = 1.194 \cdot in^2$

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. F2.1.1-4,5)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(1.0 \cdot L_{iso}\right)^2}\right] = 40 \cdot ksi$$

$$\sigma_{ey} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{iso}}{r_y}\right)^2} = 21 \cdot ksi \qquad \frac{1.0 \cdot L_{iso}}{r_y} = 118$$

KL_r = "KL/r < 200, OK"

Cb per Eq. F2.1.1-2

$$M_A := \frac{\omega_{iso} \cdot \frac{L_{iso}}{4}}{2} \cdot \left(L_{iso} - \frac{L_{iso}}{4}\right) = 10.42 \cdot kip \cdot in$$

$$M_B := M_{cx} = 13.89 \cdot kip \cdot in$$

$$M_C := \frac{\omega_{iso} \cdot \frac{3 \cdot L_{iso}}{4}}{2} \cdot \left(L_{iso} - \frac{3 \cdot L_{iso}}{4}\right) = 10.42 \cdot kip \cdot in$$

$$C_b := \min\left(1.0, \frac{12.5 \cdot M_{cx}}{2.5 \cdot M_{cx} + 3 \cdot M_A + 4 \cdot M_B + 3.M_C}\right) = 1$$

Elastic Critical Lateral-Torsional Buckling Stress per Eq. F2.1.1-1 for Singly Symmetry:

$$F_e := \frac{C_b \cdot r_o \cdot A_e}{S_x} \cdot \sqrt{\sigma_{ey} \cdot \sigma_t} = 47 \cdot ksi$$

LTB Design Stress: Eq. F2.1-3,4,5:

$$F_c := \begin{cases} F_y & \text{if } F_e \geq 2.78 \cdot F_y \\ \frac{10}{9} \cdot F_y \cdot \left(1 - \frac{10 \cdot F_y}{36 \cdot F_e}\right) & \text{if } 2.78 \cdot F_y > F_e > 0.56 \cdot F_y \\ F_e & \text{if } 0.56 \cdot F_y \geq F_e \end{cases} = 39 \cdot ksi$$

Moment Capacity Eq. F2.1-1:

$$\phi M_{nx} := 0.9 \cdot S_x \cdot \min\left(F_c, F_y\right) = 65 \cdot kip \cdot in$$

D/C Ratio of Bending:

$$DCR := \frac{M_{cx}}{\phi M_{nx}} = 0.213$$

$Iso_{Bending}$ = "OK"

Check Curb Bending of Long Side (Weak axis)

Center-to-Center Spacing of Braces

$$L_{brace} := \max\left(40in, \frac{L_{curb}}{N_{iso.long} - 1}\right) = 40 \cdot in$$

Note for weak-axis bracing length:
Max weak-axis span length of Iso Rail is larger than L_{brace} per cut sheet. However, the Iso Rail is braced with clip at max 24" O.C. at top and isolator at max 36" O.C. at bottom such that the actual unbraced length is as follows.

Distributed Load

$$\omega_{iso} := \frac{\max\left(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit}\right)}{L_{curb}} = 0.661\ klf$$

Moment Demand on Iso Rail

$$M_{cy} := \frac{\omega_{iso} \cdot L_{brace}^{2}}{8} = 11.02 \cdot kip \cdot in$$

Member per CFS:

CFS_{member} = "10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. F2.1.1-4,5)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(1.0 \cdot L_{brace}\right)^2}\right] = 23 \cdot ksi$$

$$\sigma_{ex} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{brace}}{r_x}\right)^2} = 1128 \cdot ksi \qquad \frac{1.0 \cdot L_{brace}}{r_x} = 16$$

KL_r = "KL/r < 200, OK"

Cb per Eq. F2.1.1-2

$$M_A := \frac{\omega_{iso} \cdot \frac{L_{brace}}{4}}{2} \cdot \left(L_{brace} - \frac{L_{brace}}{4}\right) = 8.27 \cdot kip \cdot in$$

$$M_B := M_{cy} = 11.02 \cdot kip \cdot in$$

$$M_C := \frac{\omega_{iso} \cdot \frac{3 \cdot L_{brace}}{4}}{2} \cdot \left(L_{brace} - \frac{3 \cdot L_{brace}}{4}\right) = 8.27 \cdot kip \cdot in$$

$$C_b := \min\left(1.0, \frac{12.5 \cdot M_{cx}}{2.5 \cdot M_{cx} + 3 \cdot M_A + 4 \cdot M_B + 3.M_C}\right) = 1$$

Elastic Critical Lateral-Torsional Buckling Stress per Eq. F2.1.1-1 for Singly Symmetry:

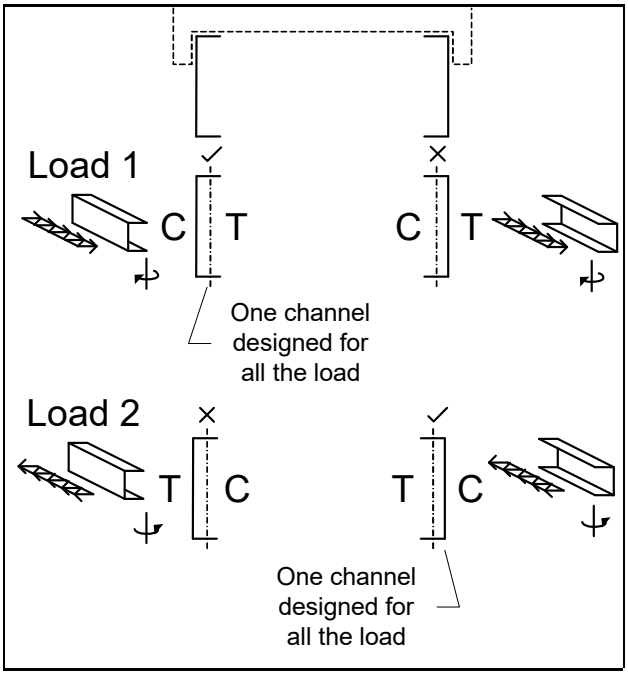
$$F_e := \frac{C_b \cdot r_o \cdot A_e}{S_y} \cdot \sqrt{\sigma_{ey} \cdot \sigma_t} = 180 \cdot ksi$$

LTB Design Stress: Eq. F2.1-3,4,5:

$$2.78 \cdot F_y = 139 \cdot ksi$$

$$0.56 \cdot F_y = 28 \cdot ksi$$

$$F_c := \begin{cases} F_y & \text{if } F_e \geq 2.78 \cdot F_y \\ \frac{10}{9} \cdot F_y \cdot \left(1 - \frac{10 \cdot F_y}{36 \cdot F_e}\right) & \text{if } 2.78 \cdot F_y > F_e > 0.56 \cdot F_y \\ F_e & \text{if } 0.56 \cdot F_y \geq F_e \end{cases} = 50 \cdot ksi$$



Note:

For ISO rail weak-axis bending capacity, rails are oriented and designed so that the stiffer side of ISO rail can take the entire bending load by itself without putting a lot of bending load to the iso rail on the other side

Moment Capacity Eq. F2.1-1:

$$\phi M_{ny} := 0.9 \cdot S_y \cdot \min\left(F_c, F_y\right) = 16.5105 \cdot kip \cdot in$$

D/C Ratio of Bending:

$$DCR := \frac{M_{cy}}{\phi M_{ny}} = 0.667$$

$$Iso_{Bending} := \text{if}\left(M_{cy} < \phi M_{ny}, \text{"OK"}, \text{"NG"}\right)$$

$Iso_{Bending} = \text{"OK"}$

Web Crippling of ISO Rail (AISI S100-16 G.5)

Governing Compression:

$$P_{web.crip} := \frac{\omega_{x.L.vert} \cdot L_{iso}}{2} = 2062 \cdot lbs$$

Yield Strength:

$$F_y := 50ksi$$

Bearing Length:

$N := 2in$ **2 in. for CQAs**

Thickness of Curb:

$t_{Curb.iso} = \text{"10GA"} \quad t := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Inside Bend Radius:

$R := R_{iso} = 0.186 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web:

$h = 6.85 \cdot in$

Angle btween plane of web and bearing surface:

$\theta := 90deg$

Web Crippling Limit Check (AISI Table G5-2):

$$\frac{R}{t} = 1 \quad \frac{h}{t} = 50 \quad \frac{N}{t} = 14 \quad \frac{N}{h} = 0.29$$

$$LimitCheck_{webcrippling} := if\left[\left(\frac{h}{t} < 200\right) \wedge \left(\frac{N}{t} < 210\right) \wedge \left(\frac{N}{h} < 2\right) \wedge \left(\frac{R}{t} < 2\right), \text{"OK"}, \text{"NG, Need Reinf"}\right]$$

$LimitCheck_{webcrippling} = \text{"OK"}$

End Case Coefficient Single Web Channel (AISI Table G5-2):

$C := 2$ $C_R := 0.11$ $C_N := 0.37$ $C_h := 0.01$

Reduction Factor Web Crippling Strength:

$\phi_{web.end} := 0.75$ **(For Unfastened Flanges with Two-Flange Loading or Reaction. Worst Case)**

$\phi_{web.int} := 0.8$

Design Web Crippling Strength:

$$P_{n.end} := C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 3729 \cdot lbs$$

$$\phi P_{n.end} := \phi_{web.end} \cdot P_{n.end} = 2796 \cdot lbs$$

Interior Case Coefficient Single Web Channel (AISI Table G5-2):

$C := 13$ $C_R := 0.47$ $C_N := 0.25$ $C_h := 0.04$

Design Web Crippling Strength:

$$P_{n.interior} := C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 7905 \cdot lbs$$

$$\phi P_{n.interior} := \left(\phi_{web.int}\right) \cdot P_{n.interior} = 6324 \cdot lbs$$

Design Strength:

$$P_{n.web.crip} := \min\left(P_{n.end}, P_{n.interior}\right) = 3729 \cdot lbs$$

$$\phi P_{n.web.crip} := \min\left(\phi P_{n.end}, \phi P_{n.interior}\right) = 2796 \cdot lbs$$

D/C Ratio of Shear:

$$DCR := \frac{P_{web.crip}}{\phi P_{n.web.crip}} = 0.737$$

Demand/Capacity Ratio:

$$Web_{crippling} := \text{if}\left[\left(P_{web.crip} < \phi P_{n.web.crip}\right) \wedge \left(\phi P_{n.end} > 0\right) \wedge \frac{h}{t} < 200, \text{"OK"}, \text{"NG, Need Reinf"}\right]$$

$Web_{crippling} = \text{"OK"}$

D/C Ratio of Interaction:
AISI Eq. H3-1b

$$DCR_{int.web} := \frac{0.91 \cdot \left(\frac{P_{web.crip}}{P_{n.web.crip}}\right) + \frac{M_{cx}}{\left(\frac{\phi M_{nx}}{0.9}\right)}}{1.33 \cdot 0.9} = 0.58$$

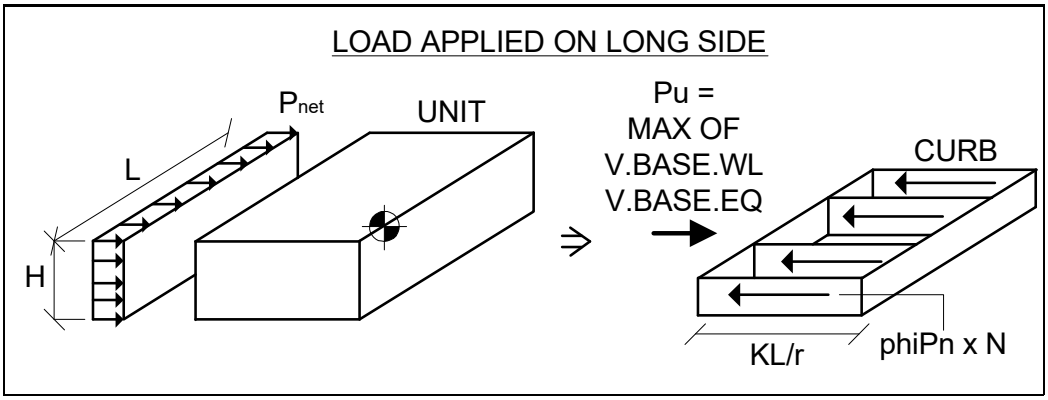
$Iso_{Shear} = \text{"OK"}$

$Iso_{Interaction} = \text{"OK"}$

Per AISI S100-16 H3,
Only x-axis needs to check for interaction

Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI S100-16 E2)

Curb Axial Load Check due to Load on Long Side



Wind Base Shear of Unit on Long Side: $V_{base.W.L} := P_{net} \cdot L_{unit} \cdot H_{unit} = 3.1\,kip$

Seismic Base Shear of Unit on Long Side: $V_{base.S.L} := F_p \cdot Wt_{unit} = 3.7\,kip$

Max Axial: $P_u := \max\left(V_{base.S.L}, V_{base.W.L}\right) = 3712.5 \cdot lbs$

Member per CFS: $CFS_{member} =$ "10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"

Number of Curb in Length: $n_{iso} := 3$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{iso}} = 1.24\,kip$

Max Braced Length of Member: $L_{member} := W_{curb} = 37 \cdot in$

Effective Length factor: $K := 0.5$

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. E2.2-5, E2.2-6)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(K \cdot L_{member}\right)^2}\right] = 75 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2} = 44 \cdot ksi$$

$$\frac{K \cdot L_{member}}{r_{min}} = 81$$

KL_r = "KL/r < 200, OK"

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 28 \cdot ksi$$

Nominal Compressive Stress Capacity (Eq E2-4):

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 1.343$$

$$F_n := \begin{cases} 0.658^{\lambda_c^{\,2}} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^{\,2}}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 23.51 \cdot ksi$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot A_e \cdot F_n = 23.85\ kip$$

D/C Ratio of Compression:

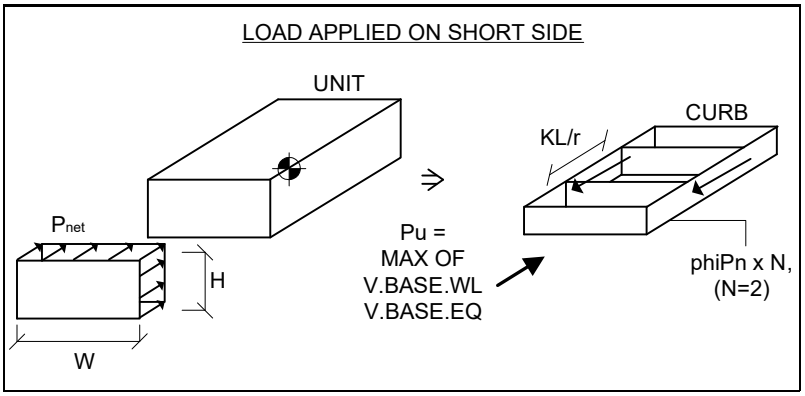
$$DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.052$$

$$Axial_{reinf} := \text{if}\left(P_{u.EAmember} < \phi P_{n.member}, \text{"OK"}, \text{"NG"}\right)$$

$Axial_{reinf}$ = "OK"

Note:
No need to check for interaction since equipment is not attached to the short side

Curb Axial Load Check due to Load on Short Side



Wind Base Shear on Short Side: $V_{base.W.H} := P_{net} \cdot W_{unit} \cdot H_{unit} = 2.5\,kip$

Seismic Base Shear of Unit on Short Side: $V_{base.S.W} := F_p \cdot Wt_{unit} = 3.7\,kip$

Max Axial: $P_u := \max\left(V_{base.S.W}, V_{base.W.H}\right) = 3712.5 \cdot lbs$

Member per CFS: CFS_{member} = "10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"

Number of Curb in Length: $n_{curb} := 2$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{curb}} = 1.86\,kip$

Max Braced Length of Member: $L_{member} := \frac{L_{curb}}{n_{iso} - 1} = 34 \cdot in$

Effective Length factor: $K := 0.5$

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. E2.2-5, E2.2-6)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(K \cdot L_{member}\right)^2}\right] = 89 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2} = 54 \cdot ksi \qquad \frac{K \cdot L_{member}}{r_{min}} = 74$$

KL_r = "KL/r < 200, OK"

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 34 \cdot ksi$$

Nominal Compressive Stress Capacity (Eq E2-4):

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 1.221$$

$$F_n := \begin{cases} 0.658^{\lambda_c^2} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^2}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 26.79 \cdot \text{ksi}$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot A_e \cdot F_n = 27.18\ \text{kip}$$

D/C Ratio of Compression:

$$DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.068$$

$$Axial_{reinf} := \text{if}\left(P_{u.EAmember} < \phi P_{n.member}, \text{"OK"}, \text{"NG"}\right)$$

$Axial_{reinf} = \text{"OK"}$

Note:
If the load direction is in perpedicular plane to the short side of the equipment, the channels will only experience axial load and no bending will occur at the channel. Therefore, no need to check for interaction since the channels

Shear of ISO Rail Webs without Holes (AISI S100-16 G2)

Note: The connection holes are not centered at mid-depth of isolated curb rail so AISI G2 shall be used

Deeper Section (h = depth)

Thickness of Curb: $t := \text{thick}(t_{Curb.iso}) = 0.138 \cdot in$

Depth-to-Thickness Ratio: $\frac{h}{t} = 50$

Curb Elastic Modulus: $E := 29500ksi$

Clear distance b/w transverse stiffeners of reinforced web: $a := L_{iso} = 27 \cdot in$

Clear Distance-to-Thickness Ratio: $\frac{a}{h} = 3.93$

Nominal Shear Stress:

$$k_v := \begin{cases} 5.34 & \text{if } a = L_{iso} \\ 4.00 + \frac{5.34}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \frac{4.00}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 5.6$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 57 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 87$$

Curb Shear Check due to Load on Longer Side

Area of Web Element:

$$A_w := h \cdot t = 0.947 \cdot in^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 60.7 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} = 58\,kip \qquad V_y := 0.6 \cdot A_w \cdot F_y = 28\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.703$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 28.404 \cdot kip$$

Number of Members within Length: $n := 1$ **(Per Curb Design)**

Design Shear Capacity:

$$\phi V_{n.h} := 0.95 \cdot n \cdot V_n = 26.98 \cdot kip$$

Design Shear Demand:

$$V_{u.h} := \frac{\omega_{x.L.vert} \cdot L_{iso}}{2} = 2062.3 \cdot lbs$$

D/C Ratio of Shear:

$$DCR := \frac{V_{u.h}}{\phi V_{n.h}} = 0.076$$

Demand/Capacity Ratio:

$Shear_{in.plane} = \text{"OK"}$

Shallower Section (h.w = Width)

Thickness of Curb: $t := thick(t_{Curb.iso}) = 0.138 \cdot in$

Depth-to-Thickness Ratio: $\frac{h_w}{t} = 7$

Curb Elastic Modulus: $E := 29500 ksi$

Clear distance b/w transverse stiffeners of reinforced web: $a := L_{brace} = 40 \cdot in$

Clear Distance-to-Thickness Ratio: $\frac{a}{h_w} = 40$

Nominal Shear Stress:

$$k_v := \begin{cases} 5.34 \text{ if } a = L_{brace} \\ 4.00 + \frac{5.34}{\left(\frac{a}{h_w}\right)^2} \text{ if } \left(\frac{a}{h_w} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \frac{4.00}{\left(\frac{a}{h_w}\right)^2} \text{ if } \left(\frac{a}{h_w} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 5.34$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 56 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 85$$

Curb Shear Check due to Load on Longer Side

Area of Web Element: $A_w := h_w \cdot t = 0.1382 \cdot in^2$

Number of Members within Length: $n := 1$ **(Per Curb Design)**

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 58 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} = 8 \, kip \qquad V_y := 0.6 \cdot A_w \cdot F_y = 4 \, kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.719$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 4.146 \cdot \text{kip}$$

Design Shear Capacity:

$$\phi V_{n.hw} := 0.95 \cdot n \cdot V_n = 3.9 \cdot \text{kip}$$

Design Shear Demand:

$$V_{u.hw} := \frac{\left(\frac{\max\left(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit}\right)}{L_{curb}} \right) \cdot L_{brace}}{2} = 1102 \cdot \text{lbs}$$

D/C Ratio of Shear:

$$DCR := \frac{V_{u.hw}}{\phi V_{n.hw}} = 0.28$$

Demand/Capacity Ratio:

$Shear_{in.plane}$ = "OK"

D/C Ratio of Vx and Mx:

$$DCR_{V.M.int} := \begin{cases} \left(0.6 \cdot \frac{M_{cx}}{\phi M_{nx}} + \frac{V_{u.h}}{\phi V_{n.h}}\right) \cdot \frac{1}{1.3} & \text{if } \frac{M_{cx}}{\phi M_{nx}} > 0.5 \wedge \frac{V_{u.h}}{\phi V_{n.h}} > 0.7 \\ \sqrt{\left(\frac{M_{cx}}{\phi M_{nx}}\right)^2 + \left(\frac{V_{u.h}}{\phi V_{n.h}}\right)^2} & \text{otherwise} \end{cases} = 0.226$$

Demand/Capacity Ratio:

$VandMx_{int}$ = "OK"

D/C Ratio of Vy and My:

$$DCR_{V.M.int} := \begin{cases} \left(0.6 \cdot \frac{M_{cy}}{\phi M_{ny}} + \frac{V_{u.hw}}{\phi V_{n.hw}}\right) \cdot \frac{1}{1.3} & \text{if } \frac{M_{cy}}{\phi M_{ny}} > 0.5 \wedge \frac{V_{u.hw}}{\phi V_{n.hw}} > 0.7 \\ \sqrt{\left(\frac{M_{cy}}{\phi M_{ny}}\right)^2 + \left(\frac{V_{u.hw}}{\phi V_{n.hw}}\right)^2} & \text{otherwise} \end{cases} = 0.724$$

Demand/Capacity Ratio:

$VandMy_{int}$ = "OK"

Web Crippling/Compression of Non-iso CanFab Curb (AISI S100-16 G5)

Governing Compression for Non-Isolated Curb:

$$P_{web.crip.int} := \max\left[\frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}}, \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}}\right] \cdot L_{spacing.non.iso} = 2366 \cdot lbs$$

$$P_{web.crip.end} := 0.5 \cdot P_{web.crip.int} = 1183 \cdot lbs$$

Yield Strength: $F_y := 50ksi$

Bearing Length: $N_{bearing} := L_{spacing.non.iso} = 15 \cdot in$

Thickness of Curb: $t_{Curb} = \text{"14GA"}$ $t := thick(t_{Curb}) = 0.0785 \cdot in$

Inside Bend Radius: $R := R_{curb} = 0.107 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web: $h := 18in - 2 \cdot (t + R) = 17.63 \cdot in$

Angle btween plane of web and bearing surface: $\theta := 90deg$

Web Crippling Limit Check (AISI Table G5-2): $\frac{R}{t} = 1$ $\frac{h}{t} = 225$ $\frac{N_{bearing}}{t} = 197$ $\frac{N_{bearing}}{h} = 0.88$

End Case Coefficient Single Web Channel (AISI Table G5-2): $C := 13$ $C_R := 0.32$ $C_N := 0.05$ $C_h := 0.04$

Reduction Factor Web Crippling Strength: $\phi_{web.end} := 0.9$ $\phi_{web.int} := 0.8$ **(For Unfastened partially Stiffened Flanges with Two-Flange Loading or Reaction.)**

Design Web Crippling Strength:

$$\phi P_{n.end} := \left(\phi_{web.end}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 1540 \cdot lbs$$

Interior Case Coefficient Single Web Channel (AISI Table G5-2): $C := 24$ $C_R := 0.52$ $C_N := 0.15$ $C_h := 0.001$

Design Web Crippling Strength:

$$\phi P_{n.interior} := \left(\phi_{web.int}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 7114 \cdot lbs$$

D/C Ratio of Shear: $DCR_{end} := \frac{P_{web.crip.end}}{2 \cdot \phi P_{n.end}} = 0.384$ $DCR_{int} := \frac{P_{web.crip.int}}{\phi P_{n.interior}} = 0.333$

Demand/Capacity Ratio: **Note: Factor of 2 for two ends connected together at the end**

$Web_{crippling} = \text{"OK"}$

Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Length

Roof Curb thickness

$t_{Curb} = \text{"14GA"}$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

Min width of Roof Curb

$b_{curb} := L_{curb} + \frac{W_{curb}}{2} \cdot 2 + 3in \cdot 2 \cdot 2 = 116.56 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := L_{curb} + \min\left(\frac{W_{curb}}{2} \cdot 2, \frac{L_{curb}}{2}\right) = 101 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{array}{c} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{array} \right] \right] = 5387 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.L.vert.up} \cdot L_{curb}) \cdot (0.75in) = 4770 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.885$

$Curb_{BotFlangeBending} = \text{"OK"}$

Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Width

Roof Curb thickness

$t_{Curb} = \text{"14GA"}$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

Min width of Roof Curb

$b_{curb} := W_{curb} + \frac{L_{curb}}{4} \cdot 2 + 3in \cdot 2 = 76.88 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := W_{curb} + \min\left(\frac{L_{curb}}{6} \cdot 2, W_{curb}\right) = 60 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{array}{c} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{array} \right] \right] = 3553 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.W.vert.up} \cdot W_{curb}) \cdot (0.75in) = 2501 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.704$

$Curb_{BotFlangeBending} = \text{"OK"}$

Web Crippling/Compression of Iso CanFab Curb (AISI S100-16 G5)

Note: Curb stiffeners directly transfer the compressive load from isolator to the base. Therefore, curb web crippling is prevented.

Curb Web with Reinforcement

Max Compression: $Comp_{maxtot} := \max(|C_S|, |C_W|) = 12196.09 \cdot lbs$

Reinforcement per CFS: $CFS_{reinf} :=$ "Single Stiffener 10GA 1"x7"x1" Fy=50ksi 18" Tall on min. 16GA "

Note: min. of 10 GA channel and min. 16 GA curb web

Number of Reinforcement in Length: $n_{reinf} := N_{iso.long} = 4$

Max Compression per Reinf: $Comp_{per.reinf} := \frac{Comp_{maxtot}}{n_{reinf}} = 3.485\,kip$

Spacing: $Spacing := \frac{L_{curb}}{n_{reinf}} = 19 \cdot in$ $KL_r := \frac{1.0 \cdot (H_{curb} - 12.5in)}{0.2339in} = 77$

Factored Nominal Comp. Capacity per reinforcement: $\phi P_{n.reinf} = 21.066 \cdot kip$ **(See attached CFS)**

Total Factored nominal Comp Capacity: $\phi P_{n.tot} := n_{reinf} \cdot \phi P_{n.reinf} = 74 \cdot kip$

D/C Ratio of Compression: $DCR := \frac{Comp_{maxtot}}{\phi P_{n.tot}} = 0.17$

$Comp_{reinf} := if(Comp_{maxtot} < \phi P_{n.tot}, "OK", "NG")$ $Comp_{reinf} = "OK"$

Check CanFab Curb for Compressive Force due to T/C Coupling of Overturning

Note:
-Since the equipment is only attached to the longer sides of the CanFab Curb, most likely there will be compressive force onto the curb due to T/C coupling.
- Rectangular CanFab Curb will be considered as "Channel" to resist the compressive force.

Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Flanges*

Flat Width:

$$w := \frac{W_{curb}}{2} - R_{curb} = 18.487 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Unstiffened"}$$

Stress at the end of the Width:

$$f_2 := 50ksi \qquad f_1 := 50ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \left| \frac{f_2}{f_1} \right| = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 0.43$$

Critical Compressive Stress (Eq 1.1-4):

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w}\right)^2 = 0.21 \cdot ksi$$

Stress in Compression Element:

$$f := F_y = 50 \cdot ksi \qquad \textbf{(Assume f = Fy)}$$

Slenderness Factor (Eq 1.1-3):

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 15.55$$

Local reduction factor (Eq 1.1-2):

$$\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 0.063$$

Effective Width of the Flanges:

$$b_{eff.flange} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 1.172 \cdot in$$

Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Web*

Flat Width:

$$w := L_{curb} - R_{curb} \cdot 2 = 67.161 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Stiffened"}$$

Stress at the end of the Width:

$$f_2 := 50ksi \qquad f_1 := 50ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \left| \frac{f_2}{f_1} \right| = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 4$$

Critical Compressive Stress (Eq 1.1-4):

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w} \right)^2 = 0.15 \cdot ksi$$

Stress in Compression Element:

$$f := F_y = 50 \cdot ksi \qquad \textbf{(Assume f = Fy)}$$

Slenderness Factor (Eq 1.1-3):

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 18.52$$

Local reduction factor (Eq 1.1-2):

$$\rho := \left(1 - \frac{0.22}{\lambda}\right) \frac{1}{\lambda} = 0.053$$

Effective Width of the Web:

$$b_{eff.web} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 3.582 \cdot in$$

Effective Area of the Member:

$$A_e := 2 \cdot \left(b_{eff.flange} \cdot t_{curb} \right) + b_{eff.web} \cdot t_{curb} = 0.465 \cdot in^2$$

Length of the Compressive Member: $L_{curb.web} := h = 17.629 \cdot in$

Young's Modulus for Cold Form Steel: $E := 29500ksi$

Curb Shear Modulus: $G := 11300ksi$

Poisson's Ratio $\mu := 0.3$

Section Properties of the Member (From Section Properties Calculator):

$A_{half.curb} := 6.087in^2$ $r_o := 28.35in$ $I_x := 3577in^4$ $I_y := 311in^4$

$J := 0.006in^4$ $r_x := \sqrt{\frac{I_x}{A_{half.curb}}} = 24.241 \cdot in$ $r_y := \sqrt{\frac{I_y}{A_{half.curb}}} = 7.148 \cdot in$

$C_w := 209700in^6$ $r_{min} := \min(r_x, r_y) = 7.148 \cdot in$

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^2}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{(1.0 \cdot L_{curb.web})^2}\right] = 525419.037 \cdot ksi$$

$$\sigma_{e.y} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_y}\right)^2} = 47864.512 \cdot ksi \qquad \sigma_{e.x} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_x}\right)^2} = 550518.845 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2} = 47864.512 \cdot ksi$$

$$\frac{1.0 \cdot L_{curb.web}}{r_{min}} = 2.47$$

$KL_r = \text{"KL/r < 200, OK"}$

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 43868.215 \cdot ksi$$

Nominal Compressive Stress Capacity: (Eq E2-4)

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 0.034$$

$$F_n := \begin{cases} 0.658^{\lambda_c^2} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^2}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 49.98 \cdot ksi$$

Compressive Capacity:

$$P_{n.member} := A_e \cdot F_n = 23.25 \cdot kip$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot P_{n.member} = 19.76 \cdot kip$$

Factored Max Compressive Force:

$$P_{comp.max} := \max\left(\left|C_S\right|, \left|C_W\right|\right) = 12.196\,kip$$

D/C Ratio of Compression:

$$DCR := \frac{P_{comp.max}}{\phi P_{n.member}} = 0.617$$

$$Axial_{curb.comp} := \text{if}\left(P_{comp.max} < \phi P_{n.member}, \text{"OK"}, \text{"Provide Channel from above as Web Stiffener"}\right)$$

$Axial_{curb.comp} = \text{"OK"}$

Note: No need to check for interaction since the curb is only subjected to the compressive force.

Shear of CanFab Curb Webs without Holes (AISI S100-16 G2)

Note: Since the unit is stiffer than the curb and the curb is firmly attached to the unit and to the base structure, curbs will mainly take the lateral forces as shear and axial load rather than bending.

Thickness of Curb:

$$t := \text{thick}(t_{Curb}) = 0.079 \cdot \text{in}$$

Depth-to-Thickness Ratio:

$$\frac{h}{t} = 225$$

Curb Elastic Modulus:

$$E := 29500\text{ksi}$$

Clear distance b/w transverse stiffeners of reinforced web:

$$a := \max\left(\frac{L_{curb}}{2}, W_{curb}\right) = 37 \cdot \text{in} \qquad \frac{a}{h} = 2.11$$

$$k_v := \begin{cases} 5.34 & \text{if } a = L_{curb} \\ 4.00 + \dfrac{5.34}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \dfrac{4.00}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 6.24$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 61 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 92$$

Curb Shear Check due to Load on Longer Side

Area of Web Element:

$$A_w := W_{curb} \cdot t = 3 \cdot \text{in}^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 3.3 \cdot \text{ksi}$$

$V_{cr} := A_w \cdot F_{cr} = 10\,kip$ $V_y := 0.6 \cdot A_w \cdot F_y = 88\,kip$ $\lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 3.016$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 9.628 \cdot kip$$

Number of Members within Length: $n := 2$ **(Per Curb Design)**

Design Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 18293.8 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.H} := P_{net} \cdot L_{unit} \cdot H_{total} = 5342.3 \cdot lbs$

Design Shear Demand: $V_u := \max(V_{base.S}, V_{base.W.H}) = 5720.6 \cdot lbs$

D/C Ratio of Shear: $DCR := \frac{V_u}{\phi V_n} = 0.313$

Demand/Capacity Ratio:

$Shear_{in.plane} := \text{if}(V_u < \phi V_n, \text{"OK"}, \text{"NG"})$

$Shear_{in.plane} = \text{"OK"}$

Curb Shear Check due to Load on Shorter Side

Area of Web Element: $A_w := L_{curb} \cdot t = 5 \cdot in^2$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot (1 - \mu^2) \cdot \left(\frac{h}{t}\right)^2} = 3.3 \cdot ksi$$

$V_{cr} := A_w \cdot F_{cr} = 17\,kip$ $V_y := 0.6 \cdot A_w \cdot F_y = 159\,kip$ $\lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 3.016$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 17.444 \cdot kip$$

Number of Members within Length: $n := 2$ **(Per Curb Design)**

Factored Nominal Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 33144.1 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot W_{unit} \cdot H_{total} = 4309.8 \cdot lbs$

Factored Shear Demand: $V_u := \max(V_{base.S}, V_{base.W.L}) = 5720.6 \cdot lbs$

D/C Ratio of Shear: $DCR := \frac{V_u}{\phi V_n} = 0.173$

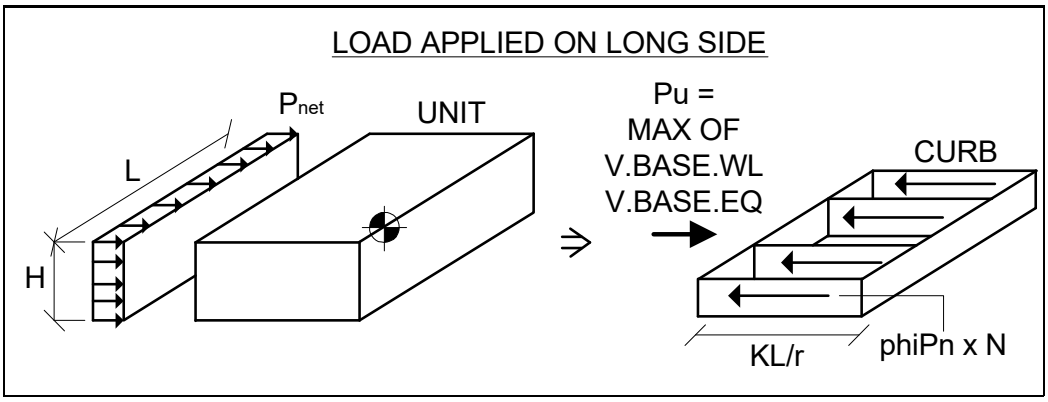
Demand/Capacity Ratio:

$Shear_{in.plane} := if(V_u < \phi V_n, "OK", "NG")$

$Shear_{in.plane} = "OK"$

Check CanFab Curb for In-Plane Axial due to EQ and Wind (AISI S100-16 E2)

Curb Axial Load Check due to Load on Long Side



Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot L_{unit} \cdot H_{total} = 5.3\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.L}) = 5720.62 \cdot lbs$

Member per CFS: $CFS_{member} :=$ "16GA Custom Curb 18" Tall L.b = 78in"

Max Braced Length of Member: $L_{member} := W_{curb} = 37 \cdot in$

Number of Curb in Length: $n_{curb.long} := 2$

Radius of gyration in y-axis: $r_{y.curb} := 0.675\,in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{2} = 2.86\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 55$ $KL_r =$ "KL/r < 200, OK"

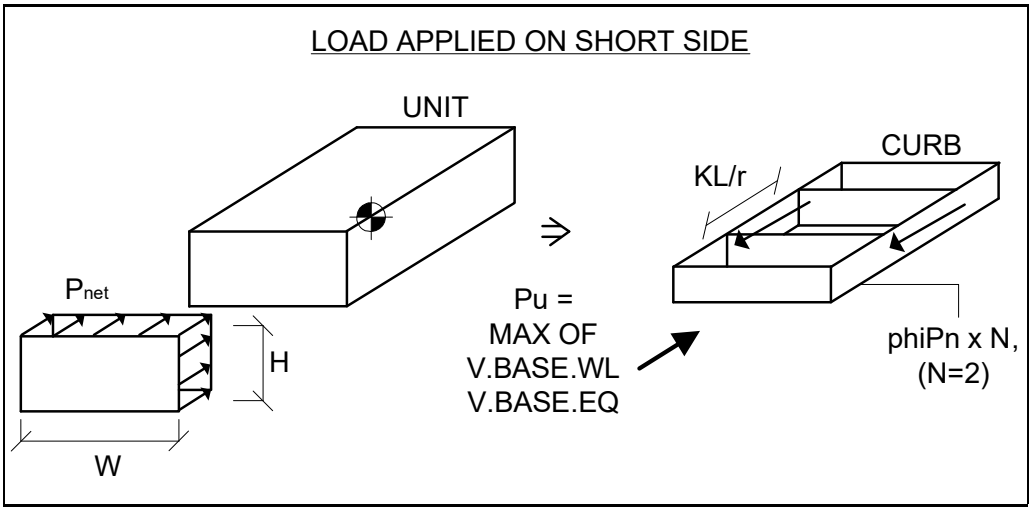
Spacing: $Spacing := \frac{L_{curb}}{n_{curb.long}} = 34 \cdot in$

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 6.018 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.475$

$Axial_{short.curb} =$ "OK"

Curb Axial Load Check due to Load on Short Side



Wind Base Shear on Short Side: $V_{base.W.H} := P_{net} \cdot W_{unit} \cdot H_{total} = 4.3\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.H}) = 5720.62 \cdot lbs$

Member per CFS: CFS_{member} = "16GA Custom Curb 18" Tall L.b = 78in"

Max Braced Length of Member: $L_{member} := \frac{L_{curb}}{n_{curb.long} - 1} = 67 \cdot in$

Number of Curb in Length: $n_{curb} := 2$

Radius of gyration in y-axis: $r_{y.curb} := 0.675\,in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{curb}} = 2.86\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 100$ KL_r = "KL/r < 200, OK"

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 6.018 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.475$

$Axial_{long.curb}$ = "OK"

DESIGN
for
ISOLATED CURB
1006 XIC (Max Curb Height of 22")

Design Wind Loads for Rooftop Equipment (ASCE 7-16 § Table 29.1-1)

$z := 60ft$ — **Height above ground level**

$B := 60ft$ — **Horizontal dimension of building measured normal to wind direction**

$Exp_{category} := "C"$ — **Exposure Category per ASCE 7-16 § 26.7**

$Risk_{category} := "IV"$ — **Risk Category per ASCE 7-16 Table 1.5-1**

$$V := \begin{cases} 0mph & \text{if } Risk_{category} = "I" \\ 0mph & \text{if } Risk_{category} = "II" \\ 175mph & \text{otherwise} \end{cases} = 175 \cdot mph$$

Basic Wind Speed per ASCE 7-16 Figure 26.5-1 A,B or C

$K_z = 1.14$ — **Velocity Pressure Exposure Coefficient per ASCE 7-16 Table 29.10-1 [Exposure Category "C"]**

$K_{zt} := 1.0$ — **Topographic Factor per ASCE 7-16 § 26.8, Figure 26.8-1**

$K_e := 1.0$ — **Ground Elevation Factor per ASCE 7-16 § 26.9, Table 26.9-1**

$K_d := 0.85$ — **Wind Directionality Factor per ASCE 7-16 § 26.6, Table 26.6-1 (Equipment)**

$q_z := 0.00256 K_z \cdot K_{zt} \cdot K_d \cdot K_e \cdot V^2 = 75.74 \cdot psf$ — **Velocity pressure evaluated at height z above ground per ASCE 7-10 § 26.10.2; Eq. 26.10-1**

$GC_{r.lateral.max} := 1.9$ — **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.9 for rooftop structures and equipment with Af less than (0.1Bh). (GCr) shall be permitted to be reduced linearly from 1.9 to 1.0 as the value of Af is increased from (0.1Bh) to (Bh)

$GC_{r.vertical.max} := 1.5$ — **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.5 for rooftop structures and equipment with A_r less than (0.1*BL*). (GC_r) shall be permitted to be reduced linearly from 1.5 to 1.0 as the value of A_r is increased from (0.1*BL*) to (*BL*)

$P_{net} := q_z \cdot GC_{r.lateral.max} = 143.91 \cdot psf$ — **Design Lateral Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-2**

$P_v := q_z \cdot GC_{r.vertical.max} = 113.61 \cdot psf$ — **Design Vertical Uplift Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-3**

Seismic Demands on Nonstructural Components (ASCE 7-16 § 13.3 & 13.6):

$S_{DS} := 1.5$ — **Design spectral response acceleration parameter at short periods per USGS map**

$I_p := 1.5$ — **Component importance factor ASCE 7-16 § 13.1.3**

$\Omega_0 := 2.0$ — **Overstrength factor ASCE 7-16 Table 13.6.1**

Vibr_Isolation = "Yes" — **Placement of Unit Vibration Isolated:**

Note: Only "F_p" at seismic concrete anchor has been increased with overstrength factor "Ω_0"

$a_p := 2.5$ $R_p = 2.0$ — **Seismic coefficients a_p & R_p**
Per ASCE 7-16 Table 13.6-1 for
Mechanical & Electrical Components

$z = 60\,ft$ — **Height in structure of point of attachment of component with respect to the base**

$h := 60ft$ — **Average roof height of structure with respect to the base**
Where for roof top equipment:

$z \div h = 1$

F_p: Horizontal Seismic Design Force per *ASCE7-16 § 13.3.1*

F_p shall be takes as $\left(\frac{0.4 \cdot a_p \cdot S_{DS} \cdot I_p}{R_p}\right) \cdot \left(1 + 2 \cdot \frac{z}{h}\right) \cdot W_p = 337.5 \cdot \%_{\cdot} W_p$

F_p is not required to be taken as greater than $\left(1.6 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 360 \cdot \%_{\cdot} W_p$

F_p shall not be taken as less than $\left(0.3 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 67.5 \cdot \%_{\cdot} W_p$

Governing F_p : Horizontal Seismic Design Force $F_p = 337.5 \cdot \%_{\cdot} W_p$

F_v: Vertical Load per ASCE7-16 § 13.3.1.2

Concurrent Vertical Seismic Force: $F_v := 0.2 \cdot S_{DS} \cdot W_p = 30 \cdot \%_{\cdot} W_p$

Flat Roof Snow Loads (ASCE 7-16 § 7.3):

$Terrain_{CAT} := "C"$ — **Terrain Category ASCE 7-16 § 26.7 & Table 7.3-1**

$Exp_{Roof} := "Partially\ Exposed"$ — **Exposure of Roof ASCE 7-16 Table 7.3-1**

$C_e = 1$ — **Exposure Factor ASCE 7-16 Table 7.3-1**

$Thermal_{condition} := "All\ structures\ except\ below"$ — **Thermal Condition ASCE 7-16 Table 7.3-2**

$C_t = 1$ — **Thermal Factor ASCE 7-16 Table 7.3-2**

$Risk_{category} = "IV"$ — **Risk Category per ASCE 7-16 Table 1.5-1**

$I_s = 1.2$ — **Snow Importance Factor ASCE 7-16 Table 1.5-2**

$p_g := 40psf$ — **Ground Snow Loads ASCE 7-16 Figure 7.2-1**

$$p_f := \max\left(0.7 \cdot C_e \cdot C_t \cdot I_s \cdot p_g, \text{if}\left(p_g > 20psf, 20psf \cdot I_s, I_s \cdot p_g\right)\right) = 34 \cdot psf$$

Flat Roof Snow Loads ASCE 7-16 Equation 7.3-1 and § 7.3.4

Mechanical Unit Dimensions

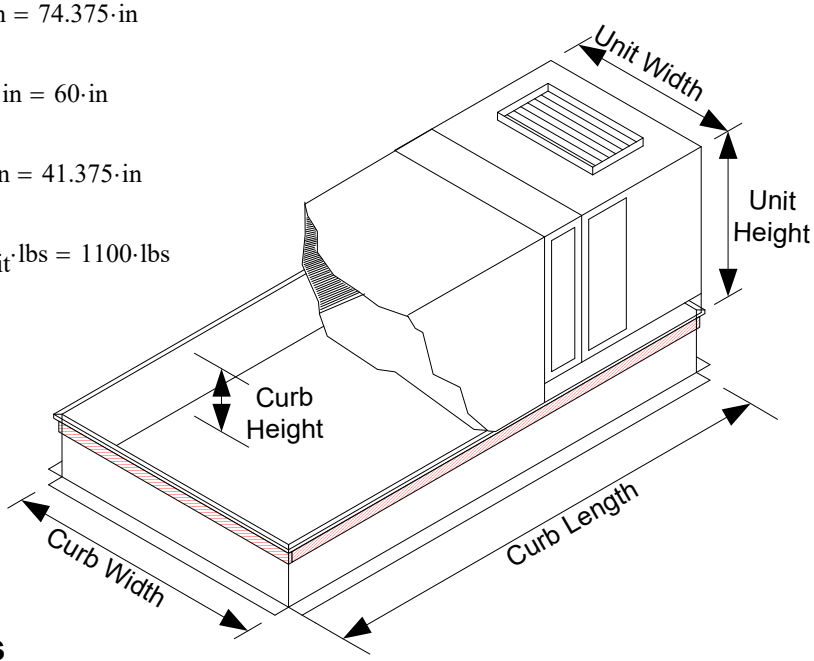
Curb = "C-1006 XIC"

Length of Unit $L_{unit} := L_{unit} \cdot in = 74.375 \cdot in$

Width of Unit $W_{unit} := W_{unit} \cdot in = 60 \cdot in$

Height of Unit $H_{unit} := H_{unit} \cdot in = 41.375 \cdot in$

Weight of Unit $Wt_{unit} := Wt_{unit} \cdot lbs = 1100 \cdot lbs$



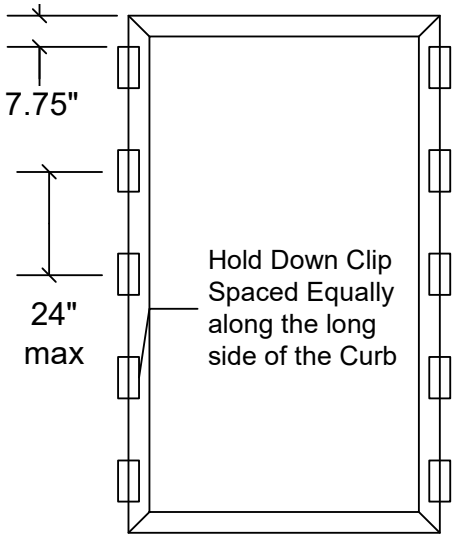
Roof Curb Dimensions

Length of Curb $L_{curb} := L_{curb} \cdot in = 67.375 \cdot in$

Width of Curb $W_{curb} := W_{curb} \cdot in = 37.188 \cdot in$

Height of Curb $H_{curb} := H_{curb} \cdot in = 34.5 \cdot in$

Weight of Curb $Wt_{curb} := Wt_{curb} \cdot lbs = 595 \cdot lbs$



Curb Plan

Overall System Dimensions

Total Weight

$Wt_{tot} := Wt_{unit} + Wt_{curb} = 1695 \cdot lbs$

Total height

$H_{total} := H_{unit} + H_{curb} = 75.875 \cdot in$

Seismic Loading + Snow Loading

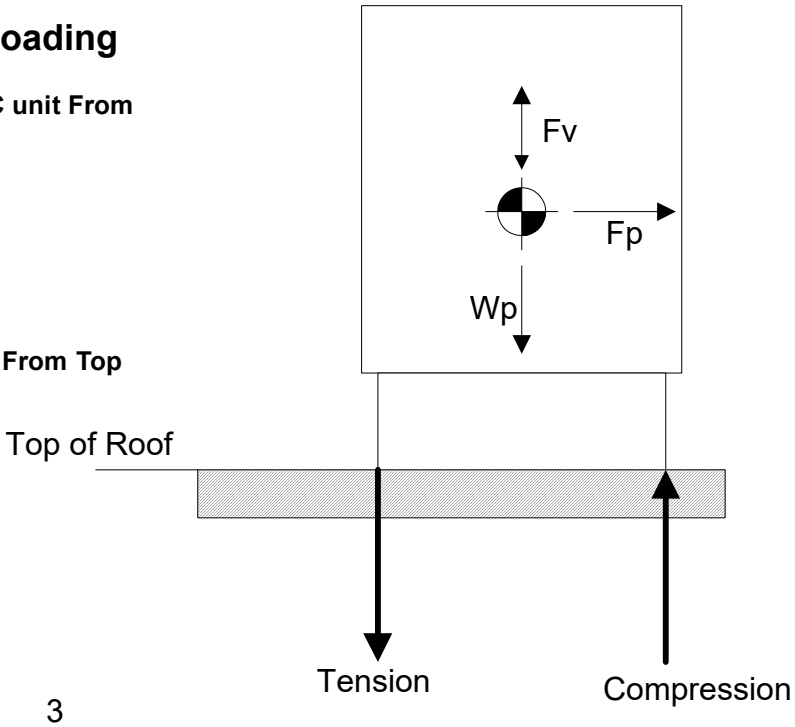
Height for Center of Gravity for HVAC unit From Top of Roof

$h_{CG.unit} := \frac{1}{2} H_{unit} = 21 \cdot in$

$h_{CG} := H_{curb} + h_{CG.unit} = 55.19 \cdot in$

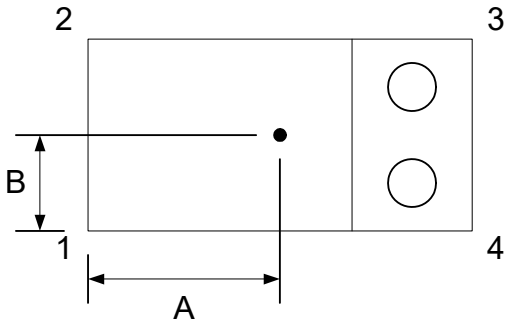
Height for Center of Gravity for Curb From Top of Roof

$h_{CG.curb} := \frac{H_{curb}}{2} = 17.25 \cdot in$



Max Seismic Base Shear

$V_{base.S} := F_p \cdot Wt_{tot} = 5721 \cdot lbs$



Unit C.G. distance in axis parallel to Curb Width $B_{ecc.width} := CG_{short} \cdot in = 22.5 \cdot in$

Eccentricity in axis parallel to Curb Width

$$e_{width} := \begin{cases} 0in & \text{if } B_{ecc.width} = \text{"N/A"} \\ \left| B_{ecc.width} - \frac{W_{unit}}{2} \right| & \text{otherwise} \end{cases} = 7.5 \cdot in$$

Unit C.G. distance in axis parallel to Curb Length $A_{ecc.length} := CG_{long} \cdot in = 34.625 \cdot in$

Eccentricity in axis parallel to Curb Length

$$e_{length} := \begin{cases} 0in & \text{if } A_{ecc.length} = \text{"N/A"} \\ \left| A_{ecc.length} - \frac{L_{unit}}{2} \right| & \text{otherwise} \end{cases} = 2.56 \cdot in$$

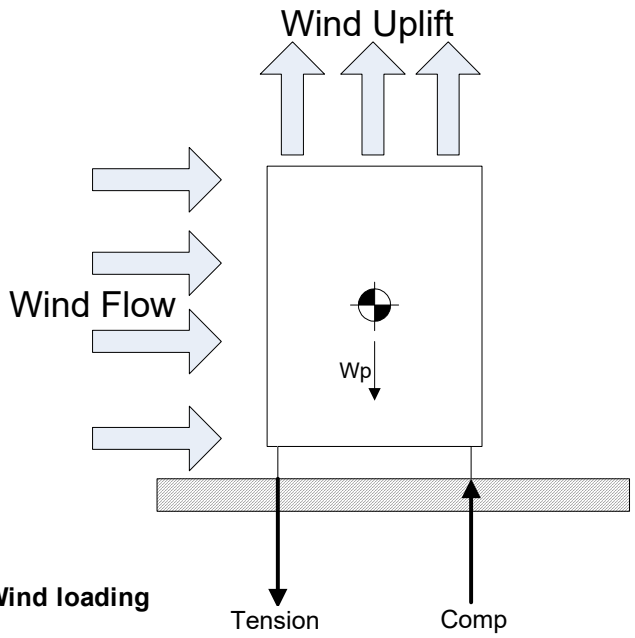
Max Net Tension Reaction On Each Side Due To Seismic Loads

$$T_S := \begin{bmatrix} \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{W_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{W_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} \right] \\ \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{L_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{L_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} \right] \end{bmatrix} = \begin{pmatrix} -6066 \\ -3072 \end{pmatrix}\cdot lbs$$

Max Net Compression Reaction On Each Side Due To Seismic Loads

$$C_S := \begin{bmatrix} \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{W_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \\ \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{L_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \end{bmatrix} = \begin{pmatrix} 10927 \\ 6853 \end{pmatrix}\cdot lbs$$

Wind Loading + Snow Loading



Max Base Shear due to wind loading

$V_{base.W} := P_{net} \cdot L_{unit} \cdot H_{total} = 5640 \cdot lbs$

Max Uplift due to wind loading

$L_{unit.up} := L_{unit} - 0in = 74.375 \cdot in$

$P_{uplift.W} := P_v \cdot L_{unit.up} \cdot W_{unit} = 3521 \cdot lbs$

Max Net Tension Reaction On Each Side Due To Wind loading

$$T_W := \begin{pmatrix} \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} - \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \\ \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} - \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} -6951 \\ -3597 \end{pmatrix} \cdot lbs$$

Max Net Compression Reaction On Each Side Due To Wind loading

$$C_W := \begin{pmatrix} \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} + \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \\ \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} + \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} 7870 \\ 4462 \end{pmatrix} \cdot lbs$$

Governing Loading @ Curb

Max uplift vertical load along the length of the curb

$$\omega_{x.L.vert.up} := \frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}} = 1238 \cdot plf$$

Max compressive vertical load along the length of the curb

$$\omega_{x.L.vert.comp} := \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}} = 1946 \cdot plf$$

Max vertical load along the length of the curb

$$\omega_{x.L.vert} := \max\left(\omega_{x.L.vert.up}, \omega_{x.L.vert.comp}\right) = 1946 \cdot plf$$

Max uplift vertical load along the width of the curb

$$\omega_{x.W.vert.up} := \frac{\max\left[\left|T_{S_{(1)}}\right|, \left|T_{W_{(1)}}\right|\right]}{W_{curb}} = 1161 \cdot plf$$

Max compressive vertical load along the width of the curb

$$\omega_{x.W.vert.comp} := \frac{\max\left[\left|C_{S_{(1)}}\right|, \left|C_{W_{(1)}}\right|\right]}{W_{curb}} = 2211 \cdot plf$$

Max vertical loading along the width of the curb

$$\omega_{x.W.vert} := \max\left(\omega_{x.W.vert.up}, \omega_{x.W.vert.comp}\right) = 2211 \cdot plf$$

$$\begin{pmatrix} V_{base.S} \\ V_{base.W} \end{pmatrix} = \begin{pmatrix} 5721 \\ 5640 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} \left|T_S\right| \\ \left|C_S\right| \end{pmatrix} = \begin{pmatrix} 6799 \\ 12898 \end{pmatrix} \cdot lbs$$

$$\begin{pmatrix} F_v \cdot Wt_{tot} \\ P_v \cdot L_{unit} \cdot W_{unit} \end{pmatrix} = \begin{pmatrix} 509 \\ 3521 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} \left|T_W\right| \\ \left|C_W\right| \end{pmatrix} = \begin{pmatrix} 7826 \\ 9047 \end{pmatrix} \cdot lbs$$

Anchorage To Concrete [Expansion Anchor per ACI 318-14]

Number of connection on the long side

$N_B := 3 + 2$

Moment Arm for overturning (Short side)

$B := W_{curb} + 3in \cdot 2 = 43 \cdot in$

Number of Connection on the Short side.

$N_L := 2 + 2$

Moment Arm for over turning (Long side)

$L := L_{curb} + 3in \cdot 2 = 73 \cdot in$

Total Number of Connections

$N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 10$

Max Net Tension Reaction Due to Seismic Load, Fp

$$R_{c.EQ.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 23 \cdot lbs \qquad R_{c.EQ.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 6 \cdot lbs$$

$$R_{c.EQ} := MAX+\left[\begin{bmatrix}\left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{c.EQ.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{c.EQ.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}2140 \\ 1536\end{pmatrix} \cdot lbs$$

Max net Tension Reaction Due to Wind Load, Pnet

$$R_{c.W} := MAX+\left[\begin{bmatrix}\frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}1225 \\ 796\end{pmatrix} \cdot lbs$$

Governing Load Case:

$Govern := if\left(\left|R_{c.EQ}\right| > \left|R_{c.W}\right|, "Seismic", "Wind"\right) = "Seismic"$

Governing Tension Reaction at Each anchor Point:

$R_c := if\left(Govern = "Seismic", R_{c.EQ}, R_{c.W}\right) = \begin{pmatrix}2140 \\ 1536\end{pmatrix} \cdot lbs$

Max Tension on anchor: $N_{ua} := |R_c| = 2634 \cdot lbs$

Max Shear on anchor: $V_{ua} := \frac{\max(\Omega_0 \cdot V_{base.S}, V_{base.W})}{N_t} = 1144 \cdot lbs$

Hilti Kwik Bolt TZ – Carbon Steel
5/8" Anchor with min 4" embedment
Base material: 6" thick Cracked concrete w/
Compressive strength fc' = 3000 psi
Min 6" away from the concrete edge
Evaluation Report: ICC-ESR 1917

Loading Condition:	**Seismic**

Design Tension Capacity [ϕN_n]:	3,631	[lbs]
Design Shear Capacity [ϕV_n]:	4,940	[lbs]

$\phi N_n := \phi N_n \cdot lbs = 3631 \cdot lbs$

$\phi V_n := \phi V_n \cdot lbs = 4940 \cdot lbs$

Utilization:

Tension Utilization: $\beta_N := \frac{N_{ua}}{\phi N_n} = 73 \cdot \%$

Shear Utilization: $\beta_V := \frac{V_{ua}}{\phi V_n} = 23 \cdot \%$

Interaction of Tensile and Shear Forces:
Per ACI 318-14 Sec. 17.6

$\beta_{NV} := \frac{(\beta_N) + (\beta_V)}{1.2} = 80 \cdot \%$

$$check\_interaction := \begin{pmatrix} if(\beta_N < 1.0, "OK", "NG") \\ if(\beta_V < 1.0, "OK", "NG") \\ if(\beta_{NV} < 1.0, "OK", "NG") \end{pmatrix} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

$$check\_interaction = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

Anchorage To Structural Steel [Fillet Weld Conn. per AISI S100-16]

Fillet Weld 2" Long Along the Long and Short Side. Min 2 Connections per Side
Spacing: 48" O.C. for Non-Isolated Curbs; 24" for Isolated Curbs

Number of Welds on the Long Side $N_B := 3$

Moment Arm for Overturning (Short Side) $B := W_{curb} = 37 \cdot in$

Number of Welds on the Short Side. $N_L := 2$

Moment Arm for Overturning (Long Side) $L := L_{curb} = 67 \cdot in$

Total Number of Connections $N_t := \left[\left(N_B\right) + \left(N_L\right)\right] \cdot 2sides = 10$

Max Net Tension Reaction due to Seismic Load FP

$$R_{weld.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 44 \cdot lbs$$

$$R_{weld.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 13 \cdot lbs$$

$$R_{weld.EQ} := MAX+\left[\begin{bmatrix}\left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{weld.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{weld.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}2090 \\ 1688\end{pmatrix} \cdot lbs$$

Max Net Tension Reaction due to Wind Load Pnet

$$R_{weld.W} := MAX+\left[\begin{bmatrix}\frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}2184 \\ 1499\end{pmatrix} \cdot lbs$$

Tension Design Force; SRSS for Loading from Each Direction $T_{u.weld} := \max\left(\left|R_{weld.EQ}\right|, \left|R_{weld.W}\right|\right) = 2687 \cdot lbs$

Shear Load at Each Weld Connection $V_{u.weld} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{N_t} = 572 \cdot lbs$

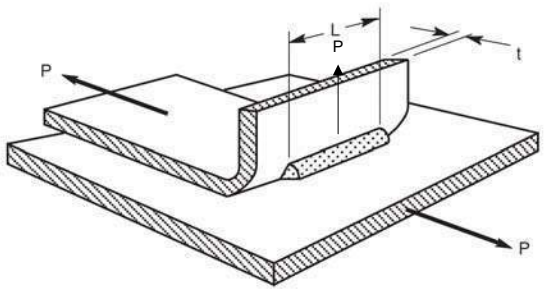
Total Demand: SRSS of V and T

$$R_{u.weld} := \sqrt{T_{u.weld}^2 + V_{u.weld}^2} = 2747 \cdot lbs$$

Fillet Weld Design per AISI S100-16 Section J2.5

Weld Length at Each Connection Point

$$L_w := 2in$$



Effective Throat Fillet Weld Size

$$t_w := \left(\frac{1}{8}in\right) \cdot 0.707 = 0.088 \cdot in$$

Thickness for the Thinnest Martial Being Welded
Min Curb Thickness = 16GA with Fu=65 ksi

$$t_1 := thick("14GA") = 0.0785 \cdot in$$

$$F_u := 65ksi$$

Min weld material strength

$$F_{exx} := 70ksi$$

For Longitudinal Loading [Parallel capacity is considered to be loading in the direction of the length of the weld] per (Eq. J2.5-1) &(Eq. J2.5-2)

$$\phi P_{long} := \begin{cases} (0.6)\left(1 - \frac{0.01 \cdot L_w}{t_1}\right) \cdot L_w \cdot t_1 \cdot F_u & \text{if } \frac{L_w}{t_1} < 25 \\ (0.5) \cdot 0.75 \cdot t_1 \cdot L_w \cdot F_u & \text{otherwise} \end{cases} = 3827 \cdot lbs$$

where $L_w \div t_1 = 25$

For Transverse Loading per (Eq. J2.5-5)

$$\phi P_{trans} := (0.65) \cdot t_1 \cdot L_w \cdot F_u = 6633 \cdot lbs$$

Strength of Weld Material per (Eq. J2.5-7)

$$\phi P_{weld} := (0.6) \cdot 0.75 \cdot t_w \cdot L_w \cdot F_{exx} = 5568 \cdot lbs$$

Design Strength of Fillet Weld

$$\phi P_n := \min\left(\phi P_{long}, \phi P_{trans}, \phi P_{weld}\right) = 3827 \cdot lbs$$

D/C Ratio for the Welded Connection

$$\beta_{NW} := \frac{R_{u.weld}}{\phi P_n} = 72 \cdot \%$$

$$weld_{check} := if\left(\beta_{NW} < 1.0, "OK", "NG"\right)$$

$weld_{check} = "OK"$

Anchorage To Wood Member WITH Lag Screws [NDS-2018 LRFD Strength Design]

*** Use 3/8" Lag Screws along Each Side of the Curb**
*** Assume G=0.5 Douglas Fir-Larch**

Wood Lag Screw Capacity per NDS 2018 Section 11.3

Wet Service Factor: $Cond := "DRY"$ **(e.g. CA = "DRY", AK = "WET")**

$$C_M := \begin{cases} 1.0 & \text{if } Cond = "DRY" \\ 0.7 & \text{if } Cond = "WET" \end{cases} = 1$$ **NDS 2018 Table 11.3.3**

Temperature Factor:
$$C_t := \begin{cases} 0.8 & \text{if } Cond = "DRY" \\ 0.7 & \text{if } Cond = "WET" \end{cases} = 0.8$$ **NDS 2018 Table 11.3.4**

Group Action Factor: $C_g := 0.97$ **NDS 2018 Table 11.3.6C**

Geometry Factor: $C_\Delta := 1.0$ **NDS 2018 Table 12.5.1A,B**

End Grain Factor: $C_{eg} := 1.0$ **NDS 2018 Sec. 12.5.2**

Diaphragm Factor: $C_{di} := 1.0$ **NDS 2018 Sec. 12.5.3**

Toe-Nail Factor: $C_{tn} := 1.0$ **NDS 2018 Sec. 12.5.4**

Format Conversion Factor: $K_F := 3.32$ **NDS 2018 Table 11.3.1**

Resistance Factor: $\phi := 0.65$ **NDS 2018 Table 11.3.1**

Time Effect Factor: $\lambda := 1.0$ **NDS 2018 App N.3.3**

Lateral Design Value: $Z := 130lbs$ **NDS 2018 Table 12K**

Withdrawal Design Value: $W := 305lbs$ **NDS 2018 Table 12.2A**

Lag Screw Diameter: $D_{lag} := \frac{3}{8}in$

Lag Screw Length: $L_{lag} := 4in$

Length of Tapered Tip: $E_{lag} := \frac{7}{32}in$

Lag Screw Penetration: $P_{lag} := 3.78125in$

Eff. Lag Screw Penetration for withdrawal: $P_{\omega.lag} := 2in + \frac{9}{32}in = 2.28 \cdot in$ **NDS 2018 Appx. Table L2**

NDS 2018 Sec. 12.1.4.6

Minimum Penetration DCR <1.0: $DCR_{min.penetration} := \frac{4 \cdot D_{lag}}{P_{\omega.lag}} = 0.66$ $DCR_{min.penetration} = "OK"$

Adj. Lateral Design Value: $Z' := Z \cdot C_M \cdot C_t \cdot C_g \cdot C_\Delta \cdot C_{eg} \cdot C_{di} \cdot C_{tn} \cdot K_F \cdot \phi \cdot \lambda = 218 \cdot lbs$

Adj. Withdrawal Design Value: $W' := W \cdot C_M^{\,2} \cdot C_t \cdot C_{eg} \cdot C_{tn} \cdot K_F \cdot \phi \cdot \lambda = 527 \cdot lbs$ **NDS 2018 Table 11.3.1**

Number of Lag Screws on the Long Side $N_B := 13 + 2$

Moment Arm for Overturning (Short Side) $B := W_{curb} = 37 \cdot in$

Number of Lag Screws on the Short Side $N_L := 7 + 2$

Moment Arm for Overturning (Long Side) $L := L_{curb} = 67 \cdot in$

Total Number of Lag Screws $N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 40$

Max net Tension Reaction due to Seismic, Fp

$$R_{lag.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 9 \cdot lbs$$

$$R_{lag.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 3 \cdot lbs$$

$$R_{lag.EQ} := MAX+\left[\begin{bmatrix} \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{lag.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{lag.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 413 \\ 372 \end{pmatrix} \cdot lbs$$

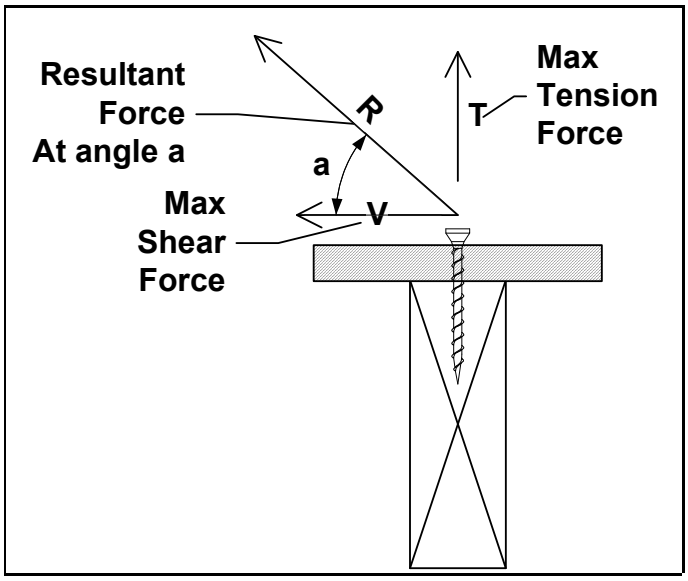
Max net Tension Reaction due to Wind load, Pnet

$$R_{lag.W} := MAX+\left[\begin{bmatrix} \frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{L \cdot N_L \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 447 \\ 339 \end{pmatrix} \cdot lbs$$

Tension Design force; SRSS for loading from Each direction $T_{lag} := \max\left(\left|R_{lag.EQ}\right|, \left|R_{lag.W}\right|\right) = 561 \cdot lbs$

Shear load at each anchor location $V_{lag} := \frac{\max\left(V_{base.S} \cdot \sqrt{2}, V_{base.W}\right)}{N_t} = 202 \cdot lbs$

For Lag Screws Subjected to Combined Lateral and Withdrawal Loading; Design Strength of the Lag Screw Shall Be Adjusted per Hankinson Formula as Prescribed by NDS 2018 Equation 12.4-1



Angle Between Wood Surface and Direction of Resultant Applied Load

$$(\alpha) := \operatorname{atan}\left(\frac{T_{lag}}{V_{lag}}\right) = 70\cdot deg$$

Combined Demand per Lag Screw @ Strength Level

$$R_{lag} := \sqrt{T_{lag}^{2} + V_{lag}^{2}} = 596\cdot lbs$$

Adjusted Capacity per NDS 2018 Equation 12.4-1 @ Strength Level

$$Z'_{\alpha} := \frac{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot Z'}{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot\cos(\alpha)^{2} + Z'\cdot\sin(\alpha)^{2}} = 790\cdot lbs$$

D/C Ratio for the Lag Screw connection to Wood Structure

$$\beta_{Lag} := \frac{R_{lag}}{Z'_{\alpha}} = 75\cdot\%$$

$$Lag_{Screw.Check} := \text{if}\left(\beta_{Lag} < 1.0, \text{"OK"}, \text{"NG"}\right)$$

$Lag_{Screw.Check} = \text{"OK"}$

Bearing and Tilting in Curb Bolted Connection AISI S100-16

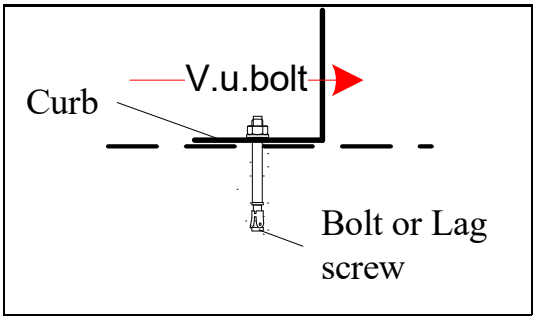
Nominal bolt diameter $d := 0.5in$

Uncoated sheet thickness $t_{curb} := thick("14GA") = 0.079 \cdot in$

Tensile strength of sheet $F_u := 65ksi$

Coefficient for conversion of units $\alpha := 1.0$

Modification Factor $m_f := 1.0$



Modification factor for type of bearing connection, per Table J3.3.1-2; For single shear connection with washers

Bearing Factor

$$C := \begin{cases} 3 \text{ if } \left(\frac{d}{t_{curb}} < 10\right) \wedge \left(0.024in < t_{curb} < 0.1875in\right) = 3 \\ "NG" \text{ if } \frac{d}{t_{curb}} > 10 \end{cases}$$

Bearing factor, which shall be determined according to Table J3.3.1-1 For d/t<10 where $d \div t_{curb} = 6$

Bearing Design Strength per AISI S100-16 Eq. J3.3.1-1

$$\phi P_{n_{(0)}} := (0.6) \cdot \left(m_f \cdot C \cdot d \cdot t_{curb} \cdot F_u\right) = 4592 \cdot lbs$$

Bolt Hole Deformation Design Strength per AISI S100-16 Eq. J3.3.2-1

$$\phi P_{n_{(1)}} := (0.65) \cdot \left[4.64 \cdot \left(\frac{\alpha}{in}\right) \cdot t_{curb} + 1.53\right] \cdot d \cdot t_{curb} \cdot F_u = 3141 \cdot lbs$$

Curb Connection Shear Capacity $\phi P_n := \min\left(\phi P_n\right) = 3141 \cdot lbs$

Loading demand at connection

$$V_{u.bolt} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{4} = 1430 \cdot lbs$$

$Curb\_Conn\_Shear := if\left(V_{u.bolt} < \phi P_n, "OK", "NG"\right)$ Curb_Conn_Shear = "OK"

Thickness of Curb, ISO Rail and Clip

(Per AISC Table 17-10 Galvanized)

Hold Down Clip thickness

$t_{Clip} := "12GA"$ $t_{clip} := thick(t_{Clip}) = 0.1084 \cdot in$

Roof Curb thickness

$t_{Curb} := "14GA"$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

ISO RAIL thickness

$t_{Curb.iso} := "10GA"$ $t_{curb.iso} := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Note: Iso Rail thickness is only used if the curb is isolated. Not used for non-isolated curbs

Sheet Metal Screws (SMS) Equations and References

SMS properties (ESR-2196 Table 5)

$SMS_{Table} =$

"SMS"	"Diameter"	"HeadDiameter"	"Tension"	"Shear"
"Size"	"d"	"dw"	"Pts"	"Pss"
"#8"	0.164	0.335	1000	1170
"#10"	0.19	0.399	1370	1215
"#12"	0.216	0.415	2325	1880
"#14"	0.25	0.5	4580	2440

SMS Tension Eqns

$P_{not} = 0.85 \cdot t \cdot d \cdot F_u$

$P_{nov} = 1.5 \cdot t \cdot d_w \cdot F_u$

$P_{nts} = 0.8 \cdot P_{ts}$

(AISI S100-16 J4.4.1 & J4.4.2)

FOR THE MOST CASES, PULL-OUT CAPACITY IS THE LOWEST

SMS Shearn Eqns

$P_{vnot} = 4.2 \cdot \sqrt{(d \cdot t^3)} \cdot F_u$

$P_{vnov} = 2.7 \cdot t \cdot d \cdot F_u$

$P_{vnss} = 0.8 \cdot P_{ss}$

(AISI S100-16 J4.3.1)

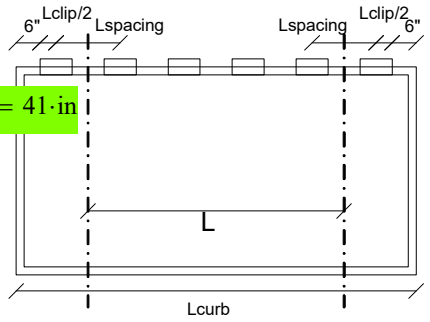
Hold Down Clip Design (Connection of the Mechanical unit to Curb)

Number of Clips on the long side $N_B := 4$

Moment Arm for overturning (Short side) $B := W_{curb} + 1.75in \cdot 2 = 41 \cdot in$

Number of Clips on the Short side. $N_L := 4$

Width of Clips $L_{clip} := 9in$



Curb Centerline Spacing (Long side)

$$L_{spacing} := \frac{L_{curb} - \left(6in + \frac{L_{clip}}{2}\right) \cdot 2}{N_B - 1} = 15.458 \cdot in$$

Moment Arm for overturning (Long side)

$$L := L_{curb} - 2 \cdot \left[6in + \frac{L_{clip}}{2} + L_{spacing} \cdot \frac{(N_L - 2)}{4}\right] = 30.917 \cdot in$$

Total Number of Clips

$$N_t := (N_B) \cdot 2sides = 8$$

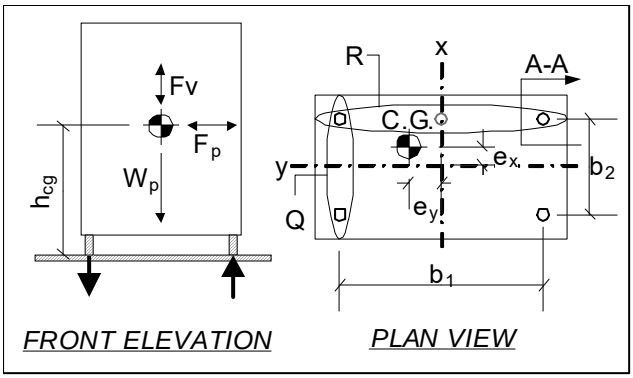
Max net Tension Reaction due to Seismic, Fp

$$R_{clip.EQ} := MAX+\left[\begin{array}{l} \left[\frac{F_p \cdot Wt_{unit}}{B \cdot N_B} \cdot h_{CG.unit} + \frac{(0.9 - F_v) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B}\right] - \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} \\ \left[\frac{F_p \cdot Wt_{unit}}{L \cdot N_L} \cdot h_{CG.unit} + \frac{(0.9 - F_v) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L}\right] - \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} \end{array}\right] = \begin{pmatrix} 420 \\ 552 \end{pmatrix} \cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$R_{clip.W} := MAX+\left(\begin{array}{l} \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{unit}^2}{2}}{B \cdot N_B} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{unit}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{unit}^2}{2}}{L \cdot N_L} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{unit}}{N_t} \end{array}\right) = \begin{pmatrix} 753 \\ 752 \end{pmatrix} \cdot lbs$$

Tensile and Shear Load calculation per ASHRAE RP-812



Eccentricity along X-X

$e_x := e_{width} = 7.5 \cdot in$

Eccentricity along Y-Y

$e_y := e_{length} = 2.562 \cdot in$

Distance between Seismic Restraints Along Y-Y

$b_1 := L_{curb} - 2 \cdot 6in = 55 \cdot in$

Distance between Seismic Restraints Along X-X

$b_2 := W_{curb} = 37 \cdot in$

Moment of Inertia about X-X

$$I_{xx} := \frac{N_t \cdot (N_t + 2) \cdot (b_1)^2}{12 \cdot (N_t - 2)} = 3407 \cdot in^2$$

Moment of Inertia about Y-Y

$$I_{yy} := \frac{N_t \cdot (b_2)^2}{4} = 2766 \cdot in^2$$

Angle about Tensile Load

$$\Theta_t := \operatorname{atan}\left[\frac{I_{yy} \cdot (b_1)}{I_{xx} \cdot (b_2)}\right] = 50 \cdot deg$$

Angle about Shear Load

$$\Theta_s := \begin{cases} \operatorname{atan}\left(\frac{e_x}{e_y}\right) & \text{if } e_y \neq 0 \\ 0deg & \text{if } e_y = 0 \end{cases} = 71 \cdot deg$$

Max Net Tensile Load Due to Seismic Load, Fp

$$T_{U.EQ.pt1} := \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} - \frac{(0.9 - F_v) \cdot Wt_{unit}}{b_1 \cdot b_2} \cdot \left(\frac{b_1}{2} \cdot e_x + \frac{b_2}{2} \cdot e_y - e_x \cdot e_y\right) = 7 \cdot lbs$$

$$T_{U.EQ.pt2} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \cos(\Theta_t) \cdot \frac{0.5 \cdot b_2}{I_{yy}} = -329 \cdot lbs$$

$$T_{U.EQ.pt3} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \sin(\Theta_t) \cdot \frac{0.5 \cdot b_1}{I_{xx}} = -481 \cdot lbs$$

$$T_{U.EQ} := T_{U.EQ.pt1} + T_{U.EQ.pt2} + T_{U.EQ.pt3} = -803 \cdot lbs$$

Max Net Shear Load Due to Seismic Load, Fp

$$V_{Ux.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\cos(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_2 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_1 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 277 \cdot lbs$$

$$V_{Uy.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\sin(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_1 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_2 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 532 \cdot lbs$$

$$V_{U.EQ} := \sqrt{V_{Ux.EQ}^2 + V_{Uy.EQ}^2} = 600 \cdot lbs$$

Tension Design force for Hold Down Clips

$$T_{clip} := \max\left(R_{clip.W_0}, R_{clip.W_1}, \left|R_{clip.EQ}\right|, \left|T_{U.EQ}\right|\right) = 803 \cdot lbs$$

Based on ASCE 7-16 Figure 29.4-1 magnitude of force coefficient,

Wind in diagonal direction to the face of equipment produces less force than that of the wind in perpendicular direction to the face of the equipment. Therefore, wind in diagonal direction does not need to be used

$$\left|R_{clip.EQ}\right| = 694 \cdot lbs \qquad \left|T_{U.EQ}\right| = 803 \cdot lbs$$

$$\left|R_{clip.W}\right| = 1064 \cdot lbs$$

$$T_{clip.EQ.max} := \max\left(\left|R_{clip.EQ}\right|, \left|T_{U.EQ}\right|\right) = 803 \cdot lbs$$

$$T_{clip.W.max} := \max\left(\left|R_{clip.W}\right|\right) = 1064 \cdot lbs$$

Shear Design force for Hold Down Clips

$$V_{clip} := \max\left(\frac{\max\left(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit}\right)}{N_t}, \left|V_{U.EQ}\right|\right) = 600 \cdot lbs$$

$$F_p \cdot Wt_{unit} \cdot \frac{1}{N_t} = 464 \cdot lbs \qquad \left|V_{U.EQ}\right| = 600 \cdot lbs$$

$$P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t} = 384 \cdot lbs$$

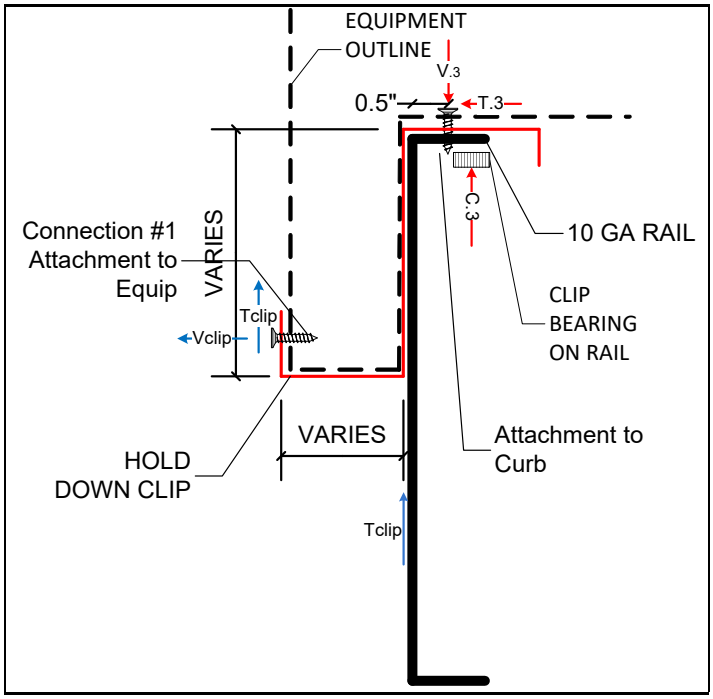
$$V_{clip.EQ.max} := \max\left[\left(F_p \cdot Wt_{unit} \cdot \frac{1}{N_t}\right), \left|V_{U.EQ}\right|\right] = 600 \cdot lbs$$

$$V_{clip.W.max} := \max\left(\left(P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t}\right)\right) = 384 \cdot lbs$$

Loading at Hold Down Clips @ Isolator Curb

$b_{return.iso} := Clip_b \cdot in = 2.625 \cdot in$

$b_{depth.iso} := Clip_c \cdot in = 4.563 \cdot in$



*For Reference Only

Mu Bending moment in the hold down

$M_u := T_{clip} \cdot b_{return.iso} = 2108 \cdot in \cdot lbs$

Resolve bending moment a T/C couple
Assume 0.5" bearing length
Moment Arm for T/C couple

$d_{T/C} := 1in - 0.5in = 0.5 \cdot in$

V3 is acting as shear on the screws. due to eccentricity of Tension force T

$$V_3 := \frac{T_{clip} \cdot \left[b_{return.iso} + (0) \right]}{d_{T/C}} = 4217 \cdot lbs$$

Additional load from Direct Shear acting out of plane (SRSS)

$$V_3 := \sqrt{V_3^{\,2} + V_{clip}^{\,2}} = 4259 \cdot lbs$$

Reaction C3 [compression force] is resisted by bearing of the hold down on the curb lip. Assume 0.5" bearing length

$C_3 := V_3 - T_{clip} = 3456 \cdot lbs$

T3 Load due to the shear acting out of plane tension on the screws.

$$T_3 := \left(\max\left(\frac{T_{clip} \cdot b_{return.iso}}{b_{depth.iso}}, V_{clip} \right) \right) = 600 \cdot lbs$$

Check Bending in Clip @ Isolator Curb

There are several restraints that prevents the hold down clip for iso-curb to have local bending at the bottom and transfer vertical load demand directly to the face of the curb.

- Hold down is bearing on the face of iso-rail / non-iso curb lip.
- Gasket will act as a "link" member to allow unit base rail and bottom flange to move totegther so flange can't bend unless the unit base rail bends first. However, unit base rail is not likely to bend so bottom flange won't bend

Hold Down Clip thickness

$t_{Clip} = \text{"12GA"}$ $t_{clip} := \text{thick}(t_{Clip}) = 0.1084 \cdot in$

Effective width of hold down clip

$b_c := L_{clip} = 9 \cdot in$

Yield strength of the Clip

$F_{y.c} := 50ksi$

Strength reduction for bending

$\phi_{clip} := 0.9$

Design Bending Capacity (LRFD)

$$\phi M_n := \phi_{clip} \cdot F_{y.c} \left(\frac{b_c \cdot t_{clip}^{\,2}}{6} \right) = 793 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.clip} := T_{clip} \cdot 0.5in = 402 \cdot in \cdot lbs$

D/C Ratio for bending

$$DCR := \frac{M_{u.clip}}{\phi M_n} = 0.506$$

$Clip_{Bending} = \text{"OK"}$

Check Flange Bending in Clip @ Isolator Curb

Note:
- **If the curb flange is welded to the 10GA channel and 10GA channel is welded back to the base of the curb, then both tension and compression due to equipment overturning will be taken care by the 10GA channel.**
- **Since the curb will be reinforced with 10GA channel under each isolator, it can be assumed that the loads will trasnferred down to the base structure through the channels. Therefore, flange downward bending at curb due to compressive load does not need to be checked.**

Roof Curb thickness

$t_{Curb} = \text{"14GA"}$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

Clip edge to edge distance

$$b_{edge2edge} := \frac{L_{curb} - \left(6in + \frac{L_{clip}}{2}\right) \cdot 2}{N_B - 1} - L_{clip} = 6.458 \cdot in$$

Effective width of Roof Curb

$b_{curb} := L_{clip} + b_{edge2edge} = 15.46 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\frac{b_{curb} \cdot (t_{curb})^2}{6}\right] = 714 \cdot in \cdot lbs$$

Width of Isolator

$w_{JQ.iso} := 2in$ **2 in. for CQAs**

Flexural bending demand

$$M_{u.Curb} := T_{clip} \cdot \left(\max\left(\frac{1.75in}{2} - 0.5in, \frac{w_{JQ.iso}}{2} - 1in\right)\right) = 301 \cdot in \cdot lbs$$

D/C Ratio for bending

$$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.422$$

$Curb_{Bending} = \text{"OK, Weld 10GA channel ends to curb flange"}$

Design of Connection#1 Connection of Equipment to hold Down clip

Ultimate SMS screw connection Strength (LRFD)
Strength based on the smallest thickness of Curb and Equipment Housing (min 16 GA) [Fy = 50ksi & Fu=65ksi]

$n_{sms} := 4$ $\quad Size_{ss} := "\#14"$

$t_{ss} := "16GA"$ $\quad F_{u.ss} := 65ksi$

Nominal Tension Strength

$$P_{nt} := n_{sms} \cdot T_s\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 3508 \cdot lbs$$

$$P_{not} := n_{sms} \cdot T_{not}\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 3508 \cdot lbs$$

$$P_{nov} := n_{sms} \cdot T_{nov}\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 12383 \cdot lbs$$

$$P_{nts} := n_{sms} \cdot T_{nts}\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 14656 \cdot lbs$$

Nominal Shear Strength

$$P_{ns} := n_{sms} \cdot V_s\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 7808 \cdot lbs$$

$$P_{vnot} := n_{sms} \cdot V_{not}\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 8737 \cdot lbs$$

$$P_{vnov} := n_{sms} \cdot V_{nov}\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 11144 \cdot lbs$$

$$P_{vnss} := n_{sms} \cdot V_{nss}\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 7808 \cdot lbs$$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} V_{clip} \div \left(\phi_{sms} \cdot P_{nt}\right) \\ T_{clip} \div \left(\phi_{sms} \cdot P_{ns}\right) \end{bmatrix} = \begin{pmatrix} 34 \\ 21 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left(\begin{bmatrix} \left[\frac{T_{clip}}{P_{vnov}} + 0.71\left(\frac{V_{clip}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{T_{clip}}{P_{vnot}} + \left(\frac{V_{clip}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{T_{clip}}{P_{vnss}} + \left(\frac{V_{clip}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right) = 38 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

Design of Connection#2 Connection of hold Down clip to Curb

Tension loads on SMS connection

$T_{s2} := V_3 = 4259 \cdot lbs$

Shear loads on SMS connection

$V_{s2} := T_3 = 600 \cdot lbs$

Ultimate SMS screw connection Strength (LRFD)
Strength based on the smallest thickness of Curb and Equipment Housing (min 16 GA) [Fy = 50ksi & Fu=65ksi]

$n_{sms} := 8$ $Size_{ss} := "\#14"$

$t_{ss} := (t_{Curb.iso}) = "10GA"$ $F_{u.ss} := 65ksi$

Nominal Tension Strength

$P_{nt} := n_{sms} \cdot T_s(Size_{ss}, t_{ss}, F_{u.ss}) = 15271 \cdot lbs$

Note:
SMS is getting pulled up so the thicker curb iso rail is engaged for SMS capacity , rather than just the clip itself.

$P_{not} := n_{sms} \cdot T_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 15271 \cdot lbs$

$P_{nov} := n_{sms} \cdot T_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 53898 \cdot lbs$

$P_{nts} := n_{sms} \cdot T_{nts}(Size_{ss}, t_{ss}, F_{u.ss}) = 29312 \cdot lbs$

Nominal Shear Strength

$P_{ns} := n_{sms} \cdot V_s(Size_{ss}, t_{ss}, F_{u.ss}) = 15616 \cdot lbs$

$P_{vnot} := n_{sms} \cdot V_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 56103 \cdot lbs$

$P_{vnov} := n_{sms} \cdot V_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 48508 \cdot lbs$

$P_{vnss} := n_{sms} \cdot V_{nss}(Size_{ss}, t_{ss}, F_{u.ss}) = 15616 \cdot lbs$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} T_{s2} \div (\phi_{sms} \cdot P_{nt}) \\ V_{s2} \div (\phi_{sms} \cdot P_{ns}) \end{bmatrix} = \begin{pmatrix} 56 \\ 8 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left[\begin{bmatrix} \left[\frac{V_{s2}}{P_{vnov}} + 0.71\left(\frac{T_{s2}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{V_{s2}}{P_{vnot}} + \left(\frac{T_{s2}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{V_{s2}}{P_{vnss}} + \left(\frac{T_{s2}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right] = 42 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

Hold Down clip Bending and Shear Interaction

Diameter of SMS:

$d_{sms} := vlookup(Size_{ss}, SMS_{Table}, 1)_0 \cdot in = 0.25 \cdot in$

Depth of flat web portion

$h_{clip.shear} := L_{clip} - n_{sms} \cdot d_{sms} = 7 \cdot in$

Depth-to-Thickness Ratio:

$\frac{h_{clip.shear}}{t_{clip}} = 65 \qquad E := 29500ksi \qquad F_y := 50ksi \qquad \mu := 0.3$

Nominal Shear Stress:
(For unreinforced web)
AISI S100-16 G2.1

$k_v := 5.34 \qquad \sqrt{\frac{E \cdot k_v}{F_y}} = 56 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 85$

Area of Web Element:

$A_w := h_{clip.shear} \cdot t_{clip} = 0.759 \cdot in^2$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h_{clip.shear}}{t_{clip}}\right)^2} = 34.1 \cdot ksi$$

$V_{cr} := A_w \cdot F_{cr} \qquad V_y := 0.6 \cdot A_w \cdot F_y = 23\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.937$

Hole Shear Reduction Factor:
(for circular holes, AISI S100-16 Eq G3-1)

$c := \frac{h_{clip.shear}}{2} - \frac{d_{sms}}{2.83} = 3.41 \cdot in$

$$q_s := \begin{cases} 1.0 & \text{if } \frac{c}{t_{clip}} \geq 54 \\ \frac{c}{54 \cdot t_{clip}} & \text{if } 5 \leq \frac{c}{t_{clip}} < 54 \end{cases} = 0.583$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \leq 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \leq 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 19.792 \cdot kip$$

Design Shear Capacity with holes:

$\phi V_{n.clip} := 0.95 \cdot V_n \cdot q_s = 11 \cdot kip$

D/C Ratio of V and M per AISI S100-16 Eq H2-1

$$DCR_{V.M.int.clip} := \sqrt{\left(\frac{M_{u.clip}}{\phi M_n}\right)^2 + \left(\frac{\max(T_{clip}, V_{clip})}{\phi V_{n.clip}}\right)^2} = 0.5116$$

Demand/Capacity Ratio:

$VandM_{int.clip} = \text{"OK"}$

ISOLATOR DESIGN [PER OPM-0401-13]

OPM-0401-13 is based on allowable stress design

Number of isolators on the long side

$N_B := 4.5$ $N_{iso.long} := N_B = 5$

Moment Arm for overturning (Short side)

$B := W_{curb} + \frac{1.75in}{2} \cdot 2 = 39 \cdot in$

Number of isolators on the Short side.

$N_L := 4$

Isolator Centerline Spacing (Long side)

$L_{spacing.iso} := \frac{L_{curb} - (6in) \cdot 2}{N_B - 1} = 15.82 \cdot in$

Moment Arm for overturning (Long side)

$L := L_{curb} - 2 \cdot 6in - 2 \cdot L_{spacing.iso} \cdot \frac{(N_L - 2)}{4} = 40 \cdot in$

Total Number of isolators

$N_t := (N_B) \cdot 2sides = 9$

Max net Tension Reaction due to Seismic, Fp

$EQ_{ASD} := \left[0.6 - (0.7 \cdot F_v)\right] \cdot Wt_{unit} = 0.429\ kip$

$$R_{iso.EQ} := MAX+\left[\begin{bmatrix}\left[\frac{(0.7F_p) \cdot Wt_{unit}}{B \cdot N_B} \cdot (h_{CG.unit} + 0in) + \frac{EQ_{ASD} \cdot e_{width}}{B \cdot N_B}\right] - \frac{EQ_{ASD}}{N_t} \\ \left[\frac{(0.7F_p) \cdot Wt_{unit}}{L \cdot N_L} \cdot (h_{CG.unit} + 0in) + \frac{EQ_{ASD} \cdot e_{length}}{L \cdot N_L}\right] - \frac{EQ_{ASD}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}278 \\ 299\end{pmatrix} \cdot lbs$$

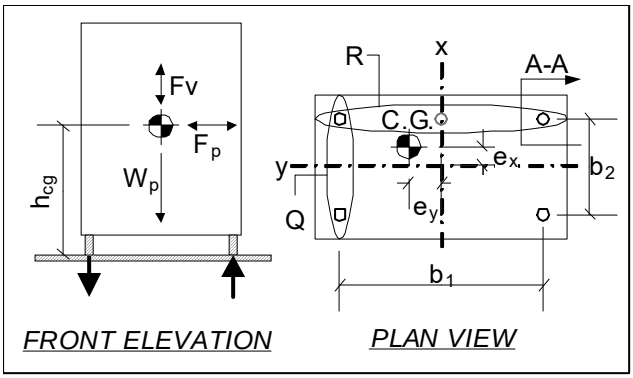
Max net Tension Reaction due to Wind load, Pnet

$$F_{wind.B} := \frac{P_{net} \cdot L_{unit} \cdot (H_{unit} + 0in)}{B \cdot N_B} \cdot \left(\frac{1}{2} \cdot H_{unit} + 0in\right) = 363 \cdot lbs$$

$$F_{wind.L} := \frac{P_{net} \cdot W_{unit} \cdot (H_{unit} + 0in)}{L \cdot N_L} \cdot \left(\frac{1}{2} \cdot H_{unit} + 0in\right) = 324 \cdot lbs$$

$$R_{iso.W} := (0.6) \cdot MAX+\left(\begin{pmatrix}F_{wind.B} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{Wt_{unit}}{N_t} \\ F_{wind.L} + \frac{P_v \cdot L_{unit.up} W_{unit}}{N_t} + \frac{Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{Wt_{unit}}{N_t}\end{pmatrix}\right) = \begin{pmatrix}407 \\ 367\end{pmatrix} \cdot lbs$$

Tensile and Shear Load calculation per ASHRAE RP-812



Eccentricity along X-X

$e_x := e_{width} = 7.5 \cdot in$

Eccentricity along Y-Y

$e_y := e_{length} = 2.56 \cdot in$

Distance between Seismic Restraints Along Y-Y

$b_1 := L_{curb} - 2 \cdot 6in = 55 \cdot in$

Distance between Seismic Restraints Along X-X

$b_2 := W_{curb} + 2 \cdot \frac{1.75in}{2} = 39 \cdot in$

Moment of Inertia about X-X

$I_{xx} := \frac{N_t \cdot (N_t + 2) \cdot (b_1)^2}{12 \cdot (N_t - 2)} = 3614 \cdot in^2$

Moment of Inertia about Y-Y

$I_{yy} := \frac{N_t \cdot (b_2)^2}{4} = 3411 \cdot in^2$

Angle about Tensile Load

$\Theta_t := \operatorname{atan}\left[\frac{I_{yy} \cdot (b_1)}{I_{xx} \cdot (b_2)}\right] = 53 \cdot deg$

Angle about Shear Load

$$\Theta_s := \begin{cases} \operatorname{atan}\left(\frac{e_x}{e_y}\right) & \text{if } e_y \neq 0 \\ 0deg & \text{if } e_y = 0 \end{cases} = 71 \cdot deg$$

Max Net Tensile Load Due to Seismic Load, Fp

$$T_{U.EQ.pt1} := \frac{(0.6 - 0.7 \cdot F_v) \cdot Wt_{unit}}{N_t} - \frac{(0.6 - 0.7 \cdot F_v) \cdot Wt_{unit}}{b_1 \cdot b_2} \cdot \left(\frac{b_1}{2} \cdot e_x + \frac{b_2}{2} \cdot e_y - e_x \cdot e_y\right) = 0 \cdot lbs$$

$$T_{U.EQ.pt2} := -0.7 \cdot (F_p \cdot Wt_{unit}) \cdot (h_{CG.unit} + 0in) \cdot \cos(\Theta_t) \cdot \frac{0.5 \cdot b_2}{I_{yy}} = -183 \cdot lbs$$

$$T_{U.EQ.pt3} := -0.7 \cdot (F_p \cdot Wt_{unit}) \cdot (h_{CG.unit} + 0in) \cdot \sin(\Theta_t) \cdot \frac{0.5 \cdot b_1}{I_{xx}} = -330 \cdot lbs$$

$T_{U.EQ} := T_{U.EQ.pt1} + T_{U.EQ.pt2} + T_{U.EQ.pt3} = -513 \cdot lbs$

Max Net Shear Load Due to Seismic Load, Fp

$$V_{Ux.EQ} := 0.7 \cdot F_p \cdot Wt_{unit} \cdot \frac{\cos(\Theta_s)}{N_t} + \frac{0.7 \cdot F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_2 \cdot e_y + 0.7 \cdot F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_1 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 172 \cdot lbs$$

$$V_{Uy.EQ} := 0.7 \cdot F_p \cdot Wt_{unit} \cdot \frac{\sin(\Theta_s)}{N_t} + \frac{0.7 \cdot F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_1 \cdot e_y + 0.7 \cdot F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_2 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 333 \cdot lbs$$

$$V_{U.EQ} := \sqrt{V_{Ux.EQ}^2 + V_{Uy.EQ}^2} = 375 \cdot lbs$$

Tension Design force SRSS for loading from Each direction

$R_{iso.EQ.1.RP812} := \left| T_{U.EQ.pt1} + T_{U.EQ.pt3} \right| = 330 \cdot lbs$

$R_{iso.EQ.0.RP812} := \left| T_{U.EQ.pt1} + T_{U.EQ.pt2} \right| = 183 \cdot lbs$

$$R_{iso.EQ.max_1} := \max\left[\left(R_{iso.EQ.1.RP812} + 0 \cdot R_{iso.EQ.0.RP812}\right), \left(R_{iso.EQ_1} + 0 \cdot R_{iso.EQ_0}\right)\right] = 330 \cdot lbs$$

$$R_{iso.EQ.max_0} := \max\left[\left(R_{iso.EQ.0.RP812} + 0 \cdot R_{iso.EQ.1.RP812}\right), \left(R_{iso.EQ_0} + 0 \cdot R_{iso.EQ_1}\right)\right] = 278 \cdot lbs$$

For the plot:

$R_{iso.EQ.max_1} = 330 \cdot lbs$ $R_{iso.W_1} = 367 \cdot lbs$

$R_{iso.EQ.max_0} = 278 \cdot lbs$ $R_{iso.W_0} = 407 \cdot lbs$

Shear load at each anchor location

For the plot:

$$V_{iso.E} := \max\left[\left[\begin{array}{c} 1.0 \cdot V_{Ux.EQ} + 0 \cdot V_{Uy.EQ} \\ 0.3 \cdot V_{Ux.EQ} + 0 \cdot V_{Uy.EQ} \\ \left[\left(0.7F_p\right) \cdot Wt_{unit} \cdot \frac{1}{N_t}\right] \end{array}\right]\right] = 289 \cdot lbs \qquad V_{iso.W} := 0.6P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t} = 205 \cdot lbs$$

Isolator Capacity:

$ID_{Iso} := "CQA"$

$T_{n.\Omega} := 2117lbs$ **(ASD)**

$T_{n.\Omega.45} := 808lbs$ **(ASD)**

$V_{n.\Omega} := 775lbs$ **(ASD)**

Isolator Demand:

$R_{iso.max} := \max\left[\left(R_{iso.EQ.max_1}\right), \left(R_{iso.EQ.max_0}\right), \left(R_{iso.W_1}\right), \left(R_{iso.W_0}\right)\right] = 407 \cdot lbs$

$V_{iso.max} := \max\left(V_{iso.E}, V_{iso.W}\right) = 289 \cdot lbs$

D/C Ratio of Tension Only.:

$$DCR_{tension} := \frac{R_{iso.max}}{T_{n.\Omega}} = 0.192$$

$DCR_{tension} = "OK"$

D/C Ratio of Shear Only.:

$$DCR_{shear} := \frac{V_{iso.max}}{V_{n.\Omega}} = 0.373$$

$DCR_{shear} = "OK"$

D/C Ratio of Tension Only.:

$$DCR_{Int} := \frac{V_{iso.max}}{V_{n.\Omega}} + \frac{R_{iso.max}}{T_{n.\Omega.45}} = 0.877$$

$DCR_{Int} = "OK"$

ISOLATOR "SPRING" DESIGN [PER OPM-0401-13]

Factor of Safety of Spring

$FS_{spring} := 0.75$

Compressive Strength of Spring

$$C_{spring.\Omega} := \begin{cases} \left(FS_{spring} \cdot 300lbs\right) & \text{if } ID_{Iso} = "CQA" \\ \left(FS_{spring} \cdot 918lbs\right) & \text{if } ID_{Iso} = "CQB" \\ \left(FS_{spring} \cdot 918lbs\right) & \text{if } ID_{Iso} = "CQBX" \end{cases} = 225 \cdot lbs$$

Rated Load per unit self-weight

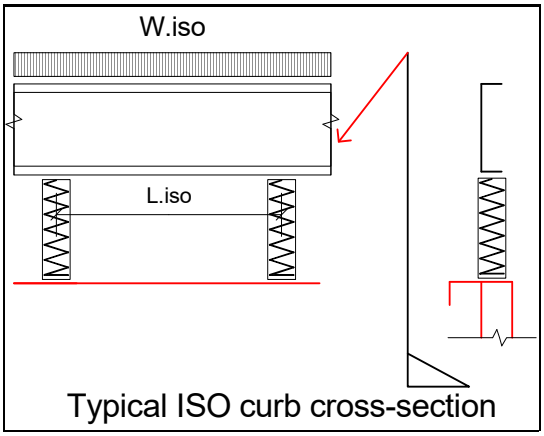
$$C_{unit.rated.load} := \frac{Wt_{unit}}{N_t} = 122 \cdot lbs$$

D/C Ratio of Spring Compression:

$$DCR := \frac{C_{unit.rated.load}}{C_{spring.\Omega}} = 0.543$$

$IsoSpring_{compression} = "OK"$

Check ISO Rail for Bending about Strong and Weak Axis (AISI S100-16 F2.1)



Typical ISO curb cross-section

Thickness of Curb:

$t_{Curb.iso}$ = "10GA" $t := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Inside Bend Radius:

$R := R_{iso} = 0.186 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web:

$h := 7.5in - 2 \cdot (t + R) = 6.85 \cdot in$

Width of Flange:

$h_w := 1in$

Check Curb Bending of Long Side (Strong axis)

Member per CFS: $CFS_{member} :=$ "10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"

Number of Isolators on each Long Side: $N_{iso.long} = 5$

Center-to-Center Spacing of Isolators $L_{iso} := \frac{L_{curb}}{N_{iso.long} - 1} = 19 \cdot in$

Distributed Load $\omega_{iso} := \omega_{x.L.vert} = 1.946\,klf$

Moment Demand on Iso Rail $M_{cx} := \frac{\omega_{iso} \cdot L_{iso}^2}{8} = 7.512 \cdot kip \cdot in$

Curb Elastic Modulus / Yield Stress: $E := 29500ksi$ $F_y := 50ksi$

Curb Shear Modulus: $G := 11300ksi$

Poisson's Ratio $\mu := 0.3$

Section Properties from CFS: $r_x = 2.4893 \cdot in$ $r_o = 2.519 \cdot in$ $C_w = 0.595 \cdot in^6$ $S_x = 1.855 \cdot in^3$

$r_y = 0.2288 \cdot in$ $J = 0.0058 \cdot in^4$ $S_y = 0.3669 \cdot in^3$

$r_{min} := \min(r_x, r_y) = 0.2288 \cdot in$

Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Flanges*

Flat Width: $w := h_w - R_{curb} = 0.893 \cdot in$

Stiffened Web Check: $Stiffened_{check} := "Unstiffened"$

Stress at the end of the Width: $f_2 := 11.407ksi$ $f_1 := 11.407ksi$

Compressive Stress Ratio (Eq. 1.1.2-1): $\Psi := \frac{f_2}{f_1} = 1$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = "Stiffened" \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = "Unstiffened" \end{cases} = 0.43$$

Critical Compressive Stress: $F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot (1 - \mu^2)} \cdot \left(\frac{t}{w}\right)^2 = 274.53 \cdot ksi$

Stress in Compression Element: $f := 18ksi$

Note: Use f from "Elastive Flexural Buckling Stress" on "Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI E2)"

Slenderness Factor: $\lambda := \sqrt{\frac{f}{F_{cr}}} = 0.26$

Local reduction factor: $\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 0.55$

Effective Width of the Flanges:

$$b_{eff.flange} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 0.893 \cdot in$$

Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Web*

Flat Width: $w := h = 6.851 \cdot in$

Stiffened Web Check: $Stiffened_{check} := "Stiffened"$

Stress at the end of the Width: $f_2 := 11.407ksi$ $f_1 := 11.407ksi$

Compressive Stress Ratio (Eq. 1.1.2-1): $\Psi := \frac{f_2}{f_1} = 1$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = "Stiffened" \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = "Unstiffened" \end{cases} = 4$$

Critical Compressive Stress: $F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t}{w}\right)^2 = 43.4 \cdot ksi$

Stress in Compression Element: $f := 18ksi$

Note: Use f from "Elastive Flexural Buckling Stress" on "Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI E2)"

Slenderness Factor: $\lambda := \sqrt{\frac{f}{F_{cr}}} = 0.64$

Local reduction factor: $\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 1.022$

Effective Width of the Web:

$$b_{eff.web} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 6.851 \cdot in$$

Effective Area of the Member: $A_e := 2 \cdot \left(b_{eff.flange} \cdot t\right) + b_{eff.web} \cdot t = 1.194 \cdot in^2$

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. F2.1.1-4,5)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(1.0 \cdot L_{iso}\right)^2}\right] = 70 \cdot ksi$$

$$\sigma_{ey} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{iso}}{r_y}\right)^2} = 41 \cdot ksi \qquad \frac{1.0 \cdot L_{iso}}{r_y} = 84$$

KL_r = "KL/r < 200, OK"

Cb per Eq. F2.1.1-2

$$M_A := \frac{\omega_{iso} \cdot \frac{L_{iso}}{4}}{2} \cdot \left(L_{iso} - \frac{L_{iso}}{4}\right) = 5.63 \cdot kip \cdot in$$

$$M_B := M_{cx} = 7.51 \cdot kip \cdot in$$

$$M_C := \frac{\omega_{iso} \cdot \frac{3 \cdot L_{iso}}{4}}{2} \cdot \left(L_{iso} - \frac{3 \cdot L_{iso}}{4}\right) = 5.63 \cdot kip \cdot in$$

$$C_b := \min\left(1.0, \frac{12.5 \cdot M_{cx}}{2.5 \cdot M_{cx} + 3 \cdot M_A + 4 \cdot M_B + 3.M_C}\right) = 1$$

Elastic Critical Lateral-Torsional Buckling Stress per Eq. F2.1.1-1 for Singly Symmetry:

$$F_e := \frac{C_b \cdot r_o \cdot A_e}{S_x} \cdot \sqrt{\sigma_{ey} \cdot \sigma_t} = 87 \cdot ksi$$

LTB Design Stress: Eq. F2.1-3,4,5:

$$F_c := \begin{cases} F_y & \text{if } F_e \geq 2.78 \cdot F_y \\ \frac{10}{9} \cdot F_y \cdot \left(1 - \frac{10 \cdot F_y}{36 \cdot F_e}\right) & \text{if } 2.78 \cdot F_y > F_e > 0.56 \cdot F_y \\ F_e & \text{if } 0.56 \cdot F_y \geq F_e \end{cases} = 47 \cdot ksi$$

Moment Capacity Eq. F2.1-1:

$$\phi M_{nx} := 0.9 \cdot S_x \cdot \min\left(F_c, F_y\right) = 78 \cdot kip \cdot in$$

D/C Ratio of Bending:

$$DCR := \frac{M_{cx}}{\phi M_{nx}} = 0.096$$

$Iso_{Bending}$ = "OK"

Check Curb Bending of Long Side (Weak axis)

Center-to-Center Spacing of Braces

$$L_{brace} := \max\left(40in, \frac{L_{curb}}{N_{iso.long} - 1}\right) = 40 \cdot in$$

Note for weak-axis bracing length:
Max weak-axis span length of Iso Rail is larger than L_{brace} per cut sheet. However, the Iso Rail is braced with clip at max 24" O.C. at top and isolator at max 36" O.C. at bottom such that the actual unbraced length is as follows.

Distributed Load

$$\omega_{iso} := \frac{\max\left(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit}\right)}{L_{curb}} = 0.661\ klf$$

Moment Demand on Iso Rail

$$M_{cy} := \frac{\omega_{iso} \cdot L_{brace}^{2}}{8} = 11.02 \cdot kip \cdot in$$

Member per CFS:

$$CFS_{member} = \text{"10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"}$$

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. F2.1.1-4,5)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(1.0 \cdot L_{brace}\right)^2}\right] = 23 \cdot ksi$$

$$\sigma_{ex} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{brace}}{r_x}\right)^2} = 1128 \cdot ksi \qquad \frac{1.0 \cdot L_{brace}}{r_x} = 16$$

$$KL_r = \text{"KL/r < 200, OK"}$$

Cb per Eq. F2.1.1-2

$$M_A := \frac{\omega_{iso} \cdot \frac{L_{brace}}{4}}{2} \cdot \left(L_{brace} - \frac{L_{brace}}{4}\right) = 8.27 \cdot kip \cdot in$$

$$M_B := M_{cy} = 11.02 \cdot kip \cdot in$$

$$M_C := \frac{\omega_{iso} \cdot \frac{3 \cdot L_{brace}}{4}}{2} \cdot \left(L_{brace} - \frac{3 \cdot L_{brace}}{4}\right) = 8.27 \cdot kip \cdot in$$

$$C_b := \min\left(1.0, \frac{12.5 \cdot M_{cx}}{2.5 \cdot M_{cx} + 3 \cdot M_A + 4 \cdot M_B + 3.M_C}\right) = 0.84$$

Elastic Critical Lateral-Torsional Buckling Stress per Eq. F2.1.1-1 for Singly Symmetry:

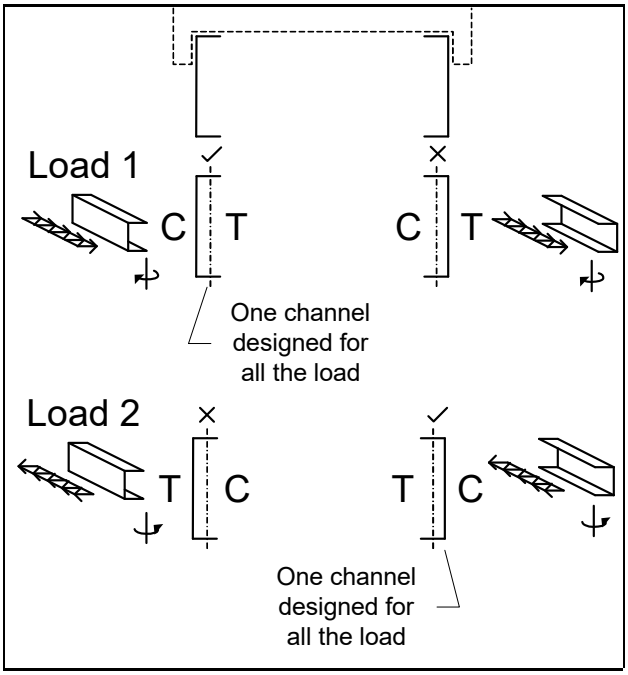
$$F_e := \frac{C_b \cdot r_o \cdot A_e}{S_y} \cdot \sqrt{\sigma_{ey} \cdot \sigma_t} = 210 \cdot ksi$$

LTB Design Stress: Eq. F2.1-3,4,5:

$$2.78 \cdot F_y = 139 \cdot ksi$$

$$0.56 \cdot F_y = 28 \cdot ksi$$

$$F_c := \begin{cases} F_y & \text{if } F_e \geq 2.78 \cdot F_y \\ \frac{10}{9} \cdot F_y \cdot \left(1 - \frac{10 \cdot F_y}{36 \cdot F_e}\right) & \text{if } 2.78 \cdot F_y > F_e > 0.56 \cdot F_y \\ F_e & \text{if } 0.56 \cdot F_y \geq F_e \end{cases} = 50 \cdot ksi$$



Note:

For ISO rail weak-axis bending capacity, rails are oriented and designed so that the stiffer side of ISO rail can take the entire bending load by itself without putting a lot of bending load to the iso rail on the other side

Moment Capacity Eq. F2.1-1:

$$\phi M_{ny} := 0.9 \cdot S_y \cdot \min(F_c, F_y) = 16.5105 \cdot kip \cdot in$$

D/C Ratio of Bending:

$$DCR := \frac{M_{cy}}{\phi M_{ny}} = 0.667$$

$$Iso_{Bending} := \text{if}(M_{cy} < \phi M_{ny}, \text{"OK"}, \text{"NG"})$$

$Iso_{Bending} = \text{"OK"}$

Web Crippling of ISO Rail (AISI S100-16 G.5)

Governing Compression:

$$P_{web.crip} := \frac{\omega_{x.L.vert} \cdot L_{iso}}{2} = 1561 \cdot lbs$$

Yield Strength:

$$F_y := 50ksi$$

Bearing Length:

$N := 2in$ **2 in. for CQAs**

Thickness of Curb:

$t_{Curb.iso} = "10GA"$ $t := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Inside Bend Radius:

$R := R_{iso} = 0.186 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web:

$h = 6.85 \cdot in$

Angle btween plane of web and bearing surface:

$\theta := 90deg$

Web Crippling Limit Check (AISI Table G5-2):

$\frac{R}{t} = 1$ $\frac{h}{t} = 50$ $\frac{N}{t} = 14$ $\frac{N}{h} = 0.29$

$$LimitCheck_{webcrippling} := if\left[\left(\frac{h}{t} < 200\right) \wedge \left(\frac{N}{t} < 210\right) \wedge \left(\frac{N}{h} < 2\right) \wedge \left(\frac{R}{t} < 2\right), "OK", "NG, Need Reinf"\right]$$

$LimitCheck_{webcrippling} = "OK"$

End Case Coefficient Single Web Channel (AISI Table G5-2):

$C := 2$ $C_R := 0.11$ $C_N := 0.37$ $C_h := 0.01$

Reduction Factor Web Crippling Strength:

$\phi_{web.end} := 0.75$ **(For Unfastened Flanges with Two-Flange Loading or Reaction. Worst Case)**

$\phi_{web.int} := 0.8$

Design Web Crippling Strength:

$$P_{n.end} := C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 3729 \cdot lbs$$

$$\phi P_{n.end} := \phi_{web.end} \cdot P_{n.end} = 2796 \cdot lbs$$

Interior Case Coefficient Single Web Channel (AISI Table G5-2):

$C := 13$ $C_R := 0.47$ $C_N := 0.25$ $C_h := 0.04$

Design Web Crippling Strength:

$$P_{n.interior} := C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 7905 \cdot lbs$$

$$\phi P_{n.interior} := \left(\phi_{web.int}\right) \cdot P_{n.interior} = 6324 \cdot lbs$$

Design Strength:

$$P_{n.web.crip} := \min\left(P_{n.end}, P_{n.interior}\right) = 3729 \cdot lbs$$

$$\phi P_{n.web.crip} := \min\left(\phi P_{n.end}, \phi P_{n.interior}\right) = 2796 \cdot lbs$$

D/C Ratio of Shear:

$$DCR := \frac{P_{web.crip}}{\phi P_{n.web.crip}} = 0.558$$

Demand/Capacity Ratio:

$$Web_{crippling} := if\left[\left(P_{web.crip} < \phi P_{n.web.crip}\right) \wedge \left(\phi P_{n.end} > 0\right) \wedge \frac{h}{t} < 200, "OK", "NG, Need Reinf"\right]$$

$Web_{crippling} = "OK"$

D/C Ratio of Interaction:
AISI Eq. H3-1b

$$DCR_{int.web} := \frac{0.91 \cdot \left(\frac{P_{web.crip}}{P_{n.web.crip}}\right) + \frac{M_{cx}}{\left(\frac{\phi M_{nx}}{0.9}\right)}}{1.33 \cdot 0.9} = 0.391$$

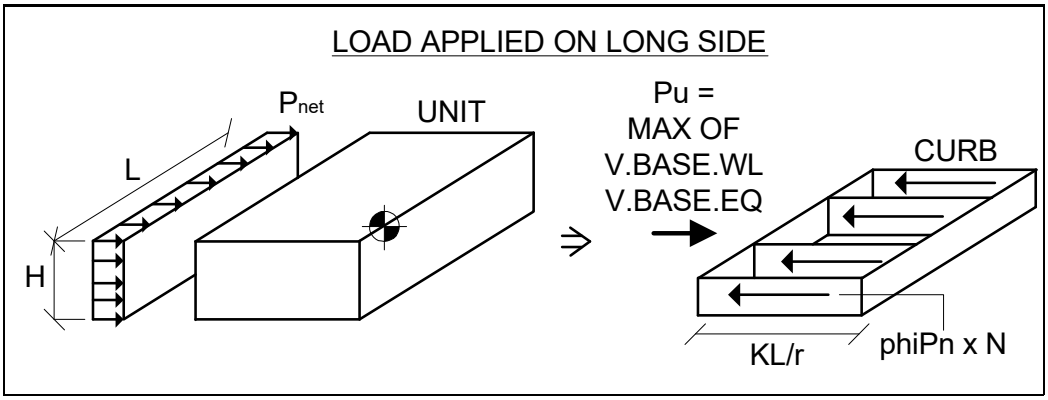
$Iso_{Shear} = "OK"$

$Iso_{Interaction} = "OK"$

Per AISI S100-16 H3,
Only x-axis needs to check for interaction

Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI S100-16 E2)

Curb Axial Load Check due to Load on Long Side



Wind Base Shear of Unit on Long Side: $V_{base.W.L} := P_{net} \cdot L_{unit} \cdot H_{unit} = 3.1\,kip$

Seismic Base Shear of Unit on Long Side: $V_{base.S.L} := F_p \cdot Wt_{unit} = 3.7\,kip$

Max Axial: $P_u := \max\left(V_{base.S.L}, V_{base.W.L}\right) = 3712.5 \cdot lbs$

Member per CFS: $CFS_{member} =$ "10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"

Number of Curb in Length: $n_{iso} := 3$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{iso}} = 1.24\,kip$

Max Braced Length of Member: $L_{member} := W_{curb} = 37 \cdot in$

Effective Length factor: $K := 0.5$

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. E2.2-5, E2.2-6)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(K \cdot L_{member}\right)^2}\right] = 75 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2} = 44 \cdot ksi$$

$$\frac{K \cdot L_{member}}{r_{min}} = 81$$

KL_r = "KL/r < 200, OK"

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 28 \cdot ksi$$

Nominal Compressive Stress Capacity (Eq E2-4):

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 1.343$$

$$F_n := \begin{cases} 0.658^{\lambda_c^{\,2}} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^{\,2}}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 23.51 \cdot ksi$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot A_e \cdot F_n = 23.85\ kip$$

D/C Ratio of Compression:

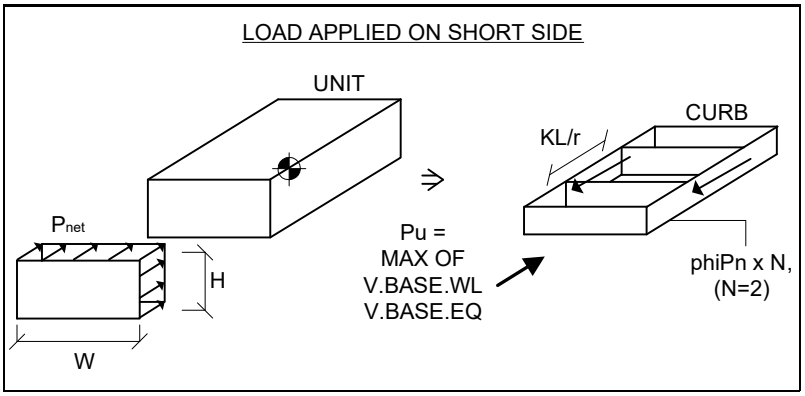
$$DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.052$$

$$Axial_{reinf} := \text{if}\left(P_{u.EAmember} < \phi P_{n.member}, \text{"OK"}, \text{"NG"}\right)$$

$Axial_{reinf}$ = "OK"

Note:
No need to check for interaction since equipment is not attached to the short side

Curb Axial Load Check due to Load on Short Side



Wind Base Shear on Short Side: $V_{base.W.H} := P_{net} \cdot W_{unit} \cdot H_{unit} = 2.5\,kip$

Seismic Base Shear of Unit on Short Side: $V_{base.S.W} := F_p \cdot Wt_{unit} = 3.7\,kip$

Max Axial: $P_u := \max\left(V_{base.S.W}, V_{base.W.H}\right) = 3712.5 \cdot lbs$

Member per CFS: CFS_{member} = "10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"

Number of Curb in Length: $n_{curb} := 2$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{curb}} = 1.86\,kip$

Max Braced Length of Member: $L_{member} := \frac{L_{curb}}{n_{iso} - 1} = 34 \cdot in$

Effective Length factor: $K := 0.5$

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. E2.2-5, E2.2-6)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(K \cdot L_{member}\right)^2}\right] = 89 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2} = 54 \cdot ksi \qquad \frac{K \cdot L_{member}}{r_{min}} = 74$$

KL_r = "KL/r < 200, OK"

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 34 \cdot ksi$$

Nominal Compressive Stress Capacity (Eq E2-4):

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 1.221$$

$$F_n := \begin{cases} 0.658^{\lambda_c^2} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^2}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 26.79 \cdot \text{ksi}$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot A_e \cdot F_n = 27.18\ \text{kip}$$

D/C Ratio of Compression:

$$DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.068$$

$$Axial_{reinf} := \text{if}\left(P_{u.EAmember} < \phi P_{n.member}, \text{"OK"}, \text{"NG"}\right)$$

$Axial_{reinf} = \text{"OK"}$

Note:
If the load direction is in perpedicular plane to the short side of the equipment, the channels will only experience axial load and no bending will occur at the channel. Therefore, no need to check for interaction since the channels

Shear of ISO Rail Webs without Holes (AISI S100-16 G2)

Note: The connection holes are not centered at mid-depth of isolated curb rail so AISI G2 shall be used

Deeper Section (h = depth)

Thickness of Curb: $t := \text{thick}(t_{Curb.iso}) = 0.138 \cdot \text{in}$

Depth-to-Thickness Ratio: $\frac{h}{t} = 50$

Curb Elastic Modulus: $E := 29500\text{ksi}$

Clear distance b/w transverse stiffeners of reinforced web: $a := L_{iso} = 19 \cdot \text{in}$

Clear Distance-to-Thickness Ratio: $\frac{a}{h} = 2.81$

Nominal Shear Stress:

$$k_v := \begin{cases} 5.34 & \text{if } a = L_{iso} \\ 4.00 + \frac{5.34}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \frac{4.00}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 5.85$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 59 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 89$$

Curb Shear Check due to Load on Longer Side

Area of Web Element:

$$A_w := h \cdot t = 0.947 \cdot in^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 63.4 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} = 60\,kip \qquad V_y := 0.6 \cdot A_w \cdot F_y = 28\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.688$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 28.404 \cdot kip$$

Number of Members within Length: $n := 1$ **(Per Curb Design)**

Design Shear Capacity:

$$\phi V_{n.h} := 0.95 \cdot n \cdot V_n = 26.98 \cdot kip$$

Design Shear Demand:

$$V_{u.h} := \frac{\omega_{x.L.vert} \cdot L_{iso}}{2} = 1560.9 \cdot lbs$$

D/C Ratio of Shear:

$$DCR := \frac{V_{u.h}}{\phi V_{n.h}} = 0.058$$

Demand/Capacity Ratio:

$Shear_{in.plane} = \text{"OK"}$

Shallower Section (h.w = Width)

Thickness of Curb: $t := thick(t_{Curb.iso}) = 0.138 \cdot in$

Depth-to-Thickness Ratio: $\frac{h_w}{t} = 7$

Curb Elastic Modulus: $E := 29500 ksi$

Clear distance b/w transverse stiffeners of reinforced web: $a := L_{brace} = 40 \cdot in$

Clear Distance-to-Thickness Ratio: $\frac{a}{h_w} = 40$

Nominal Shear Stress:

$$k_v := \begin{cases} 5.34 \text{ if } a = L_{brace} \\ 4.00 + \frac{5.34}{\left(\frac{a}{h_w}\right)^2} \text{ if } \left(\frac{a}{h_w} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \frac{4.00}{\left(\frac{a}{h_w}\right)^2} \text{ if } \left(\frac{a}{h_w} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 5.34$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 56 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 85$$

Curb Shear Check due to Load on Longer Side

Area of Web Element: $A_w := h_w \cdot t = 0.1382 \cdot in^2$

Number of Members within Length: $n := 1$ **(Per Curb Design)**

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 58 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} = 8 \, kip \qquad V_y := 0.6 \cdot A_w \cdot F_y = 4 \, kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.719$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 4.146 \cdot \text{kip}$$

Design Shear Capacity:

$$\phi V_{n.hw} := 0.95 \cdot n \cdot V_n = 3.9 \cdot \text{kip}$$

Design Shear Demand:

$$V_{u.hw} := \frac{\left(\frac{\max\left(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit}\right)}{L_{curb}} \right) \cdot L_{brace}}{2} = 1102 \cdot \text{lbs}$$

D/C Ratio of Shear:

$$DCR := \frac{V_{u.hw}}{\phi V_{n.hw}} = 0.28$$

Demand/Capacity Ratio:

$Shear_{in.plane}$ = "OK"

D/C Ratio of Vx and Mx:

$$DCR_{V.M.int} := \begin{cases} \left(0.6 \cdot \frac{M_{cx}}{\phi M_{nx}} + \frac{V_{u.h}}{\phi V_{n.h}}\right) \cdot \frac{1}{1.3} & \text{if } \frac{M_{cx}}{\phi M_{nx}} > 0.5 \wedge \frac{V_{u.h}}{\phi V_{n.h}} > 0.7 \\ \sqrt{\left(\frac{M_{cx}}{\phi M_{nx}}\right)^2 + \left(\frac{V_{u.h}}{\phi V_{n.h}}\right)^2} & \text{otherwise} \end{cases} = 0.112$$

Demand/Capacity Ratio:

$VandMx_{int}$ = "OK"

D/C Ratio of Vy and My:

$$DCR_{V.M.int} := \begin{cases} \left(0.6 \cdot \frac{M_{cy}}{\phi M_{ny}} + \frac{V_{u.hw}}{\phi V_{n.hw}}\right) \cdot \frac{1}{1.3} & \text{if } \frac{M_{cy}}{\phi M_{ny}} > 0.5 \wedge \frac{V_{u.hw}}{\phi V_{n.hw}} > 0.7 \\ \sqrt{\left(\frac{M_{cy}}{\phi M_{ny}}\right)^2 + \left(\frac{V_{u.hw}}{\phi V_{n.hw}}\right)^2} & \text{otherwise} \end{cases} = 0.724$$

Demand/Capacity Ratio:

$VandMy_{int}$ = "OK"

Web Crippling/Compression of Non-iso CanFab Curb (AISI S100-16 G5)

Governing Compression for Non-Isolated Curb:

$$P_{web.crip.int} := \max\left[\frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}}, \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}}\right] \cdot L_{spacing.non.iso} = 2507 \cdot lbs$$

$$P_{web.crip.end} := 0.5 \cdot P_{web.crip.int} = 1253 \cdot lbs$$

Yield Strength: $F_y := 50ksi$

Bearing Length: $N_{bearing} := L_{spacing.non.iso} = 15 \cdot in$

Thickness of Curb: $t_{Curb} = \text{"14GA"}$ $t := thick(t_{Curb}) = 0.0785 \cdot in$

Inside Bend Radius: $R := R_{curb} = 0.107 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web: $h := 22in - 2 \cdot (t + R) = 21.63 \cdot in$

Angle btween plane of web and bearing surface: $\theta := 90deg$

Web Crippling Limit Check (AISI Table G5-2): $\frac{R}{t} = 1$ $\frac{h}{t} = 276$ $\frac{N_{bearing}}{t} = 197$ $\frac{N_{bearing}}{h} = 0.71$

End Case Coefficient Single Web Channel (AISI Table G5-2): $C := 13$ $C_R := 0.32$ $C_N := 0.05$ $C_h := 0.04$

Reduction Factor Web Crippling Strength: $\phi_{web.end} := 0.9$ $\phi_{web.int} := 0.8$ **(For Unfastened partially Stiffened Flanges with Two-Flange Loading or Reaction.)**

Design Web Crippling Strength:

$$\phi P_{n.end} := \left(\phi_{web.end}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 1292 \cdot lbs$$

Interior Case Coefficient Single Web Channel (AISI Table G5-2): $C := 24$ $C_R := 0.52$ $C_N := 0.15$ $C_h := 0.001$

Design Web Crippling Strength:

$$\phi P_{n.interior} := \left(\phi_{web.int}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 7102 \cdot lbs$$

D/C Ratio of Shear: $DCR_{end} := \frac{P_{web.crip.end}}{2 \cdot \phi P_{n.end}} = 0.485$ $DCR_{int} := \frac{P_{web.crip.int}}{\phi P_{n.interior}} = 0.353$

Demand/Capacity Ratio: **Note: Factor of 2 for two ends connected together at the end**

$Web_{crippling} = \text{"OK"}$

Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Length

Roof Curb thickness

$t_{Curb} = \text{"14GA"}$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

Min width of Roof Curb

$b_{curb} := L_{curb} + \frac{W_{curb}}{2} \cdot 2 + 3in \cdot 2 \cdot 4 = 128.56 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := L_{curb} + \min\left(\frac{W_{curb}}{2} \cdot 2, \frac{L_{curb}}{2}\right) = 101 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{array}{c} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{array} \right] \right] = 5942 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.L.vert.up} \cdot L_{curb}) \cdot (0.75in) = 5213 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.877$

$Curb_{BotFlangeBending} = \text{"OK"}$

Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Width

Roof Curb thickness

$t_{Curb} = \text{"14GA"}$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

Min width of Roof Curb

$b_{curb} := W_{curb} + \frac{L_{curb}}{4} \cdot 2 + 3in \cdot 2 = 76.88 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := W_{curb} + \min\left(\frac{L_{curb}}{6} \cdot 2, W_{curb}\right) = 60 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{array}{c} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{array} \right] \right] = 3553 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.W.vert.up} \cdot W_{curb}) \cdot (0.75in) = 2698 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.759$

$Curb_{BotFlangeBending} = \text{"OK"}$

Web Crippling/Compression of Iso CanFab Curb (AISI S100-16 G5)

Note: Curb stiffeners directly transfer the compressive load from isolator to the base. Therefore, curb web crippling is prevented.

Curb Web with Reinforcement

Max Compression: $Comp_{maxtot} := \max(|C_S|, |C_W|) = 12897.76 \cdot lbs$

Reinforcement per CFS: $CFS_{reinf} :=$ "Single Stiffener 10GA 1"x7"x1" Fy=50ksi 22" Tall on min. 16GA "

Note: min. of 10 GA channel and min. 16 GA curb web

Number of Reinforcement in Length: $n_{reinf} := N_{iso.long} = 5$

Max Compression per Reinf: $Comp_{per.reinf} := \frac{Comp_{maxtot}}{n_{reinf}} = 2.866\,kip$

Spacing: $Spacing := \frac{L_{curb}}{n_{reinf}} = 15 \cdot in$ $KL_r := \frac{1.0 \cdot (H_{curb} - 12.5in)}{0.2339in} = 94$

Factored Nominal Comp. Capacity per reinforcement: $\phi P_{n.reinf} = 18.898 \cdot kip$ **(See attached CFS)**

Total Factored nominal Comp Capacity: $\phi P_{n.tot} := n_{reinf} \cdot \phi P_{n.reinf} = 85 \cdot kip$

D/C Ratio of Compression: $DCR := \frac{Comp_{maxtot}}{\phi P_{n.tot}} = 0.15$

$Comp_{reinf} := if(Comp_{maxtot} < \phi P_{n.tot}, "OK", "NG")$ $Comp_{reinf} = "OK"$

Check CanFab Curb for Compressive Force due to T/C Coupling of Overturning

Note:
-Since the equipment is only attached to the longer sides of the CanFab Curb, most likely there will be compressive force onto the curb due to T/C coupling.
- Rectangular CanFab Curb will be considered as "Channel" to resist the compressive force.

Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Flanges*

Flat Width:

$$w := \frac{W_{curb}}{2} - R_{curb} = 18.487 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Unstiffened"}$$

Stress at the end of the Width:

$$f_2 := 50ksi \qquad f_1 := 50ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \left| \frac{f_2}{f_1} \right| = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 0.43$$

Critical Compressive Stress (Eq 1.1-4):

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w}\right)^2 = 0.21 \cdot ksi$$

Stress in Compression Element:

$$f := F_y = 50 \cdot ksi \qquad \textbf{(Assume f = Fy)}$$

Slenderness Factor (Eq 1.1-3):

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 15.55$$

Local reduction factor (Eq 1.1-2):

$$\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 0.063$$

Effective Width of the Flanges:

$$b_{eff.flange} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 1.172 \cdot in$$

Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Web*

Flat Width:

$$w := L_{curb} - R_{curb} \cdot 2 = 67.161 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Stiffened"}$$

Stress at the end of the Width:

$$f_2 := 50ksi \qquad f_1 := 50ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \left| \frac{f_2}{f_1} \right| = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 4$$

Critical Compressive Stress (Eq 1.1-4):

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w} \right)^2 = 0.15 \cdot ksi$$

Stress in Compression Element:

$$f := F_y = 50 \cdot ksi \qquad \textbf{(Assume f = Fy)}$$

Slenderness Factor (Eq 1.1-3):

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 18.52$$

Local reduction factor (Eq 1.1-2):

$$\rho := \left(1 - \frac{0.22}{\lambda}\right) \frac{1}{\lambda} = 0.053$$

Effective Width of the Web:

$$b_{eff.web} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 3.582 \cdot in$$

Effective Area of the Member:

$$A_e := 2 \cdot \left(b_{eff.flange} \cdot t_{curb} \right) + b_{eff.web} \cdot t_{curb} = 0.465 \cdot in^2$$

Length of the Compressive Member: $L_{curb.web} := h = 21.629 \cdot in$

Young's Modulus for Cold Form Steel: $E := 29500ksi$

Curb Shear Modulus: $G := 11300ksi$

Poisson's Ratio $\mu := 0.3$

Section Properties of the Member (From Section Properties Calculator):

$A_{half.curb} := 6.087in^2$ $r_o := 28.35in$ $I_x := 3577in^4$ $I_y := 311in^4$

$J := 0.006in^4$ $r_x := \sqrt{\frac{I_x}{A_{half.curb}}} = 24.241 \cdot in$ $r_y := \sqrt{\frac{I_y}{A_{half.curb}}} = 7.148 \cdot in$

$C_w := 209700in^6$ $r_{min} := \min(r_x, r_y) = 7.148 \cdot in$

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^2}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{(1.0 \cdot L_{curb.web})^2}\right] = 349052.037 \cdot ksi$$

$$\sigma_{e.y} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_y}\right)^2} = 31797.863 \cdot ksi \qquad \sigma_{e.x} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_x}\right)^2} = 365726.548 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2} = 31797.863 \cdot ksi$$

$$\frac{1.0 \cdot L_{curb.web}}{r_{min}} = 3.03$$

$KL_r = \text{"KL/r < 200, OK"}$

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 29143.001 \cdot ksi$$

Nominal Compressive Stress Capacity: (Eq E2-4)

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 0.041$$

$$F_n := \begin{cases} 0.658^{\lambda_c^2} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^2}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 49.96 \cdot \text{ksi}$$

Compressive Capacity:

$$P_{n.member} := A_e \cdot F_n = 23.24 \cdot \text{kip}$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot P_{n.member} = 19.76 \cdot \text{kip}$$

Factored Max Compressive Force:

$$P_{comp.max} := \max\left(\left|C_S\right|, \left|C_W\right|\right) = 12.898\ \text{kip}$$

D/C Ratio of Compression:

$$DCR := \frac{P_{comp.max}}{\phi P_{n.member}} = 0.653$$

$$Axial_{curb.comp} := \text{if}\left(P_{comp.max} < \phi P_{n.member}, \text{"OK"}, \text{"Provide Channel from above as Web Stiffener"}\right)$$

$Axial_{curb.comp}$ = "OK"

Note: No need to check for interaction since the curb is only subjected to the compressive force.

Shear of CanFab Curb Webs without Holes (AISI S100-16 G2)

Note: Since the unit is stiffer than the curb and the curb is firmly attached to the unit and to the base structure, curbs will mainly take the lateral forces as shear and axial load rather than bending.

Thickness of Curb:

$$t := \text{thick}(t_{Curb}) = 0.079 \cdot \text{in}$$

Depth-to-Thickness Ratio:

$$\frac{h}{t} = 276$$

Curb Elastic Modulus:

$$E := 29500\text{ksi}$$

Clear distance b/w transverse stiffeners of reinforced web:

$$a := \max\left(\frac{L_{curb}}{2}, W_{curb}\right) = 37 \cdot \text{in} \qquad \frac{a}{h} = 1.72$$

$$k_v := \begin{cases} 5.34 & \text{if } a = L_{curb} \\ 4.00 + \dfrac{5.34}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \dfrac{4.00}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 6.69$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 63 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 95$$

Curb Shear Check due to Load on Longer Side

Area of Web Element:

$$A_w := W_{curb} \cdot t = 3 \cdot \text{in}^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 2.4 \cdot \text{ksi}$$

$V_{cr} := A_w \cdot F_{cr} = 7\,kip$ $V_y := 0.6 \cdot A_w \cdot F_y = 88\,kip$ $\lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 3.572$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 6.862 \cdot kip$$

Number of Members within Length: $n := 2$ **(Per Curb Design)**

Design Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 13037.9 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.H} := P_{net} \cdot L_{unit} \cdot H_{total} = 5639.6 \cdot lbs$

Design Shear Demand: $V_u := \max(V_{base.S}, V_{base.W.H}) = 5720.6 \cdot lbs$

D/C Ratio of Shear: $DCR := \frac{V_u}{\phi V_n} = 0.439$

Demand/Capacity Ratio:

$Shear_{in.plane} := \text{if}(V_u < \phi V_n, \text{"OK"}, \text{"NG"})$

$Shear_{in.plane} = \text{"OK"}$

Curb Shear Check due to Load on Shorter Side

Area of Web Element: $A_w := L_{curb} \cdot t = 5 \cdot in^2$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot (1 - \mu^2) \cdot \left(\frac{h}{t}\right)^2} = 2.4 \cdot ksi$$

$V_{cr} := A_w \cdot F_{cr} = 12\,kip$ $V_y := 0.6 \cdot A_w \cdot F_y = 159\,kip$ $\lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 3.572$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 12.432 \cdot kip$$

Number of Members within Length: $n := 2$ **(Per Curb Design)**

Factored Nominal Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 23621.7 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot W_{unit} \cdot H_{total} = 4549.6 \cdot lbs$

Factored Shear Demand: $V_u := \max\left(V_{base.S}, V_{base.W.L}\right) = 5720.6 \cdot lbs$

D/C Ratio of Shear: $DCR := \frac{V_u}{\phi V_n} = 0.242$

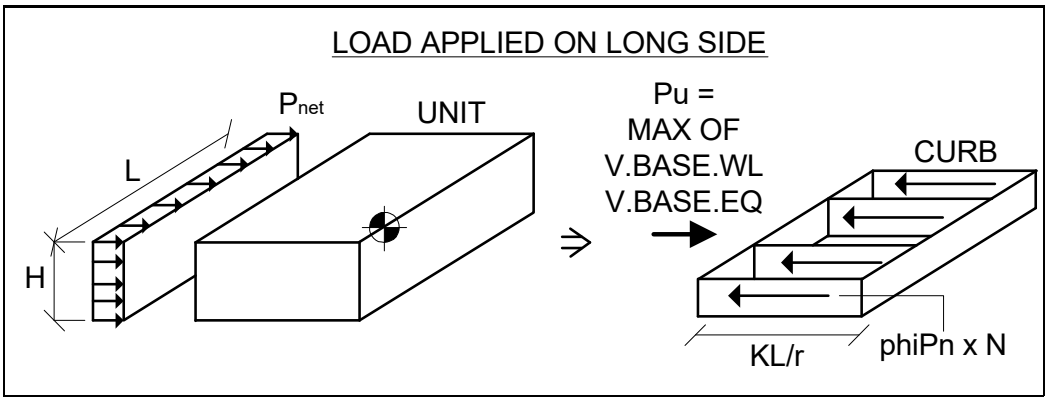
Demand/Capacity Ratio:

$Shear_{in.plane} := \text{if}\left(V_u < \phi V_n, \text{"OK"}, \text{"NG"}\right)$

$Shear_{in.plane} = \text{"OK"}$

Check CanFab Curb for In-Plane Axial due to EQ and Wind (AISI S100-16 E2)

Curb Axial Load Check due to Load on Long Side



Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot L_{unit} \cdot H_{total} = 5.6\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.L}) = 5720.62 \cdot lbs$

Member per CFS: $CFS_{member} :=$ "14GA Custom Curb 22" Tall L.b = 78in"

Max Braced Length of Member: $L_{member} := W_{curb} = 37 \cdot in$

Number of Curb in Length: $n_{curb.long} := 2$

Radius of gyration in y-axis: $r_{y.curb} := 0.630\,in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{2} = 2.86\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 59$ $KL_r =$ "KL/r < 200, OK"

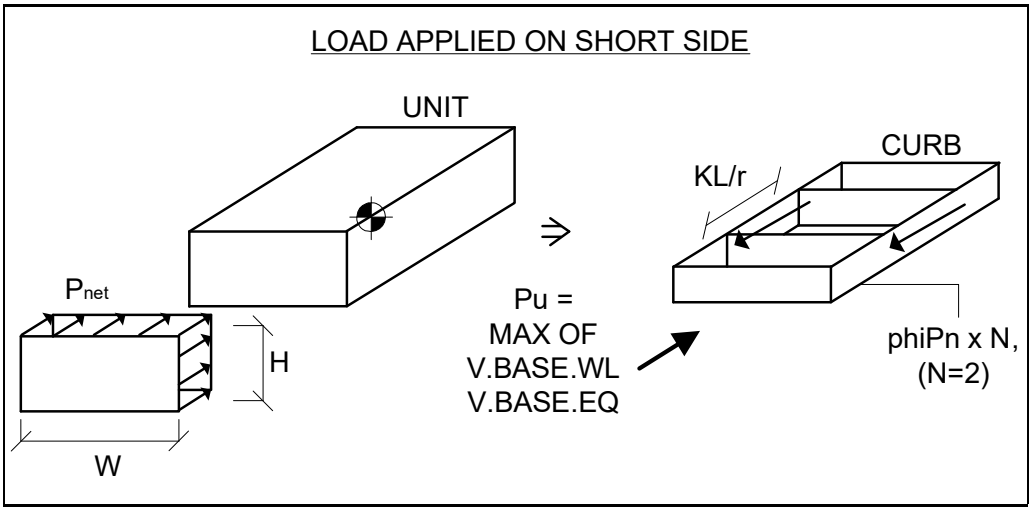
Spacing: $Spacing := \frac{L_{curb}}{n_{curb.long}} = 34 \cdot in$

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 8.034 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.356$

$Axial_{short.curb} =$ "OK"

Curb Axial Load Check due to Load on Short Side



Wind Base Shear on Short Side: $V_{base.W.H} := P_{net} \cdot W_{unit} \cdot H_{total} = 4.5\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.H}) = 5720.62 \cdot lbs$

Member per CFS: CFS_{member} = "14GA Custom Curb 22" Tall L.b = 78in"

Max Braced Length of Member: $L_{member} := \frac{L_{curb}}{n_{curb.long} - 1} = 67 \cdot in$

Number of Curb in Length: $n_{curb} := 2$

Radius of gyration in y-axis: $r_{y.curb} := 0.630\,in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{curb}} = 2.86\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 107$ KL_r = "KL/r < 200, OK"

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 8.034 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.356$

$Axial_{long.curb}$ = "OK"

DESIGN
for
ISOLATED CURB
1006 XIC (Max Curb Height of 30")

Design Wind Loads for Rooftop Equipment (ASCE 7-16 § Table 29.1-1)

$z := 60ft$ — **Height above ground level**

$B := 60ft$ — **Horizontal dimension of building measured normal to wind direction**

$Exp_{category} := "C"$ — **Exposure Category per ASCE 7-16 § 26.7**

$Risk_{category} := "IV"$ — **Risk Category per ASCE 7-16 Table 1.5-1**

$$V := \begin{cases} 0mph & \text{if } Risk_{category} = "I" \\ 0mph & \text{if } Risk_{category} = "II" \\ 175mph & \text{otherwise} \end{cases} = 175 \cdot mph$$

Basic Wind Speed per ASCE 7-16 Figure 26.5-1 A,B or C

$K_z = 1.14$ — **Velocity Pressure Exposure Coefficient per ASCE 7-16 Table 29.10-1 [Exposure Category "C"]**

$K_{zt} := 1.0$ — **Topographic Factor per ASCE 7-16 § 26.8, Figure 26.8-1**

$K_e := 1.0$ — **Ground Elevation Factor per ASCE 7-16 § 26.9, Table 26.9-1**

$K_d := 0.85$ — **Wind Directionality Factor per ASCE 7-16 § 26.6, Table 26.6-1 (Equipment)**

$q_z := 0.00256 K_z \cdot K_{zt} \cdot K_d \cdot K_e \cdot V^2 = 75.74 \cdot psf$ — **Velocity pressure evaluated at height z above ground per ASCE 7-10 § 26.10.2; Eq. 26.10-1**

$GC_{r.lateral.max} := 1.9$ — **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.9 for rooftop structures and equipment with Af less than (0.1Bh). (GCr) shall be permitted to be reduced linearly from 1.9 to 1.0 as the value of Af is increased from (0.1Bh) to (Bh)

$GC_{r.vertical.max} := 1.5$ — **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.5 for rooftop structures and equipment with A_r less than (0.1*BL*). (GC_r) shall be permitted to be reduced linearly from 1.5 to 1.0 as the value of A_r is increased from (0.1*BL*) to (*BL*)

$P_{net} := q_z \cdot GC_{r.lateral.max} = 143.91 \cdot psf$ — **Design Lateral Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-2**

$P_v := q_z \cdot GC_{r.vertical.max} = 113.61 \cdot psf$ — **Design Vertical Uplift Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-3**

Seismic Demands on Nonstructural Components (ASCE 7-16 § 13.3 & 13.6):

$S_{DS} := 1.5$ — **Design spectral response acceleration parameter at short periods per USGS map**

$I_p := 1.5$ — **Component importance factor ASCE 7-16 § 13.1.3**

$\Omega_0 := 2.0$ — **Overstrength factor ASCE 7-16 Table 13.6.1**

Vibr_Isolation = "Yes" — **Placement of Unit Vibration Isolated:**

Note: Only "F_p" at seismic concrete anchor has been increased with overstrength factor "Ω_0"

$a_p := 2.5$ $R_p = 2.0$ — **Seismic coefficients a_p & R_p**
Per ASCE 7-16 Table 13.6-1 for
Mechanical & Electrical Components

$z = 60\,ft$ — **Height in structure of point of attachment of component with respect to the base**

$h := 60ft$ — **Average roof height of structure with respect to the base**
Where for roof top equipment:

$z \div h = 1$

F_p: Horizontal Seismic Design Force per *ASCE7-16 § 13.3.1*

F_p shall be takes as $\left(\frac{0.4 \cdot a_p \cdot S_{DS} \cdot I_p}{R_p}\right) \cdot \left(1 + 2 \cdot \frac{z}{h}\right) \cdot W_p = 337.5 \cdot \%_{\cdot} W_p$

F_p is not required to be taken as greater than $\left(1.6 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 360 \cdot \%_{\cdot} W_p$

F_p shall not be taken as less than $\left(0.3 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 67.5 \cdot \%_{\cdot} W_p$

Governing F_p : Horizontal Seismic Design Force $F_p = 337.5 \cdot \%_{\cdot} W_p$

F_v: Vertical Load per ASCE7-16 § 13.3.1.2

Concurrent Vertical Seismic Force: $F_v := 0.2 \cdot S_{DS} \cdot W_p = 30 \cdot \%_{\cdot} W_p$

Flat Roof Snow Loads (ASCE 7-16 § 7.3):

$Terrain_{CAT} := "C"$ — **Terrain Category ASCE 7-16 § 26.7 & Table 7.3-1**

$Exp_{Roof} := "Partially\ Exposed"$ — **Exposure of Roof ASCE 7-16 Table 7.3-1**

$C_e = 1$ — **Exposure Factor ASCE 7-16 Table 7.3-1**

$Thermal_{condition} := "All\ structures\ except\ below"$ — **Thermal Condition ASCE 7-16 Table 7.3-2**

$C_t = 1$ — **Thermal Factor ASCE 7-16 Table 7.3-2**

$Risk_{category} = "IV"$ — **Risk Category per ASCE 7-16 Table 1.5-1**

$I_s = 1.2$ — **Snow Importance Factor ASCE 7-16 Table 1.5-2**

$p_g := 40psf$ — **Ground Snow Loads ASCE 7-16 Figure 7.2-1**

$$p_f := \max\left(0.7 \cdot C_e \cdot C_t \cdot I_s \cdot p_g, \text{if}\left(p_g > 20psf, 20psf \cdot I_s, I_s \cdot p_g\right)\right) = 34 \cdot psf$$

Flat Roof Snow Loads ASCE 7-16 Equation 7.3-1 and § 7.3.4

Mechanical Unit Dimensions

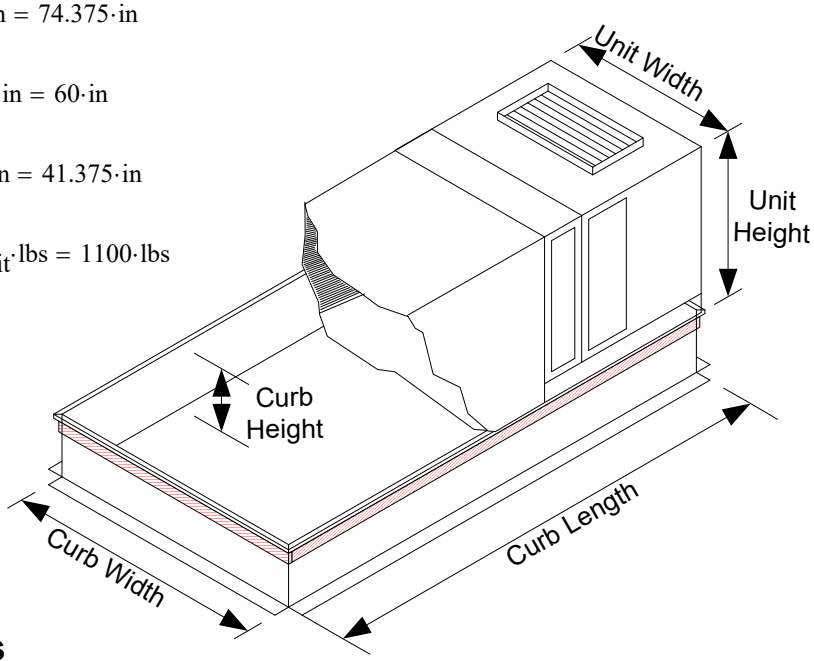
Curb = "C-1006 XIC"

Length of Unit $L_{unit} := L_{unit} \cdot in = 74.375 \cdot in$

Width of Unit $W_{unit} := W_{unit} \cdot in = 60 \cdot in$

Height of Unit $H_{unit} := H_{unit} \cdot in = 41.375 \cdot in$

Weight of Unit $Wt_{unit} := Wt_{unit} \cdot lbs = 1100 \cdot lbs$



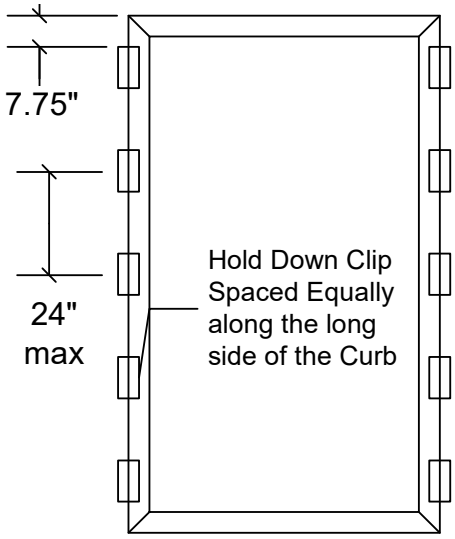
Roof Curb Dimensions

Length of Curb $L_{curb} := L_{curb} \cdot in = 67.375 \cdot in$

Width of Curb $W_{curb} := W_{curb} \cdot in = 37.188 \cdot in$

Height of Curb $H_{curb} := H_{curb} \cdot in = 42.5 \cdot in$

Weight of Curb $Wt_{curb} := Wt_{curb} \cdot lbs = 595 \cdot lbs$



Curb Plan

Overall System Dimensions

Total Weight

$Wt_{tot} := Wt_{unit} + Wt_{curb} = 1695 \cdot lbs$

Total height

$H_{total} := H_{unit} + H_{curb} = 83.875 \cdot in$

Seismic Loading + Snow Loading

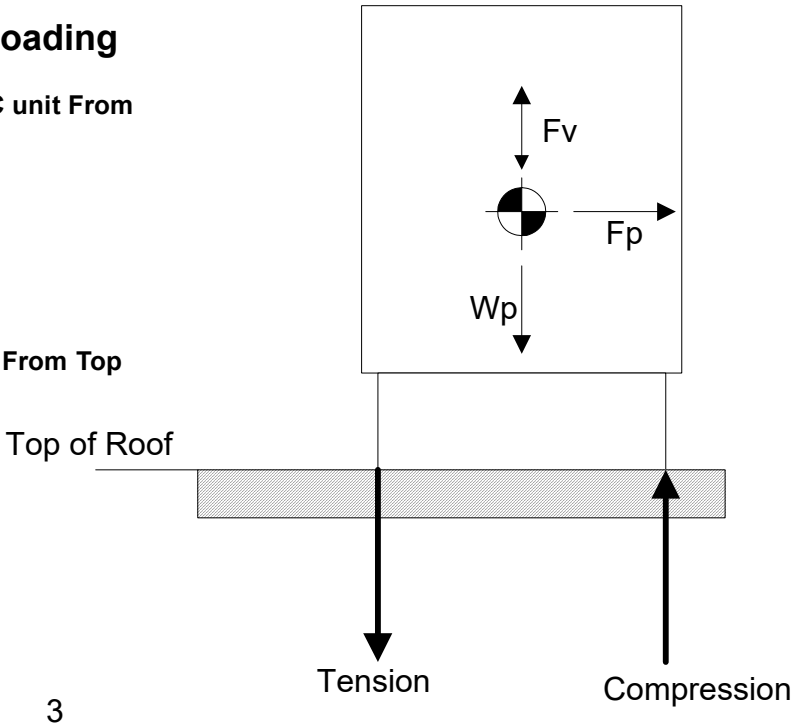
Height for Center of Gravity for HVAC unit From Top of Roof

$h_{CG.unit} := \frac{1}{2} H_{unit} = 21 \cdot in$

$h_{CG} := H_{curb} + h_{CG.unit} = 63.19 \cdot in$

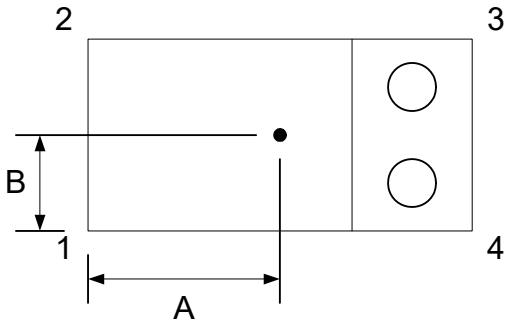
Height for Center of Gravity for Curb From Top of Roof

$h_{CG.curb} := \frac{H_{curb}}{2} = 21.25 \cdot in$



Max Seismic Base Shear

$V_{base.S} := F_p \cdot Wt_{tot} = 5721 \cdot lbs$



Unit C.G. distance in axis parallel to Curb Width $B_{ecc.width} := CG_{short} \cdot in = 22.5 \cdot in$

Eccentricity in axis parallel to Curb Width

$$e_{width} := \begin{cases} 0in & \text{if } B_{ecc.width} = \text{"N/A"} \\ \left| B_{ecc.width} - \frac{W_{unit}}{2} \right| & \text{otherwise} \end{cases} = 7.5 \cdot in$$

Unit C.G. distance in axis parallel to Curb Length $A_{ecc.length} := CG_{long} \cdot in = 34.625 \cdot in$

Eccentricity in axis parallel to Curb Length

$$e_{length} := \begin{cases} 0in & \text{if } A_{ecc.length} = \text{"N/A"} \\ \left| A_{ecc.length} - \frac{L_{unit}}{2} \right| & \text{otherwise} \end{cases} = 2.56 \cdot in$$

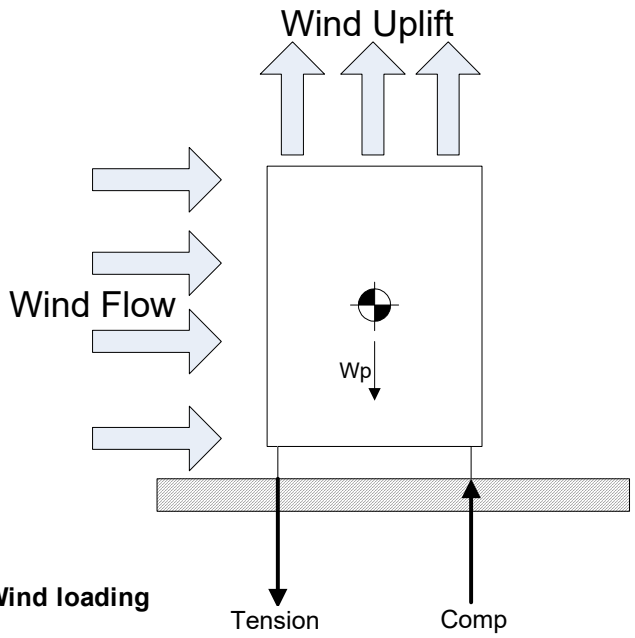
Max Net Tension Reaction On Each Side Due To Seismic Loads

$$T_S := \begin{bmatrix} \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{W_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{W_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} \right] \\ \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{L_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{L_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} \right] \end{bmatrix} = \begin{pmatrix} -7080 \\ -3632 \end{pmatrix}\cdot lbs$$

Max Net Compression Reaction On Each Side Due To Seismic Loads

$$C_S := \begin{bmatrix} \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{W_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \\ \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{L_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \end{bmatrix} = \begin{pmatrix} 12157 \\ 7532 \end{pmatrix}\cdot lbs$$

Wind Loading + Snow Loading



Max Base Shear due to wind loading

$V_{base.W} := P_{net} \cdot L_{unit} \cdot H_{total} = 6234 \cdot lbs$

Max Uplift due to wind loading

$L_{unit.up} := L_{unit} - 0in = 74.375 \cdot in$

$P_{uplift.W} := P_v \cdot L_{unit.up} \cdot W_{unit} = 3521 \cdot lbs$

Max Net Tension Reaction On Each Side Due To Wind loading

$$T_W := \begin{pmatrix} \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} - \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \\ \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} - \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} -8228 \\ -4166 \end{pmatrix} \cdot lbs$$

Max Net Compression Reaction On Each Side Due To Wind loading

$$C_W := \begin{pmatrix} \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} + \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \\ \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} + \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} 9147 \\ 5031 \end{pmatrix} \cdot lbs$$

Governing Loading @ Curb

Max uplift vertical load along the length of the curb

$$\omega_{x.L.vert.up} := \frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}} = 1465 \cdot plf$$

Max compressive vertical load along the length of the curb

$$\omega_{x.L.vert.comp} := \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}} = 2165 \cdot plf$$

Max vertical load along the length of the curb

$$\omega_{x.L.vert} := \max\left(\omega_{x.L.vert.up}, \omega_{x.L.vert.comp}\right) = 2165 \cdot plf$$

Max uplift vertical load along the width of the curb

$$\omega_{x.W.vert.up} := \frac{\max\left[\left|T_{S_{(1)}}\right|, \left|T_{W_{(1)}}\right|\right]}{W_{curb}} = 1344 \cdot plf$$

Max compressive vertical load along the width of the curb

$$\omega_{x.W.vert.comp} := \frac{\max\left[\left|C_{S_{(1)}}\right|, \left|C_{W_{(1)}}\right|\right]}{W_{curb}} = 2431 \cdot plf$$

Max vertical loading along the width of the curb

$$\omega_{x.W.vert} := \max\left(\omega_{x.W.vert.up}, \omega_{x.W.vert.comp}\right) = 2431 \cdot plf$$

$$\begin{pmatrix} V_{base.S} \\ V_{base.W} \end{pmatrix} = \begin{pmatrix} 5721 \\ 6234 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} \left|T_S\right| \\ \left|C_S\right| \end{pmatrix} = \begin{pmatrix} 7957 \\ 14301 \end{pmatrix} \cdot lbs$$

$$\begin{pmatrix} F_v \cdot Wt_{tot} \\ P_v \cdot L_{unit} \cdot W_{unit} \end{pmatrix} = \begin{pmatrix} 509 \\ 3521 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} \left|T_W\right| \\ \left|C_W\right| \end{pmatrix} = \begin{pmatrix} 9222 \\ 10439 \end{pmatrix} \cdot lbs$$

Anchorage To Concrete [Expansion Anchor per ACI 318-14]

Number of connection on the long side

$N_B := 4 + 2$

Moment Arm for overturning (Short side)

$B := W_{curb} + 3in \cdot 2 = 43 \cdot in$

Number of Connection on the Short side.

$N_L := 3 + 2$

Moment Arm for over turning (Long side)

$L := L_{curb} + 3in \cdot 2 = 73 \cdot in$

Total Number of Connections

$N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 14$

Max Net Tension Reaction Due to Seismic Load, Fp

$$R_{c.EQ.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 19 \cdot lbs \qquad R_{c.EQ.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 5 \cdot lbs$$

$$R_{c.EQ} := MAX+\left[\begin{bmatrix}\left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{c.EQ.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{c.EQ.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}2086 \\ 1443\end{pmatrix} \cdot lbs$$

Max net Tension Reaction Due to Wind Load, Pnet

$$R_{c.W} := MAX+\left[\begin{bmatrix}\frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}1180 \\ 724\end{pmatrix} \cdot lbs$$

Governing Load Case:

$Govern := if\left(\left|R_{c.EQ}\right| > \left|R_{c.W}\right|, "Seismic", "Wind"\right) = "Seismic"$

Governing Tension Reaction at Each anchor Point:

$R_c := if\left(Govern = "Seismic", R_{c.EQ}, R_{c.W}\right) = \begin{pmatrix}2086 \\ 1443\end{pmatrix} \cdot lbs$

Max Tension on anchor: $N_{ua} := |R_c| = 2537 \cdot lbs$

Max Shear on anchor: $V_{ua} := \frac{\max(\Omega_0 \cdot V_{base.S}, V_{base.W})}{N_t} = 817 \cdot lbs$

Hilti Kwik Bolt TZ – Carbon Steel
5/8" Anchor with min 4" embedment
Base material: 6" thick Cracked concrete w/
Compressive strength fc' = 3000 psi
Min 6" away from the concrete edge
Evaluation Report: ICC-ESR 1917

Loading Condition:	**Seismic**

Design Tension Capacity [ϕN_n]:	3,631	[lbs]
Design Shear Capacity [ϕV_n]:	4,940	[lbs]

$\phi N_n := \phi N_n \cdot lbs = 3631 \cdot lbs$

$\phi V_n := \phi V_n \cdot lbs = 4940 \cdot lbs$

Utilization:

Tension Utilization: $\beta_N := \frac{N_{ua}}{\phi N_n} = 70 \cdot \%$

Shear Utilization: $\beta_V := \frac{V_{ua}}{\phi V_n} = 17 \cdot \%$

Interaction of Tensile and Shear Forces:
Per ACI 318-14 Sec. 17.6

$\beta_{NV} := \frac{(\beta_N) + (\beta_V)}{1.2} = 72 \cdot \%$

$$check\_interaction := \begin{pmatrix} if(\beta_N < 1.0, "OK", "NG") \\ if(\beta_V < 1.0, "OK", "NG") \\ if(\beta_{NV} < 1.0, "OK", "NG") \end{pmatrix} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

$$check\_interaction = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

Anchorage To Structural Steel [Fillet Weld Conn. per AISI S100-16]

Fillet Weld 2" Long Along the Long and Short Side. Min 2 Connections per Side
Spacing: 48" O.C. for Non-Isolated Curbs; 24" for Isolated Curbs

Number of Welds on the Long Side $N_B := 3$

Moment Arm for Overturning (Short Side) $B := W_{curb} = 37 \cdot in$

Number of Welds on the Short Side. $N_L := 2$

Moment Arm for Overturning (Long Side) $L := L_{curb} = 67 \cdot in$

Total Number of Connections $N_t := \left[\left(N_B\right) + \left(N_L\right)\right] \cdot 2sides = 10$

Max Net Tension Reaction due to Seismic Load FP

$$R_{weld.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 44 \cdot lbs$$

$$R_{weld.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 13 \cdot lbs$$

$$R_{weld.EQ} := MAX+\left[\left[\begin{array}{l} \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{weld.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{weld.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \end{array}\right]\right] = \begin{pmatrix} 2428 \\ 1968 \end{pmatrix} \cdot lbs$$

Max Net Tension Reaction due to Wind Load Pnet

$$R_{weld.W} := MAX+\left[\left[\begin{array}{l} \frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t} \end{array}\right]\right] = \begin{pmatrix} 2610 \\ 1784 \end{pmatrix} \cdot lbs$$

Tension Design Force; SRSS for Loading from Each Direction $T_{u.weld} := \max\left(\left|R_{weld.EQ}\right|, \left|R_{weld.W}\right|\right) = 3161 \cdot lbs$

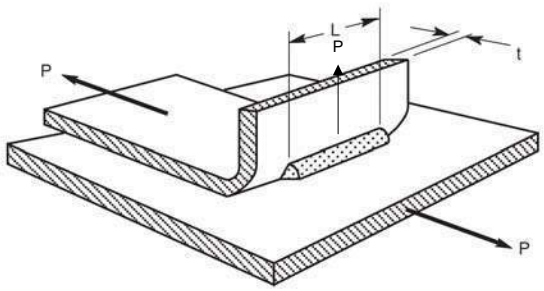
Shear Load at Each Weld Connection $V_{u.weld} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{N_t} = 623 \cdot lbs$

Total Demand: SRSS of V and T

$$R_{u.weld} := \sqrt{T_{u.weld}^2 + V_{u.weld}^2} = 3222 \cdot lbs$$

Fillet Weld Design per AISI S100-16 Section J2.5

Weld Length at Each Connection Point $L_w := 2in$



Effective Throat Fillet Weld Size

$$t_w := \left(\frac{1}{8}in\right) \cdot 0.707 = 0.088 \cdot in$$

Thickness for the Thinnest Martial Being Welded
Min Curb Thickness = 16GA with Fu=65 ksi

$t_1 := thick("12GA") = 0.1084 \cdot in$

$F_u := 65ksi$

Min weld material strength

$F_{exx} := 70ksi$

For Longitudinal Loading [Parallel capacity is considered to be loading in the direction of the length of the weld] per (Eq. J2.5-1) &(Eq. J2.5-2)

$$\phi P_{long} := \begin{cases} (0.6)\left(1 - \frac{0.01 \cdot L_w}{t_1}\right) \cdot L_w \cdot t_1 \cdot F_u & \text{if } \frac{L_w}{t_1} < 25 \\ (0.5) \cdot 0.75 \cdot t_1 \cdot L_w \cdot F_u & \text{otherwise} \end{cases} = 6895 \cdot lbs$$

where $L_w \div t_1 = 18$

For Transverse Loading per (Eq. J2.5-5)

$$\phi P_{trans} := (0.65) \cdot t_1 \cdot L_w \cdot F_u = 9160 \cdot lbs$$

Strength of Weld Material per (Eq. J2.5-7)

$$\phi P_{weld} := (0.6) \cdot 0.75 \cdot t_w \cdot L_w \cdot F_{exx} = 5568 \cdot lbs$$

Design Strength of Fillet Weld

$$\phi P_n := \min\left(\phi P_{long}, \phi P_{trans}, \phi P_{weld}\right) = 5568 \cdot lbs$$

D/C Ratio for the Welded Connection

$$\beta_{NW} := \frac{R_{u.weld}}{\phi P_n} = 58 \cdot \%$$

$weld_{check} := if\left(\beta_{NW} < 1.0, "OK", "NG"\right)$

$weld_{check} = "OK"$

Anchorage To Wood Member WITH Lag Screws [NDS-2018 LRFD Strength Design]

*** Use 3/8" Lag Screws along Each Side of the Curb**
*** Assume G=0.5 Douglas Fir-Larch**

Wood Lag Screw Capacity per NDS 2018 Section 11.3

Wet Service Factor: $Cond := "DRY"$ **(e.g. CA = "DRY", AK = "WET")**

$$C_M := \begin{cases} 1.0 & \text{if } Cond = "DRY" \\ 0.7 & \text{if } Cond = "WET" \end{cases} = 1$$ **NDS 2018 Table 11.3.3**

Temperature Factor:
$$C_t := \begin{cases} 0.8 & \text{if } Cond = "DRY" \\ 0.7 & \text{if } Cond = "WET" \end{cases} = 0.8$$ **NDS 2018 Table 11.3.4**

Group Action Factor: $C_g := 0.97$ **NDS 2018 Table 11.3.6C**

Geometry Factor: $C_\Delta := 1.0$ **NDS 2018 Table 12.5.1A,B**

End Grain Factor: $C_{eg} := 1.0$ **NDS 2018 Sec. 12.5.2**

Diaphragm Factor: $C_{di} := 1.0$ **NDS 2018 Sec. 12.5.3**

Toe-Nail Factor: $C_{tn} := 1.0$ **NDS 2018 Sec. 12.5.4**

Format Conversion Factor: $K_F := 3.32$ **NDS 2018 Table 11.3.1**

Resistance Factor: $\phi := 0.65$ **NDS 2018 Table 11.3.1**

Time Effect Factor: $\lambda := 1.0$ **NDS 2018 App N.3.3**

Lateral Design Value: $Z := 130lbs$ **NDS 2018 Table 12K**

Withdrawal Design Value: $W := 305lbs$ **NDS 2018 Table 12.2A**

Lag Screw Diameter: $D_{lag} := \frac{3}{8}in$

Lag Screw Length: $L_{lag} := 4in$

Length of Tapered Tip: $E_{lag} := \frac{7}{32}in$

Lag Screw Penetration: $P_{lag} := 3.78125in$

Eff. Lag Screw Penetration for withdrawal: $P_{\omega.lag} := 2in + \frac{9}{32}in = 2.28 \cdot in$ **NDS 2018 Appx. Table L2**

NDS 2018 Sec. 12.1.4.6

Minimum Penetration DCR <1.0: $DCR_{min.penetration} := \frac{4 \cdot D_{lag}}{P_{\omega.lag}} = 0.66$ $DCR_{min.penetration} = "OK"$

Adj. Lateral Design Value: $Z' := Z \cdot C_M \cdot C_t \cdot C_g \cdot C_\Delta \cdot C_{eg} \cdot C_{di} \cdot C_{tn} \cdot K_F \cdot \phi \cdot \lambda = 218 \cdot lbs$

Adj. Withdrawal Design Value: $W' := W \cdot C_M^{\,2} \cdot C_t \cdot C_{eg} \cdot C_{tn} \cdot K_F \cdot \phi \cdot \lambda = 527 \cdot lbs$ **NDS 2018 Table 11.3.1**

Number of Lag Screws on the Long Side $N_B := 14 + 2$

Moment Arm for Overturning (Short Side) $B := W_{curb} = 37 \cdot in$

Number of Lag Screws on the Short Side $N_L := 7 + 2$

Moment Arm for Overturning (Long Side) $L := L_{curb} = 67 \cdot in$

Total Number of Lag Screws $N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 42$

Max net Tension Reaction due to Seismic, Fp

$$R_{lag.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 8 \cdot lbs$$

$$R_{lag.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 3 \cdot lbs$$

$$R_{lag.EQ} := MAX+\left[\begin{bmatrix} \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{lag.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{lag.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 450 \\ 436 \end{pmatrix} \cdot lbs$$

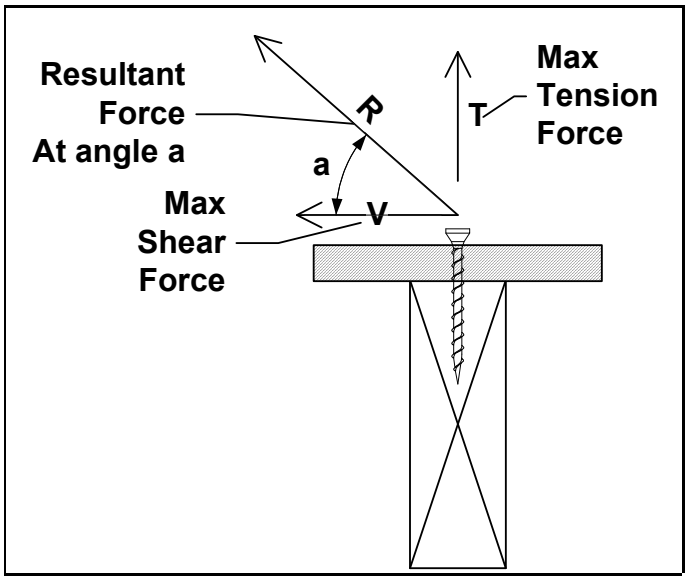
Max net Tension Reaction due to Wind load, Pnet

$$R_{lag.W} := MAX+\left[\begin{bmatrix} \frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{L \cdot N_L \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 499 \\ 400 \end{pmatrix} \cdot lbs$$

Tension Design force; SRSS for loading from Each direction $T_{lag} := \max\left(\left|R_{lag.EQ}\right|, \left|R_{lag.W}\right|\right) = 640 \cdot lbs$

Shear load at each anchor location $V_{lag} := \frac{\max\left(V_{base.S} \cdot \sqrt{2}, V_{base.W}\right)}{N_t} = 193 \cdot lbs$

For Lag Screws Subjected to Combined Lateral and Withdrawal Loading; Design Strength of the Lag Screw Shall Be Adjusted per Hankinson Formula as Prescribed by NDS 2018 Equation 12.4-1



Angle Between Wood Surface and Direction of Resultant Applied Load

$$(\alpha) := \operatorname{atan}\left(\frac{T_{lag}}{V_{lag}}\right) = 73\cdot deg$$

Combined Demand per Lag Screw @ Strength Level

$$R_{lag} := \sqrt{T_{lag}^{2} + V_{lag}^{2}} = 668\cdot lbs$$

Adjusted Capacity per NDS 2018 Equation 12.4-1 @ Strength Level

$$Z'_{\alpha} := \frac{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot Z'}{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot\cos(\alpha)^{2} + Z'\cdot\sin(\alpha)^{2}} = 873\cdot lbs$$

D/C Ratio for the Lag Screw connection to Wood Structure

$$\beta_{Lag} := \frac{R_{lag}}{Z'_{\alpha}} = 76\cdot\%$$

$$Lag_{Screw.Check} := \text{if}\left(\beta_{Lag} < 1.0, \text{"OK"}, \text{"NG"}\right)$$

$Lag_{Screw.Check} = \text{"OK"}$

Bearing and Tilting in Curb Bolted Connection AISI S100-16

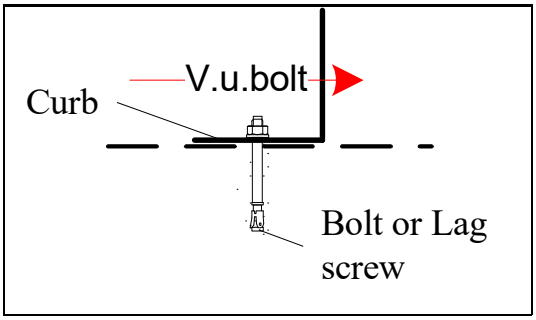
Nominal bolt diameter $d := 0.5in$

Uncoated sheet thickness $t_{curb} := thick("12GA") = 0.108 \cdot in$

Tensile strength of sheet $F_u := 65ksi$

Coefficient for conversion of units $\alpha := 1.0$

Modification Factor $m_f := 1.0$



Modification factor for type of bearing connection, per Table J3.3.1-2; For single shear connection with washers

Bearing Factor $C := \begin{cases} 3 \text{ if } \left(\frac{d}{t_{curb}} < 10\right) \wedge \left(0.024in < t_{curb} < 0.1875in\right) = 3 \\ "NG" \text{ if } \frac{d}{t_{curb}} > 10 \end{cases}$

Bearing factor, which shall be determined according to Table J3.3.1-1 For d/t<10 where $d \div t_{curb} = 5$

Bearing Design Strength per AISI S100-16 Eq. J3.3.1-1

$$\phi P_{n_{(0)}} := (0.6) \cdot \left(m_f \cdot C \cdot d \cdot t_{curb} \cdot F_u\right) = 6341 \cdot lbs$$

Bolt Hole Deformation Design Strength per AISI S100-16 Eq. J3.3.2-1

$$\phi P_{n_{(1)}} := (0.65) \cdot \left[4.64 \cdot \left(\frac{\alpha}{in}\right) \cdot t_{curb} + 1.53\right] \cdot d \cdot t_{curb} \cdot F_u = 4655 \cdot lbs$$

Curb Connection Shear Capacity $\phi P_n := \min\left(\phi P_n\right) = 4655 \cdot lbs$

Loading demand at connection $V_{u.bolt} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{4} = 1559 \cdot lbs$

$Curb\_Conn\_Shear := \text{if}\left(V_{u.bolt} < \phi P_n, "OK", "NG"\right)$ Curb_Conn_Shear = "OK"

Thickness of Curb, ISO Rail and Clip

(Per AISC Table 17-10 Galvanized)

Hold Down Clip thickness

$t_{Clip} := \text{"12GA"}$ $t_{clip} := thick(t_{Clip}) = 0.1084 \cdot in$

Roof Curb thickness

$t_{Curb} := \text{"12GA"}$ $t_{curb} := thick(t_{Curb}) = 0.1084 \cdot in$

ISO RAIL thickness

$t_{Curb.iso} := \text{"10GA"}$ $t_{curb.iso} := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Note: Iso Rail thickness is only used if the curb is isolated. Not used for non-isolated curbs

Sheet Metal Screws (SMS) Equations and References

SMS properties (ESR-2196 Table 5)

$SMS_{Table} =$

"SMS"	"Diameter"	"HeadDiameter"	"Tension"	"Shear"
"Size"	"d"	"dw"	"Pts"	"Pss"
"#8"	0.164	0.335	1000	1170
"#10"	0.19	0.399	1370	1215
"#12"	0.216	0.415	2325	1880
"#14"	0.25	0.5	4580	2440

SMS Tension Eqns

$P_{not} = 0.85 \cdot t \cdot d \cdot F_u$ **(AISI S100-16 J4.4.1 & J4.4.2)**

$P_{nov} = 1.5 \cdot t \cdot d_w \cdot F_u$

$P_{nts} = 0.8 \cdot P_{ts}$

FOR THE MOST CASES, PULL-OUT CAPACITY IS THE LOWEST

SMS Shearn Eqns

$P_{vnot} = 4.2 \cdot \sqrt{(d \cdot t^3)} \cdot F_u$ **(AISI S100-16 J4.3.1)**

$P_{vnov} = 2.7 \cdot t \cdot d \cdot F_u$

$P_{vnss} = 0.8 \cdot P_{ss}$

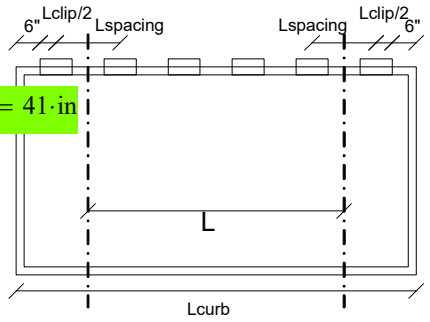
Hold Down Clip Design (Connection of the Mechanical unit to Curb)

Number of Clips on the long side $N_B := 4$

Moment Arm for overturning (Short side) $B := W_{curb} + 1.75in \cdot 2 = 41 \cdot in$

Number of Clips on the Short side. $N_L := 4$

Width of Clips $L_{clip} := 9in$



Curb Centerline Spacing (Long side)

$$L_{spacing} := \frac{L_{curb} - \left(6in + \frac{L_{clip}}{2}\right) \cdot 2}{N_B - 1} = 15.458 \cdot in$$

Moment Arm for overturning (Long side)

$$L := L_{curb} - 2 \cdot \left[6in + \frac{L_{clip}}{2} + L_{spacing} \cdot \frac{(N_L - 2)}{4}\right] = 30.917 \cdot in$$

Total Number of Clips

$$N_t := (N_B) \cdot 2sides = 8$$

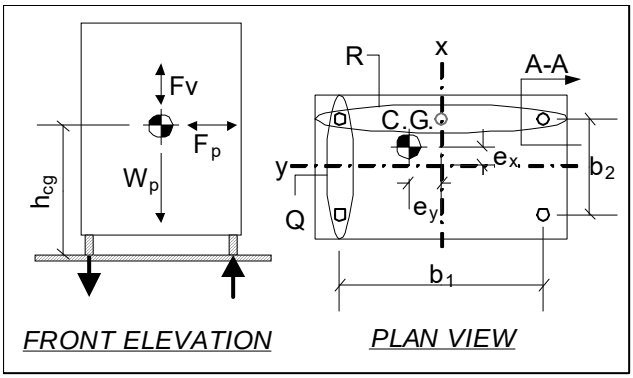
Max net Tension Reaction due to Seismic, Fp

$$R_{clip.EQ} := MAX+\left[\begin{array}{l} \left[\frac{F_p \cdot Wt_{unit}}{B \cdot N_B} \cdot h_{CG.unit} + \frac{(0.9 - F_v) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B}\right] - \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} \\ \left[\frac{F_p \cdot Wt_{unit}}{L \cdot N_L} \cdot h_{CG.unit} + \frac{(0.9 - F_v) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L}\right] - \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} \end{array}\right] = \begin{pmatrix} 420 \\ 552 \end{pmatrix} \cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$R_{clip.W} := MAX+\left(\begin{array}{l} \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{unit}^2}{2}}{B \cdot N_B} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{unit}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{unit}^2}{2}}{L \cdot N_L} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{unit}}{N_t} \end{array}\right) = \begin{pmatrix} 753 \\ 752 \end{pmatrix} \cdot lbs$$

Tensile and Shear Load calculation per ASHRAE RP-812



Eccentricity along X-X

$e_x := e_{width} = 7.5 \cdot in$

Eccentricity along Y-Y

$e_y := e_{length} = 2.562 \cdot in$

Distance between Seismic Restraints Along Y-Y

$b_1 := L_{curb} - 2 \cdot 6in = 55 \cdot in$

Distance between Seismic Restraints Along X-X

$b_2 := W_{curb} = 37 \cdot in$

Moment of Inertia about X-X

$$I_{xx} := \frac{N_t \cdot (N_t + 2) \cdot (b_1)^2}{12 \cdot (N_t - 2)} = 3407 \cdot in^2$$

Moment of Inertia about Y-Y

$$I_{yy} := \frac{N_t \cdot (b_2)^2}{4} = 2766 \cdot in^2$$

Angle about Tensile Load

$$\Theta_t := \operatorname{atan}\left[\frac{I_{yy} \cdot (b_1)}{I_{xx} \cdot (b_2)}\right] = 50 \cdot deg$$

Angle about Shear Load

$$\Theta_s := \begin{cases} \operatorname{atan}\left(\frac{e_x}{e_y}\right) & \text{if } e_y \neq 0 \\ 0deg & \text{if } e_y = 0 \end{cases} = 71 \cdot deg$$

Max Net Tensile Load Due to Seismic Load, Fp

$$T_{U.EQ.pt1} := \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} - \frac{(0.9 - F_v) \cdot Wt_{unit}}{b_1 \cdot b_2} \cdot \left(\frac{b_1}{2} \cdot e_x + \frac{b_2}{2} \cdot e_y - e_x \cdot e_y\right) = 7 \cdot lbs$$

$$T_{U.EQ.pt2} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \cos(\Theta_t) \cdot \frac{0.5 \cdot b_2}{I_{yy}} = -329 \cdot lbs$$

$$T_{U.EQ.pt3} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \sin(\Theta_t) \cdot \frac{0.5 \cdot b_1}{I_{xx}} = -481 \cdot lbs$$

$$T_{U.EQ} := T_{U.EQ.pt1} + T_{U.EQ.pt2} + T_{U.EQ.pt3} = -803 \cdot lbs$$

Max Net Shear Load Due to Seismic Load, Fp

$$V_{Ux.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\cos(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_2 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_1 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 277 \cdot lbs$$

$$V_{Uy.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\sin(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_1 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_2 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 532 \cdot lbs$$

$$V_{U.EQ} := \sqrt{V_{Ux.EQ}^2 + V_{Uy.EQ}^2} = 600 \cdot lbs$$

Tension Design force for Hold Down Clips

$$T_{clip} := \max\left(R_{clip.W_0}, R_{clip.W_1}, \left|R_{clip.EQ}\right|, \left|T_{U.EQ}\right|\right) = 803 \cdot lbs$$

Based on ASCE 7-16 Figure 29.4-1 magnitude of force coefficient,

Wind in diagonal direction to the face of equipment produces less force than that of the wind in perpendicular direction to the face of the equipment. Therefore, wind in diagonal direction does not need to be used

$$\left|R_{clip.EQ}\right| = 694 \cdot lbs \qquad \left|T_{U.EQ}\right| = 803 \cdot lbs$$

$$\left|R_{clip.W}\right| = 1064 \cdot lbs$$

$$T_{clip.EQ.max} := \max\left(\left|R_{clip.EQ}\right|, \left|T_{U.EQ}\right|\right) = 803 \cdot lbs$$

$$T_{clip.W.max} := \max\left(\left|R_{clip.W}\right|\right) = 1064 \cdot lbs$$

Shear Design force for Hold Down Clips

$$V_{clip} := \max\left(\frac{\max\left(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit}\right)}{N_t}, \left|V_{U.EQ}\right|\right) = 600 \cdot lbs$$

$$F_p \cdot Wt_{unit} \cdot \frac{1}{N_t} = 464 \cdot lbs \qquad \left|V_{U.EQ}\right| = 600 \cdot lbs$$

$$P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t} = 384 \cdot lbs$$

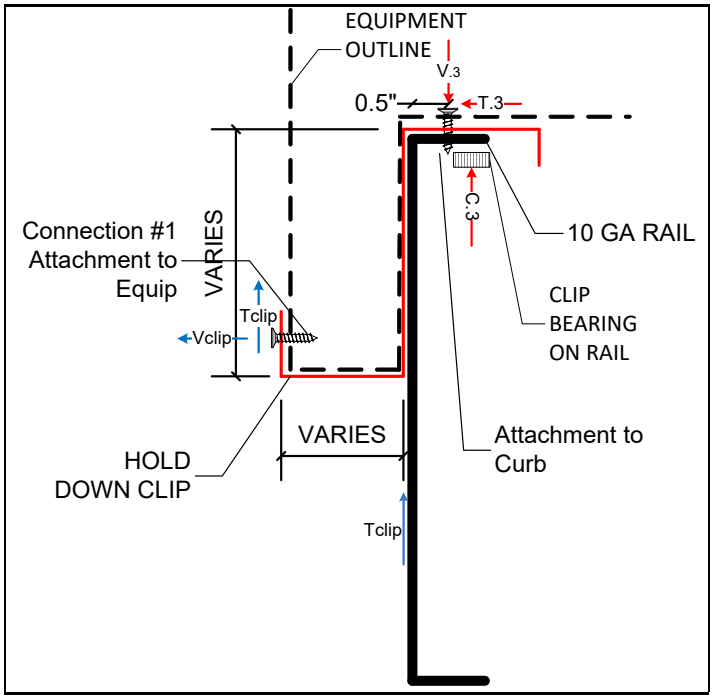
$$V_{clip.EQ.max} := \max\left[\left(F_p \cdot Wt_{unit} \cdot \frac{1}{N_t}\right), \left|V_{U.EQ}\right|\right] = 600 \cdot lbs$$

$$V_{clip.W.max} := \max\left(\left(P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t}\right)\right) = 384 \cdot lbs$$

Loading at Hold Down Clips @ Isolator Curb

$b_{return.iso} := Clip_b \cdot in = 2.625 \cdot in$

$b_{depth.iso} := Clip_c \cdot in = 4.563 \cdot in$



*For Reference Only

Mu Bending moment in the hold down

$M_u := T_{clip} \cdot b_{return.iso} = 2108 \cdot in \cdot lbs$

Resolve bending moment a T/C couple
Assume 0.5" bearing length
Moment Arm for T/C couple

$d_{T/C} := 1in - 0.5in = 0.5 \cdot in$

V3 is acting as shear on the screws. due to eccentricity of Tension force T

$$V_3 := \frac{T_{clip} \cdot \left[b_{return.iso} + (0) \right]}{d_{T/C}} = 4217 \cdot lbs$$

Additional load from Direct Shear acting out of plane (SRSS)

$$V_3 := \sqrt{V_3^{\,2} + V_{clip}^{\,2}} = 4259 \cdot lbs$$

Reaction C3 [compression force] is resisted by bearing of the hold down on the curb lip. Assume 0.5" bearing length

$C_3 := V_3 - T_{clip} = 3456 \cdot lbs$

T3 Load due to the shear acting out of plane tension on the screws.

$$T_3 := \left(\max\left(\frac{T_{clip} \cdot b_{return.iso}}{b_{depth.iso}}, V_{clip} \right) \right) = 600 \cdot lbs$$

Check Bending in Clip @ Isolator Curb

There are several restraints that prevents the hold down clip for iso-curb to have local bending at the bottom and transfer vertical load demand directly to the face of the curb.

- Hold down is bearing on the face of iso-rail / non-iso curb lip.
- Gasket will act as a "link" member to allow unit base rail and bottom flange to move totegther so flange can't bend unless the unit base rail bends first. However, unit base rail is not likely to bend so bottom flange won't bend

Hold Down Clip thickness

$t_{Clip} = \text{"12GA"}$ $t_{clip} := \text{thick}(t_{Clip}) = 0.1084 \cdot in$

Effective width of hold down clip

$b_c := L_{clip} = 9 \cdot in$

Yield strength of the Clip

$F_{y.c} := 50ksi$

Strength reduction for bending

$\phi_{clip} := 0.9$

Design Bending Capacity (LRFD)

$$\phi M_n := \phi_{clip} \cdot F_{y.c} \left(\frac{b_c \cdot t_{clip}^{\,2}}{6} \right) = 793 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.clip} := T_{clip} \cdot 0.5in = 402 \cdot in \cdot lbs$

D/C Ratio for bending

$$DCR := \frac{M_{u.clip}}{\phi M_n} = 0.506$$

$Clip_{Bending} = \text{"OK"}$

Check Flange Bending in Clip @ Isolator Curb

Note:
- **If the curb flange is welded to the 10GA channel and 10GA channel is welded back to the base of the curb, then both tension and compression due to equipment overturning will be taken care by the 10GA channel.**
- **Since the curb will be reinforced with 10GA channel under each isolator, it can be assumed that the loads will trasnferred down to the base structure through the channels. Therefore, flange downward bending at curb due to compressive load does not need to be checked.**

Roof Curb thickness

$t_{Curb} = \text{"12GA"}$ $t_{curb} := thick(t_{Curb}) = 0.1084 \cdot in$

Clip edge to edge distance

$$b_{edge2edge} := \frac{L_{curb} - \left(6in + \frac{L_{clip}}{2}\right)\cdot 2}{N_B - 1} - L_{clip} = 6.458 \cdot in$$

Effective width of Roof Curb

$b_{curb} := L_{clip} + b_{edge2edge} = 15.46 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb}\left[\frac{b_{curb}\cdot(t_{curb})^2}{6}\right] = 1362 \cdot in \cdot lbs$$

Width of Isolator

$w_{JQ.iso} := 2in$ **2 in. for CQAs**

Flexural bending demand

$$M_{u.Curb} := T_{clip}\cdot\left(\max\left(\frac{1.75in}{2} - 0.5in, \frac{w_{JQ.iso}}{2} - 1in\right)\right) = 301 \cdot in \cdot lbs$$

D/C Ratio for bending

$$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.221$$

$Curb_{Bending} = \text{"OK, Weld 10GA channel ends to curb flange"}$

Design of Connection#1 Connection of Equipment to hold Down clip

Ultimate SMS screw connection Strength (LRFD)
Strength based on the smallest thickness of Curb and Equipment Housing (min 16 GA) [Fy = 50ksi & Fu=65ksi]

$n_{sms} := 4$ $\quad Size_{ss} := "\#14"$

$t_{ss} := "16GA"$ $\quad F_{u.ss} := 65ksi$

Nominal Tension Strength

$$P_{nt} := n_{sms} \cdot T_s\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 3508 \cdot lbs$$

$$P_{not} := n_{sms} \cdot T_{not}\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 3508 \cdot lbs$$

$$P_{nov} := n_{sms} \cdot T_{nov}\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 12383 \cdot lbs$$

$$P_{nts} := n_{sms} \cdot T_{nts}\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 14656 \cdot lbs$$

Nominal Shear Strength

$$P_{ns} := n_{sms} \cdot V_s\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 7808 \cdot lbs$$

$$P_{vnot} := n_{sms} \cdot V_{not}\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 8737 \cdot lbs$$

$$P_{vnov} := n_{sms} \cdot V_{nov}\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 11144 \cdot lbs$$

$$P_{vnss} := n_{sms} \cdot V_{nss}\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 7808 \cdot lbs$$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} V_{clip} \div \left(\phi_{sms} \cdot P_{nt}\right) \\ T_{clip} \div \left(\phi_{sms} \cdot P_{ns}\right) \end{bmatrix} = \begin{pmatrix} 34 \\ 21 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left(\begin{bmatrix} \left[\frac{T_{clip}}{P_{vnov}} + 0.71\left(\frac{V_{clip}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{T_{clip}}{P_{vnot}} + \left(\frac{V_{clip}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{T_{clip}}{P_{vnss}} + \left(\frac{V_{clip}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right) = 38 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

Design of Connection#2 Connection of hold Down clip to Curb

Tension loads on SMS connection

$T_{s2} := V_3 = 4259 \cdot lbs$

Shear loads on SMS connection

$V_{s2} := T_3 = 600 \cdot lbs$

Ultimate SMS screw connection Strength (LRFD)
Strength based on the smallest thickness of Curb and Equipment Housing (min 16 GA) [Fy = 50ksi & Fu=65ksi]

$n_{sms} := 8$ $Size_{ss} := "\#14"$

$t_{ss} := (t_{Curb.iso}) = "10GA"$ $F_{u.ss} := 65ksi$

Nominal Tension Strength

$P_{nt} := n_{sms} \cdot T_s(Size_{ss}, t_{ss}, F_{u.ss}) = 15271 \cdot lbs$

Note:
SMS is getting pulled up so the thicker curb iso rail is engaged for SMS capacity , rather than just the clip itself.

$P_{not} := n_{sms} \cdot T_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 15271 \cdot lbs$

$P_{nov} := n_{sms} \cdot T_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 53898 \cdot lbs$

$P_{nts} := n_{sms} \cdot T_{nts}(Size_{ss}, t_{ss}, F_{u.ss}) = 29312 \cdot lbs$

Nominal Shear Strength

$P_{ns} := n_{sms} \cdot V_s(Size_{ss}, t_{ss}, F_{u.ss}) = 15616 \cdot lbs$

$P_{vnot} := n_{sms} \cdot V_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 56103 \cdot lbs$

$P_{vnov} := n_{sms} \cdot V_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 48508 \cdot lbs$

$P_{vnss} := n_{sms} \cdot V_{nss}(Size_{ss}, t_{ss}, F_{u.ss}) = 15616 \cdot lbs$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} T_{s2} \div (\phi_{sms} \cdot P_{nt}) \\ V_{s2} \div (\phi_{sms} \cdot P_{ns}) \end{bmatrix} = \begin{pmatrix} 56 \\ 8 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left[\begin{bmatrix} \left[\frac{V_{s2}}{P_{vnov}} + 0.71\left(\frac{T_{s2}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{V_{s2}}{P_{vnot}} + \left(\frac{T_{s2}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{V_{s2}}{P_{vnss}} + \left(\frac{T_{s2}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right] = 42 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

Hold Down clip Bending and Shear Interaction

Diameter of SMS:

$d_{sms} := vlookup(Size_{ss}, SMS_{Table}, 1)_0 \cdot in = 0.25 \cdot in$

Depth of flat web portion

$h_{clip.shear} := L_{clip} - n_{sms} \cdot d_{sms} = 7 \cdot in$

Depth-to-Thickness Ratio:

$\frac{h_{clip.shear}}{t_{clip}} = 65 \qquad E := 29500ksi \qquad F_y := 50ksi \qquad \mu := 0.3$

Nominal Shear Stress:
(For unreinforced web)
AISI S100-16 G2.1

$k_v := 5.34 \qquad \sqrt{\frac{E \cdot k_v}{F_y}} = 56 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 85$

Area of Web Element:

$A_w := h_{clip.shear} \cdot t_{clip} = 0.759 \cdot in^2$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h_{clip.shear}}{t_{clip}}\right)^2} = 34.1 \cdot ksi$$

$V_{cr} := A_w \cdot F_{cr} \qquad V_y := 0.6 \cdot A_w \cdot F_y = 23\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.937$

Hole Shear Reduction Factor:
(for circular holes, AISI S100-16 Eq G3-1)

$c := \frac{h_{clip.shear}}{2} - \frac{d_{sms}}{2.83} = 3.41 \cdot in$

$$q_s := \begin{cases} 1.0 & \text{if } \frac{c}{t_{clip}} \geq 54 \\ \frac{c}{54 \cdot t_{clip}} & \text{if } 5 \leq \frac{c}{t_{clip}} < 54 \end{cases} = 0.583$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \leq 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \leq 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 19.792 \cdot kip$$

Design Shear Capacity with holes:

$\phi V_{n.clip} := 0.95 \cdot V_n \cdot q_s = 11 \cdot kip$

D/C Ratio of V and M per AISI S100-16 Eq H2-1

$$DCR_{V.M.int.clip} := \sqrt{\left(\frac{M_{u.clip}}{\phi M_n}\right)^2 + \left(\frac{\max(T_{clip}, V_{clip})}{\phi V_{n.clip}}\right)^2} = 0.5116$$

Demand/Capacity Ratio:

$VandM_{int.clip} = \text{"OK"}$

ISOLATOR DESIGN [PER OPM-0401-13]

OPM-0401-13 is based on allowable stress design

Number of isolators on the long side

$N_B := 4.5$ $N_{iso.long} := N_B = 5$

Moment Arm for overturning (Short side)

$B := W_{curb} + \frac{1.75in}{2} \cdot 2 = 39 \cdot in$

Number of isolators on the Short side.

$N_L := 4$

Isolator Centerline Spacing (Long side)

$L_{spacing.iso} := \frac{L_{curb} - (6in) \cdot 2}{N_B - 1} = 15.82 \cdot in$

Moment Arm for overturning (Long side)

$L := L_{curb} - 2 \cdot 6in - 2 \cdot L_{spacing.iso} \cdot \frac{(N_L - 2)}{4} = 40 \cdot in$

Total Number of isolators

$N_t := (N_B) \cdot 2sides = 9$

Max net Tension Reaction due to Seismic, Fp

$EQ_{ASD} := \left[0.6 - (0.7 \cdot F_v)\right] \cdot Wt_{unit} = 0.429\ kip$

$$R_{iso.EQ} := MAX+\left[\begin{bmatrix}\left[\frac{(0.7F_p) \cdot Wt_{unit}}{B \cdot N_B} \cdot (h_{CG.unit} + 0in) + \frac{EQ_{ASD} \cdot e_{width}}{B \cdot N_B}\right] - \frac{EQ_{ASD}}{N_t} \\ \left[\frac{(0.7F_p) \cdot Wt_{unit}}{L \cdot N_L} \cdot (h_{CG.unit} + 0in) + \frac{EQ_{ASD} \cdot e_{length}}{L \cdot N_L}\right] - \frac{EQ_{ASD}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}278 \\ 299\end{pmatrix} \cdot lbs$$

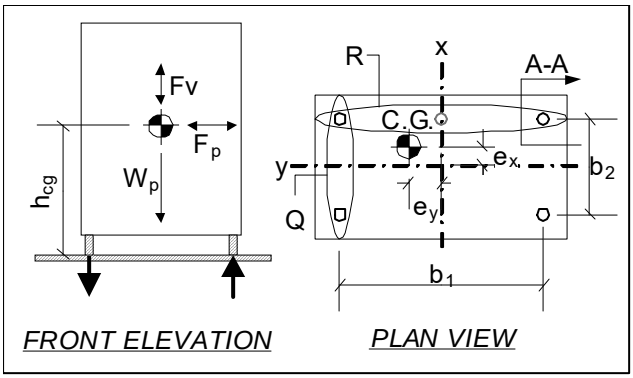
Max net Tension Reaction due to Wind load, Pnet

$$F_{wind.B} := \frac{P_{net} \cdot L_{unit} \cdot (H_{unit} + 0in)}{B \cdot N_B} \cdot \left(\frac{1}{2} \cdot H_{unit} + 0in\right) = 363 \cdot lbs$$

$$F_{wind.L} := \frac{P_{net} \cdot W_{unit} \cdot (H_{unit} + 0in)}{L \cdot N_L} \cdot \left(\frac{1}{2} \cdot H_{unit} + 0in\right) = 324 \cdot lbs$$

$$R_{iso.W} := (0.6) \cdot MAX+\left(\begin{pmatrix}F_{wind.B} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{Wt_{unit}}{N_t} \\ F_{wind.L} + \frac{P_v \cdot L_{unit.up} W_{unit}}{N_t} + \frac{Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{Wt_{unit}}{N_t}\end{pmatrix}\right) = \begin{pmatrix}407 \\ 367\end{pmatrix} \cdot lbs$$

Tensile and Shear Load calculation per ASHRAE RP-812



Eccentricity along X-X

$e_x := e_{width} = 7.5 \cdot in$

Eccentricity along Y-Y

$e_y := e_{length} = 2.56 \cdot in$

Distance between Seismic Restraints Along Y-Y

$b_1 := L_{curb} - 2 \cdot 6in = 55 \cdot in$

Distance between Seismic Restraints Along X-X

$b_2 := W_{curb} + 2 \cdot \frac{1.75in}{2} = 39 \cdot in$

Moment of Inertia about X-X

$I_{xx} := \frac{N_t \cdot (N_t + 2) \cdot (b_1)^2}{12 \cdot (N_t - 2)} = 3614 \cdot in^2$

Moment of Inertia about Y-Y

$I_{yy} := \frac{N_t \cdot (b_2)^2}{4} = 3411 \cdot in^2$

Angle about Tensile Load

$\Theta_t := \operatorname{atan}\left[\frac{I_{yy} \cdot (b_1)}{I_{xx} \cdot (b_2)}\right] = 53 \cdot deg$

Angle about Shear Load

$$\Theta_s := \begin{cases} \operatorname{atan}\left(\frac{e_x}{e_y}\right) & \text{if } e_y \neq 0 \\ 0deg & \text{if } e_y = 0 \end{cases} = 71 \cdot deg$$

Max Net Tensile Load Due to Seismic Load, Fp

$$T_{U.EQ.pt1} := \frac{(0.6 - 0.7 \cdot F_v) \cdot Wt_{unit}}{N_t} - \frac{(0.6 - 0.7 \cdot F_v) \cdot Wt_{unit}}{b_1 \cdot b_2} \cdot \left(\frac{b_1}{2} \cdot e_x + \frac{b_2}{2} \cdot e_y - e_x \cdot e_y\right) = 0 \cdot lbs$$

$$T_{U.EQ.pt2} := -0.7 \cdot (F_p \cdot Wt_{unit}) \cdot (h_{CG.unit} + 0in) \cdot \cos(\Theta_t) \cdot \frac{0.5 \cdot b_2}{I_{yy}} = -183 \cdot lbs$$

$$T_{U.EQ.pt3} := -0.7 \cdot (F_p \cdot Wt_{unit}) \cdot (h_{CG.unit} + 0in) \cdot \sin(\Theta_t) \cdot \frac{0.5 \cdot b_1}{I_{xx}} = -330 \cdot lbs$$

$T_{U.EQ} := T_{U.EQ.pt1} + T_{U.EQ.pt2} + T_{U.EQ.pt3} = -513 \cdot lbs$

Max Net Shear Load Due to Seismic Load, Fp

$$V_{Ux.EQ} := 0.7 \cdot F_p \cdot Wt_{unit} \cdot \frac{\cos(\Theta_s)}{N_t} + \frac{0.7 \cdot F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_2 \cdot e_y + 0.7 \cdot F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_1 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 172 \cdot lbs$$

$$V_{Uy.EQ} := 0.7 \cdot F_p \cdot Wt_{unit} \cdot \frac{\sin(\Theta_s)}{N_t} + \frac{0.7 \cdot F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_1 \cdot e_y + 0.7 \cdot F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_2 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 333 \cdot lbs$$

$$V_{U.EQ} := \sqrt{V_{Ux.EQ}^2 + V_{Uy.EQ}^2} = 375 \cdot lbs$$

Tension Design force SRSS for loading from Each direction

$R_{iso.EQ.1.RP812} := \left| T_{U.EQ.pt1} + T_{U.EQ.pt3} \right| = 330 \cdot lbs$

$R_{iso.EQ.0.RP812} := \left| T_{U.EQ.pt1} + T_{U.EQ.pt2} \right| = 183 \cdot lbs$

$$R_{iso.EQ.max_1} := \max\left[\left(R_{iso.EQ.1.RP812} + 0 \cdot R_{iso.EQ.0.RP812}\right), \left(R_{iso.EQ_1} + 0 \cdot R_{iso.EQ_0}\right)\right] = 330 \cdot lbs$$

$$R_{iso.EQ.max_0} := \max\left[\left(R_{iso.EQ.0.RP812} + 0 \cdot R_{iso.EQ.1.RP812}\right), \left(R_{iso.EQ_0} + 0 \cdot R_{iso.EQ_1}\right)\right] = 278 \cdot lbs$$

For the plot:

$R_{iso.EQ.max_1} = 330 \cdot lbs$ $R_{iso.W_1} = 367 \cdot lbs$

$R_{iso.EQ.max_0} = 278 \cdot lbs$ $R_{iso.W_0} = 407 \cdot lbs$

Shear load at each anchor location

For the plot:

$$V_{iso.E} := \max\left[\left[\begin{array}{c} 1.0 \cdot V_{Ux.EQ} + 0 \cdot V_{Uy.EQ} \\ 0.3 \cdot V_{Ux.EQ} + 0 \cdot V_{Uy.EQ} \\ \left[\left(0.7F_p\right) \cdot Wt_{unit} \cdot \frac{1}{N_t}\right] \end{array}\right]\right] = 289 \cdot lbs \qquad V_{iso.W} := 0.6P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t} = 205 \cdot lbs$$

Isolator Capacity:

$ID_{Iso} := "CQA"$

$T_{n.\Omega} := 2117lbs$ **(ASD)**

$T_{n.\Omega.45} := 808lbs$ **(ASD)**

$V_{n.\Omega} := 775lbs$ **(ASD)**

Isolator Demand:

$R_{iso.max} := \max\left[\left(R_{iso.EQ.max_1}\right), \left(R_{iso.EQ.max_0}\right), \left(R_{iso.W_1}\right), \left(R_{iso.W_0}\right)\right] = 407 \cdot lbs$

$V_{iso.max} := \max\left(V_{iso.E}, V_{iso.W}\right) = 289 \cdot lbs$

D/C Ratio of Tension Only.:

$$DCR_{tension} := \frac{R_{iso.max}}{T_{n.\Omega}} = 0.192$$

$DCR_{tension} = "OK"$

D/C Ratio of Shear Only.:

$$DCR_{shear} := \frac{V_{iso.max}}{V_{n.\Omega}} = 0.373$$

$DCR_{shear} = "OK"$

D/C Ratio of Tension Only.:

$$DCR_{Int} := \frac{V_{iso.max}}{V_{n.\Omega}} + \frac{R_{iso.max}}{T_{n.\Omega.45}} = 0.877$$

$DCR_{Int} = "OK"$

ISOLATOR "SPRING" DESIGN [PER OPM-0401-13]

Factor of Safety of Spring

$FS_{spring} := 0.75$

Compressive Strength of Spring

$$C_{spring.\Omega} := \begin{cases} \left(FS_{spring} \cdot 300lbs\right) & \text{if } ID_{Iso} = "CQA" \\ \left(FS_{spring} \cdot 918lbs\right) & \text{if } ID_{Iso} = "CQB" \\ \left(FS_{spring} \cdot 918lbs\right) & \text{if } ID_{Iso} = "CQBX" \end{cases} = 225 \cdot lbs$$

Rated Load per unit self-weight

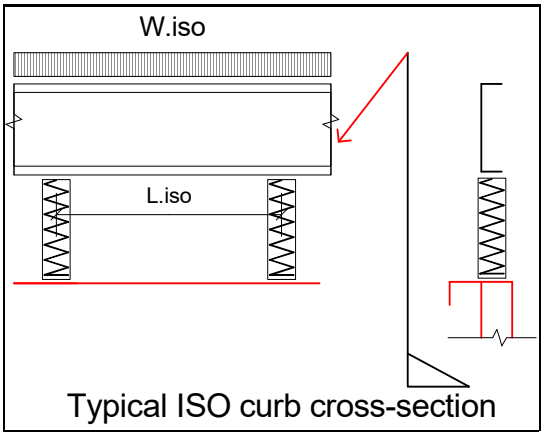
$$C_{unit.rated.load} := \frac{Wt_{unit}}{N_t} = 122 \cdot lbs$$

D/C Ratio of Spring Compression:

$$DCR := \frac{C_{unit.rated.load}}{C_{spring.\Omega}} = 0.543$$

$IsoSpring_{compression} = "OK"$

Check ISO Rail for Bending about Strong and Weak Axis (AISI S100-16 F2.1)



Typical ISO curb cross-section

Thickness of Curb:

$t_{Curb.iso}$ = "10GA" $t := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Inside Bend Radius:

$R := R_{iso} = 0.186 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web:

$h := 7.5in - 2 \cdot (t + R) = 6.85 \cdot in$

Width of Flange:

$h_w := 1in$

Check Curb Bending of Long Side (Strong axis)

Member per CFS: $CFS_{member} :=$ "10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"

Number of Isolators on each Long Side: $N_{iso.long} = 5$

Center-to-Center Spacing of Isolators $L_{iso} := \frac{L_{curb}}{N_{iso.long} - 1} = 19 \cdot in$

Distributed Load $\omega_{iso} := \omega_{x.L.vert} = 2.165\,klf$

Moment Demand on Iso Rail $M_{cx} := \frac{\omega_{iso} \cdot L_{iso}^{2}}{8} = 8.358 \cdot kip \cdot in$

Curb Elastic Modulus / Yield Stress: $E := 29500ksi$ $F_y := 50ksi$

Curb Shear Modulus: $G := 11300ksi$

Poisson's Ratio $\mu := 0.3$

Section Properties from CFS: $r_x = 2.4893 \cdot in$ $r_o = 2.519 \cdot in$ $C_w = 0.595 \cdot in^6$ $S_x = 1.855 \cdot in^3$

$r_y = 0.2288 \cdot in$ $J = 0.0058 \cdot in^4$ $S_y = 0.3669 \cdot in^3$

$r_{min} := \min(r_x, r_y) = 0.2288 \cdot in$

Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Flanges*

Flat Width: $w := h_w - R_{curb} = 0.847 \cdot in$

Stiffened Web Check: $Stiffened_{check} := "Unstiffened"$

Stress at the end of the Width: $f_2 := 11.407ksi$ $f_1 := 11.407ksi$

Compressive Stress Ratio (Eq. 1.1.2-1): $\Psi := \frac{f_2}{f_1} = 1$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = "Stiffened" \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = "Unstiffened" \end{cases} = 0.43$$

Critical Compressive Stress: $F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot (1 - \mu^2)} \cdot \left(\frac{t}{w}\right)^2 = 304.86 \cdot ksi$

Stress in Compression Element: $f := 18ksi$

Note: Use f from "Elastive Flexural Buckling Stress" on "Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI E2)"

Slenderness Factor: $\lambda := \sqrt{\frac{f}{F_{cr}}} = 0.24$

Local reduction factor: $\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 0.389$

Effective Width of the Flanges:

$$b_{eff.flange} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 0.847 \cdot in$$

Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Web*

Flat Width: $w := h = 6.851 \cdot in$

Stiffened Web Check: $Stiffened_{check} := "Stiffened"$

Stress at the end of the Width: $f_2 := 11.407ksi$ $f_1 := 11.407ksi$

Compressive Stress Ratio (Eq. 1.1.2-1): $\Psi := \frac{f_2}{f_1} = 1$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = "Stiffened" \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = "Unstiffened" \end{cases} = 4$$

Critical Compressive Stress: $F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot (1 - \mu^2)} \cdot \left(\frac{t}{w}\right)^2 = 43.4 \cdot ksi$

Stress in Compression Element: $f := 18ksi$

Note: Use f from "Elastive Flexural Buckling Stress" on "Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI E2)"

Slenderness Factor: $\lambda := \sqrt{\frac{f}{F_{cr}}} = 0.64$

Local reduction factor: $\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 1.022$

Effective Width of the Web:

$$b_{eff.web} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 6.851 \cdot in$$

Effective Area of the Member: $A_e := 2 \cdot (b_{eff.flange} \cdot t) + b_{eff.web} \cdot t = 1.181 \cdot in^2$

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. F2.1.1-4,5)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(1.0 \cdot L_{iso}\right)^2}\right] = 71 \cdot ksi$$

$$\sigma_{ey} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{iso}}{r_y}\right)^2} = 41 \cdot ksi \qquad \frac{1.0 \cdot L_{iso}}{r_y} = 84$$

KL_r = "KL/r < 200, OK"

Cb per Eq. F2.1.1-2

$$M_A := \frac{\omega_{iso} \cdot \frac{L_{iso}}{4}}{2} \cdot \left(L_{iso} - \frac{L_{iso}}{4}\right) = 6.27 \cdot kip \cdot in$$

$$M_B := M_{cx} = 8.36 \cdot kip \cdot in$$

$$M_C := \frac{\omega_{iso} \cdot \frac{3 \cdot L_{iso}}{4}}{2} \cdot \left(L_{iso} - \frac{3 \cdot L_{iso}}{4}\right) = 6.27 \cdot kip \cdot in$$

$$C_b := \min\left(1.0, \frac{12.5 \cdot M_{cx}}{2.5 \cdot M_{cx} + 3 \cdot M_A + 4 \cdot M_B + 3.M_C}\right) = 1$$

Elastic Critical Lateral-Torsional Buckling Stress per Eq. F2.1.1-1 for Singly Symmetry:

$$F_e := \frac{C_b \cdot r_o \cdot A_e}{S_x} \cdot \sqrt{\sigma_{ey} \cdot \sigma_t} = 87 \cdot ksi$$

LTB Design Stress: Eq. F2.1-3,4,5:

$$F_c := \begin{cases} F_y & \text{if } F_e \geq 2.78 \cdot F_y \\ \frac{10}{9} \cdot F_y \cdot \left(1 - \frac{10 \cdot F_y}{36 \cdot F_e}\right) & \text{if } 2.78 \cdot F_y > F_e > 0.56 \cdot F_y \\ F_e & \text{if } 0.56 \cdot F_y \geq F_e \end{cases} = 47 \cdot ksi$$

Moment Capacity Eq. F2.1-1:

$$\phi M_{nx} := 0.9 \cdot S_x \cdot \min\left(F_c, F_y\right) = 78 \cdot kip \cdot in$$

D/C Ratio of Bending:

$$DCR := \frac{M_{cx}}{\phi M_{nx}} = 0.107$$

$Iso_{Bending}$ = "OK"

Check Curb Bending of Long Side (Weak axis)

Center-to-Center Spacing of Braces

$$L_{brace} := \max\left(40in, \frac{L_{curb}}{N_{iso.long} - 1}\right) = 40 \cdot in$$

Note for weak-axis bracing length:
Max weak-axis span length of Iso Rail is larger than L_{brace} per cut sheet. However, the Iso Rail is braced with clip at max 24" O.C. at top and isolator at max 36" O.C. at bottom such that the actual unbraced length is as follows.

Distributed Load

$$\omega_{iso} := \frac{\max\left(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit}\right)}{L_{curb}} = 0.661\ klf$$

Moment Demand on Iso Rail

$$M_{cy} := \frac{\omega_{iso} \cdot L_{brace}^{2}}{8} = 11.02 \cdot kip \cdot in$$

Member per CFS:

$$CFS_{member} = \text{"10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"}$$

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. F2.1.1-4,5)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(1.0 \cdot L_{brace}\right)^2}\right] = 23 \cdot ksi$$

$$\sigma_{ex} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{brace}}{r_x}\right)^2} = 1128 \cdot ksi \qquad \frac{1.0 \cdot L_{brace}}{r_x} = 16$$

$$KL_r = \text{"KL/r < 200, OK"}$$

Cb per Eq. F2.1.1-2

$$M_A := \frac{\omega_{iso} \cdot \frac{L_{brace}}{4}}{2} \cdot \left(L_{brace} - \frac{L_{brace}}{4}\right) = 8.27 \cdot kip \cdot in$$

$$M_B := M_{cy} = 11.02 \cdot kip \cdot in$$

$$M_C := \frac{\omega_{iso} \cdot \frac{3 \cdot L_{brace}}{4}}{2} \cdot \left(L_{brace} - \frac{3 \cdot L_{brace}}{4}\right) = 8.27 \cdot kip \cdot in$$

$$C_b := \min\left(1.0, \frac{12.5 \cdot M_{cx}}{2.5 \cdot M_{cx} + 3 \cdot M_A + 4 \cdot M_B + 3.M_C}\right) = 0.91$$

Elastic Critical Lateral-Torsional Buckling Stress per Eq. F2.1.1-1 for Singly Symmetry:

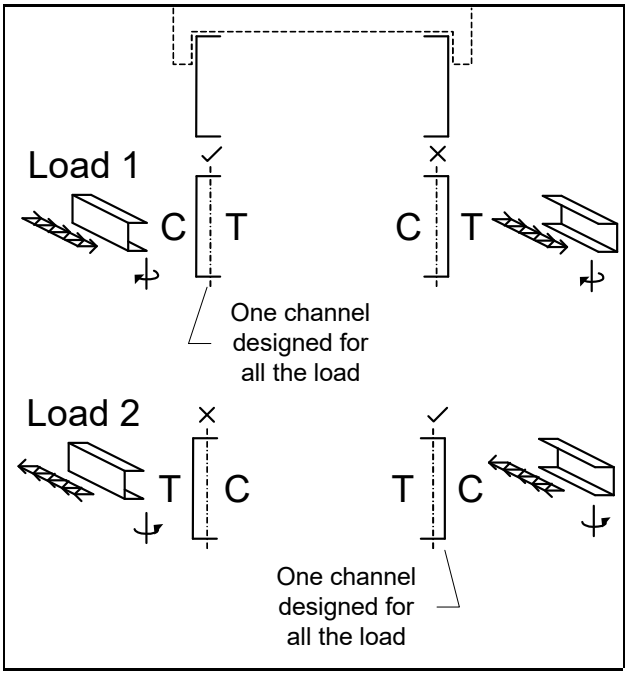
$$F_e := \frac{C_b \cdot r_o \cdot A_e}{S_y} \cdot \sqrt{\sigma_{ey} \cdot \sigma_t} = 228 \cdot ksi$$

LTB Design Stress: Eq. F2.1-3,4,5:

$$2.78 \cdot F_y = 139 \cdot ksi$$

$$0.56 \cdot F_y = 28 \cdot ksi$$

$$F_c := \begin{cases} F_y & \text{if } F_e \geq 2.78 \cdot F_y \\ \frac{10}{9} \cdot F_y \cdot \left(1 - \frac{10 \cdot F_y}{36 \cdot F_e}\right) & \text{if } 2.78 \cdot F_y > F_e > 0.56 \cdot F_y \\ F_e & \text{if } 0.56 \cdot F_y \geq F_e \end{cases} = 50 \cdot ksi$$



Note:

For ISO rail weak-axis bending capacity, rails are oriented and designed so that the stiffer side of ISO rail can take the entire bending load by itself without putting a lot of bending load to the iso rail on the other side

Moment Capacity Eq. F2.1-1:

$$\phi M_{ny} := 0.9 \cdot S_y \cdot \min(F_c, F_y) = 16.5105 \cdot kip \cdot in$$

D/C Ratio of Bending:

$$DCR := \frac{M_{cy}}{\phi M_{ny}} = 0.667$$

$$Iso_{Bending} := \text{if}(M_{cy} < \phi M_{ny}, \text{"OK"}, \text{"NG"})$$

$Iso_{Bending} = \text{"OK"}$

Web Crippling of ISO Rail (AISI S100-16 G.5)

Governing Compression:

$$P_{web.crip} := \frac{\omega_{x.L.vert} \cdot L_{iso}}{2} = 1737 \cdot lbs$$

Yield Strength:

$$F_y := 50ksi$$

Bearing Length:

$N := 2in$ **2 in. for CQAs**

Thickness of Curb:

$t_{Curb.iso} = "10GA"$ $t := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Inside Bend Radius:

$R := R_{iso} = 0.186 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web:

$h = 6.85 \cdot in$

Angle btween plane of web and bearing surface:

$\theta := 90deg$

Web Crippling Limit Check (AISI Table G5-2):

$\frac{R}{t} = 1$ $\frac{h}{t} = 50$ $\frac{N}{t} = 14$ $\frac{N}{h} = 0.29$

$$LimitCheck_{webcrippling} := if\left[\left(\frac{h}{t} < 200\right) \wedge \left(\frac{N}{t} < 210\right) \wedge \left(\frac{N}{h} < 2\right) \wedge \left(\frac{R}{t} < 2\right), "OK", "NG, Need Reinf"\right]$$

$LimitCheck_{webcrippling} = "OK"$

End Case Coefficient Single Web Channel (AISI Table G5-2):

$C := 2$ $C_R := 0.11$ $C_N := 0.37$ $C_h := 0.01$

Reduction Factor Web Crippling Strength:

$\phi_{web.end} := 0.75$ **(For Unfastened Flanges with Two-Flange Loading or Reaction. Worst Case)**

$\phi_{web.int} := 0.8$

Design Web Crippling Strength:

$$P_{n.end} := C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 3729 \cdot lbs$$

$$\phi P_{n.end} := \phi_{web.end} \cdot P_{n.end} = 2796 \cdot lbs$$

Interior Case Coefficient Single Web Channel (AISI Table G5-2):

$C := 13$ $C_R := 0.47$ $C_N := 0.25$ $C_h := 0.04$

Design Web Crippling Strength:

$$P_{n.interior} := C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 7905 \cdot lbs$$

$$\phi P_{n.interior} := \left(\phi_{web.int}\right) \cdot P_{n.interior} = 6324 \cdot lbs$$

Design Strength:

$$P_{n.web.crip} := \min\left(P_{n.end}, P_{n.interior}\right) = 3729 \cdot lbs$$

$$\phi P_{n.web.crip} := \min\left(\phi P_{n.end}, \phi P_{n.interior}\right) = 2796 \cdot lbs$$

D/C Ratio of Shear:

$$DCR := \frac{P_{web.crip}}{\phi P_{n.web.crip}} = 0.621$$

Demand/Capacity Ratio:

$$Web_{crippling} := \text{if}\left[\left(P_{web.crip} < \phi P_{n.web.crip}\right) \wedge \left(\phi P_{n.end} > 0\right) \wedge \frac{h}{t} < 200, \text{"OK"}, \text{"NG, Need Reinf"}\right]$$

$Web_{crippling} = \text{"OK"}$

D/C Ratio of Interaction:
AISI Eq. H3-1b

$$DCR_{int.web} := \frac{0.91 \cdot \left(\frac{P_{web.crip}}{P_{n.web.crip}}\right) + \frac{M_{cx}}{\left(\frac{\phi M_{nx}}{0.9}\right)}}{1.33 \cdot 0.9} = 0.435$$

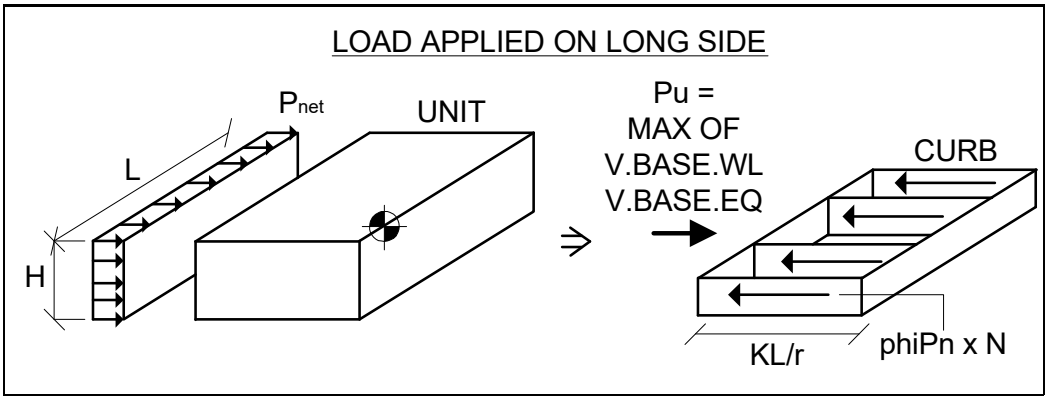
$Iso_{Shear} = \text{"OK"}$

$Iso_{Interaction} = \text{"OK"}$

Per AISI S100-16 H3,
Only x-axis needs to check for interaction

Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI S100-16 E2)

Curb Axial Load Check due to Load on Long Side



Wind Base Shear of Unit on Long Side: $V_{base.W.L} := P_{net} \cdot L_{unit} \cdot H_{unit} = 3.1\,kip$

Seismic Base Shear of Unit on Long Side: $V_{base.S.L} := F_p \cdot Wt_{unit} = 3.7\,kip$

Max Axial: $P_u := \max\left(V_{base.S.L}, V_{base.W.L}\right) = 3712.5 \cdot lbs$

Member per CFS: $CFS_{member} =$ "10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"

Number of Curb in Length: $n_{iso} := 3$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{iso}} = 1.24\,kip$

Max Braced Length of Member: $L_{member} := W_{curb} = 37 \cdot in$

Effective Length factor: $K := 0.5$

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. E2.2-5, E2.2-6)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(K \cdot L_{member}\right)^2}\right] = 76 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2} = 44 \cdot ksi$$

$$\frac{K \cdot L_{member}}{r_{min}} = 81$$

KL_r = "KL/r < 200, OK"

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 28 \cdot ksi$$

Nominal Compressive Stress Capacity (Eq E2-4):

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 1.34$$

$$F_n := \begin{cases} 0.658^{\lambda_c^{\,2}} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^{\,2}}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 23.58 \cdot ksi$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot A_e \cdot F_n = 23.67\ kip$$

D/C Ratio of Compression:

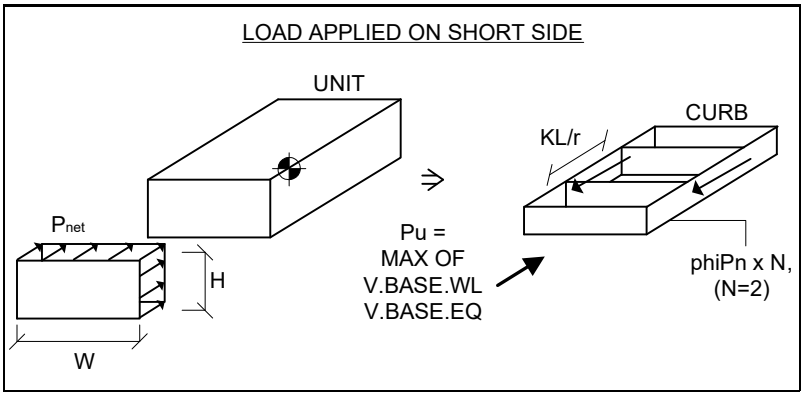
$$DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.052$$

Note:
No need to check for interaction since equipment is not attached to the short side

$$Axial_{reinf} := \text{if}\left(P_{u.EAmember} < \phi P_{n.member}, \text{"OK"}, \text{"NG"}\right)$$

$Axial_{reinf}$ = "OK"

Curb Axial Load Check due to Load on Short Side



Wind Base Shear on Short Side: $V_{base.W.H} := P_{net} \cdot W_{unit} \cdot H_{unit} = 2.5\,kip$

Seismic Base Shear of Unit on Short Side: $V_{base.S.W} := F_p \cdot Wt_{unit} = 3.7\,kip$

Max Axial: $P_u := \max\left(V_{base.S.W}, V_{base.W.H}\right) = 3712.5 \cdot lbs$

Member per CFS: CFS_{member} = "10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"

Number of Curb in Length: $n_{curb} := 2$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{curb}} = 1.86\,kip$

Max Braced Length of Member: $L_{member} := \frac{L_{curb}}{n_{iso} - 1} = 34 \cdot in$

Effective Length factor: $K := 0.5$

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. E2.2-5, E2.2-6)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(K \cdot L_{member}\right)^2}\right] = 90 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2} = 54 \cdot ksi \qquad \frac{K \cdot L_{member}}{r_{min}} = 74$$

KL_r = "KL/r < 200, OK"

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 34 \cdot ksi$$

Nominal Compressive Stress Capacity (Eq E2-4):

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 1.219$$

$$F_n := \begin{cases} 0.658^{\lambda_c^2} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^2}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 26.85 \cdot \text{ksi}$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot A_e \cdot F_n = 26.96 \text{ kip}$$

D/C Ratio of Compression:

$$DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.069$$

$$Axial_{reinf} := \text{if}\left(P_{u.EAmember} < \phi P_{n.member}, \text{"OK"}, \text{"NG"}\right)$$

$Axial_{reinf} = \text{"OK"}$

Note:
If the load direction is in perpedicular plane to the short side of the equipment, the channels will only experience axial load and no bending will occur at the channel. Therefore, no need to check for interaction since the channels

Shear of ISO Rail Webs without Holes (AISI S100-16 G2)

Note: The connection holes are not centered at mid-depth of isolated curb rail so AISI G2 shall be used

Deeper Section (h = depth)

Thickness of Curb: $t := \text{thick}(t_{Curb.iso}) = 0.138 \cdot \text{in}$

Depth-to-Thickness Ratio: $\frac{h}{t} = 50$

Curb Elastic Modulus: $E := 29500\text{ksi}$

Clear distance b/w transverse stiffeners of reinforced web: $a := L_{iso} = 19 \cdot \text{in}$

Clear Distance-to-Thickness Ratio: $\frac{a}{h} = 2.81$

Nominal Shear Stress:

$$k_v := \begin{cases} 5.34 & \text{if } a = L_{iso} \\ 4.00 + \frac{5.34}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \frac{4.00}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 5.85$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 59 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 89$$

Curb Shear Check due to Load on Longer Side

Area of Web Element:

$$A_w := h \cdot t = 0.947 \cdot in^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 63.4 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} = 60\,kip \qquad V_y := 0.6 \cdot A_w \cdot F_y = 28\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.688$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 28.404 \cdot kip$$

Number of Members within Length: $n := 1$ **(Per Curb Design)**

Design Shear Capacity:

$$\phi V_{n.h} := 0.95 \cdot n \cdot V_n = 26.98 \cdot kip$$

Design Shear Demand:

$$V_{u.h} := \frac{\omega_{x.L.vert} \cdot L_{iso}}{2} = 1736.8 \cdot lbs$$

D/C Ratio of Shear:

$$DCR := \frac{V_{u.h}}{\phi V_{n.h}} = 0.064$$

Demand/Capacity Ratio:

$Shear_{in.plane} = \text{"OK"}$

Shallower Section (h.w = Width)

Thickness of Curb: $t := thick(t_{Curb.iso}) = 0.138 \cdot in$

Depth-to-Thickness Ratio: $\frac{h_w}{t} = 7$

Curb Elastic Modulus: $E := 29500 ksi$

Clear distance b/w transverse stiffeners of reinforced web: $a := L_{brace} = 40 \cdot in$

Clear Distance-to-Thickness Ratio: $\frac{a}{h_w} = 40$

Nominal Shear Stress:

$$k_v := \begin{cases} 5.34 \text{ if } a = L_{brace} \\ 4.00 + \frac{5.34}{\left(\frac{a}{h_w}\right)^2} \text{ if } \left(\frac{a}{h_w} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \frac{4.00}{\left(\frac{a}{h_w}\right)^2} \text{ if } \left(\frac{a}{h_w} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 5.34$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 56 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 85$$

Curb Shear Check due to Load on Longer Side

Area of Web Element: $A_w := h_w \cdot t = 0.1382 \cdot in^2$

Number of Members within Length: $n := 1$ **(Per Curb Design)**

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 58 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} = 8 \, kip \qquad V_y := 0.6 \cdot A_w \cdot F_y = 4 \, kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.719$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 4.146 \cdot \text{kip}$$

Design Shear Capacity:

$$\phi V_{n.hw} := 0.95 \cdot n \cdot V_n = 3.9 \cdot \text{kip}$$

Design Shear Demand:

$$V_{u.hw} := \frac{\left(\frac{\max\left(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit}\right)}{L_{curb}} \right) \cdot L_{brace}}{2} = 1102 \cdot \text{lbs}$$

D/C Ratio of Shear:

$$DCR := \frac{V_{u.hw}}{\phi V_{n.hw}} = 0.28$$

Demand/Capacity Ratio:

$Shear_{in.plane}$ = "OK"

D/C Ratio of Vx and Mx:

$$DCR_{V.M.int} := \begin{cases} \left(0.6 \cdot \frac{M_{cx}}{\phi M_{nx}} + \frac{V_{u.h}}{\phi V_{n.h}}\right) \cdot \frac{1}{1.3} & \text{if } \frac{M_{cx}}{\phi M_{nx}} > 0.5 \wedge \frac{V_{u.h}}{\phi V_{n.h}} > 0.7 \\ \sqrt{\left(\frac{M_{cx}}{\phi M_{nx}}\right)^2 + \left(\frac{V_{u.h}}{\phi V_{n.h}}\right)^2} & \text{otherwise} \end{cases} = 0.125$$

Demand/Capacity Ratio:

$VandMx_{int}$ = "OK"

D/C Ratio of Vy and My:

$$DCR_{V.M.int} := \begin{cases} \left(0.6 \cdot \frac{M_{cy}}{\phi M_{ny}} + \frac{V_{u.hw}}{\phi V_{n.hw}}\right) \cdot \frac{1}{1.3} & \text{if } \frac{M_{cy}}{\phi M_{ny}} > 0.5 \wedge \frac{V_{u.hw}}{\phi V_{n.hw}} > 0.7 \\ \sqrt{\left(\frac{M_{cy}}{\phi M_{ny}}\right)^2 + \left(\frac{V_{u.hw}}{\phi V_{n.hw}}\right)^2} & \text{otherwise} \end{cases} = 0.724$$

Demand/Capacity Ratio:

$VandMy_{int}$ = "OK"

Web Crippling/Compression of Non-iso CanFab Curb (AISI S100-16 G5)

Governing Compression for Non-Isolated Curb:

$$P_{web.crip.int} := \max\left[\frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}}, \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}}\right] \cdot L_{spacing.non.iso} = 2789 \cdot lbs$$

$$P_{web.crip.end} := 0.5 \cdot P_{web.crip.int} = 1395 \cdot lbs$$

Yield Strength: $F_y := 50ksi$

Bearing Length: $N_{bearing} := L_{spacing.non.iso} = 15 \cdot in$

Thickness of Curb: $t_{Curb} = \text{"12GA"}$ $t := thick(t_{Curb}) = 0.1084 \cdot in$

Inside Bend Radius: $R := R_{curb} = 0.153 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web: $h := 30in - 2 \cdot (t + R) = 29.48 \cdot in$

Angle btween plane of web and bearing surface: $\theta := 90deg$

Web Crippling Limit Check (AISI Table G5-2): $\frac{R}{t} = 1$ $\frac{h}{t} = 272$ $\frac{N_{bearing}}{t} = 143$ $\frac{N_{bearing}}{h} = 0.52$

End Case Coefficient Single Web Channel (AISI Table G5-2): $C := 13$ $C_R := 0.32$ $C_N := 0.05$ $C_h := 0.04$

Reduction Factor Web Crippling Strength: $\phi_{web.end} := 0.9$ $\phi_{web.int} := 0.8$ **(For Unfastened partially Stiffened Flanges with Two-Flange Loading or Reaction.)**

Design Web Crippling Strength:

$$\phi P_{n.end} := \left(\phi_{web.end}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 2319 \cdot lbs$$

Interior Case Coefficient Single Web Channel (AISI Table G5-2): $C := 24$ $C_R := 0.52$ $C_N := 0.15$ $C_h := 0.001$

Design Web Crippling Strength:

$$\phi P_{n.interior} := \left(\phi_{web.int}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 11868 \cdot lbs$$

D/C Ratio of Shear: $DCR_{end} := \frac{P_{web.crip.end}}{2 \cdot \phi P_{n.end}} = 0.301$ $DCR_{int} := \frac{P_{web.crip.int}}{\phi P_{n.interior}} = 0.235$

Demand/Capacity Ratio: **Note: Factor of 2 for two ends connected together at the end**

$Web_{crippling} = \text{"OK"}$

Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Length

Roof Curb thickness

$t_{Curb} = \text{"12GA"}$ $t_{curb} := thick(t_{Curb}) = 0.1084 \cdot in$

Min width of Roof Curb

$b_{curb} := L_{curb} + \frac{W_{curb}}{2} \cdot 2 + 3in \cdot 2 \cdot 4 = 128.56 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := L_{curb} + \min\left(\frac{W_{curb}}{2} \cdot 2, \frac{L_{curb}}{2}\right) = 101 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{array}{c} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{array} \right] \right] = 11330 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.L.vert.up} \cdot L_{curb}) \cdot (0.75in) = 6171 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.545$

$Curb_{BotFlangeBending} = \text{"OK"}$

Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Width

Roof Curb thickness

$t_{Curb} = \text{"12GA"}$ $t_{curb} := thick(t_{Curb}) = 0.1084 \cdot in$

Min width of Roof Curb

$b_{curb} := W_{curb} + \frac{L_{curb}}{4} \cdot 2 + 3in \cdot 2 = 76.88 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := W_{curb} + \min\left(\frac{L_{curb}}{6} \cdot 2, W_{curb}\right) = 60 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{array}{c} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{array} \right] \right] = 6775 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.W.vert.up} \cdot W_{curb}) \cdot (0.75in) = 3124 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.461$

$Curb_{BotFlangeBending} = \text{"OK"}$

Web Crippling/Compression of Iso CanFab Curb (AISI S100-16 G5)

Note: Curb stiffeners directly transfer the compressive load from isolator to the base. Therefore, curb web crippling is prevented.

Curb Web with Reinforcement

Max Compression: $Comp_{maxtot} := \max(|C_S|, |C_W|) = 14301.46 \cdot lbs$

Reinforcement per CFS: $CFS_{reinf} :=$ "Single Stiffener 10GA 1"x7"x1" Fy=50ksi 30" Tall on min. 16GA "

Note: min. of 10 GA channel and min. 16 GA curb web

Number of Reinforcement in Length: $n_{reinf} := N_{iso.long} = 5$

Max Compression per Reinf: $Comp_{per.reinf} := \frac{Comp_{maxtot}}{n_{reinf}} = 3.178\,kip$

Spacing: $Spacing := \frac{L_{curb}}{n_{reinf}} = 15 \cdot in$ $KL_r := \frac{1.0 \cdot (H_{curb} - 12.5in)}{0.2339in} = 128$

Factored Nominal Comp. Capacity per reinforcement: $\phi P_{n.reinf} = 13.633 \cdot kip$ **(See attached CFS)**

Total Factored nominal Comp Capacity: $\phi P_{n.tot} := n_{reinf} \cdot \phi P_{n.reinf} = 61 \cdot kip$

D/C Ratio of Compression: $DCR := \frac{Comp_{maxtot}}{\phi P_{n.tot}} = 0.23$

$Comp_{reinf} := if(Comp_{maxtot} < \phi P_{n.tot}, "OK", "NG")$ $Comp_{reinf} = "OK"$

Check CanFab Curb for Compressive Force due to T/C Coupling of Overturning

Note:
-Since the equipment is only attached to the longer sides of the CanFab Curb, most likely there will be compressive force onto the curb due to T/C coupling.
- Rectangular CanFab Curb will be considered as "Channel" to resist the compressive force.

Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Flanges*

Flat Width:

$$w := \frac{W_{curb}}{2} - R_{curb} = 18.441 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Unstiffened"}$$

Stress at the end of the Width:

$$f_2 := 50ksi \qquad f_1 := 50ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \left| \frac{f_2}{f_1} \right| = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 0.43$$

Critical Compressive Stress (Eq 1.1-4):

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w}\right)^2 = 0.4 \cdot ksi$$

Stress in Compression Element:

$$f := F_y = 50 \cdot ksi \qquad \textbf{(Assume f = Fy)}$$

Slenderness Factor (Eq 1.1-3):

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 11.23$$

Local reduction factor (Eq 1.1-2):

$$\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 0.087$$

Effective Width of the Flanges:

$$b_{eff.flange} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 1.609 \cdot in$$

Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Web*

Flat Width: $w := L_{curb} - R_{curb} \cdot 2 = 67.07 \cdot in$

Stiffened Web Check: $Stiffened_{check} := \text{"Stiffened"}$

Stress at the end of the Width: $f_2 := 50ksi \qquad f_1 := 50ksi$

Compressive Stress Ratio (Eq. 1.1.2-1): $\Psi := \left| \frac{f_2}{f_1} \right| = 1$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 4$$

Critical Compressive Stress (Eq 1.1-4): $F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w} \right)^2 = 0.28 \cdot ksi$

Stress in Compression Element: $f := F_y = 50 \cdot ksi$ **(Assume f = Fy)**

Slenderness Factor (Eq 1.1-3): $\lambda := \sqrt{\frac{f}{F_{cr}}} = 13.4$

Local reduction factor (Eq 1.1-2): $\rho := \left(1 - \frac{0.22}{\lambda}\right) \frac{1}{\lambda} = 0.073$

Effective Width of the Web:

$$b_{eff.web} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 4.924 \cdot in$$

Effective Area of the Member: $A_e := 2 \cdot \left(b_{eff.flange} \cdot t_{curb} \right) + b_{eff.web} \cdot t_{curb} = 0.883 \cdot in^2$

Length of the Compressive Member: $L_{curb.web} := h = 29.478 \cdot in$

Young's Modulus for Cold Form Steel: $E := 29500ksi$

Curb Shear Modulus: $G := 11300ksi$

Poisson's Ratio $\mu := 0.3$

Section Properties of the Member (From Section Properties Calculator):

$A_{half.curb} := 6.087in^2$ $r_o := 28.35in$ $I_x := 3577in^4$ $I_y := 311in^4$

$J := 0.006in^4$ $r_x := \sqrt{\frac{I_x}{A_{half.curb}}} = 24.241 \cdot in$ $r_y := \sqrt{\frac{I_y}{A_{half.curb}}} = 7.148 \cdot in$

$C_w := 209700in^6$ $r_{min} := \min(r_x, r_y) = 7.148 \cdot in$

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^2}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{(1.0 \cdot L_{curb.web})^2}\right] = 99039.942 \cdot ksi$$

$$\sigma_{e.y} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_y}\right)^2} = 17118.942 \cdot ksi \qquad \sigma_{e.x} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_x}\right)^2} = 196895.358 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2} = 17118.942 \cdot ksi$$

$$\frac{1.0 \cdot L_{curb.web}}{r_{min}} = 4.12$$

$KL_r = \text{"KL/r < 200, OK"}$

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 14596.034 \cdot ksi$$

Nominal Compressive Stress Capacity: (Eq E2-4)

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 0.059$$

$$F_n := \begin{cases} 0.658^{\lambda_c^2} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^2}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 49.93 \cdot \text{ksi}$$

Compressive Capacity:

$$P_{n.member} := A_e \cdot F_n = 44.07 \cdot \text{kip}$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot P_{n.member} = 37.46 \cdot \text{kip}$$

Factored Max Compressive Force:

$$P_{comp.max} := \max\left(\left|C_S\right|, \left|C_W\right|\right) = 14.301 \text{ kip}$$

D/C Ratio of Compression:

$$DCR := \frac{P_{comp.max}}{\phi P_{n.member}} = 0.382$$

$$Axial_{curb.comp} := \text{if}\left(P_{comp.max} < \phi P_{n.member}, \text{"OK"}, \text{"Provide Channel from above as Web Stiffener"}\right)$$

$Axial_{curb.comp} = \text{"OK"}$

Note: No need to check for interaction since the curb is only subjected to the compressive force.

Shear of CanFab Curb Webs without Holes (AISI S100-16 G2)

Note: Since the unit is stiffer than the curb and the curb is firmly attached to the unit and to the base structure, curbs will mainly take the lateral forces as shear and axial load rather than bending.

Thickness of Curb:

$$t := \text{thick}(t_{Curb}) = 0.108 \cdot \text{in}$$

Depth-to-Thickness Ratio:

$$\frac{h}{t} = 272$$

Curb Elastic Modulus:

$$E := 29500\text{ksi}$$

Clear distance b/w transverse stiffeners of reinforced web:

$$a := \max\left(\frac{L_{curb}}{2}, W_{curb}\right) = 37 \cdot \text{in} \qquad \frac{a}{h} = 1.26$$

$$k_v := \begin{cases} 5.34 & \text{if } a = L_{curb} \\ 4.00 + \dfrac{5.34}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \dfrac{4.00}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 7.85$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 68 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 103$$

Curb Shear Check due to Load on Longer Side

Area of Web Element:

$$A_w := W_{curb} \cdot t = 4 \cdot \text{in}^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 2.8 \cdot \text{ksi}$$

$V_{cr} := A_w \cdot F_{cr} = 11\,kip \quad V_y := 0.6 \cdot A_w \cdot F_y = 121\,kip \quad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 3.255$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 11.414 \cdot kip$$

Number of Members within Length: $n := 2$ **(Per Curb Design)**

Design Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 21686.8 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.H} := P_{net} \cdot L_{unit} \cdot H_{total} = 6234.2 \cdot lbs$

Design Shear Demand: $V_u := \max(V_{base.S}, V_{base.W.H}) = 6234.2 \cdot lbs$

D/C Ratio of Shear: $DCR := \frac{V_u}{\phi V_n} = 0.287$

Demand/Capacity Ratio:

$Shear_{in.plane} := \text{if}(V_u < \phi V_n, \text{"OK"}, \text{"NG"})$

$Shear_{in.plane} = \text{"OK"}$

Curb Shear Check due to Load on Shorter Side

Area of Web Element: $A_w := L_{curb} \cdot t = 7 \cdot in^2$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot (1 - \mu^2) \cdot \left(\frac{h}{t}\right)^2} = 2.8 \cdot ksi$$

$V_{cr} := A_w \cdot F_{cr} = 21\,kip \quad V_y := 0.6 \cdot A_w \cdot F_y = 219\,kip \quad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 3.255$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 20.68 \cdot kip$$

Number of Members within Length: $n := 2$ **(Per Curb Design)**

Factored Nominal Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 39291.4 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot W_{unit} \cdot H_{total} = 5029.3 \cdot lbs$

Factored Shear Demand: $V_u := \max\left(V_{base.S}, V_{base.W.L}\right) = 5720.6 \cdot lbs$

D/C Ratio of Shear: $DCR := \frac{V_u}{\phi V_n} = 0.146$

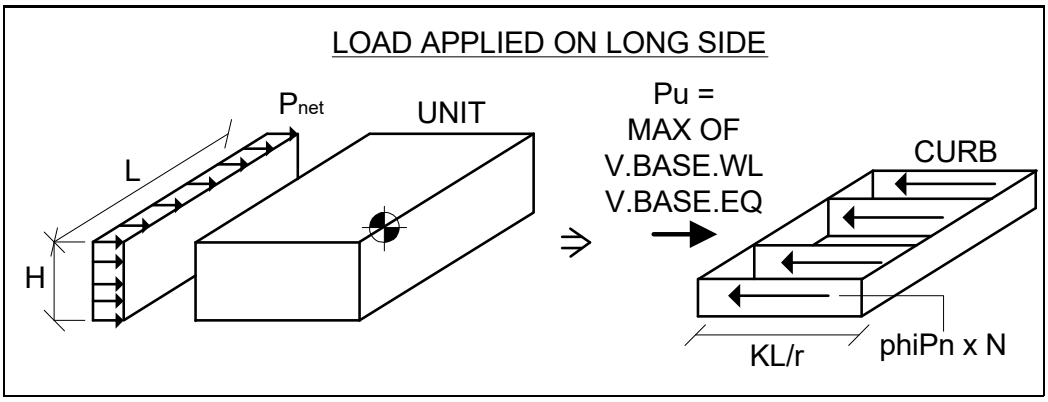
Demand/Capacity Ratio:

$Shear_{in.plane} := \text{if}\left(V_u < \phi V_n, \text{"OK"}, \text{"NG"}\right)$

$Shear_{in.plane} = \text{"OK"}$

Check CanFab Curb for In-Plane Axial due to EQ and Wind (AISI S100-16 E2)

Curb Axial Load Check due to Load on Long Side



Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot L_{unit} \cdot H_{total} = 6.2\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.L}) = 6234.24 \cdot lbs$

Member per CFS: $CFS_{member} :=$ "12GA Custom Curb 30" Tall L.b = 78in"

Max Braced Length of Member: $L_{member} := W_{curb} = 37 \cdot in$

Number of Curb in Length: $n_{curb.long} := 2$

Radius of gyration in y-axis: $r_{y.curb} := 0.558\,in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{2} = 3.12\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 67$ $KL_r =$ "KL/r < 200, OK"

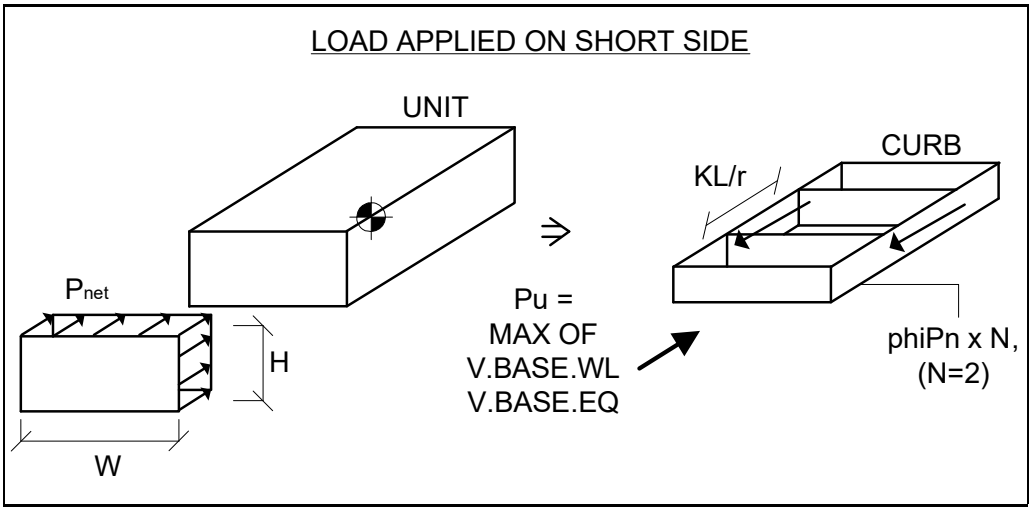
Spacing: $Spacing := \frac{L_{curb}}{n_{curb.long}} = 34 \cdot in$

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 12.036 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.259$

$Axial_{short.curb} =$ "OK"

Curb Axial Load Check due to Load on Short Side



Wind Base Shear on Short Side: $V_{base.W.H} := P_{net} \cdot W_{unit} \cdot H_{total} = 5\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.H}) = 5720.62 \cdot lbs$

Member per CFS: CFS_{member} = "12GA Custom Curb 30" Tall L.b = 78in"

Max Braced Length of Member: $L_{member} := \frac{L_{curb}}{n_{curb.long} - 1} = 67 \cdot in$

Number of Curb in Length: $n_{curb} := 2$

Radius of gyration in y-axis: $r_{y.curb} := 0.558\,in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{curb}} = 2.86\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 121$ KL_r = "KL/r < 200, OK"

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 12.036 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.238$

$Axial_{long.curb}$ = "OK"

JOHN A. MARTIN and ASSOCIATES, INC. ☐ STRUCTURAL ENGINEERS

Architect: CANNON FABRICATION, INC. Sheet

Project: IBC 2018 Group A Job No. J13001 . 380

Date NOV/21/2018

CURB & ANCHORAGE DESIGN Engineer LK

DESIGN
for
ISOLATED CURB
1006 XIC (Max Curb Height of 36")

950 S. GRAND AVENUE, 4TH FLOOR, LOS ANGELES, CALIFORNIA 90015 (213) 483-6490

Design Wind Loads for Rooftop Equipment (ASCE 7-16 § Table 29.1-1)

$z := 60ft$ — **Height above ground level**

$B := 60ft$ — **Horizontal dimension of building measured normal to wind direction**

$Exp_{category} := "C"$ — **Exposure Category per ASCE 7-16 § 26.7**

$Risk_{category} := "IV"$ — **Risk Category per ASCE 7-16 Table 1.5-1**

$$V := \begin{cases} 0mph & \text{if } Risk_{category} = "I" \\ 0mph & \text{if } Risk_{category} = "II" \\ 175mph & \text{otherwise} \end{cases} = 175 \cdot mph$$

Basic Wind Speed per ASCE 7-16 Figure 26.5-1 A,B or C

$K_z = 1.14$ — **Velocity Pressure Exposure Coefficient per ASCE 7-16 Table 29.10-1 [Exposure Category "C"]**

$K_{zt} := 1.0$ — **Topographic Factor per ASCE 7-16 § 26.8, Figure 26.8-1**

$K_e := 1.0$ — **Ground Elevation Factor per ASCE 7-16 § 26.9, Table 26.9-1**

$K_d := 0.85$ — **Wind Directionality Factor per ASCE 7-16 § 26.6, Table 26.6-1 (Equipment)**

$q_z := 0.00256 K_z \cdot K_{zt} \cdot K_d \cdot K_e \cdot V^2 = 75.74 \cdot psf$ — **Velocity pressure evaluated at height z above ground per ASCE 7-10 § 26.10.2; Eq. 26.10-1**

$GC_{r.lateral.max} := 1.9$ — **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.9 for rooftop structures and equipment with Af less than (0.1Bh). (GCr) shall be permitted to be reduced linearly from 1.9 to 1.0 as the value of Af is increased from (0.1Bh) to (Bh)

$GC_{r.vertical.max} := 1.5$ — **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.5 for rooftop structures and equipment with A_r less than (0.1*BL*). (GC_r) shall be permitted to be reduced linearly from 1.5 to 1.0 as the value of A_r is increased from (0.1*BL*) to (*BL*)

$P_{net} := q_z \cdot GC_{r.lateral.max} = 143.91 \cdot psf$ — **Design Lateral Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-2**

$P_v := q_z \cdot GC_{r.vertical.max} = 113.61 \cdot psf$ — **Design Vertical Uplift Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-3**

Seismic Demands on Nonstructural Components (ASCE 7-16 § 13.3 & 13.6):

$S_{DS} := 1.5$ — **Design spectral response acceleration parameter at short periods per USGS map**

$I_p := 1.5$ — **Component importance factor ASCE 7-16 § 13.1.3**

$\Omega_0 := 2.0$ — **Overstrength factor ASCE 7-16 Table 13.6.1**

Vibr_Isolation = "Yes" — **Placement of Unit Vibration Isolated:**

Note: Only "F_p" at seismic concrete anchor has been increased with overstrength factor "Ω_0"

$a_p := 2.5$ $R_p = 2.0$ — **Seismic coefficients a_p & R_p**
Per ASCE 7-16 Table 13.6-1 for
Mechanical & Electrical Components

$z = 60\,ft$ — **Height in structure of point of attachment of component with respect to the base**

$h := 60ft$ — **Average roof height of structure with respect to the base**
Where for roof top equipment:

$z \div h = 1$

F_p: Horizontal Seismic Design Force per *ASCE7-16 § 13.3.1*

F_p shall be takes as $\left(\frac{0.4 \cdot a_p \cdot S_{DS} \cdot I_p}{R_p}\right) \cdot \left(1 + 2 \cdot \frac{z}{h}\right) \cdot W_p = 337.5 \cdot \%_{\cdot} W_p$

F_p is not required to be taken as greater than $\left(1.6 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 360 \cdot \%_{\cdot} W_p$

F_p shall not be taken as less than $\left(0.3 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 67.5 \cdot \%_{\cdot} W_p$

Governing F_p : Horizontal Seismic Design Force $F_p = 337.5 \cdot \%_{\cdot} W_p$

F_v: Vertical Load per ASCE7-16 § 13.3.1.2

Concurrent Vertical Seismic Force: $F_v := 0.2 \cdot S_{DS} \cdot W_p = 30 \cdot \%_{\cdot} W_p$

Flat Roof Snow Loads (ASCE 7-16 § 7.3):

$Terrain_{CAT} := "C"$ — **Terrain Category ASCE 7-16 § 26.7 & Table 7.3-1**

$Exp_{Roof} := "Partially\ Exposed"$ — **Exposure of Roof ASCE 7-16 Table 7.3-1**

$C_e = 1$ — **Exposure Factor ASCE 7-16 Table 7.3-1**

$Thermal_{condition} := "All\ structures\ except\ below"$ — **Thermal Condition ASCE 7-16 Table 7.3-2**

$C_t = 1$ — **Thermal Factor ASCE 7-16 Table 7.3-2**

$Risk_{category} = "IV"$ — **Risk Category per ASCE 7-16 Table 1.5-1**

$I_s = 1.2$ — **Snow Importance Factor ASCE 7-16 Table 1.5-2**

$p_g := 40psf$ — **Ground Snow Loads ASCE 7-16 Figure 7.2-1**

$$p_f := \max\left(0.7 \cdot C_e \cdot C_t \cdot I_s \cdot p_g, \text{if}\left(p_g > 20psf, 20psf \cdot I_s, I_s \cdot p_g\right)\right) = 34 \cdot psf$$

Flat Roof Snow Loads ASCE 7-16 Equation 7.3-1 and § 7.3.4

Mechanical Unit Dimensions

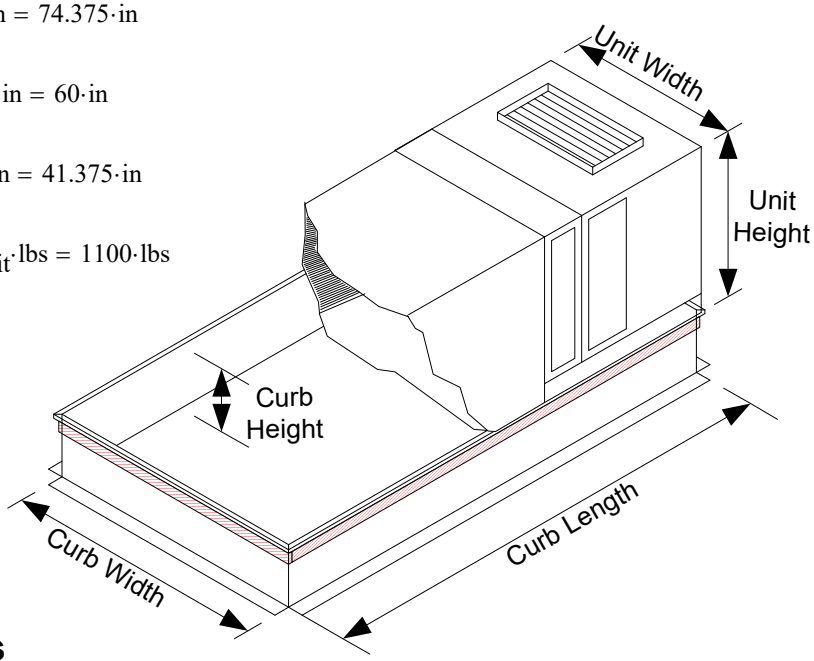
Curb = "C-1006 XIC"

Length of Unit $L_{unit} := L_{unit} \cdot in = 74.375 \cdot in$

Width of Unit $W_{unit} := W_{unit} \cdot in = 60 \cdot in$

Height of Unit $H_{unit} := H_{unit} \cdot in = 41.375 \cdot in$

Weight of Unit $Wt_{unit} := Wt_{unit} \cdot lbs = 1100 \cdot lbs$



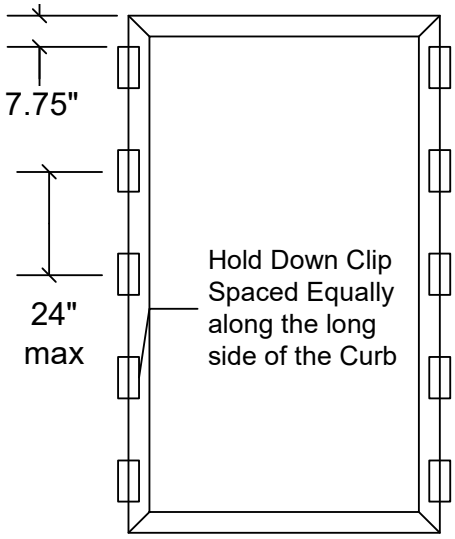
Roof Curb Dimensions

Length of Curb $L_{curb} := L_{curb} \cdot in = 67.375 \cdot in$

Width of Curb $W_{curb} := W_{curb} \cdot in = 37.188 \cdot in$

Height of Curb $H_{curb} := H_{curb} \cdot in = 48.5 \cdot in$

Weight of Curb $Wt_{curb} := Wt_{curb} \cdot lbs = 595 \cdot lbs$



Curb Plan

Overall System Dimensions

Total Weight

$Wt_{tot} := Wt_{unit} + Wt_{curb} = 1695 \cdot lbs$

Total height

$H_{total} := H_{unit} + H_{curb} = 89.875 \cdot in$

Seismic Loading + Snow Loading

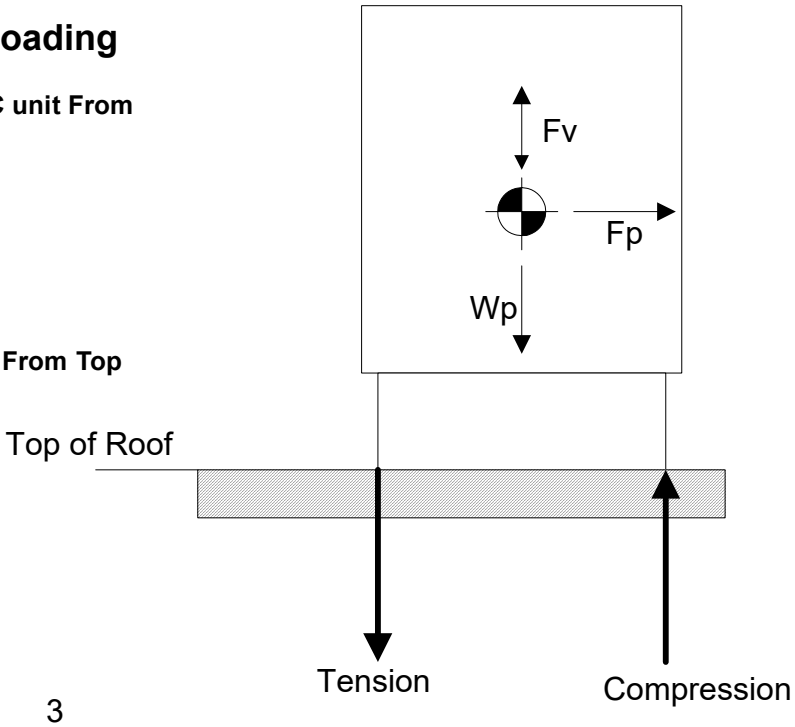
Height for Center of Gravity for HVAC unit From Top of Roof

$h_{CG.unit} := \frac{1}{2} H_{unit} = 21 \cdot in$

$h_{CG} := H_{curb} + h_{CG.unit} = 69.19 \cdot in$

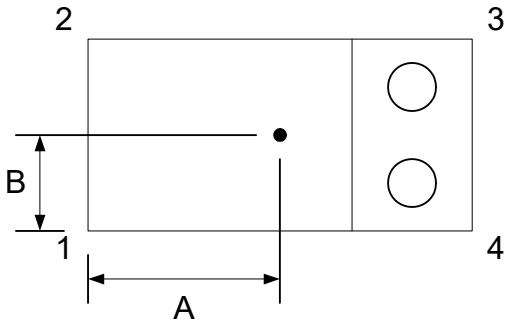
Height for Center of Gravity for Curb From Top of Roof

$h_{CG.curb} := \frac{H_{curb}}{2} = 24.25 \cdot in$



Max Seismic Base Shear

$V_{base.S} := F_p \cdot Wt_{tot} = 5721 \cdot lbs$



Unit C.G. distance in axis parallel to Curb Width $B_{ecc.width} := CG_{short} \cdot in = 22.5 \cdot in$

Eccentricity in axis parallel to Curb Width

$$e_{width} := \begin{cases} 0in & \text{if } B_{ecc.width} = \text{"N/A"} \\ \left| B_{ecc.width} - \frac{W_{unit}}{2} \right| & \text{otherwise} \end{cases} = 7.5 \cdot in$$

Unit C.G. distance in axis parallel to Curb Length $A_{ecc.length} := CG_{long} \cdot in = 34.625 \cdot in$

Eccentricity in axis parallel to Curb Length

$$e_{length} := \begin{cases} 0in & \text{if } A_{ecc.length} = \text{"N/A"} \\ \left| A_{ecc.length} - \frac{L_{unit}}{2} \right| & \text{otherwise} \end{cases} = 2.56 \cdot in$$

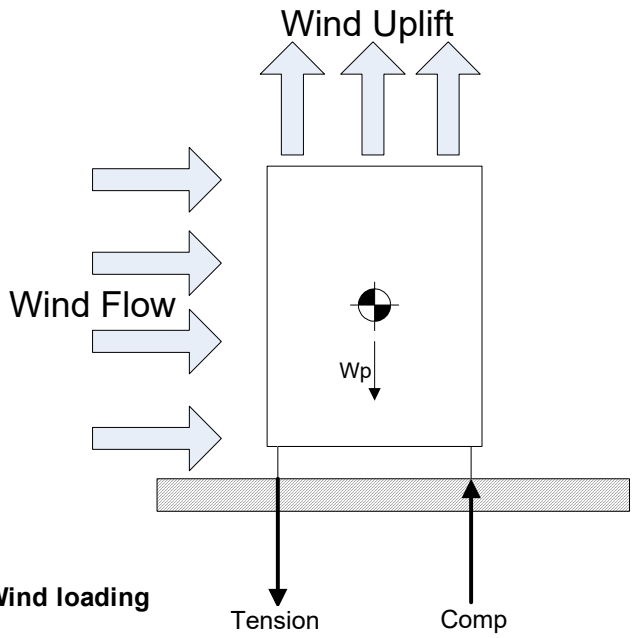
Max Net Tension Reaction On Each Side Due To Seismic Loads

$$T_S := \begin{bmatrix} \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{W_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{W_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} \right] \\ \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{L_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{L_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} \right] \end{bmatrix} = \begin{pmatrix} -7841 \\ -4052 \end{pmatrix}\cdot lbs$$

Max Net Compression Reaction On Each Side Due To Seismic Loads

$$C_S := \begin{bmatrix} \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{W_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \\ \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{L_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \end{bmatrix} = \begin{pmatrix} 13080 \\ 8042 \end{pmatrix}\cdot lbs$$

Wind Loading + Snow Loading



Max Base Shear due to wind loading

$V_{base.W} := P_{net} \cdot L_{unit} \cdot H_{total} = 6680 \cdot lbs$

Max Uplift due to wind loading

$L_{unit.up} := L_{unit} - 0in = 74.375 \cdot in$

$P_{uplift.W} := P_v \cdot L_{unit.up} \cdot W_{unit} = 3521 \cdot lbs$

Max Net Tension Reaction On Each Side Due To Wind loading

$$T_W := \begin{pmatrix} \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} - \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \\ \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} - \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} -9270 \\ -4630 \end{pmatrix} \cdot lbs$$

Max Net Compression Reaction On Each Side Due To Wind loading

$$C_W := \begin{pmatrix} \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} + \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \\ \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} + \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} 10189 \\ 5495 \end{pmatrix} \cdot lbs$$

Governing Loading @ Curb

Max uplift vertical load along the length of the curb

$$\omega_{x.L.vert.up} := \frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}} = 1651 \cdot plf$$

Max compressive vertical load along the length of the curb

$$\omega_{x.L.vert.comp} := \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}} = 2330 \cdot plf$$

Max vertical load along the length of the curb

$$\omega_{x.L.vert} := \max\left(\omega_{x.L.vert.up}, \omega_{x.L.vert.comp}\right) = 2330 \cdot plf$$

Max uplift vertical load along the width of the curb

$$\omega_{x.W.vert.up} := \frac{\max\left[\left|T_{S_{(1)}}\right|, \left|T_{W_{(1)}}\right|\right]}{W_{curb}} = 1494 \cdot plf$$

Max compressive vertical load along the width of the curb

$$\omega_{x.W.vert.comp} := \frac{\max\left[\left|C_{S_{(1)}}\right|, \left|C_{W_{(1)}}\right|\right]}{W_{curb}} = 2595 \cdot plf$$

Max vertical loading along the width of the curb

$$\omega_{x.W.vert} := \max\left(\omega_{x.W.vert.up}, \omega_{x.W.vert.comp}\right) = 2595 \cdot plf$$

$$\begin{pmatrix} V_{base.S} \\ V_{base.W} \end{pmatrix} = \begin{pmatrix} 5721 \\ 6680 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} \left|T_S\right| \\ \left|C_S\right| \end{pmatrix} = \begin{pmatrix} 8826 \\ 15354 \end{pmatrix} \cdot lbs$$

$$\begin{pmatrix} F_v \cdot Wt_{tot} \\ P_v \cdot L_{unit} \cdot W_{unit} \end{pmatrix} = \begin{pmatrix} 509 \\ 3521 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} \left|T_W\right| \\ \left|C_W\right| \end{pmatrix} = \begin{pmatrix} 10362 \\ 11576 \end{pmatrix} \cdot lbs$$

Anchorage To Concrete [Expansion Anchor per ACI 318-14]

Number of connection on the long side

$N_B := 4 + 2$

Moment Arm for overturning (Short side)

$B := W_{curb} + 3in \cdot 2 = 43 \cdot in$

Number of Connection on the Short side.

$N_L := 3 + 2$

Moment Arm for over turning (Long side)

$L := L_{curb} + 3in \cdot 2 = 73 \cdot in$

Total Number of Connections

$N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 14$

Max Net Tension Reaction Due to Seismic Load, Fp

$$R_{c.EQ.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 19 \cdot lbs \qquad R_{c.EQ.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 5 \cdot lbs$$

$$R_{c.EQ} := MAX+\left[\left[\left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{c.EQ.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t}\right]\right] = \begin{pmatrix} 2305 \\ 1598 \end{pmatrix} \cdot lbs$$

$$\left[\left[\left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{c.EQ.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t}\right]\right]$$

Max net Tension Reaction Due to Wind Load, Pnet

$$R_{c.W} := MAX+\left[\left[\begin{array}{l} \frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t} \end{array}\right]\right] = \begin{pmatrix} 1330 \\ 810 \end{pmatrix} \cdot lbs$$

Governing Load Case:

$Govern := if\left(\left|R_{c.EQ}\right| > \left|R_{c.W}\right|, "Seismic", "Wind"\right) = "Seismic"$

Governing Tension Reaction at Each anchor Point:

$R_c := if\left(Govern = "Seismic", R_{c.EQ}, R_{c.W}\right) = \begin{pmatrix} 2305 \\ 1598 \end{pmatrix} \cdot lbs$

Max Tension on anchor: $N_{ua} := |R_c| = 2804 \cdot lbs$

Max Shear on anchor: $V_{ua} := \frac{\max(\Omega_0 \cdot V_{base.S}, V_{base.W})}{N_t} = 817 \cdot lbs$

Hilti Kwik Bolt TZ – Carbon Steel
5/8" Anchor with min 4" embedment
Base material: 6" thick Cracked concrete w/
Compressive strength fc' = 3000 psi
Min 6" away from the concrete edge
Evaluation Report: ICC-ESR 1917

Loading Condition:	**Seismic**

Design Tension Capacity [ϕN_n]:	3,631	[lbs]
Design Shear Capacity [ϕV_n]:	4,940	[lbs]

$\phi N_n := \phi N_n \cdot lbs = 3631 \cdot lbs$

$\phi V_n := \phi V_n \cdot lbs = 4940 \cdot lbs$

Utilization:

Tension Utilization: $\beta_N := \frac{N_{ua}}{\phi N_n} = 77 \cdot \%$

Shear Utilization: $\beta_V := \frac{V_{ua}}{\phi V_n} = 17 \cdot \%$

Interaction of Tensile and Shear Forces:
Per ACI 318-14 Sec. 17.6

$\beta_{NV} := \frac{(\beta_N) + (\beta_V)}{1.2} = 78 \cdot \%$

$$check\_interaction := \begin{pmatrix} if(\beta_N < 1.0, "OK", "NG") \\ if(\beta_V < 1.0, "OK", "NG") \\ if(\beta_{NV} < 1.0, "OK", "NG") \end{pmatrix} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

$$check\_interaction = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

Anchorage To Structural Steel [Fillet Weld Conn. per AISI S100-16]

Fillet Weld 2" Long Along the Long and Short Side. Min 2 Connections per Side
Spacing: 48" O.C. for Non-Isolated Curbs; 24" for Isolated Curbs

Number of Welds on the Long Side $N_B := 4$

Moment Arm for Overturning (Short Side) $B := W_{curb} = 37 \cdot in$

Number of Welds on the Short Side. $N_L := 2$

Moment Arm for Overturning (Long Side) $L := L_{curb} = 67 \cdot in$

Total Number of Connections $N_t := \left[\left(N_B\right) + \left(N_L\right)\right] \cdot 2sides = 12$

Max Net Tension Reaction due to Seismic Load FP

$$R_{weld.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 33 \cdot lbs$$

$$R_{weld.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 13 \cdot lbs$$

$$R_{weld.EQ} := MAX+\left[\begin{bmatrix}\left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{weld.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{weld.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}2003 \\ 2195\end{pmatrix} \cdot lbs$$

Max Net Tension Reaction due to Wind Load Pnet

$$R_{weld.W} := MAX+\left[\begin{bmatrix}\frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}2234 \\ 1982\end{pmatrix} \cdot lbs$$

Tension Design Force; SRSS for Loading from Each Direction $T_{u.weld} := \max\left(\left|R_{weld.EQ}\right|, \left|R_{weld.W}\right|\right) = 2987 \cdot lbs$

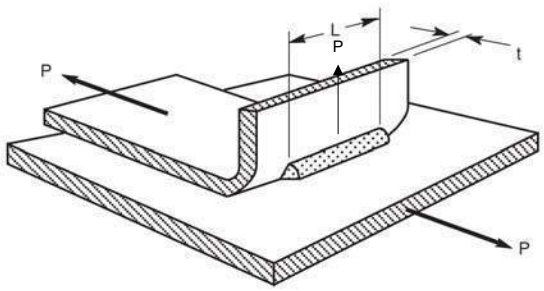
Shear Load at Each Weld Connection $V_{u.weld} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{N_t} = 557 \cdot lbs$

Total Demand: SRSS of V and T

$$R_{u.weld} := \sqrt{T_{u.weld}^2 + V_{u.weld}^2} = 3038 \cdot lbs$$

Fillet Weld Design per AISI S100-16 Section J2.5

Weld Length at Each Connection Point $L_w := 2in$



Effective Throat Fillet Weld Size

$$t_w := \left(\frac{1}{8}in\right) \cdot 0.707 = 0.088 \cdot in$$

Thickness for the Thinnest Martial Being Welded
Min Curb Thickness = 16GA with Fu=65 ksi

$t_1 := thick("12GA") = 0.1084 \cdot in$

$F_u := 65ksi$

Min weld material strength

$F_{exx} := 70ksi$

For Longitudinal Loading [Parallel capacity is considered to be loading in the direction of the length of the weld] per (Eq. J2.5-1) &(Eq. J2.5-2)

$$\phi P_{long} := \begin{cases} (0.6)\left(1 - \frac{0.01 \cdot L_w}{t_1}\right) \cdot L_w \cdot t_1 \cdot F_u & \text{if } \frac{L_w}{t_1} < 25 \\ (0.5) \cdot 0.75 \cdot t_1 \cdot L_w \cdot F_u & \text{otherwise} \end{cases} = 6895 \cdot lbs$$

where $L_w \div t_1 = 18$

For Transverse Loading per (Eq. J2.5-5)

$$\phi P_{trans} := (0.65) \cdot t_1 \cdot L_w \cdot F_u = 9160 \cdot lbs$$

Strength of Weld Material per (Eq. J2.5-7)

$$\phi P_{weld} := (0.6) \cdot 0.75 \cdot t_w \cdot L_w \cdot F_{exx} = 5568 \cdot lbs$$

Design Strength of Fillet Weld

$$\phi P_n := \min\left(\phi P_{long}, \phi P_{trans}, \phi P_{weld}\right) = 5568 \cdot lbs$$

D/C Ratio for the Welded Connection

$$\beta_{NW} := \frac{R_{u.weld}}{\phi P_n} = 55 \cdot \%$$

$weld_{check} := if\left(\beta_{NW} < 1.0, "OK", "NG"\right)$

$weld_{check} = "OK"$

Anchorage To Wood Member WITH Lag Screws [NDS-2018 LRFD Strength Design]

*** Use 3/8" Lag Screws along Each Side of the Curb**
*** Assume G=0.5 Douglas Fir-Larch**

Wood Lag Screw Capacity per NDS 2018 Section 11.3

Wet Service Factor: $Cond := "DRY"$ **(e.g. CA = "DRY", AK = "WET")**

$$C_M := \begin{cases} 1.0 & \text{if } Cond = "DRY" \\ 0.7 & \text{if } Cond = "WET" \end{cases} = 1$$ **NDS 2018 Table 11.3.3**

Temperature Factor:
$$C_t := \begin{cases} 0.8 & \text{if } Cond = "DRY" \\ 0.7 & \text{if } Cond = "WET" \end{cases} = 0.8$$ **NDS 2018 Table 11.3.4**

Group Action Factor: $C_g := 0.97$ **NDS 2018 Table 11.3.6C**

Geometry Factor: $C_\Delta := 1.0$ **NDS 2018 Table 12.5.1A,B**

End Grain Factor: $C_{eg} := 1.0$ **NDS 2018 Sec. 12.5.2**

Diaphragm Factor: $C_{di} := 1.0$ **NDS 2018 Sec. 12.5.3**

Toe-Nail Factor: $C_{tn} := 1.0$ **NDS 2018 Sec. 12.5.4**

Format Conversion Factor: $K_F := 3.32$ **NDS 2018 Table 11.3.1**

Resistance Factor: $\phi := 0.65$ **NDS 2018 Table 11.3.1**

Time Effect Factor: $\lambda := 1.0$ **NDS 2018 App N.3.3**

Lateral Design Value: $Z := 130lbs$ **NDS 2018 Table 12K**

Withdrawal Design Value: $W := 305lbs$ **NDS 2018 Table 12.2A**

Lag Screw Diameter: $D_{lag} := \frac{3}{8}in$

Lag Screw Length: $L_{lag} := 4in$

Length of Tapered Tip: $E_{lag} := \frac{7}{32}in$

Lag Screw Penetration: $P_{lag} := 3.78125in$

Eff. Lag Screw Penetration for withdrawal: $P_{\omega.lag} := 2in + \frac{9}{32}in = 2.28 \cdot in$ **NDS 2018 Appx. Table L2**

NDS 2018 Sec. 12.1.4.6

Minimum Penetration DCR <1.0: $DCR_{min.penetration} := \frac{4 \cdot D_{lag}}{P_{\omega.lag}} = 0.66$ $DCR_{min.penetration} = "OK"$

Adj. Lateral Design Value: $Z' := Z \cdot C_M \cdot C_t \cdot C_g \cdot C_\Delta \cdot C_{eg} \cdot C_{di} \cdot C_{tn} \cdot K_F \cdot \phi \cdot \lambda = 218 \cdot lbs$

Adj. Withdrawal Design Value: $W' := W \cdot C_M^{\,2} \cdot C_t \cdot C_{eg} \cdot C_{tn} \cdot K_F \cdot \phi \cdot \lambda = 527 \cdot lbs$ **NDS 2018 Table 11.3.1**

Number of Lag Screws on the Long Side $N_B := 16 + 2$

Moment Arm for Overturning (Short Side) $B := W_{curb} = 37 \cdot in$

Number of Lag Screws on the Short Side $N_L := 7 + 2$

Moment Arm for Overturning (Long Side) $L := L_{curb} = 67 \cdot in$

Total Number of Lag Screws $N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 46$

Max net Tension Reaction due to Seismic, Fp

$$R_{lag.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 7 \cdot lbs$$

$$R_{lag.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 3 \cdot lbs$$

$$R_{lag.EQ} := MAX+\left[\begin{bmatrix} \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{lag.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{lag.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 442 \\ 485 \end{pmatrix} \cdot lbs$$

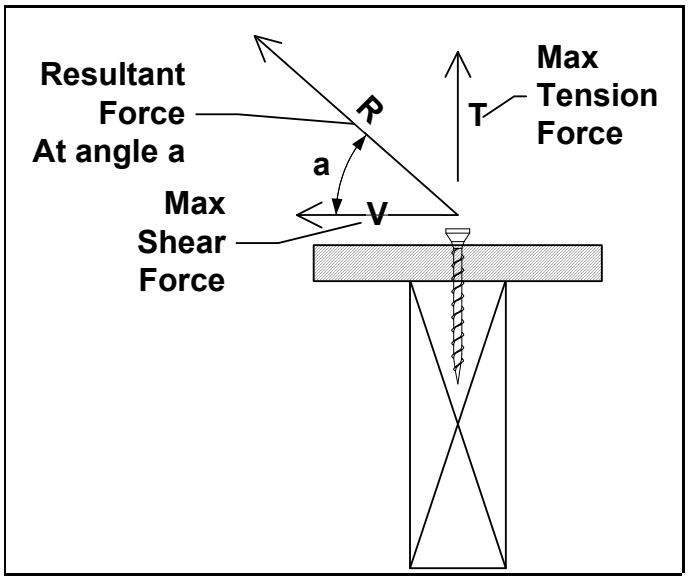
Max net Tension Reaction due to Wind load, Pnet

$$R_{lag.W} := MAX+\left[\begin{bmatrix} \frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{L \cdot N_L \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 503 \\ 447 \end{pmatrix} \cdot lbs$$

Tension Design force; SRSS for loading from Each direction $T_{lag} := \max\left(\left|R_{lag.EQ}\right|, \left|R_{lag.W}\right|\right) = 673 \cdot lbs$

Shear load at each anchor location $V_{lag} := \frac{\max\left(V_{base.S} \cdot \sqrt{2}, V_{base.W}\right)}{N_t} = 176 \cdot lbs$

For Lag Screws Subjected to Combined Lateral and Withdrawal Loading; Design Strength of the Lag Screw Shall Be Adjusted per Hankinson Formula as Prescribed by NDS 2018 Equation 12.4-1



Angle Between Wood Surface and Direction of Resultant Applied Load

$$(\alpha) := \operatorname{atan}\left(\frac{T_{lag}}{V_{lag}}\right) = 75\cdot deg$$

Combined Demand per Lag Screw @ Strength Level

$$R_{lag} := \sqrt{T_{lag}^{2} + V_{lag}^{2}} = 695\cdot lbs$$

Adjusted Capacity per NDS 2018 Equation 12.4-1 @ Strength Level

$$Z'_{\alpha} := \frac{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot Z'}{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot\cos(\alpha)^{2} + Z'\cdot\sin(\alpha)^{2}} = 932\cdot lbs$$

D/C Ratio for the Lag Screw connection to Wood Structure

$$\beta_{Lag} := \frac{R_{lag}}{Z'_{\alpha}} = 75\cdot\%$$

$$Lag_{Screw.Check} := \text{if}\left(\beta_{Lag} < 1.0, \text{"OK"}, \text{"NG"}\right)$$

$Lag_{Screw.Check}$ = "OK"

Bearing and Tilting in Curb Bolted Connection AISI S100-16

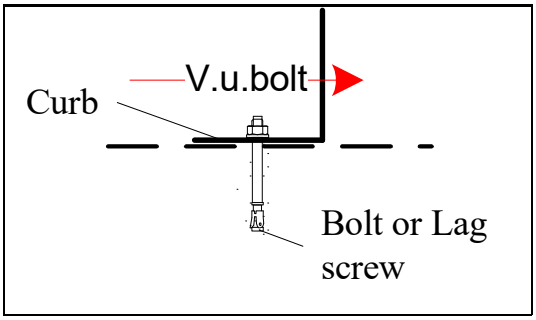
Nominal bolt diameter $d := 0.5in$

Uncoated sheet thickness $t_{curb} := thick("12GA") = 0.108 \cdot in$

Tensile strength of sheet $F_u := 65ksi$

Coefficient for conversion of units $\alpha := 1.0$

Modification Factor $m_f := 1.0$



Modification factor for type of bearing connection, per Table J3.3.1-2; For single shear connection with washers

Bearing Factor

$$C := \begin{cases} 3 \text{ if } \left(\frac{d}{t_{curb}} < 10\right) \wedge \left(0.024in < t_{curb} < 0.1875in\right) = 3 \\ "NG" \text{ if } \frac{d}{t_{curb}} > 10 \end{cases}$$

Bearing factor, which shall be determined according to Table J3.3.1-1 For d/t<10 where $d \div t_{curb} = 5$

Bearing Design Strength per AISI S100-16 Eq. J3.3.1-1

$$\phi P_{n_{(0)}} := (0.6) \cdot \left(m_f \cdot C \cdot d \cdot t_{curb} \cdot F_u\right) = 6341 \cdot lbs$$

Bolt Hole Deformation Design Strength per AISI S100-16 Eq. J3.3.2-1

$$\phi P_{n_{(1)}} := (0.65) \cdot \left[4.64 \cdot \left(\frac{\alpha}{in}\right) \cdot t_{curb} + 1.53\right] \cdot d \cdot t_{curb} \cdot F_u = 4655 \cdot lbs$$

Curb Connection Shear Capacity $\phi P_n := \min\left(\phi P_n\right) = 4655 \cdot lbs$

Loading demand at connection

$$V_{u.bolt} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{4} = 1670 \cdot lbs$$

$Curb\_Conn\_Shear := if\left(V_{u.bolt} < \phi P_n, "OK", "NG"\right)$

Curb_Conn_Shear = "OK"

Thickness of Curb, ISO Rail and Clip

(Per AISC Table 17-10 Galvanized)

Hold Down Clip thickness

$t_{Clip} := \text{"12GA"}$ $t_{clip} := thick(t_{Clip}) = 0.1084 \cdot in$

Roof Curb thickness

$t_{Curb} := \text{"12GA"}$ $t_{curb} := thick(t_{Curb}) = 0.1084 \cdot in$

ISO RAIL thickness

$t_{Curb.iso} := \text{"10GA"}$ $t_{curb.iso} := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Note: Iso Rail thickness is only used if the curb is isolated. Not used for non-isolated curbs

Sheet Metal Screws (SMS) Equations and References

SMS properties (ESR-2196 Table 5)

$SMS_{Table} =$

"SMS"	"Diameter"	"HeadDiameter"	"Tension"	"Shear"
"Size"	"d"	"dw"	"Pts"	"Pss"
"#8"	0.164	0.335	1000	1170
"#10"	0.19	0.399	1370	1215
"#12"	0.216	0.415	2325	1880
"#14"	0.25	0.5	4580	2440

SMS Tension Eqns

$P_{not} = 0.85 \cdot t \cdot d \cdot F_u$ **(AISI S100-16 J4.4.1 & J4.4.2)**

$P_{nov} = 1.5 \cdot t \cdot d_w \cdot F_u$

$P_{nts} = 0.8 \cdot P_{ts}$

FOR THE MOST CASES, PULL-OUT CAPACITY IS THE LOWEST

SMS Shearn Eqns

$P_{vnot} = 4.2 \cdot \sqrt{(d \cdot t^3)} \cdot F_u$ **(AISI S100-16 J4.3.1)**

$P_{vnov} = 2.7 \cdot t \cdot d \cdot F_u$

$P_{vnss} = 0.8 \cdot P_{ss}$

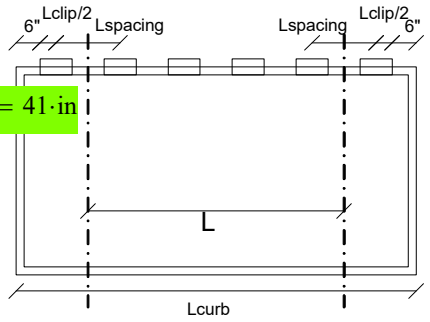
Hold Down Clip Design (Connection of the Mechanical unit to Curb)

Number of Clips on the long side $N_B := 4$

Moment Arm for overturning (Short side) $B := W_{curb} + 1.75in \cdot 2 = 41 \cdot in$

Number of Clips on the Short side. $N_L := 4$

Width of Clips $L_{clip} := 9in$



Curb Centerline Spacing (Long side)

$$L_{spacing} := \frac{L_{curb} - \left(6in + \frac{L_{clip}}{2}\right) \cdot 2}{N_B - 1} = 15.458 \cdot in$$

Moment Arm for overturning (Long side)

$$L := L_{curb} - 2 \cdot \left[6in + \frac{L_{clip}}{2} + L_{spacing} \cdot \frac{(N_L - 2)}{4}\right] = 30.917 \cdot in$$

Total Number of Clips

$$N_t := (N_B) \cdot 2sides = 8$$

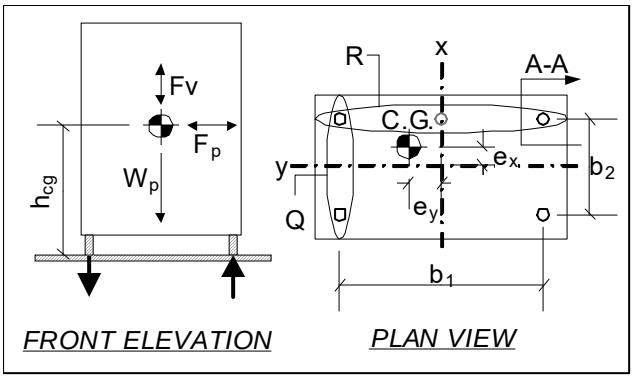
Max net Tension Reaction due to Seismic, Fp

$$R_{clip.EQ} := MAX+\left[\begin{array}{l} \left[\frac{F_p \cdot Wt_{unit}}{B \cdot N_B} \cdot h_{CG.unit} + \frac{(0.9 - F_v) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B}\right] - \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} \\ \left[\frac{F_p \cdot Wt_{unit}}{L \cdot N_L} \cdot h_{CG.unit} + \frac{(0.9 - F_v) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L}\right] - \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} \end{array}\right] = \begin{pmatrix} 420 \\ 552 \end{pmatrix} \cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$R_{clip.W} := MAX+\left(\begin{array}{l} \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{unit}^2}{2}}{B \cdot N_B} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{unit}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{unit}^2}{2}}{L \cdot N_L} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{unit}}{N_t} \end{array}\right) = \begin{pmatrix} 753 \\ 752 \end{pmatrix} \cdot lbs$$

Tensile and Shear Load calculation per ASHRAE RP-812



Eccentricity along X-X

$e_x := e_{width} = 7.5 \cdot in$

Eccentricity along Y-Y

$e_y := e_{length} = 2.562 \cdot in$

Distance between Seismic Restraints Along Y-Y

$b_1 := L_{curb} - 2 \cdot 6in = 55 \cdot in$

Distance between Seismic Restraints Along X-X

$b_2 := W_{curb} = 37 \cdot in$

Moment of Inertia about X-X

$$I_{xx} := \frac{N_t \cdot (N_t + 2) \cdot (b_1)^2}{12 \cdot (N_t - 2)} = 3407 \cdot in^2$$

Moment of Inertia about Y-Y

$$I_{yy} := \frac{N_t \cdot (b_2)^2}{4} = 2766 \cdot in^2$$

Angle about Tensile Load

$$\Theta_t := \operatorname{atan}\left[\frac{I_{yy} \cdot (b_1)}{I_{xx} \cdot (b_2)}\right] = 50 \cdot deg$$

Angle about Shear Load

$$\Theta_s := \begin{cases} \operatorname{atan}\left(\frac{e_x}{e_y}\right) & \text{if } e_y \neq 0 \\ 0deg & \text{if } e_y = 0 \end{cases} = 71 \cdot deg$$

Max Net Tensile Load Due to Seismic Load, Fp

$$T_{U.EQ.pt1} := \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} - \frac{(0.9 - F_v) \cdot Wt_{unit}}{b_1 \cdot b_2} \cdot \left(\frac{b_1}{2} \cdot e_x + \frac{b_2}{2} \cdot e_y - e_x \cdot e_y\right) = 7 \cdot lbs$$

$$T_{U.EQ.pt2} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \cos(\Theta_t) \cdot \frac{0.5 \cdot b_2}{I_{yy}} = -329 \cdot lbs$$

$$T_{U.EQ.pt3} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \sin(\Theta_t) \cdot \frac{0.5 \cdot b_1}{I_{xx}} = -481 \cdot lbs$$

$$T_{U.EQ} := T_{U.EQ.pt1} + T_{U.EQ.pt2} + T_{U.EQ.pt3} = -803 \cdot lbs$$

Max Net Shear Load Due to Seismic Load, Fp

$$V_{Ux.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\cos(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_2 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_1 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 277 \cdot lbs$$

$$V_{Uy.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\sin(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_1 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_2 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 532 \cdot lbs$$

$$V_{U.EQ} := \sqrt{V_{Ux.EQ}^2 + V_{Uy.EQ}^2} = 600 \cdot lbs$$

Tension Design force for Hold Down Clips

$$T_{clip} := \max\left(R_{clip.W_0}, R_{clip.W_1}, \left|R_{clip.EQ}\right|, \left|T_{U.EQ}\right|\right) = 803 \cdot lbs$$

Based on ASCE 7-16 Figure 29.4-1 magnitude of force coefficient,

Wind in diagonal direction to the face of equipment produces less force than that of the wind in perpendicular direction to the face of the equipment. Therefore, wind in diagonal direction does not need to be used

$$\left|R_{clip.EQ}\right| = 694 \cdot lbs \qquad \left|T_{U.EQ}\right| = 803 \cdot lbs$$

$$\left|R_{clip.W}\right| = 1064 \cdot lbs$$

$$T_{clip.EQ.max} := \max\left(\left|R_{clip.EQ}\right|, \left|T_{U.EQ}\right|\right) = 803 \cdot lbs$$

$$T_{clip.W.max} := \max\left(\left|R_{clip.W}\right|\right) = 1064 \cdot lbs$$

Shear Design force for Hold Down Clips

$$V_{clip} := \max\left(\frac{\max\left(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit}\right)}{N_t}, \left|V_{U.EQ}\right|\right) = 600 \cdot lbs$$

$$F_p \cdot Wt_{unit} \cdot \frac{1}{N_t} = 464 \cdot lbs \qquad \left|V_{U.EQ}\right| = 600 \cdot lbs$$

$$P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t} = 384 \cdot lbs$$

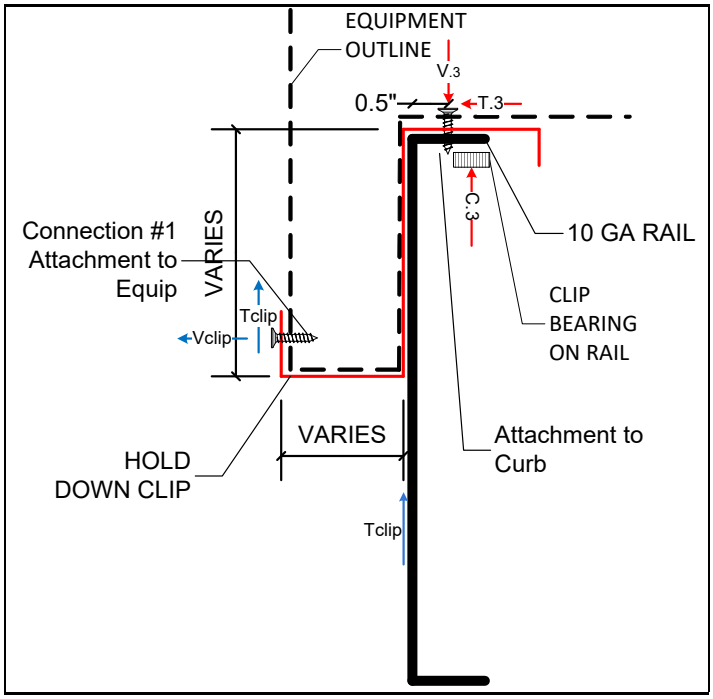
$$V_{clip.EQ.max} := \max\left[\left(F_p \cdot Wt_{unit} \cdot \frac{1}{N_t}\right), \left|V_{U.EQ}\right|\right] = 600 \cdot lbs$$

$$V_{clip.W.max} := \max\left(\left(P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t}\right)\right) = 384 \cdot lbs$$

Loading at Hold Down Clips @ Isolator Curb

$b_{return.iso} := Clip_b \cdot in = 2.625 \cdot in$

$b_{depth.iso} := Clip_c \cdot in = 4.563 \cdot in$



*For Reference Only

Mu Bending moment in the hold down

$M_u := T_{clip} \cdot b_{return.iso} = 2108 \cdot in \cdot lbs$

Resolve bending moment a T/C couple
Assume 0.5" bearing length
Moment Arm for T/C couple

$d_{T/C} := 1in - 0.5in = 0.5 \cdot in$

V3 is acting as shear on the screws. due to eccentricity of Tension force T

$$V_3 := \frac{T_{clip} \cdot \left[b_{return.iso} + (0) \right]}{d_{T/C}} = 4217 \cdot lbs$$

Additional load from Direct Shear acting out of plane (SRSS)

$$V_3 := \sqrt{V_3^{\,2} + V_{clip}^{\,2}} = 4259 \cdot lbs$$

Reaction C3 [compression force] is resisted by bearing of the hold down on the curb lip. Assume 0.5" bearing length

$C_3 := V_3 - T_{clip} = 3456 \cdot lbs$

T3 Load due to the shear acting out of plane tension on the screws.

$$T_3 := \left(\max\left(\frac{T_{clip} \cdot b_{return.iso}}{b_{depth.iso}}, V_{clip} \right) \right) = 600 \cdot lbs$$

Check Bending in Clip @ Isolator Curb

There are several restraints that prevents the hold down clip for iso-curb to have local bending at the bottom and transfer vertical load demand directly to the face of the curb.

- Hold down is bearing on the face of iso-rail / non-iso curb lip.
- Gasket will act as a "link" member to allow unit base rail and bottom flange to move totegther so flange can't bend unless the unit base rail bends first. However, unit base rail is not likely to bend so bottom flange won't bend

Hold Down Clip thickness

$t_{Clip} = \text{"12GA"}$ $t_{clip} := \text{thick}(t_{Clip}) = 0.1084 \cdot in$

Effective width of hold down clip

$b_c := L_{clip} = 9 \cdot in$

Yield strength of the Clip

$F_{y.c} := 50ksi$

Strength reduction for bending

$\phi_{clip} := 0.9$

Design Bending Capacity (LRFD)

$$\phi M_n := \phi_{clip} \cdot F_{y.c} \left(\frac{b_c \cdot t_{clip}^{\,2}}{6} \right) = 793 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.clip} := T_{clip} \cdot 0.5in = 402 \cdot in \cdot lbs$

D/C Ratio for bending

$$DCR := \frac{M_{u.clip}}{\phi M_n} = 0.506$$

$Clip_{Bending} = \text{"OK"}$

Check Flange Bending in Clip @ Isolator Curb

Note:
- **If the curb flange is welded to the 10GA channel and 10GA channel is welded back to the base of the curb, then both tension and compression due to equipment overturning will be taken care by the 10GA channel.**
- **Since the curb will be reinforced with 10GA channel under each isolator, it can be assumed that the loads will trasnferred down to the base structure through the channels. Therefore, flange downward bending at curb due to compressive load does not need to be checked.**

Roof Curb thickness

$t_{Curb} = \text{"12GA"}$ $t_{curb} := thick(t_{Curb}) = 0.1084 \cdot in$

Clip edge to edge distance

$$b_{edge2edge} := \frac{L_{curb} - \left(6in + \frac{L_{clip}}{2}\right)\cdot 2}{N_B - 1} - L_{clip} = 6.458 \cdot in$$

Effective width of Roof Curb

$b_{curb} := L_{clip} + b_{edge2edge} = 15.46 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb}\left[\frac{b_{curb}\cdot(t_{curb})^2}{6}\right] = 1362 \cdot in \cdot lbs$$

Width of Isolator

$w_{JQ.iso} := 2in$ **2 in. for CQAs**

Flexural bending demand

$$M_{u.Curb} := T_{clip}\cdot\left(\max\left(\frac{1.75in}{2} - 0.5in, \frac{w_{JQ.iso}}{2} - 1in\right)\right) = 301 \cdot in \cdot lbs$$

D/C Ratio for bending

$$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.221$$

$Curb_{Bending} = \text{"OK, Weld 10GA channel ends to curb flange"}$

Design of Connection#1 Connection of Equipment to hold Down clip

Ultimate SMS screw connection Strength (LRFD)
Strength based on the smallest thickness of Curb and Equipment Housing (min 16 GA) [Fy = 50ksi & Fu=65ksi]

$n_{sms} := 4$ $\quad Size_{ss} := "\#14"$

$t_{ss} := "16GA"$ $\quad F_{u.ss} := 65ksi$

Nominal Tension Strength

$$P_{nt} := n_{sms} \cdot T_s\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 3508 \cdot lbs$$

$$P_{not} := n_{sms} \cdot T_{not}\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 3508 \cdot lbs$$

$$P_{nov} := n_{sms} \cdot T_{nov}\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 12383 \cdot lbs$$

$$P_{nts} := n_{sms} \cdot T_{nts}\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 14656 \cdot lbs$$

Nominal Shear Strength

$$P_{ns} := n_{sms} \cdot V_s\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 7808 \cdot lbs$$

$$P_{vnot} := n_{sms} \cdot V_{not}\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 8737 \cdot lbs$$

$$P_{vnov} := n_{sms} \cdot V_{nov}\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 11144 \cdot lbs$$

$$P_{vnss} := n_{sms} \cdot V_{nss}\left(Size_{ss}, t_{ss}, F_{u.ss}\right) = 7808 \cdot lbs$$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} V_{clip} \div \left(\phi_{sms} \cdot P_{nt}\right) \\ T_{clip} \div \left(\phi_{sms} \cdot P_{ns}\right) \end{bmatrix} = \begin{pmatrix} 34 \\ 21 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left(\begin{bmatrix} \left[\frac{T_{clip}}{P_{vnov}} + 0.71\left(\frac{V_{clip}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{T_{clip}}{P_{vnot}} + \left(\frac{V_{clip}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{T_{clip}}{P_{vnss}} + \left(\frac{V_{clip}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right) = 38 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

Design of Connection#2 Connection of hold Down clip to Curb

Tension loads on SMS connection

$T_{s2} := V_3 = 4259 \cdot lbs$

Shear loads on SMS connection

$V_{s2} := T_3 = 600 \cdot lbs$

Ultimate SMS screw connection Strength (LRFD)
Strength based on the smallest thickness of Curb and Equipment Housing (min 16 GA) [Fy = 50ksi & Fu=65ksi]

$n_{sms} := 8$ $Size_{ss} := "\#14"$

$t_{ss} := (t_{Curb.iso}) = "10GA"$ $F_{u.ss} := 65ksi$

Nominal Tension Strength

$P_{nt} := n_{sms} \cdot T_s(Size_{ss}, t_{ss}, F_{u.ss}) = 15271 \cdot lbs$

Note:
SMS is getting pulled up so the thicker curb iso rail is engaged for SMS capacity , rather than just the clip itself.

$P_{not} := n_{sms} \cdot T_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 15271 \cdot lbs$

$P_{nov} := n_{sms} \cdot T_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 53898 \cdot lbs$

$P_{nts} := n_{sms} \cdot T_{nts}(Size_{ss}, t_{ss}, F_{u.ss}) = 29312 \cdot lbs$

Nominal Shear Strength

$P_{ns} := n_{sms} \cdot V_s(Size_{ss}, t_{ss}, F_{u.ss}) = 15616 \cdot lbs$

$P_{vnot} := n_{sms} \cdot V_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 56103 \cdot lbs$

$P_{vnov} := n_{sms} \cdot V_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 48508 \cdot lbs$

$P_{vnss} := n_{sms} \cdot V_{nss}(Size_{ss}, t_{ss}, F_{u.ss}) = 15616 \cdot lbs$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} T_{s2} \div (\phi_{sms} \cdot P_{nt}) \\ V_{s2} \div (\phi_{sms} \cdot P_{ns}) \end{bmatrix} = \begin{pmatrix} 56 \\ 8 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left[\begin{bmatrix} \left[\frac{V_{s2}}{P_{vnov}} + 0.71\left(\frac{T_{s2}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{V_{s2}}{P_{vnot}} + \left(\frac{T_{s2}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{V_{s2}}{P_{vnss}} + \left(\frac{T_{s2}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right] = 42 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

Hold Down clip Bending and Shear Interaction

Diameter of SMS:

$d_{sms} := vlookup(Size_{ss}, SMS_{Table}, 1)_0 \cdot in = 0.25 \cdot in$

Depth of flat web portion

$h_{clip.shear} := L_{clip} - n_{sms} \cdot d_{sms} = 7 \cdot in$

Depth-to-Thickness Ratio:

$\frac{h_{clip.shear}}{t_{clip}} = 65 \qquad E := 29500ksi \qquad F_y := 50ksi \qquad \mu := 0.3$

Nominal Shear Stress:
(For unreinforced web)
AISI S100-16 G2.1

$k_v := 5.34 \qquad \sqrt{\frac{E \cdot k_v}{F_y}} = 56 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 85$

Area of Web Element:

$A_w := h_{clip.shear} \cdot t_{clip} = 0.759 \cdot in^2$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h_{clip.shear}}{t_{clip}}\right)^2} = 34.1 \cdot ksi$$

$V_{cr} := A_w \cdot F_{cr} \qquad V_y := 0.6 \cdot A_w \cdot F_y = 23\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.937$

Hole Shear Reduction Factor:
(for circular holes, AISI S100-16 Eq G3-1)

$c := \frac{h_{clip.shear}}{2} - \frac{d_{sms}}{2.83} = 3.41 \cdot in$

$$q_s := \begin{cases} 1.0 & \text{if } \frac{c}{t_{clip}} \geq 54 \\ \frac{c}{54 \cdot t_{clip}} & \text{if } 5 \leq \frac{c}{t_{clip}} < 54 \end{cases} = 0.583$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \leq 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \leq 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 19.792 \cdot kip$$

Design Shear Capacity with holes:

$\phi V_{n.clip} := 0.95 \cdot V_n \cdot q_s = 11 \cdot kip$

D/C Ratio of V and M per AISI S100-16 Eq H2-1

$$DCR_{V.M.int.clip} := \sqrt{\left(\frac{M_{u.clip}}{\phi M_n}\right)^2 + \left(\frac{\max(T_{clip}, V_{clip})}{\phi V_{n.clip}}\right)^2} = 0.5116$$

Demand/Capacity Ratio:

$VandM_{int.clip} = \text{"OK"}$

ISOLATOR DESIGN [PER OPM-0401-13]

OPM-0401-13 is based on allowable stress design

Number of isolators on the long side

$N_B := 4.5$ $N_{iso.long} := N_B = 5$

Moment Arm for overturning (Short side)

$B := W_{curb} + \frac{1.75in}{2} \cdot 2 = 39 \cdot in$

Number of isolators on the Short side.

$N_L := 4$

Isolator Centerline Spacing (Long side)

$L_{spacing.iso} := \frac{L_{curb} - (6in) \cdot 2}{N_B - 1} = 15.82 \cdot in$

Moment Arm for overturning (Long side)

$L := L_{curb} - 2 \cdot 6in - 2 \cdot L_{spacing.iso} \cdot \frac{(N_L - 2)}{4} = 40 \cdot in$

Total Number of isolators

$N_t := (N_B) \cdot 2sides = 9$

Max net Tension Reaction due to Seismic, Fp

$EQ_{ASD} := \left[0.6 - (0.7 \cdot F_v)\right] \cdot Wt_{unit} = 0.429\ kip$

$$R_{iso.EQ} := MAX+\left[\begin{bmatrix}\left[\frac{(0.7F_p) \cdot Wt_{unit}}{B \cdot N_B} \cdot (h_{CG.unit} + 0in) + \frac{EQ_{ASD} \cdot e_{width}}{B \cdot N_B}\right] - \frac{EQ_{ASD}}{N_t} \\ \left[\frac{(0.7F_p) \cdot Wt_{unit}}{L \cdot N_L} \cdot (h_{CG.unit} + 0in) + \frac{EQ_{ASD} \cdot e_{length}}{L \cdot N_L}\right] - \frac{EQ_{ASD}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}278 \\ 299\end{pmatrix} \cdot lbs$$

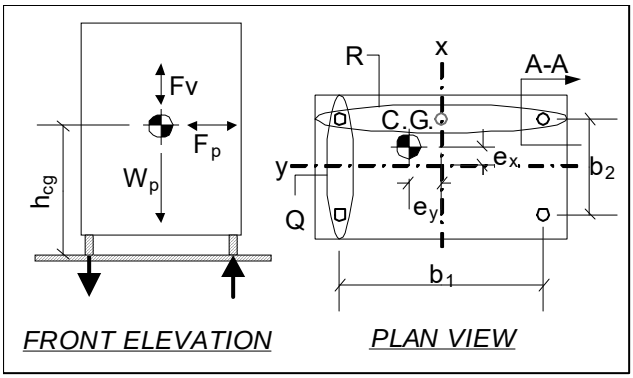
Max net Tension Reaction due to Wind load, Pnet

$$F_{wind.B} := \frac{P_{net} \cdot L_{unit} \cdot (H_{unit} + 0in)}{B \cdot N_B} \cdot \left(\frac{1}{2} \cdot H_{unit} + 0in\right) = 363 \cdot lbs$$

$$F_{wind.L} := \frac{P_{net} \cdot W_{unit} \cdot (H_{unit} + 0in)}{L \cdot N_L} \cdot \left(\frac{1}{2} \cdot H_{unit} + 0in\right) = 324 \cdot lbs$$

$$R_{iso.W} := (0.6) \cdot MAX+\left(\begin{pmatrix}F_{wind.B} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{Wt_{unit}}{N_t} \\ F_{wind.L} + \frac{P_v \cdot L_{unit.up} W_{unit}}{N_t} + \frac{Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{Wt_{unit}}{N_t}\end{pmatrix}\right) = \begin{pmatrix}407 \\ 367\end{pmatrix} \cdot lbs$$

Tensile and Shear Load calculation per ASHRAE RP-812



Eccentricity along X-X

$e_x := e_{width} = 7.5 \cdot in$

Eccentricity along Y-Y

$e_y := e_{length} = 2.56 \cdot in$

Distance between Seismic Restraints Along Y-Y

$b_1 := L_{curb} - 2 \cdot 6in = 55 \cdot in$

Distance between Seismic Restraints Along X-X

$b_2 := W_{curb} + 2 \cdot \frac{1.75in}{2} = 39 \cdot in$

Moment of Inertia about X-X

$I_{xx} := \frac{N_t \cdot (N_t + 2) \cdot (b_1)^2}{12 \cdot (N_t - 2)} = 3614 \cdot in^2$

Moment of Inertia about Y-Y

$I_{yy} := \frac{N_t \cdot (b_2)^2}{4} = 3411 \cdot in^2$

Angle about Tensile Load

$\Theta_t := \operatorname{atan}\left[\frac{I_{yy} \cdot (b_1)}{I_{xx} \cdot (b_2)}\right] = 53 \cdot deg$

Angle about Shear Load

$$\Theta_s := \begin{cases} \operatorname{atan}\left(\frac{e_x}{e_y}\right) & \text{if } e_y \neq 0 \\ 0deg & \text{if } e_y = 0 \end{cases} = 71 \cdot deg$$

Max Net Tensile Load Due to Seismic Load, Fp

$$T_{U.EQ.pt1} := \frac{(0.6 - 0.7 \cdot F_v) \cdot Wt_{unit}}{N_t} - \frac{(0.6 - 0.7 \cdot F_v) \cdot Wt_{unit}}{b_1 \cdot b_2} \cdot \left(\frac{b_1}{2} \cdot e_x + \frac{b_2}{2} \cdot e_y - e_x \cdot e_y\right) = 0 \cdot lbs$$

$$T_{U.EQ.pt2} := -0.7 \cdot (F_p \cdot Wt_{unit}) \cdot (h_{CG.unit} + 0in) \cdot \cos(\Theta_t) \cdot \frac{0.5 \cdot b_2}{I_{yy}} = -183 \cdot lbs$$

$$T_{U.EQ.pt3} := -0.7 \cdot (F_p \cdot Wt_{unit}) \cdot (h_{CG.unit} + 0in) \cdot \sin(\Theta_t) \cdot \frac{0.5 \cdot b_1}{I_{xx}} = -330 \cdot lbs$$

$T_{U.EQ} := T_{U.EQ.pt1} + T_{U.EQ.pt2} + T_{U.EQ.pt3} = -513 \cdot lbs$

Max Net Shear Load Due to Seismic Load, Fp

$$V_{Ux.EQ} := 0.7 \cdot F_p \cdot Wt_{unit} \cdot \frac{\cos(\Theta_s)}{N_t} + \frac{0.7 \cdot F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_2 \cdot e_y + 0.7 \cdot F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_1 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 172 \cdot lbs$$

$$V_{Uy.EQ} := 0.7 \cdot F_p \cdot Wt_{unit} \cdot \frac{\sin(\Theta_s)}{N_t} + \frac{0.7 \cdot F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_1 \cdot e_y + 0.7 \cdot F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_2 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 333 \cdot lbs$$

$$V_{U.EQ} := \sqrt{V_{Ux.EQ}^2 + V_{Uy.EQ}^2} = 375 \cdot lbs$$

Tension Design force SRSS for loading from Each direction

$R_{iso.EQ.1.RP812} := \left| T_{U.EQ.pt1} + T_{U.EQ.pt3} \right| = 330 \cdot lbs$

$R_{iso.EQ.0.RP812} := \left| T_{U.EQ.pt1} + T_{U.EQ.pt2} \right| = 183 \cdot lbs$

$$R_{iso.EQ.max_1} := \max\left[\left(R_{iso.EQ.1.RP812} + 0 \cdot R_{iso.EQ.0.RP812}\right), \left(R_{iso.EQ_1} + 0 \cdot R_{iso.EQ_0}\right)\right] = 330 \cdot lbs$$

$$R_{iso.EQ.max_0} := \max\left[\left(R_{iso.EQ.0.RP812} + 0 \cdot R_{iso.EQ.1.RP812}\right), \left(R_{iso.EQ_0} + 0 \cdot R_{iso.EQ_1}\right)\right] = 278 \cdot lbs$$

For the plot:

$R_{iso.EQ.max_1} = 330 \cdot lbs$ $R_{iso.W_1} = 367 \cdot lbs$

$R_{iso.EQ.max_0} = 278 \cdot lbs$ $R_{iso.W_0} = 407 \cdot lbs$

Shear load at each anchor location

For the plot:

$$V_{iso.E} := \max\left[\left[\begin{array}{c} 1.0 \cdot V_{Ux.EQ} + 0 \cdot V_{Uy.EQ} \\ 0.3 \cdot V_{Ux.EQ} + 0 \cdot V_{Uy.EQ} \\ \left[\left(0.7F_p\right) \cdot Wt_{unit} \cdot \frac{1}{N_t}\right] \end{array}\right]\right] = 289 \cdot lbs \qquad V_{iso.W} := 0.6P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t} = 205 \cdot lbs$$

Isolator Capacity:

$ID_{Iso} := "CQA"$

$T_{n.\Omega} := 2117lbs$ **(ASD)**

$T_{n.\Omega.45} := 808lbs$ **(ASD)**

$V_{n.\Omega} := 775lbs$ **(ASD)**

Isolator Demand:

$R_{iso.max} := \max\left[\left(R_{iso.EQ.max_1}\right), \left(R_{iso.EQ.max_0}\right), \left(R_{iso.W_1}\right), \left(R_{iso.W_0}\right)\right] = 407 \cdot lbs$

$V_{iso.max} := \max\left(V_{iso.E}, V_{iso.W}\right) = 289 \cdot lbs$

D/C Ratio of Tension Only.:

$$DCR_{tension} := \frac{R_{iso.max}}{T_{n.\Omega}} = 0.192$$

$DCR_{tension} = "OK"$

D/C Ratio of Shear Only.:

$$DCR_{shear} := \frac{V_{iso.max}}{V_{n.\Omega}} = 0.373$$

$DCR_{shear} = "OK"$

D/C Ratio of Tension Only.:

$$DCR_{Int} := \frac{V_{iso.max}}{V_{n.\Omega}} + \frac{R_{iso.max}}{T_{n.\Omega.45}} = 0.877$$

$DCR_{Int} = "OK"$

ISOLATOR "SPRING" DESIGN [PER OPM-0401-13]

Factor of Safety of Spring

$FS_{spring} := 0.75$

Compressive Strength of Spring

$$C_{spring.\Omega} := \begin{cases} \left(FS_{spring} \cdot 300lbs\right) & \text{if } ID_{Iso} = "CQA" \\ \left(FS_{spring} \cdot 918lbs\right) & \text{if } ID_{Iso} = "CQB" \\ \left(FS_{spring} \cdot 918lbs\right) & \text{if } ID_{Iso} = "CQBX" \end{cases} = 225 \cdot lbs$$

Rated Load per unit self-weight

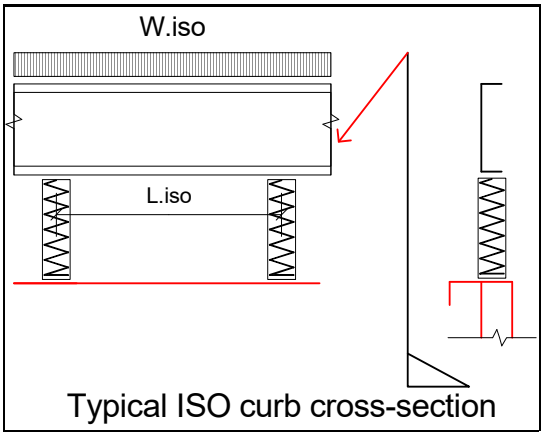
$$C_{unit.rated.load} := \frac{Wt_{unit}}{N_t} = 122 \cdot lbs$$

D/C Ratio of Spring Compression:

$$DCR := \frac{C_{unit.rated.load}}{C_{spring.\Omega}} = 0.543$$

$IsoSpring_{compression} = "OK"$

Check ISO Rail for Bending about Strong and Weak Axis (AISI S100-16 F2.1)



Typical ISO curb cross-section

Thickness of Curb:

$t_{Curb.iso}$ = "10GA" $t := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Inside Bend Radius:

$R := R_{iso} = 0.186 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web:

$h := 7.5in - 2 \cdot (t + R) = 6.85 \cdot in$

Width of Flange:

$h_w := 1in$

Check Curb Bending of Long Side (Strong axis)

Member per CFS: $CFS_{member} :=$ "10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"

Number of Isolators on each Long Side: $N_{iso.long} = 5$

Center-to-Center Spacing of Isolators $L_{iso} := \frac{L_{curb}}{N_{iso.long} - 1} = 19 \cdot in$

Distributed Load $\omega_{iso} := \omega_{x.L.vert} = 2.33\,klf$

Moment Demand on Iso Rail $M_{cx} := \frac{\omega_{iso} \cdot L_{iso}^2}{8} = 8.993 \cdot kip \cdot in$

Curb Elastic Modulus / Yield Stress: $E := 29500ksi$ $F_y := 50ksi$

Curb Shear Modulus: $G := 11300ksi$

Poisson's Ratio $\mu := 0.3$

Section Properties from CFS: $r_x = 2.4893 \cdot in$ $r_o = 2.519 \cdot in$ $C_w = 0.595 \cdot in^6$ $S_x = 1.855 \cdot in^3$

$r_y = 0.2288 \cdot in$ $J = 0.0058 \cdot in^4$ $S_y = 0.3669 \cdot in^3$

$r_{min} := min(r_x, r_y) = 0.2288 \cdot in$

Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Flanges*

Flat Width: $w := h_w - R_{curb} = 0.847 \cdot in$

Stiffened Web Check: $Stiffened_{check} := "Unstiffened"$

Stress at the end of the Width: $f_2 := 11.407ksi$ $f_1 := 11.407ksi$

Compressive Stress Ratio (Eq. 1.1.2-1): $\Psi := \frac{f_2}{f_1} = 1$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = "Stiffened" \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = "Unstiffened" \end{cases} = 0.43$$

Critical Compressive Stress: $F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot (1 - \mu^2)} \cdot \left(\frac{t}{w}\right)^2 = 304.86 \cdot ksi$

Stress in Compression Element: $f := 18ksi$

Note: Use f from "Elastive Flexural Buckling Stress" on "Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI E2)"

Slenderness Factor: $\lambda := \sqrt{\frac{f}{F_{cr}}} = 0.24$

Local reduction factor: $\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 0.389$

Effective Width of the Flanges:

$$b_{eff.flange} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 0.847 \cdot in$$

Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Web*

Flat Width: $w := h = 6.851 \cdot in$

Stiffened Web Check: $Stiffened_{check} := "Stiffened"$

Stress at the end of the Width: $f_2 := 11.407ksi$ $f_1 := 11.407ksi$

Compressive Stress Ratio (Eq. 1.1.2-1): $\Psi := \frac{f_2}{f_1} = 1$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = "Stiffened" \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = "Unstiffened" \end{cases} = 4$$

Critical Compressive Stress: $F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot (1 - \mu^2)} \cdot \left(\frac{t}{w}\right)^2 = 43.4 \cdot ksi$

Stress in Compression Element: $f := 18ksi$

Note: Use f from "Elastive Flexural Buckling Stress" on "Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI E2)"

Slenderness Factor: $\lambda := \sqrt{\frac{f}{F_{cr}}} = 0.64$

Local reduction factor: $\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 1.022$

Effective Width of the Web:

$$b_{eff.web} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 6.851 \cdot in$$

Effective Area of the Member: $A_e := 2 \cdot (b_{eff.flange} \cdot t) + b_{eff.web} \cdot t = 1.181 \cdot in^2$

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. F2.1.1-4,5)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(1.0 \cdot L_{iso}\right)^2}\right] = 71 \cdot ksi$$

$$\sigma_{ey} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{iso}}{r_y}\right)^2} = 41 \cdot ksi \qquad \frac{1.0 \cdot L_{iso}}{r_y} = 84$$

KL_r = "KL/r < 200, OK"

Cb per Eq. F2.1.1-2

$$M_A := \frac{\omega_{iso} \cdot \frac{L_{iso}}{4}}{2} \cdot \left(L_{iso} - \frac{L_{iso}}{4}\right) = 6.74 \cdot kip \cdot in$$

$$M_B := M_{cx} = 8.99 \cdot kip \cdot in$$

$$M_C := \frac{\omega_{iso} \cdot \frac{3 \cdot L_{iso}}{4}}{2} \cdot \left(L_{iso} - \frac{3 \cdot L_{iso}}{4}\right) = 6.74 \cdot kip \cdot in$$

$$C_b := \min\left(1.0, \frac{12.5 \cdot M_{cx}}{2.5 \cdot M_{cx} + 3 \cdot M_A + 4 \cdot M_B + 3.M_C}\right) = 1$$

Elastic Critical Lateral-Torsional Buckling Stress per Eq. F2.1.1-1 for Singly Symmetry:

$$F_e := \frac{C_b \cdot r_o \cdot A_e}{S_x} \cdot \sqrt{\sigma_{ey} \cdot \sigma_t} = 87 \cdot ksi$$

LTB Design Stress: Eq. F2.1-3,4,5:

$$F_c := \begin{cases} F_y & \text{if } F_e \geq 2.78 \cdot F_y \\ \frac{10}{9} \cdot F_y \cdot \left(1 - \frac{10 \cdot F_y}{36 \cdot F_e}\right) & \text{if } 2.78 \cdot F_y > F_e > 0.56 \cdot F_y \\ F_e & \text{if } 0.56 \cdot F_y \geq F_e \end{cases} = 47 \cdot ksi$$

Moment Capacity Eq. F2.1-1:

$$\phi M_{nx} := 0.9 \cdot S_x \cdot \min\left(F_c, F_y\right) = 78 \cdot kip \cdot in$$

D/C Ratio of Bending:

$$DCR := \frac{M_{cx}}{\phi M_{nx}} = 0.115$$

$Iso_{Bending}$ = "OK"

Check Curb Bending of Long Side (Weak axis)

Center-to-Center Spacing of Braces

$$L_{brace} := \max\left(40in, \frac{L_{curb}}{N_{iso.long} - 1}\right) = 40 \cdot in$$

Note for weak-axis bracing length:
Max weak-axis span length of Iso Rail is larger than L_{brace} per cut sheet. However, the Iso Rail is braced with clip at max 24" O.C. at top and isolator at max 36" O.C. at bottom such that the actual unbraced length is as follows.

Distributed Load

$$\omega_{iso} := \frac{\max\left(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit}\right)}{L_{curb}} = 0.661\ klf$$

Moment Demand on Iso Rail

$$M_{cy} := \frac{\omega_{iso} \cdot L_{brace}^{2}}{8} = 11.02 \cdot kip \cdot in$$

Member per CFS:

$$CFS_{member} = \text{"10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"}$$

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. F2.1.1-4,5)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(1.0 \cdot L_{brace}\right)^2}\right] = 23 \cdot ksi$$

$$\sigma_{ex} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{brace}}{r_x}\right)^2} = 1128 \cdot ksi \qquad \frac{1.0 \cdot L_{brace}}{r_x} = 16$$

$$KL_r = \text{"KL/r < 200, OK"}$$

Cb per Eq. F2.1.1-2

$$M_A := \frac{\omega_{iso} \cdot \frac{L_{brace}}{4}}{2} \cdot \left(L_{brace} - \frac{L_{brace}}{4}\right) = 8.27 \cdot kip \cdot in$$

$$M_B := M_{cy} = 11.02 \cdot kip \cdot in$$

$$M_C := \frac{\omega_{iso} \cdot \frac{3 \cdot L_{brace}}{4}}{2} \cdot \left(L_{brace} - \frac{3 \cdot L_{brace}}{4}\right) = 8.27 \cdot kip \cdot in$$

$$C_b := \min\left(1.0, \frac{12.5 \cdot M_{cx}}{2.5 \cdot M_{cx} + 3 \cdot M_A + 4 \cdot M_B + 3.M_C}\right) = 0.97$$

Elastic Critical Lateral-Torsional Buckling Stress per Eq. F2.1.1-1 for Singly Symmetry:

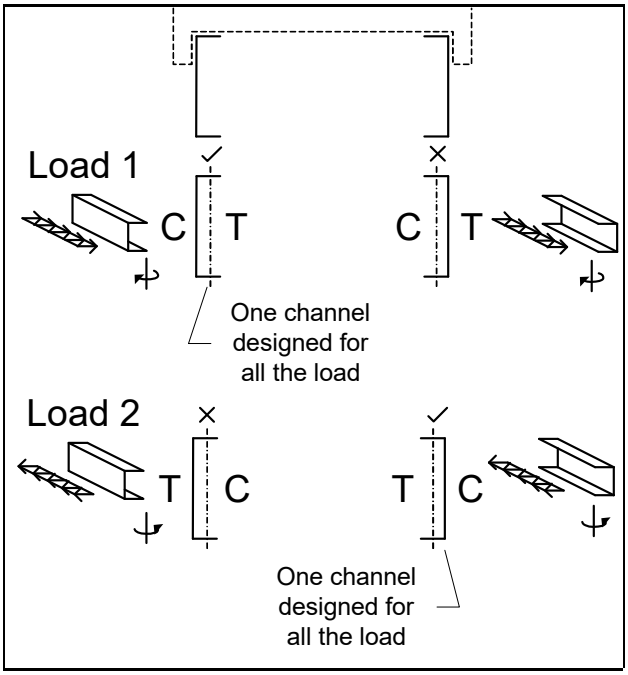
$$F_e := \frac{C_b \cdot r_o \cdot A_e}{S_y} \cdot \sqrt{\sigma_{ey} \cdot \sigma_t} = 242 \cdot ksi$$

LTB Design Stress: Eq. F2.1-3,4,5:

$$2.78 \cdot F_y = 139 \cdot ksi$$

$$0.56 \cdot F_y = 28 \cdot ksi$$

$$F_c := \begin{cases} F_y & \text{if } F_e \geq 2.78 \cdot F_y \\ \frac{10}{9} \cdot F_y \cdot \left(1 - \frac{10 \cdot F_y}{36 \cdot F_e}\right) & \text{if } 2.78 \cdot F_y > F_e > 0.56 \cdot F_y \\ F_e & \text{if } 0.56 \cdot F_y \geq F_e \end{cases} = 50 \cdot ksi$$



Note:

For ISO rail weak-axis bending capacity, rails are oriented and designed so that the stiffer side of ISO rail can take the entire bending load by itself without putting a lot of bending load to the iso rail on the other side

Moment Capacity Eq. F2.1-1:

$$\phi M_{ny} := 0.9 \cdot S_y \cdot \min\left(F_c, F_y\right) = 16.5105 \cdot kip \cdot in$$

D/C Ratio of Bending:

$$DCR := \frac{M_{cy}}{\phi M_{ny}} = 0.667$$

$$Iso_{Bending} := \text{if}\left(M_{cy} < \phi M_{ny}, \text{"OK"}, \text{"NG"}\right)$$

$Iso_{Bending} = \text{"OK"}$

Web Crippling of ISO Rail (AISI S100-16 G.5)

Governing Compression:

$$P_{web.crip} := \frac{\omega_{x.L.vert} \cdot L_{iso}}{2} = 1869 \cdot lbs$$

Yield Strength:

$$F_y := 50ksi$$

Bearing Length:

$N := 2in$ **2 in. for CQAs**

Thickness of Curb:

$t_{Curb.iso} = "10GA"$ $t := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Inside Bend Radius:

$R := R_{iso} = 0.186 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web:

$h = 6.85 \cdot in$

Angle btween plane of web and bearing surface:

$\theta := 90deg$

Web Crippling Limit Check (AISI Table G5-2):

$\frac{R}{t} = 1$ $\frac{h}{t} = 50$ $\frac{N}{t} = 14$ $\frac{N}{h} = 0.29$

$$LimitCheck_{webcrippling} := if\left[\left(\frac{h}{t} < 200\right) \wedge \left(\frac{N}{t} < 210\right) \wedge \left(\frac{N}{h} < 2\right) \wedge \left(\frac{R}{t} < 2\right), "OK", "NG, Need Reinf"\right]$$

$LimitCheck_{webcrippling} = "OK"$

End Case Coefficient Single Web Channel (AISI Table G5-2):

$C := 2$ $C_R := 0.11$ $C_N := 0.37$ $C_h := 0.01$

Reduction Factor Web Crippling Strength:

$\phi_{web.end} := 0.75$ **(For Unfastened Flanges with Two-Flange Loading or Reaction. Worst Case)**

$\phi_{web.int} := 0.8$

Design Web Crippling Strength:

$$P_{n.end} := C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 3729 \cdot lbs$$

$$\phi P_{n.end} := \phi_{web.end} \cdot P_{n.end} = 2796 \cdot lbs$$

Interior Case Coefficient Single Web Channel (AISI Table G5-2):

$C := 13$ $C_R := 0.47$ $C_N := 0.25$ $C_h := 0.04$

Design Web Crippling Strength:

$$P_{n.interior} := C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 7905 \cdot lbs$$

$$\phi P_{n.interior} := \left(\phi_{web.int}\right) \cdot P_{n.interior} = 6324 \cdot lbs$$

Design Strength:

$$P_{n.web.crip} := \min\left(P_{n.end}, P_{n.interior}\right) = 3729 \cdot lbs$$

$$\phi P_{n.web.crip} := \min\left(\phi P_{n.end}, \phi P_{n.interior}\right) = 2796 \cdot lbs$$

D/C Ratio of Shear:

$$DCR := \frac{P_{web.crip}}{\phi P_{n.web.crip}} = 0.668$$

Demand/Capacity Ratio:

$$Web_{crippling} := \text{if}\left[\left(P_{web.crip} < \phi P_{n.web.crip}\right) \wedge \left(\phi P_{n.end} > 0\right) \wedge \frac{h}{t} < 200, \text{"OK"}, \text{"NG, Need Reinf"}\right]$$

$Web_{crippling} = \text{"OK"}$

D/C Ratio of Interaction:
AISI Eq. H3-1b

$$DCR_{int.web} := \frac{0.91 \cdot \left(\frac{P_{web.crip}}{P_{n.web.crip}}\right) + \frac{M_{cx}}{\left(\frac{\phi M_{nx}}{0.9}\right)}}{1.33 \cdot 0.9} = 0.468$$

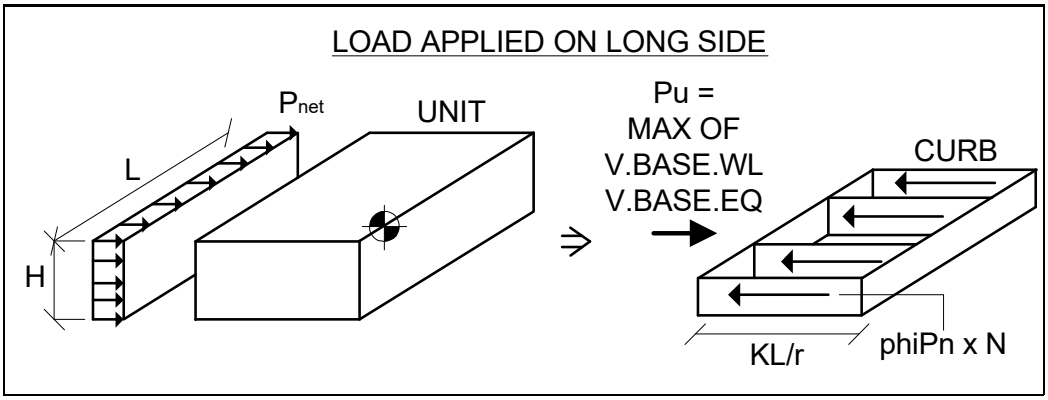
$Iso_{Shear} = \text{"OK"}$

$Iso_{Interaction} = \text{"OK"}$

Per AISI S100-16 H3,
Only x-axis needs to check for interaction

Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI S100-16 E2)

Curb Axial Load Check due to Load on Long Side



Wind Base Shear of Unit on Long Side: $V_{base.W.L} := P_{net} \cdot L_{unit} \cdot H_{unit} = 3.1\,kip$

Seismic Base Shear of Unit on Long Side: $V_{base.S.L} := F_p \cdot Wt_{unit} = 3.7\,kip$

Max Axial: $P_u := \max\left(V_{base.S.L}, V_{base.W.L}\right) = 3712.5 \cdot lbs$

Member per CFS: $CFS_{member} =$ "10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"

Number of Curb in Length: $n_{iso} := 3$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{iso}} = 1.24\,kip$

Max Braced Length of Member: $L_{member} := W_{curb} = 37 \cdot in$

Effective Length factor: $K := 0.5$

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. E2.2-5, E2.2-6)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(K \cdot L_{member}\right)^2}\right] = 76 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2} = 44 \cdot ksi$$

$$\frac{K \cdot L_{member}}{r_{min}} = 81$$

KL_r = "KL/r < 200, OK"

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 28 \cdot ksi$$

Nominal Compressive Stress Capacity (Eq E2-4):

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 1.34$$

$$F_n := \begin{cases} 0.658^{\lambda_c^{\,2}} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^{\,2}}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 23.58 \cdot ksi$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot A_e \cdot F_n = 23.67\ kip$$

D/C Ratio of Compression:

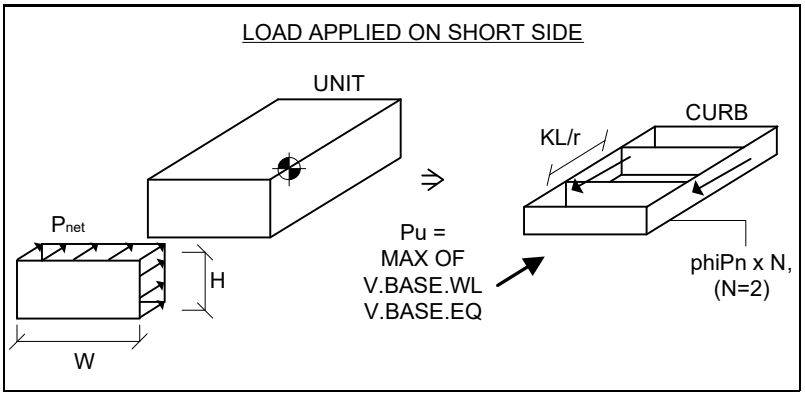
$$DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.052$$

$$Axial_{reinf} := \text{if}\left(P_{u.EAmember} < \phi P_{n.member}, \text{"OK"}, \text{"NG"}\right)$$

$Axial_{reinf}$ = "OK"

Note:
No need to check for interaction since equipment is not attached to the short side

Curb Axial Load Check due to Load on Short Side



Wind Base Shear on Short Side: $V_{base.W.H} := P_{net} \cdot W_{unit} \cdot H_{unit} = 2.5\,kip$

Seismic Base Shear of Unit on Short Side: $V_{base.S.W} := F_p \cdot Wt_{unit} = 3.7\,kip$

Max Axial: $P_u := \max\left(V_{base.S.W}, V_{base.W.H}\right) = 3712.5 \cdot lbs$

Member per CFS: CFS_{member} = "10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"

Number of Curb in Length: $n_{curb} := 2$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{curb}} = 1.86\,kip$

Max Braced Length of Member: $L_{member} := \frac{L_{curb}}{n_{iso} - 1} = 34 \cdot in$

Effective Length factor: $K := 0.5$

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. E2.2-5, E2.2-6)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(K \cdot L_{member}\right)^2}\right] = 90 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2} = 54 \cdot ksi \qquad \frac{K \cdot L_{member}}{r_{min}} = 74$$

KL_r = "KL/r < 200, OK"

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 34 \cdot ksi$$

Nominal Compressive Stress Capacity (Eq E2-4):

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 1.219$$

$$F_n := \begin{cases} 0.658^{\lambda_c^2} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^2}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 26.85 \cdot \text{ksi}$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot A_e \cdot F_n = 26.96 \text{ kip}$$

D/C Ratio of Compression:

$$DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.069$$

$$Axial_{reinf} := \text{if}\left(P_{u.EAmember} < \phi P_{n.member}, \text{"OK"}, \text{"NG"}\right)$$

$Axial_{reinf} = \text{"OK"}$

Note:
If the load direction is in perpedicular plane to the short side of the equipment, the channels will only experience axial load and no bending will occur at the channel. Therefore, no need to check for interaction since the channels

Shear of ISO Rail Webs without Holes (AISI S100-16 G2)

Note: The connection holes are not centered at mid-depth of isolated curb rail so AISI G2 shall be used

Deeper Section (h = depth)

Thickness of Curb: $t := \text{thick}(t_{Curb.iso}) = 0.138 \cdot \text{in}$

Depth-to-Thickness Ratio: $\frac{h}{t} = 50$

Curb Elastic Modulus: $E := 29500\text{ksi}$

Clear distance b/w transverse stiffeners of reinforced web: $a := L_{iso} = 19 \cdot \text{in}$

Clear Distance-to-Thickness Ratio: $\frac{a}{h} = 2.81$

Nominal Shear Stress:

$$k_v := \begin{cases} 5.34 & \text{if } a = L_{iso} \\ 4.00 + \frac{5.34}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \frac{4.00}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 5.85$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 59 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 89$$

Curb Shear Check due to Load on Longer Side

Area of Web Element:

$$A_w := h \cdot t = 0.947 \cdot in^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 63.4 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} = 60\,kip \qquad V_y := 0.6 \cdot A_w \cdot F_y = 28\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.688$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 28.404 \cdot kip$$

Number of Members within Length: $n := 1$ **(Per Curb Design)**

Design Shear Capacity:

$$\phi V_{n.h} := 0.95 \cdot n \cdot V_n = 26.98 \cdot kip$$

Design Shear Demand:

$$V_{u.h} := \frac{\omega_{x.L.vert} \cdot L_{iso}}{2} = 1868.6 \cdot lbs$$

D/C Ratio of Shear:

$$DCR := \frac{V_{u.h}}{\phi V_{n.h}} = 0.069$$

Demand/Capacity Ratio:

$Shear_{in.plane} = \text{"OK"}$

Shallower Section (h.w = Width)

Thickness of Curb: $t := thick(t_{Curb.iso}) = 0.138 \cdot in$

Depth-to-Thickness Ratio: $\frac{h_w}{t} = 7$

Curb Elastic Modulus: $E := 29500 ksi$

Clear distance b/w transverse stiffeners of reinforced web: $a := L_{brace} = 40 \cdot in$

Clear Distance-to-Thickness Ratio: $\frac{a}{h_w} = 40$

Nominal Shear Stress:

$$k_v := \begin{cases} 5.34 \text{ if } a = L_{brace} \\ 4.00 + \frac{5.34}{\left(\frac{a}{h_w}\right)^2} \text{ if } \left(\frac{a}{h_w} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \frac{4.00}{\left(\frac{a}{h_w}\right)^2} \text{ if } \left(\frac{a}{h_w} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 5.34$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 56 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 85$$

Curb Shear Check due to Load on Longer Side

Area of Web Element: $A_w := h_w \cdot t = 0.1382 \cdot in^2$

Number of Members within Length: $n := 1$ **(Per Curb Design)**

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 58 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} = 8 \, kip \qquad V_y := 0.6 \cdot A_w \cdot F_y = 4 \, kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.719$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 4.146 \cdot \text{kip}$$

Design Shear Capacity:

$$\phi V_{n.hw} := 0.95 \cdot n \cdot V_n = 3.9 \cdot \text{kip}$$

Design Shear Demand:

$$V_{u.hw} := \frac{\left(\frac{\max\left(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit}\right)}{L_{curb}} \right) \cdot L_{brace}}{2} = 1102 \cdot \text{lbs}$$

D/C Ratio of Shear:

$$DCR := \frac{V_{u.hw}}{\phi V_{n.hw}} = 0.28$$

Demand/Capacity Ratio:

$Shear_{in.plane}$ = "OK"

D/C Ratio of Vx and Mx:

$$DCR_{V.M.int} := \begin{cases} \left(0.6 \cdot \frac{M_{cx}}{\phi M_{nx}} + \frac{V_{u.h}}{\phi V_{n.h}}\right) \cdot \frac{1}{1.3} & \text{if } \frac{M_{cx}}{\phi M_{nx}} > 0.5 \wedge \frac{V_{u.h}}{\phi V_{n.h}} > 0.7 \\ \sqrt{\left(\frac{M_{cx}}{\phi M_{nx}}\right)^2 + \left(\frac{V_{u.h}}{\phi V_{n.h}}\right)^2} & \text{otherwise} \end{cases} = 0.135$$

Demand/Capacity Ratio:

$VandMx_{int}$ = "OK"

D/C Ratio of Vy and My:

$$DCR_{V.M.int} := \begin{cases} \left(0.6 \cdot \frac{M_{cy}}{\phi M_{ny}} + \frac{V_{u.hw}}{\phi V_{n.hw}}\right) \cdot \frac{1}{1.3} & \text{if } \frac{M_{cy}}{\phi M_{ny}} > 0.5 \wedge \frac{V_{u.hw}}{\phi V_{n.hw}} > 0.7 \\ \sqrt{\left(\frac{M_{cy}}{\phi M_{ny}}\right)^2 + \left(\frac{V_{u.hw}}{\phi V_{n.hw}}\right)^2} & \text{otherwise} \end{cases} = 0.724$$

Demand/Capacity Ratio:

$VandMy_{int}$ = "OK"

Web Crippling/Compression of Non-iso CanFab Curb (AISI S100-16 G5)

Governing Compression for Non-Isolated Curb:

$$P_{web.crip.int} := \max\left[\frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}}, \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}}\right] \cdot L_{spacing.non.iso} = 3001 \cdot lbs$$

$$P_{web.crip.end} := 0.5 \cdot P_{web.crip.int} = 1501 \cdot lbs$$

Yield Strength: $F_y := 50ksi$

Bearing Length: $N_{bearing} := L_{spacing.non.iso} = 15 \cdot in$

Thickness of Curb: $t_{Curb} = \text{"12GA"}$ $t := thick(t_{Curb}) = 0.1084 \cdot in$

Inside Bend Radius: $R := R_{curb} = 0.153 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web: $h := 36in - 2 \cdot (t + R) = 35.48 \cdot in$

Angle btween plane of web and bearing surface: $\theta := 90deg$

Web Crippling Limit Check (AISI Table G5-2): $\frac{R}{t} = 1$ $\frac{h}{t} = 327$ $\frac{N_{bearing}}{t} = 143$ $\frac{N_{bearing}}{h} = 0.44$

End Case Coefficient Single Web Channel (AISI Table G5-2): $C := 13$ $C_R := 0.32$ $C_N := 0.05$ $C_h := 0.04$

Reduction Factor Web Crippling Strength: $\phi_{web.end} := 0.9$ $\phi_{web.int} := 0.8$ **(For Unfastened partially Stiffened Flanges with Two-Flange Loading or Reaction.)**

Design Web Crippling Strength:

$$\phi P_{n.end} := \left(\phi_{web.end}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 1882 \cdot lbs$$

Interior Case Coefficient Single Web Channel (AISI Table G5-2): $C := 24$ $C_R := 0.52$ $C_N := 0.15$ $C_h := 0.001$

Design Web Crippling Strength:

$$\phi P_{n.interior} := \left(\phi_{web.int}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 11848 \cdot lbs$$

D/C Ratio of Shear: $DCR_{end} := \frac{P_{web.crip.end}}{2 \cdot \phi P_{n.end}} = 0.399$ $DCR_{int} := \frac{P_{web.crip.int}}{\phi P_{n.interior}} = 0.253$

Demand/Capacity Ratio: **Note: Factor of 2 for two ends connected together at the end**

$Web_{crippling} = \text{"OK"}$

Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Length

Roof Curb thickness

$t_{Curb} = \text{"12GA"}$ $t_{curb} := thick(t_{Curb}) = 0.1084 \cdot in$

Min width of Roof Curb

$b_{curb} := L_{curb} + \frac{W_{curb}}{2} \cdot 2 + 3in \cdot 2 \cdot 4 = 128.56 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := L_{curb} + \min\left(\frac{W_{curb}}{2} \cdot 2, \frac{L_{curb}}{2}\right) = 101 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{array}{c} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{array} \right] \right] = 11330 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.L.vert.up} \cdot L_{curb}) \cdot (0.75in) = 6952 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.614$

$Curb_{BotFlangeBending} = \text{"OK"}$

Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Width

Roof Curb thickness

$t_{Curb} = \text{"12GA"}$ $t_{curb} := thick(t_{Curb}) = 0.1084 \cdot in$

Min width of Roof Curb

$b_{curb} := W_{curb} + \frac{L_{curb}}{4} \cdot 2 + 3in \cdot 2 = 76.88 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := W_{curb} + \min\left(\frac{L_{curb}}{6} \cdot 2, W_{curb}\right) = 60 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{array}{c} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{array} \right] \right] = 6775 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.W.vert.up} \cdot W_{curb}) \cdot (0.75in) = 3472 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.513$

$Curb_{BotFlangeBending} = \text{"OK"}$

Web Crippling/Compression of Iso CanFab Curb (AISI S100-16 G5)

Note: Curb stiffeners directly transfer the compressive load from isolator to the base. Therefore, curb web crippling is prevented.

Curb Web with Reinforcement

Max Compression: $Comp_{maxtot} := \max(|C_S|, |C_W|) = 15354.46 \cdot lbs$

Reinforcement per CFS: $CFS_{reinf} :=$ "Single Stiffener 10GA 1"x7"x1" Fy=50ksi 36" Tall on min. 16GA "

Note: min. of 10 GA channel and min. 16 GA curb web

Number of Reinforcement in Length: $n_{reinf} := N_{iso.long} = 5$

Max Compression per Reinf: $Comp_{per.reinf} := \frac{Comp_{maxtot}}{n_{reinf}} = 3.412\,kip$

Spacing: $Spacing := \frac{L_{curb}}{n_{reinf}} = 15 \cdot in$ $KL_r := \frac{1.0 \cdot (H_{curb} - 12.5in)}{0.2339in} = 154$

Factored Nominal Comp. Capacity per reinforcement: $\phi P_{n.reinf} = 9.719 \cdot kip$ **(See attached CFS)**

Total Factored nominal Comp Capacity: $\phi P_{n.tot} := n_{reinf} \cdot \phi P_{n.reinf} = 44 \cdot kip$

D/C Ratio of Compression: $DCR := \frac{Comp_{maxtot}}{\phi P_{n.tot}} = 0.35$

$Comp_{reinf} := if(Comp_{maxtot} < \phi P_{n.tot}, "OK", "NG")$ $Comp_{reinf} = "OK"$

Check CanFab Curb for Compressive Force due to T/C Coupling of Overturning

Note:
-Since the equipment is only attached to the longer sides of the CanFab Curb, most likely there will be compressive force onto the curb due to T/C coupling.
- Rectangular CanFab Curb will be considered as "Channel" to resist the compressive force.

Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Flanges*

Flat Width:

$$w := \frac{W_{curb}}{2} - R_{curb} = 18.441 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Unstiffened"}$$

Stress at the end of the Width:

$$f_2 := 50ksi \qquad f_1 := 50ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \left| \frac{f_2}{f_1} \right| = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 0.43$$

Critical Compressive Stress (Eq 1.1-4):

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w}\right)^2 = 0.4 \cdot ksi$$

Stress in Compression Element:

$$f := F_y = 50 \cdot ksi \qquad \textbf{(Assume f = Fy)}$$

Slenderness Factor (Eq 1.1-3):

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 11.23$$

Local reduction factor (Eq 1.1-2):

$$\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 0.087$$

Effective Width of the Flanges:

$$b_{eff.flange} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 1.609 \cdot in$$

Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Web*

Flat Width: $w := L_{curb} - R_{curb} \cdot 2 = 67.07 \cdot in$

Stiffened Web Check: $Stiffened_{check} := \text{"Stiffened"}$

Stress at the end of the Width: $f_2 := 50ksi \qquad f_1 := 50ksi$

Compressive Stress Ratio (Eq. 1.1.2-1): $\Psi := \left| \frac{f_2}{f_1} \right| = 1$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 4$$

Critical Compressive Stress (Eq 1.1-4): $F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w} \right)^2 = 0.28 \cdot ksi$

Stress in Compression Element: $f := F_y = 50 \cdot ksi$ **(Assume f = Fy)**

Slenderness Factor (Eq 1.1-3): $\lambda := \sqrt{\frac{f}{F_{cr}}} = 13.4$

Local reduction factor (Eq 1.1-2): $\rho := \left(1 - \frac{0.22}{\lambda}\right) \frac{1}{\lambda} = 0.073$

Effective Width of the Web:

$$b_{eff.web} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 4.924 \cdot in$$

Effective Area of the Member: $A_e := 2 \cdot \left(b_{eff.flange} \cdot t_{curb} \right) + b_{eff.web} \cdot t_{curb} = 0.883 \cdot in^2$

Length of the Compressive Member: $L_{curb.web} := h = 35.478 \cdot in$

Young's Modulus for Cold Form Steel: $E := 29500ksi$

Curb Shear Modulus: $G := 11300ksi$

Poisson's Ratio $\mu := 0.3$

Section Properties of the Member (From Section Properties Calculator):

$A_{half.curb} := 6.087in^2$ $r_o := 28.35in$ $I_x := 3577in^4$ $I_y := 311in^4$

$J := 0.006in^4$ $r_x := \sqrt{\frac{I_x}{A_{half.curb}}} = 24.241 \cdot in$ $r_y := \sqrt{\frac{I_y}{A_{half.curb}}} = 7.148 \cdot in$

$C_w := 209700in^6$ $r_{min} := \min(r_x, r_y) = 7.148 \cdot in$

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^2}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{(1.0 \cdot L_{curb.web})^2}\right] = 68373.739 \cdot ksi$$

$$\sigma_{e.y} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_y}\right)^2} = 11818.319 \cdot ksi \qquad \sigma_{e.x} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_x}\right)^2} = 135929.664 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2} = 11818.319 \cdot ksi$$

$$\frac{1.0 \cdot L_{curb.web}}{r_{min}} = 4.96$$

$KL_r = \text{"KL/r < 200, OK"}$

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 10076.592 \cdot ksi$$

Nominal Compressive Stress Capacity: (Eq E2-4)

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 0.07$$

$$F_n := \begin{cases} 0.658^{\lambda_c^2} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^2}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 49.9 \cdot ksi$$

Compressive Capacity:

$$P_{n.member} := A_e \cdot F_n = 44.04 \cdot kip$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot P_{n.member} = 37.44 \cdot kip$$

Factored Max Compressive Force:

$$P_{comp.max} := \max\left(\left|C_S\right|, \left|C_W\right|\right) = 15.354\,kip$$

D/C Ratio of Compression:

$$DCR := \frac{P_{comp.max}}{\phi P_{n.member}} = 0.41$$

$$Axial_{curb.comp} := \text{if}\left(P_{comp.max} < \phi P_{n.member}, \text{"OK"}, \text{"Provide Channel from above as Web Stiffener"}\right)$$

$Axial_{curb.comp} = \text{"OK"}$

Note: No need to check for interaction since the curb is only subjected to the compressive force.

Shear of CanFab Curb Webs without Holes (AISI S100-16 G2)

Note: Since the unit is stiffer than the curb and the curb is firmly attached to the unit and to the base structure, curbs will mainly take the lateral forces as shear and axial load rather than bending.

Thickness of Curb:

$$t := \text{thick}(t_{Curb}) = 0.108 \cdot \text{in}$$

Depth-to-Thickness Ratio:

$$\frac{h}{t} = 327$$

Curb Elastic Modulus:

$$E := 29500\text{ksi}$$

Clear distance b/w transverse stiffeners of reinforced web:

$$a := \max\left(\frac{L_{curb}}{2}, W_{curb}\right) = 37 \cdot \text{in} \qquad \frac{a}{h} = 1.05$$

$$k_v := \begin{cases} 5.34 & \text{if } a = L_{curb} \\ 4.00 + \dfrac{5.34}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \dfrac{4.00}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 8.98$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 73 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 110$$

Curb Shear Check due to Load on Longer Side

Area of Web Element:

$$A_w := W_{curb} \cdot t = 4 \cdot \text{in}^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 2.2 \cdot \text{ksi}$$

$V_{cr} := A_w \cdot F_{cr} = 9\,kip$ $V_y := 0.6 \cdot A_w \cdot F_y = 121\,kip$ $\lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 3.663$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 9.011 \cdot kip$$

Number of Members within Length: $n := 2$ **(Per Curb Design)**

Design Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 17120.9 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.H} := P_{net} \cdot L_{unit} \cdot H_{total} = 6680.2 \cdot lbs$

Design Shear Demand: $V_u := \max(V_{base.S}, V_{base.W.H}) = 6680.2 \cdot lbs$

D/C Ratio of Shear: $DCR := \frac{V_u}{\phi V_n} = 0.39$

Demand/Capacity Ratio:

$Shear_{in.plane} := \text{if}(V_u < \phi V_n, \text{"OK"}, \text{"NG"})$

$Shear_{in.plane} = \text{"OK"}$

Curb Shear Check due to Load on Shorter Side

Area of Web Element: $A_w := L_{curb} \cdot t = 7 \cdot in^2$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 2.2 \cdot ksi$$

$V_{cr} := A_w \cdot F_{cr} = 16\,kip$ $V_y := 0.6 \cdot A_w \cdot F_y = 219\,kip$ $\lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 3.663$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 16.326 \cdot kip$$

Number of Members within Length: $n := 2$ **(Per Curb Design)**

Factored Nominal Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 31019 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot W_{unit} \cdot H_{total} = 5389.1 \cdot lbs$

Factored Shear Demand: $V_u := \max\left(V_{base.S}, V_{base.W.L}\right) = 5720.6 \cdot lbs$

D/C Ratio of Shear: $DCR := \frac{V_u}{\phi V_n} = 0.184$

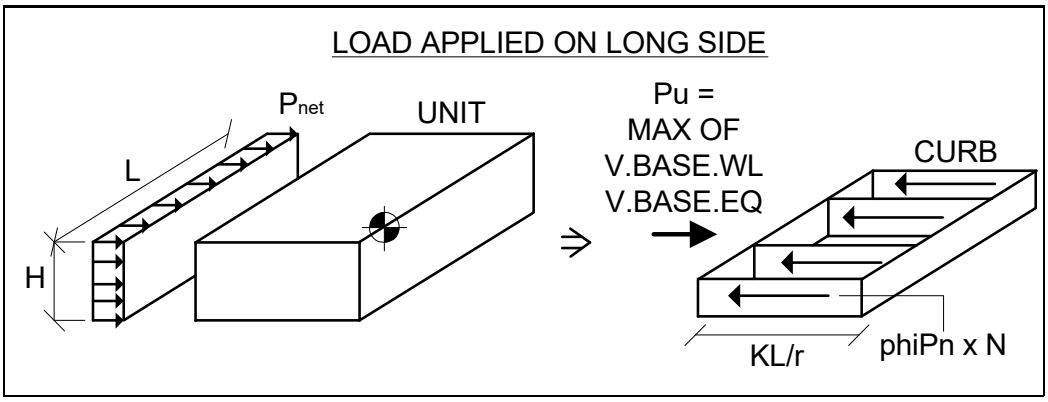
Demand/Capacity Ratio:

$Shear_{in.plane} := \text{if}\left(V_u < \phi V_n, \text{"OK"}, \text{"NG"}\right)$

$Shear_{in.plane} = \text{"OK"}$

Check CanFab Curb for In-Plane Axial due to EQ and Wind (AISI S100-16 E2)

Curb Axial Load Check due to Load on Long Side



Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot L_{unit} \cdot H_{total} = 6.7\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.L}) = 6680.21 \cdot lbs$

Member per CFS: $CFS_{member} :=$ "12GA Custom Curb 36" Tall L.b = 78in"

Max Braced Length of Member: $L_{member} := W_{curb} = 37 \cdot in$

Number of Curb in Length: $n_{curb.long} := 2$

Radius of gyration in y-axis: $r_{y.curb} := 0.521\,in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{2} = 3.34\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 71$ $KL_r =$ "KL/r < 200, OK"

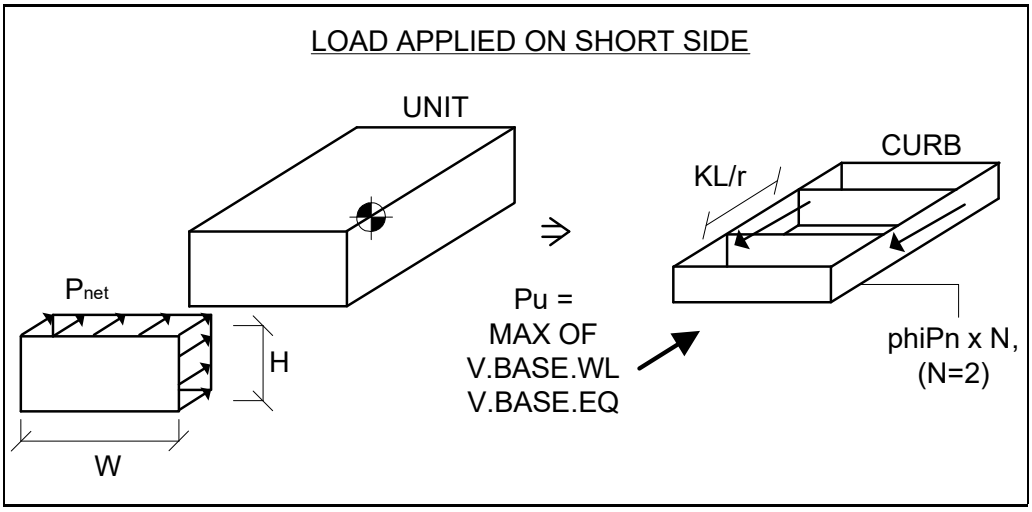
Spacing: $Spacing := \frac{L_{curb}}{n_{curb.long}} = 34 \cdot in$

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 9.846 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.339$

$Axial_{short.curb} =$ "OK"

Curb Axial Load Check due to Load on Short Side



Wind Base Shear on Short Side: $V_{base.W.H} := P_{net} \cdot W_{unit} \cdot H_{total} = 5.4\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.H}) = 5720.62 \cdot lbs$

Member per CFS: CFS_{member} = "12GA Custom Curb 36" Tall L.b = 78in"

Max Braced Length of Member: $L_{member} := \frac{L_{curb}}{n_{curb.long} - 1} = 67 \cdot in$

Number of Curb in Length: $n_{curb} := 2$

Radius of gyration in y-axis: $r_{y.curb} := 0.521\,in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{curb}} = 2.86\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 129$ KL_r = "KL/r < 200, OK"

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 9.846 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.291$

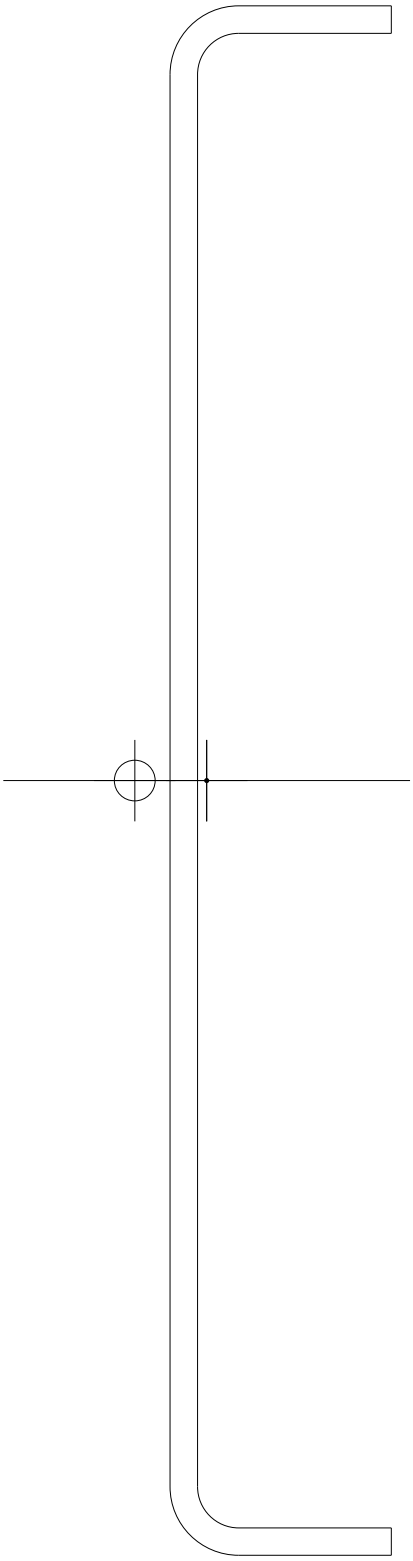
$Axial_{long.curb}$ = "OK"

REFERENCE

Section: Section 2.cfss
Channel 7x1-10 Gage

Leonard Kim
John A. Martin & Associates

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Section: Section 2.cfss
Channel 7x1-10 Gage

Leonard Kim
John A. Martin & Associates

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Section Inputs

```
Material: A653 SS Grade 33
No strength increase from cold work of forming.
Modulus of Elasticity, E          29500 ksi
Yield Strength, Fy                   33 ksi
Tensile Strength, Fu                 45 ksi
Warping Constant Override, Cw         0 in^6
Torsion Constant Override, J          0 in^4

Channel, Thickness 0.1242 in (10 Gage)
Placement of Part from Origin:
X to center of gravity           0 in
Y to center of gravity           0 in
Outside dimensions, Open shape
        Length      Angle     Radius  Web      k    Hole Size   Distance
          (in)      (deg)       (in)         Coef.       (in)       (in)
  1     1.0000    180.000    0.18630 Single  0.000     0.0000     0.5000
  2     7.0000     90.000    0.18630 Cee     0.000     0.0000     3.5000
  3     1.0000      0.000    0.18630 Single  0.000     0.0000     0.5000
```

Member Check - 2016 North American Specification - US (LRFD)

```
Material Type: A653 SS Grade 33, Fy=33 ksi
Design Parameters:
Lx        1.5000 ft     Ly        1.5000 ft     Lt        1.5000 ft
Kx        1.0000        Ky        1.0000        Kt        1.0000
Cbx       1.0000        Cby       1.0000        ex        0.0000 in
Cmx       1.0000        Cmy       1.0000        ey        0.0000 in
Braced Flange: None     kϕ             0 k
Red. Factor, R: 0       Lm        1.5000 ft

Loads:           P         Mx         Vy         My         Vx
                (k)     (k-in)        (k)     (k-in)        (k)
Entered       0.000      0.000      0.000      0.000      0.000
Applied       0.000      0.000      0.000      0.000      0.000
Strength     21.066     49.218     14.903      2.066      3.222

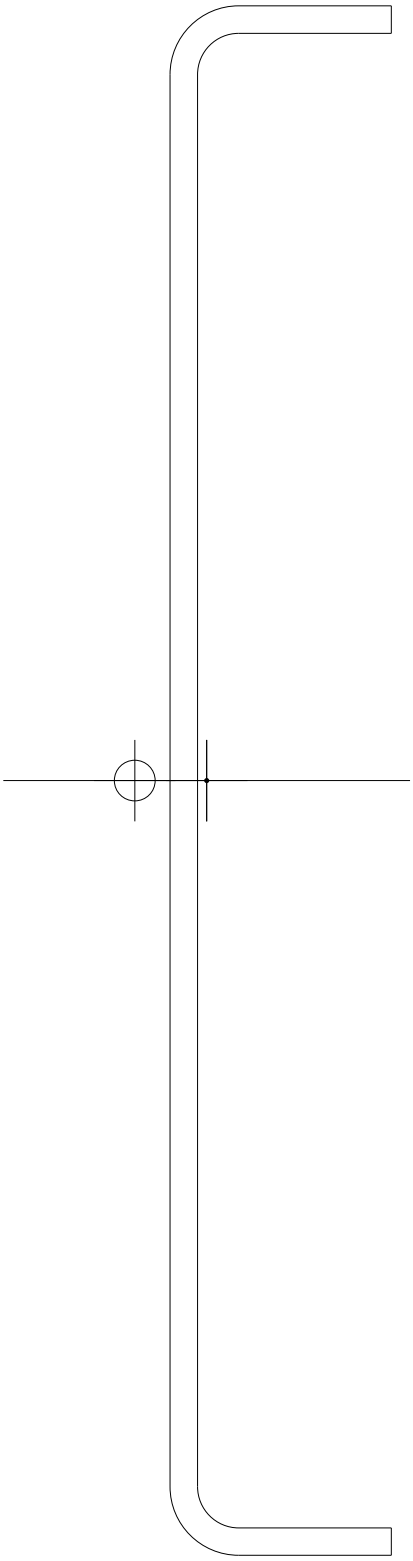
Effective section properties at applied loads:
Ae       1.06047 in^2   Ixe       5.8000 in^4   Iye       0.0580 in^4
                        Sxe(t)    1.6572 in^3   Sye(l)    0.3499 in^3
                        Sxe(b)    1.6572 in^3   Sye(r)    0.0696 in^3

Interaction Equations
NAS Eq. H1.2-1    (P, Mx, My)  0.000 + 0.000 + 0.000 = 0.000 <= 1.0
NAS Eq. H2-1         (Mx, Vy)     Sqrt(0.000 + 0.000)= 0.000 <= 1.0
NAS Eq. H2-1         (My, Vx)     Sqrt(0.000 + 0.000)= 0.000 <= 1.0
```

Section: Section 2.cfss
Channel 7x1-10 Gage

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John A. Martin & Associates

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Section: Section 2.cfss
Channel 7x1-10 Gage

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John A. Martin & Associates

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Section Inputs

```
Material: A653 SS Grade 33
No strength increase from cold work of forming.
Modulus of Elasticity, E          29500 ksi
Yield Strength, Fy                   33 ksi
Tensile Strength, Fu                 45 ksi
Warping Constant Override, Cw         0 in^6
Torsion Constant Override, J          0 in^4

Channel, Thickness 0.1242 in (10 Gage)
Placement of Part from Origin:
X to center of gravity           0 in
Y to center of gravity           0 in
Outside dimensions, Open shape
        Length      Angle     Radius  Web      k    Hole Size   Distance
          (in)      (deg)       (in)         Coef.       (in)       (in)
  1     1.0000    180.000    0.18630 Single  0.000     0.0000     0.5000
  2     7.0000     90.000    0.18630 Cee     0.000     0.0000     3.5000
  3     1.0000      0.000    0.18630 Single  0.000     0.0000     0.5000
```

Member Check - 2016 North American Specification - US (LRFD)

```
Material Type: A653 SS Grade 33, Fy=33 ksi
Design Parameters:
Lx        1.8333 ft     Ly        1.8333 ft     Lt        1.8333 ft
Kx        1.0000        Ky        1.0000        Kt        1.0000
Cbx       1.0000        Cby       1.0000        ex        0.0000 in
Cmx       1.0000        Cmy       1.0000        ey        0.0000 in
Braced Flange: None     kϕ             0 k
Red. Factor, R: 0       Lm        1.8333 ft

Loads:           P         Mx         Vy         My         Vx
                (k)     (k-in)        (k)     (k-in)        (k)
Entered       0.000      0.000      0.000      0.000      0.000
Applied       0.000      0.000      0.000      0.000      0.000
Strength     18.898     47.330     14.903      2.066      3.222

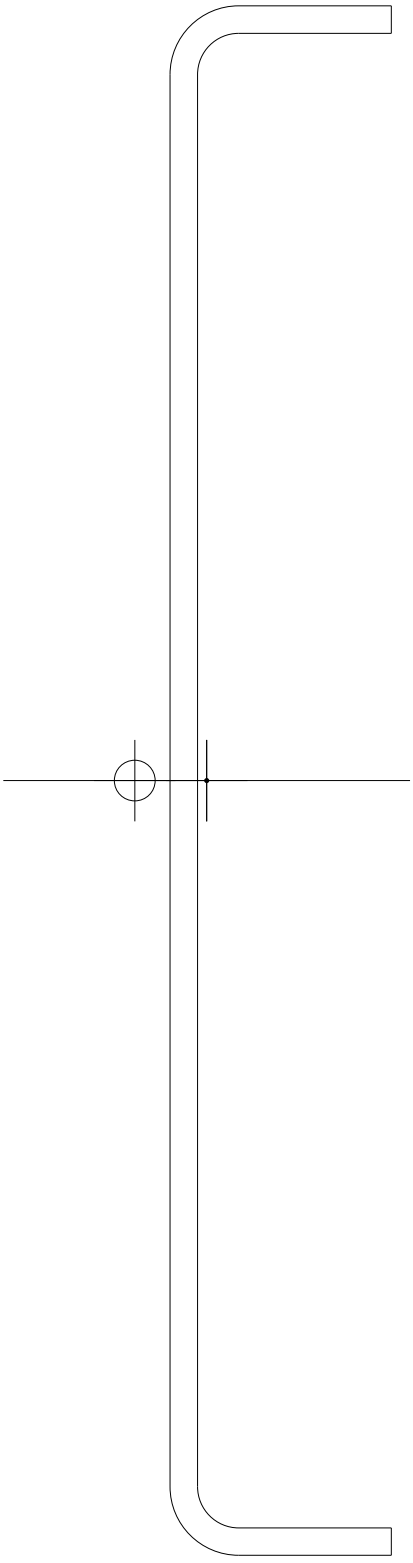
Effective section properties at applied loads:
Ae       1.06047 in^2   Ixe       5.8000 in^4   Iye       0.0580 in^4
                        Sxe(t)    1.6572 in^3   Sye(l)    0.3499 in^3
                        Sxe(b)    1.6572 in^3   Sye(r)    0.0696 in^3

Interaction Equations
NAS Eq. H1.2-1    (P, Mx, My)  0.000 + 0.000 + 0.000 = 0.000 <= 1.0
NAS Eq. H2-1         (Mx, Vy)     Sqrt(0.000 + 0.000)= 0.000 <= 1.0
NAS Eq. H2-1         (My, Vx)     Sqrt(0.000 + 0.000)= 0.000 <= 1.0
```

Section: Section 2.cfss
Channel 7x1-10 Gage

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Section: Section 2.cfss
Channel 7x1-10 Gage

Leonard Kim
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Section Inputs

```
Material: A653 SS Grade 33
No strength increase from cold work of forming.
Modulus of Elasticity, E          29500 ksi
Yield Strength, Fy                   33 ksi
Tensile Strength, Fu                 45 ksi
Warping Constant Override, Cw         0 in^6
Torsion Constant Override, J          0 in^4

Channel, Thickness 0.1242 in (10 Gage)
Placement of Part from Origin:
X to center of gravity           0 in
Y to center of gravity           0 in
Outside dimensions, Open shape
        Length      Angle     Radius  Web      k    Hole Size   Distance
          (in)      (deg)       (in)         Coef.       (in)       (in)
  1     1.0000    180.000    0.18630 Single  0.000     0.0000     0.5000
  2     7.0000     90.000    0.18630 Cee     0.000     0.0000     3.5000
  3     1.0000      0.000    0.18630 Single  0.000     0.0000     0.5000
```

Member Check - 2016 North American Specification - US (LRFD)

```
Material Type: A653 SS Grade 33, Fy=33 ksi
Design Parameters:
Lx        2.5000 ft     Ly        2.5000 ft     Lt        2.5000 ft
Kx        1.0000        Ky        1.0000        Kt        1.0000
Cbx       1.0000        Cby       1.0000        ex        0.0000 in
Cmx       1.0000        Cmy       1.0000        ey        0.0000 in
Braced Flange: None     kϕ             0 k
Red. Factor, R: 0       Lm        2.5000 ft

Loads:           P         Mx         Vy         My         Vx
                (k)     (k-in)       (k)     (k-in)       (k)
Entered       0.000      0.000      0.000      0.000      0.000
Applied       0.000      0.000      0.000      0.000      0.000
Strength     13.633     41.902     14.903      2.066      3.222

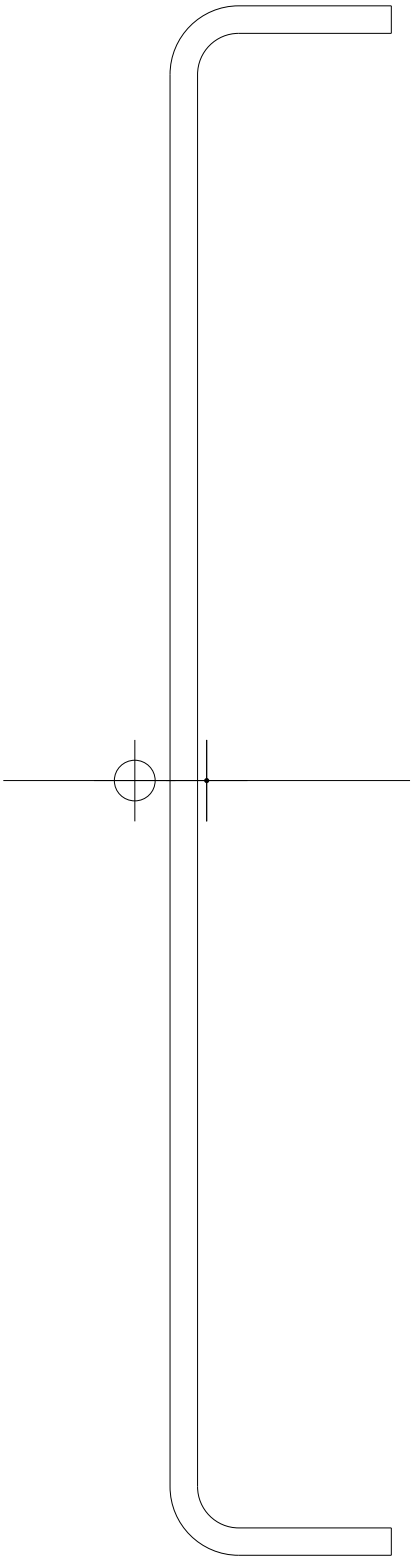
Effective section properties at applied loads:
Ae       1.06047 in^2   Ixe       5.8000 in^4   Iye       0.0580 in^4
                        Sxe(t)    1.6572 in^3   Sye(l)    0.3499 in^3
                        Sxe(b)    1.6572 in^3   Sye(r)    0.0696 in^3

Interaction Equations
NAS Eq. H1.2-1    (P, Mx, My)  0.000 + 0.000 + 0.000 = 0.000 <= 1.0
NAS Eq. H2-1         (Mx, Vy)     Sqrt(0.000 + 0.000)= 0.000 <= 1.0
NAS Eq. H2-1         (My, Vx)     Sqrt(0.000 + 0.000)= 0.000 <= 1.0
```

Section: Section 2.cfss
Channel 7x1-10 Gage

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John A. Martin & Associates

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Channel 7x1-10 Gage

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Section Inputs

```
Material: A653 SS Grade 33
No strength increase from cold work of forming.
Modulus of Elasticity, E           29500 ksi
Yield Strength, Fy                    33 ksi
Tensile Strength, Fu                  45 ksi
Warping Constant Override, Cw          0 in^6
Torsion Constant Override, J           0 in^4

Channel, Thickness 0.1242 in (10 Gage)
Placement of Part from Origin:
X to center of gravity           0 in
Y to center of gravity           0 in
Outside dimensions, Open shape
        Length      Angle     Radius  Web      k    Hole Size   Distance
          (in)      (deg)       (in)         Coef.       (in)       (in)
  1     1.0000    180.000    0.18630 Single  0.000     0.0000     0.5000
  2     7.0000     90.000    0.18630 Cee     0.000     0.0000     3.5000
  3     1.0000      0.000    0.18630 Single  0.000     0.0000     0.5000
```

Full Section Properties

```
Area      1.0605 in^2   Wt.    0.0036056 k/ft   Width     8.5384 in

Ix        5.8000 in^4   rx        2.3387 in     Ixy       0.0000 in^4
Sx(t)     1.6572 in^3   y(t)      3.5000 in     α          0.000 deg
Sx(b)     1.6572 in^3   y(b)      3.5000 in
                       Height    7.0000 in
Iy        0.0580 in^4   ry        0.2339 in     xo       -0.3251 in
Sy(l)     0.3499 in^3   x(l)      0.1658 in     yo        0.0000 in
Sy(r)     0.0696 in^3   x(r)      0.8342 in     jx        6.5817 in
                       Width     1.0000 in     jy        0.0000 in
I1        5.8000 in^4   r1        2.3387 in
I2        0.0580 in^4   r2        0.2339 in
Ic        5.8581 in^4   rc        2.3503 in     Cw       0.50479 in^6
Io        5.9701 in^4   ro        2.3727 in     J      0.0054528 in^4
```

Member Check - 2016 North American Specification - US (LRFD)

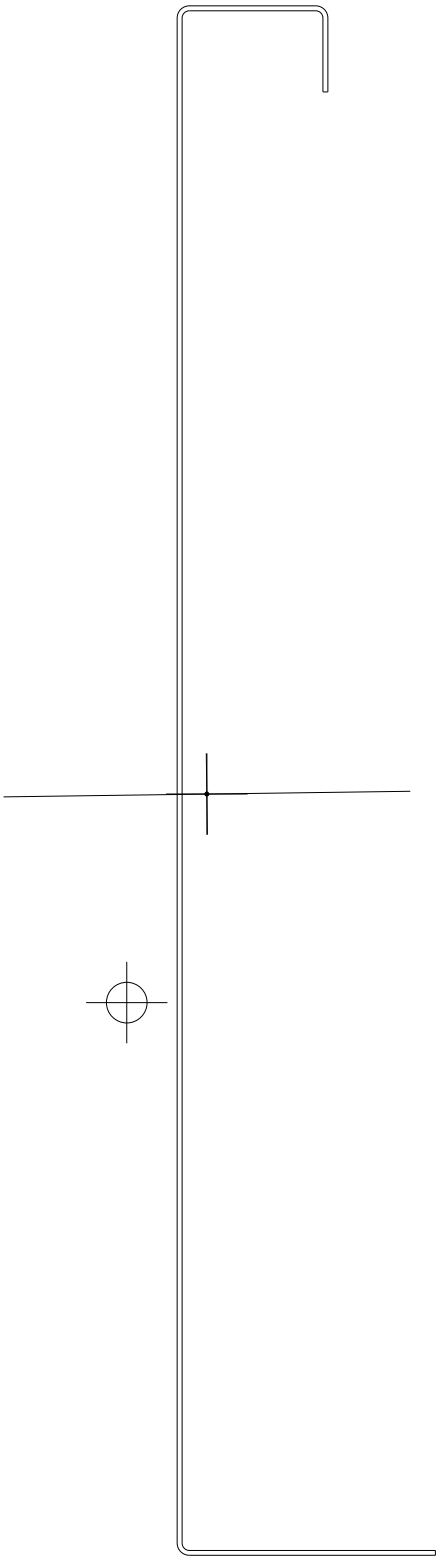
```
Material Type: A653 SS Grade 33, Fy=33 ksi
Design Parameters:
Lx        3.0000 ft     Ly        3.0000 ft     Lt        3.0000 ft
Kx        1.0000        Ky        1.0000        Kt        1.0000
Cbx       1.0000        Cby       1.0000        ex        0.0000 in
Cmx       1.0000        Cmy       1.0000        ey        0.0000 in
Braced Flange: None     kϕ             0 k
Red. Factor, R: 0       Lm        3.0000 ft

Loads:           P         Mx         Vy         My         Vx
                (k)     (k-in)        (k)     (k-in)        (k)
Entered       0.000      0.000      0.000      0.000      0.000
Applied       0.000      0.000      0.000      0.000      0.000
Strength      9.719     37.295     14.903      2.066      3.222
```

Section: Section 1.cfss
Channel 18x3x1-16 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 11/11/2018 9:08:33 PM
By: Leonard Kim
Printed: 11/11/2018 9:10:06 PM



Section: Section 1.cfss
Channel 18x3x1-16 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 11/11/2018 9:08:33 PM
By: Leonard Kim
Printed: 11/11/2018 9:10:06 PM

Section Inputs

```
Material: A653 SS Grade 50/1
No strength increase from cold work of forming.
Modulus of Elasticity, E           29500 ksi
Yield Strength, Fy                    50 ksi
Tensile Strength, Fu                  65 ksi
Warping Constant Override, Cw          0 in^6
Torsion Constant Override, J           0 in^4

Stiffened Channel, Thickness 0.0566 in (16 Gage)
Placement of Part from Origin:
X to center of gravity           0 in
Y to center of gravity           0 in
Outside dimensions, Open shape
        Length      Angle     Radius  Web      k    Hole Size   Distance
          (in)      (deg)       (in)         Coef.       (in)       (in)
  1      3.000    180.000   0.084900 Single  0.000      0.000      1.500
  2     18.000     90.000   0.084900 Cee     0.000      0.000      9.000
  3      1.750      0.000   0.084900 Single  0.000      0.000      0.875
  4      1.000    -90.000   0.084900 None    0.000      0.000      0.500
```

Full Section Properties

```
Area      1.3264 in^2   Wt.    0.0045097 k/ft   Width     23.434 in

Ix        51.769 in^4   rx         6.247 in     Ixy       -0.700 in^4
Sx(t)     5.6540 in^3   y(t)       9.156 in     α          0.784 deg
Sx(b)     5.8536 in^3   y(b)       8.844 in
                       Height    18.000 in
Iy         0.604 in^4   ry         0.675 in     xo        -0.931 in
Sy(l)     1.7526 in^3   x(l)       0.345 in     yo        -2.422 in
Sy(r)     0.2275 in^3   x(r)       2.655 in     jx        15.454 in
                       Width      3.000 in     jy         2.638 in
I1        51.778 in^4   r1         6.248 in
I2         0.594 in^4   r2         0.669 in
Ic        52.373 in^4   rc         6.284 in     Cw        34.519 in^6
Io        61.306 in^4   ro         6.799 in     J      0.0014164 in^4
```

Member Check - 2016 North American Specification - US (LRFD)

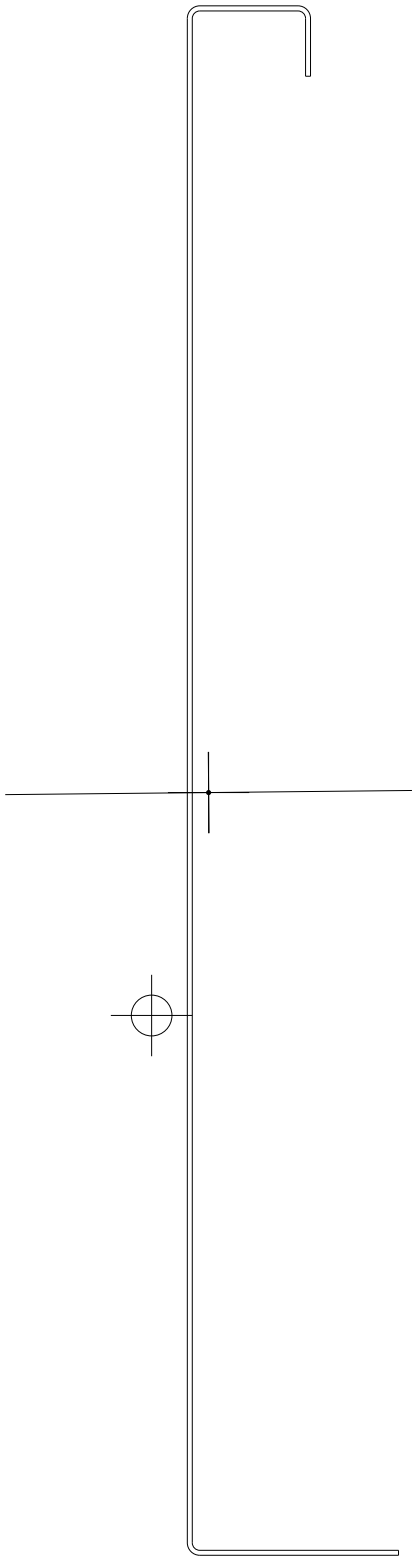
```
Material Type: A653 SS Grade 50/1, Fy=50 ksi
Design Parameters:
Lx        6.5000 ft     Ly        6.5000 ft     Lt        6.5000 ft
Kx        1.0000        Ky        1.0000        Kt        1.0000
Cbx       1.0000        Cby       1.0000        ex        0.0000 in
Cmx       1.0000        Cmy       1.0000        ey        0.0000 in
Braced Flange: None     kϕ             0 k
Red. Factor, R: 0       Lm        6.5000 ft

Loads:           P         Mx         Vy         My         Vx
                (k)     (k-in)        (k)     (k-in)        (k)
Entered      0.0000      0.000     0.0000      0.000     0.0000
Applied      0.0000      0.000     0.0000      0.000     0.0000
Strength     6.0182     86.821     1.1657      6.189     6.9775
```

Section: Section 2.cfss
Channel 22x3x1-14 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 11/11/2018 10:04:20 PM
By: Leonard Kim
Printed: 11/11/2018 10:05:35 PM



Section: Section 2.cfss
Channel 22x3x1-14 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 11/11/2018 10:04:20 PM
By: Leonard Kim
Printed: 11/11/2018 10:05:35 PM

Section Inputs

```
Material: A653 SS Grade 50/1
No strength increase from cold work of forming.
Modulus of Elasticity, E           29500 ksi
Yield Strength, Fy                    50 ksi
Tensile Strength, Fu                  65 ksi
Warping Constant Override, Cw          0 in^6
Torsion Constant Override, J           0 in^4

Stiffened Channel, Thickness 0.0713 in (14 Gage)
Placement of Part from Origin:
X to center of gravity           0 in
Y to center of gravity           0 in
Outside dimensions, Open shape
        Length      Angle     Radius  Web      k    Hole Size   Distance
          (in)      (deg)       (in)         Coef.       (in)       (in)
  1      3.000    180.000    0.10690 Single  0.000      0.000      1.500
  2     22.000     90.000    0.10690 Cee     0.000      0.000     11.000
  3      1.750      0.000    0.10690 Single  0.000      0.000      0.875
  4      1.000    -90.000    0.10690 None    0.000      0.000      0.500
```

Full Section Properties

```
Area      1.9502 in^2   Wt.    0.0066308 k/ft   Width     27.353 in

Ix        108.38 in^4   rx         7.455 in     Ixy        -1.12 in^4
Sx(t)      9.702 in^3   y(t)      11.170 in     α          0.594 deg
Sx(b)     10.007 in^3   y(b)      10.830 in
                       Height    22.000 in
Iy          0.77 in^4   ry         0.630 in     xo        -0.810 in
Sy(l)      2.552 in^3   x(l)       0.303 in     yo        -3.165 in
Sy(r)      0.287 in^3   x(r)       2.697 in     jx        22.700 in
                       Width      3.000 in     jy         3.415 in
I1        108.39 in^4   r1         7.455 in
I2          0.76 in^4   r2         0.625 in
Ic        109.15 in^4   rc         7.481 in     Cw        66.606 in^6
Io        129.97 in^4   ro         8.163 in     J      0.0033048 in^4
```

Member Check - 2016 North American Specification - US (LRFD)

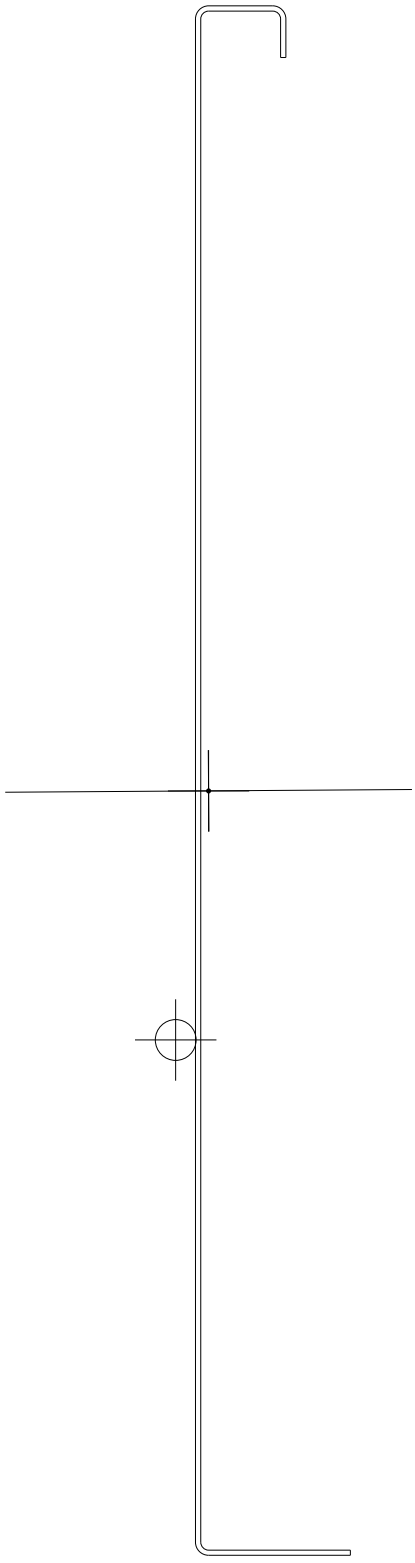
```
Material Type: A653 SS Grade 50/1, Fy=50 ksi
Design Parameters:
Lx        6.5000 ft     Ly        6.5000 ft     Lt        6.5000 ft
Kx        1.0000        Ky        1.0000        Kt        1.0000
Cbx       1.0000        Cby       1.0000        ex        0.0000 in
Cmx       1.0000        Cmy       1.0000        ey        0.0000 in
Braced Flange: None     kϕ             0 k
Red. Factor, R: 0       Lm        6.5000 ft

Loads:           P         Mx         Vy         My         Vx
                (k)     (k-in)        (k)     (k-in)        (k)
Entered      0.0000       0.00     0.0000       0.00     0.0000
Applied      0.0000       0.00     0.0000       0.00     0.0000
Strength     8.0434     134.22     1.9075       8.85     8.5659
```

Section: Section 1 30IN TALL 12 GA.cfss
Channel 30x3x1-12 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 11/11/2018 10:09:49 PM
By: Leonard Kim
Printed: 11/11/2018 10:10:48 PM



Section: Section 1 30IN TALL 12 GA.cfss Leonard Kim
Channel 30x3x1-12 Gage John A. Martin & Associates

Rev. Date: 11/11/2018 10:09:49 PM
By: Leonard Kim
Printed: 11/11/2018 10:10:49 PM

Section Inputs

```
Material: A653 SS Grade 50/1
No strength increase from cold work of forming.
Modulus of Elasticity, E           29500 ksi
Yield Strength, Fy                    50 ksi
Tensile Strength, Fu                  65 ksi
Warping Constant Override, Cw          0 in^6
Torsion Constant Override, J           0 in^4

Stiffened Channel, Thickness 0.1017 in (12 Gage)
Placement of Part from Origin:
X to center of gravity           0 in
Y to center of gravity           0 in
Outside dimensions, Open shape
        Length      Angle     Radius  Web      k    Hole Size   Distance
          (in)      (deg)       (in)         Coef.       (in)       (in)
  1      3.000    180.000    0.15250 Single  0.000      0.000      1.500
  2     30.000     90.000    0.15250 Cee     0.000      0.000     15.000
  3      1.750      0.000    0.15250 Single  0.000      0.000      0.875
  4      1.000    -90.000    0.15250 None    0.000      0.000      0.500
```

Full Section Properties

```
Area      3.5781 in^2   Wt.     0.012166 k/ft   Width     35.183 in

Ix        345.11 in^4   rx         9.821 in     Ixy        -2.32 in^4
Sx(t)     22.706 in^3   y(t)      15.199 in     α          0.387 deg
Sx(b)     23.318 in^3   y(b)      14.801 in
                       Height    30.000 in
Iy          1.11 in^4   ry         0.558 in     xo        -0.637 in
Sy(l)      4.397 in^3   x(l)       0.254 in     yo        -4.823 in
Sy(r)      0.406 in^3   x(r)       2.747 in     jx        41.980 in
                       Width      3.000 in     jy         5.132 in
I1        345.13 in^4   r1         9.821 in
I2          1.10 in^4   r2         0.554 in
Ic        346.23 in^4   rc         9.837 in     Cw        180.01 in^6
Io        430.90 in^4   ro        10.974 in     J       0.012336 in^4
```

Member Check - 2016 North American Specification - US (LRFD)

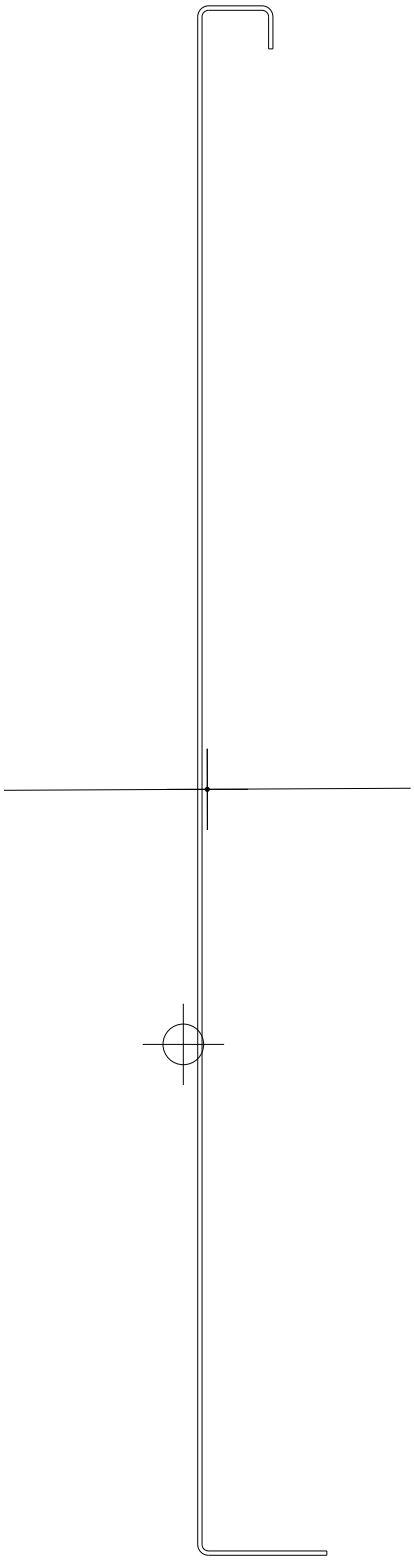
```
Material Type: A653 SS Grade 50/1, Fy=50 ksi
Design Parameters:
Lx        6.5000 ft     Ly        6.5000 ft     Lt        6.5000 ft
Kx        1.0000        Ky        1.0000        Kt        1.0000
Cbx       1.0000        Cby       1.0000        ex        0.0000 in
Cmx       1.0000        Cmy       1.0000        ey        0.0000 in
Braced Flange: None     kϕ             0 k
Red. Factor, R: 0       Lm        6.5000 ft

Loads:           P         Mx         Vy         My         Vx
                (k)     (k-in)        (k)     (k-in)        (k)
Entered       0.000       0.00      0.000       0.00      0.000
Applied       0.000       0.00      0.000       0.00      0.000
Strength     12.036     260.52      4.063      12.80     11.557
```

Section: Section 5.cfss
Channel 36x3x1-12 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 11/11/2018 10:23:02 PM
By: Leonard Kim
Printed: 11/11/2018 10:23:52 PM



Section: Section 5.cfss
Channel 36x3x1-12 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 11/11/2018 10:23:02 PM
By: Leonard Kim
Printed: 11/11/2018 10:23:53 PM

Section Inputs

```
Material: A653 SS Grade 50/1
No strength increase from cold work of forming.
Modulus of Elasticity, E           29500 ksi
Yield Strength, Fy                    50 ksi
Tensile Strength, Fu                  65 ksi
Warping Constant Override, Cw          0 in^6
Torsion Constant Override, J           0 in^4

Stiffened Channel, Thickness 0.1017 in (12 Gage)
Placement of Part from Origin:
X to center of gravity           0 in
Y to center of gravity           0 in
Outside dimensions, Open shape
        Length      Angle     Radius  Web      k    Hole Size   Distance
          (in)      (deg)       (in)         Coef.       (in)       (in)
  1      3.000    180.000    0.15250 Single  0.000      0.000      1.500
  2     36.000     90.000    0.15250 Cee     0.000      0.000     18.000
  3      1.750      0.000    0.15250 Single  0.000      0.000      0.875
  4      1.000    -90.000    0.15250 None    0.000      0.000      0.500
```

Full Section Properties

```
Area      4.1883 in^2   Wt.     0.014240 k/ft   Width     41.183 in

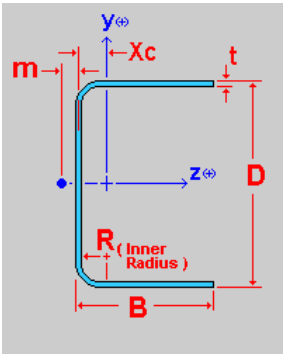
Ix        563.41 in^4   rx        11.598 in     Ixy        -2.80 in^4
Sx(t)     30.953 in^3   y(t)      18.202 in     α          0.285 deg
Sx(b)     31.657 in^3   y(b)      17.798 in
                       Height    36.000 in
Iy          1.14 in^4   ry         0.521 in     xo        -0.556 in
Sy(l)      5.074 in^3   x(l)       0.224 in     yo        -5.928 in
Sy(r)      0.409 in^3   x(r)       2.776 in     jx        60.364 in
                       Width      3.000 in     jy         6.254 in
I1        563.43 in^4   r1        11.598 in
I2          1.12 in^4   r2         0.518 in
Ic        564.55 in^4   rc        11.610 in     Cw        269.37 in^6
Io        713.01 in^4   ro        13.048 in     J       0.014440 in^4
```

Member Check - 2016 North American Specification - US (LRFD)

```
Material Type: A653 SS Grade 50/1, Fy=50 ksi
Design Parameters:
Lx        6.5000 ft     Ly        6.5000 ft     Lt        6.5000 ft
Kx        1.0000        Ky        1.0000        Kt        1.0000
Cbx       1.0000        Cby       1.0000        ex        0.0000 in
Cmx       1.0000        Cmy       1.0000        ey        0.0000 in
Braced Flange: None     kϕ             0 k
Red. Factor, R: 0       Lm        6.5000 ft

Loads:           P         Mx         Vy         My         Vx
                (k)     (k-in)        (k)     (k-in)        (k)
Entered       0.000       0.00      0.000       0.00      0.000
Applied       0.000       0.00      0.000       0.00      0.000
Strength      9.846     294.38      3.376      12.87     11.557
```

Shape Name : **Canfab Group A**
Database : **AISI Custom**
Shape Type : **CU**
Material : **Cold Formed**



D	:	61.75	in	J	:	.006	in^4
B	:	23	in	Cw	:	209700	in^6
t	:	.057	in	ro	:	28.35	in
R	:	.085	in	Xc	:	4.907	in
Area	:	6.087	in^2	m	:	7.934	in
Iyy	:	310.801	in^4	j	:	34.444	in
Izz	:	3577.482	in^4				

CANNON FABRICATION INC
182 GRANITE STREET, SUITE 101, CORONA, CA 92879
PHONE: (951)278-1830 FAX: (951)278-8444 www.canfab.com canfab@canfab.com

7.5 Ton

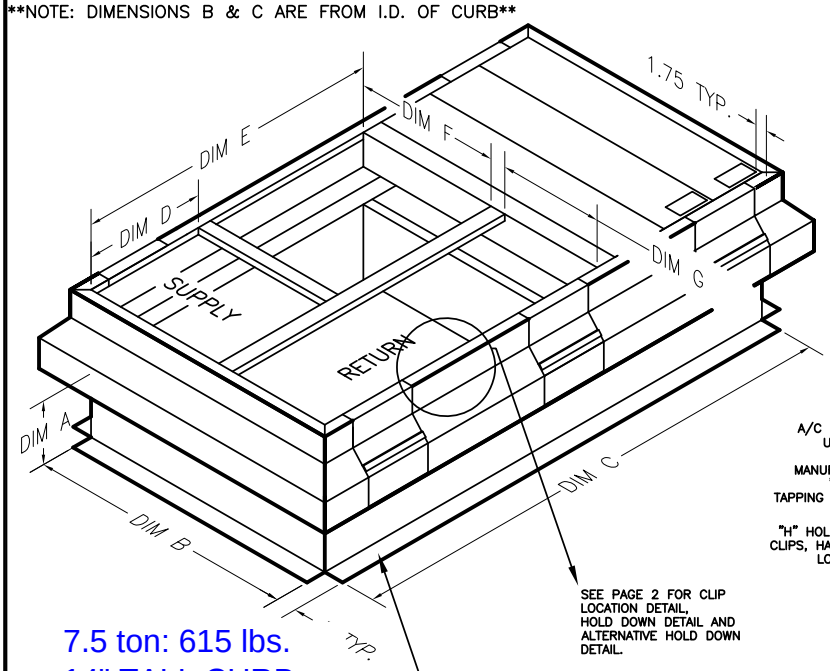
FOR: GROUP C ISO

CARRIER 12-1/2 - 15 TONS
48/50TC 016, 48/50HC 014 48/50 LC 08-12

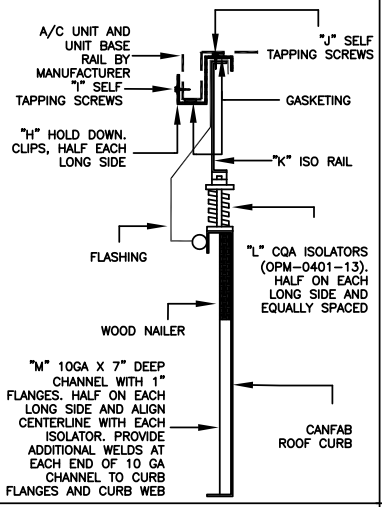
PART NO: 1094-XIC

DIM A	DIM B	DIM C	DIM D	DIM E	DIM F	DIM G	DIM H
VARIES MAX 36" SEE TABLE 3	54.0625"	105.75"	29.4375"	50.375"	35.4375"	15.3125"	N/A

NOTE: DIMENSIONS B & C ARE FROM I.D. OF CURB



7.5 ton: 615 lbs.
14" TALL CURB



NOTE: FINISH CURB HEIGHT IS 13.5" TALLER THAN DIMENSION A.

ALL WORK SHALL CONFORM TO THE STANDARD OF 2018 INTERNATIONAL BUILDING CODE & 2019 CALIFORNIA BUILDING CODE.

SEISMIC DESIGN CRITERIA
-SDS = 1.5 ap = 2.5
-I = 1.5 Rp = 2.0

WIND DESIGN CRITERIA
-MAX 60 FT TALL BUILDING
-EXPOSURE C
-175 MPH, 3 SECOND GUST WIND

NOTE:
INSTALLER TO VERIFY WITH A LICENSED STRUCTURAL ENGINEER IN THE CORRESPONDING STATE THE ADEQUACY OF THE STRUCTURE FOR LOADS IMPOSED BY THE UNIT AND THE CURB IN ADDITION TO ALL OTHER LOADS.
-INSTALLER TO VERIFY WITH A LICENSED STRUCTURAL ENGINEER IN THE CORRESPONDING STATE THAT THE SEISMIC AND WIND DESIGN CRITERIA NOTED ON THIS DRAWING ARE ADEQUATE FOR THE SITE SPECIFIC VALUES. OTHERWISE, CONTACT CANNON FABRICATION FOR A SITE SPECIFIC ANALYSIS AND DRAWINGS.

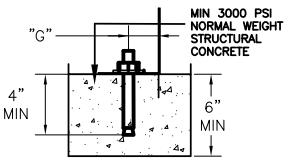
CURB CONSTRUCTION
1) ☐ WELDED
2) ☐ BOLTED
3) ☐ FINGERLOCK
-ALL WELDING CONSTRUCTION CERTIFIED TO ANSI/AWS D1.3 STRUCTURAL WELDING CODE-SHEET METAL
-SELF-DRILLING SCREW SHALL MEET ASTM C1513 SPECIFICATION AND INSTALLED PER AISI-S100
-NO GAP IS ALLOWED BETWEEN TWO METAL SHEET SURFACES WHERE SHEET METAL SCREW IS CONNECTED

CURB AND UNIT INFORMATION
"A" GAUGE GALVANIZED STEEL CURB

-SEE TABLE 3 FOR ALLOWABLE CURB AND UNIT DIMENSIONAL AND WEIGHT

-SEE TABLE 4 FOR TABULATED CURB AND ANCHORAGE INFORMATION PER VARYING CURB HEIGHT

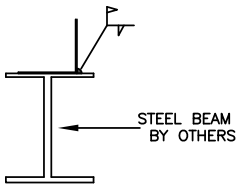
- ALPHA DESIGNATIONS "A" THRU "M", CAN BE FOUND ON TABLE 4, PAGE 3



ATTACHMENT TO STRUCTURAL CONCRETE

"B" 5/8" HILTI KWIK BOLT TZ SS 304, HALF EACH LONG SIDE.
"C" 5/8" HILTI KWIK BOLT TZ SS 304, HALF EACH SHORT SIDE.

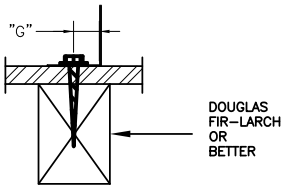
NOTE:
-MIN 6" AWAY FROM THE NEAREST CONCRETE EDGE (INSTALL PER ICC-ES ESR-1917).
-STRUCTURALLY ACCEPTABLE TO SUBSTITUTE HILTI KBTZ STAINLESS STEEL BOLTS WITH HILTI KBTZ CARBON STEEL BOLTS ONLY IF ALL THE BOLTS ARE COMPLETELY WATERPROOFED AND PROTECTED AGAINST THE WEATHER.
-BOLTS SHALL BE EQUALLY SPACED



ATTACHMENT TO STRUCTURAL STEEL

1/8" FILLET WELD, 2" LONG, "D" ON CENTER.

NOTE:
-PROVIDE MIN 2 CONNECTIONS WHERE THE CURB SIDE IS SHORTER THAN THE WELD SPACING.
-PROVIDE WELDS ON ALL SIDES



ATTACHMENT TO WOOD

"E" 3/8"x4" LAG SCREWS, HALF EACH LONG SIDE.
"F" 3/8"x4" LAG SCREWS, HALF EACH SHORT SIDE.

NOTE:
-SCREWS SHALL BE EQUALLY SPACED.

STRUCTURAL REVIEW BY:

MARTIN & associates
JOHN A. MARTIN AND ASSOCIATES
Structural Engineers
950 South Grand Ave., 4th Floor
Los Angeles, California 90015
Phone (213) 483 6490
Fax (213) 483 3084
Job No.: 19022

REGISTERED PROFESSIONAL ENGINEER
GREGORY LOUIS OROZCO
No. 4957
STRUCTURAL
STATE OF CALIFORNIA

3/13/2019

PROJECT: IBC 2018 UPDATE/ CBC 2019 UPDATE DATE: 3.12.19

ENGINEER: LD DISTRIBUTOR:

DRAWING NUMBER: GROUP_C_ISO.DWG

CanFab
CANNON FABRICATION INC
182 GRANITE STREET, SUITE 101, CORONA, CA 92879
PHONE: (951)278-1830 FAX: (951)278-8444 www.canfab.com canfab@canfab.com

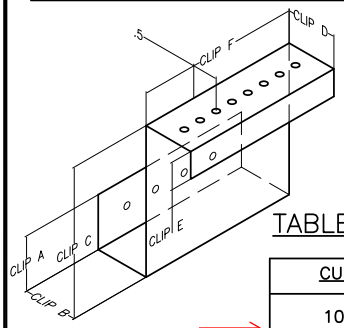
FOR: GROUP C ISO

PART NO: SEE BELOW

STRUCTURAL REVIEW BY:

MARTIN & associates
JOHN A. MARTIN AND ASSOCIATES
Structural Engineers
950 South Grand Ave., 4th Floor
Los Angeles, California 90015
Phone (213) 483 6490
Fax (213) 483 3084
Job No.: 19022

HOLD DOWN DETAIL



NOTE:
SEE TABLE 1 FOR DESIGNATED HOLD DOWN CLIP PER CURB

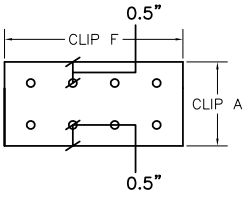


TABLE 1 HOLD DOWN CLIP PER CURB

CURB	CLIP	GAUGE	CLIP A [IN]	CLIP B [IN]	CLIP C [IN]	CLIP D [IN]	CLIP E [IN]	CLIP F [IN]
1080/ 1084/1094	1909-SHD12-12	12 GA	1.5	2.625	4.5625	1.875	1.0	9.0
3010	3902-SHD14-12	12 GA	1.5	5.295	3.825	2.0	1.0	9.0
6008/6010	6911-SHD12-12	12 GA	2.0	2.125	6.0	1.875	1.0	9.0
6010-HIC	8004-SHD-D-12-10	10 GA	2.0	N/A	N/A	N/A	N/A	9.0

**NOTE: 6010-HIC HAS FLAT STYLE CLIP (SEE LEFT)

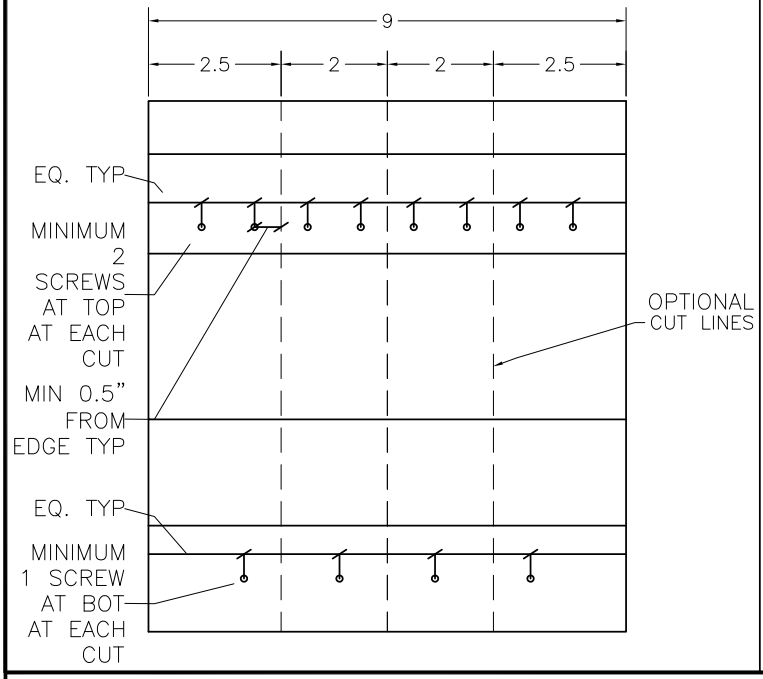


3/13/2019

ALTERNATIVE HOLD DOWN DETAIL

NOTE:
APPLICABLE ONLY FOR 9" LONG HOLD DOWN WITH (8) SCREWS AT TOP AND (4) SCREWS AT BOT EQUALLY SPACED

1. INFORMATION SHOWN ON THE STAMPED CANFAB CURB DRAWING IS THE MINIMUM REQUIREMENTS FOR THE CURB CONSTRUCTION AND INSTALLATION. NO STRUCTURAL OBJECTION TO THE USE OF LARGER SIZE SCREWS AND THICKER GAUGE SHEET METAL THAN THE INFORMATION SHOWN ON THE STAMPED CANFAB CURB DRAWING.
2. NO STRUCTURAL OBJECTION TO SHIFTING THE ATTACHMENT CLIPS ALONG THE CURB. FIRST AND LAST CLIP IN THE SERIES OF CLIPS SHALL BE LOCATED PER CLIP LOCATION DETAIL PER STAMPED CANFAB CURB DRAWING. DISTANCE SHIFTED SHALL NOT BE LARGER THAN THE LENGTH OF THE CLIP.
3. NO STRUCTURAL OBJECTION TO CUTTING THE ATTACHMENT CLIPS PER REQUIREMENTS AS SHOWN ON BELOW SKETCH.



CLIP LOCATION DETAIL

NOTE:
SEE TABLE 2 FOR CLIP LOCATION

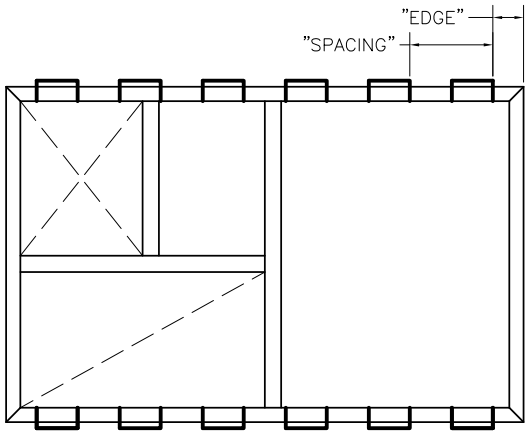


TABLE 2 CLIP LOCATION

CURB	EDGE [IN]	SPACING [IN]
1080	7.75	21.175
1084/1094	7.75	16.85
3010	7.75	16.875
6008	7.75	15.45
6010	7.75	18.4375
6010-HIC	7.75	18.4375

**NOTE: 3010-IC HAS TOTAL OF 14 CLIPS **

PROJECT: IBC 2018 UPDATE/ CBC 2019 UPDATE DATE: 3.12.19

ENGINEER: LD DISTRIBUTOR:

DRAWING NUMBER: GROUP_C_ISO.DWG

CANNON FABRICATION INC
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PHONE: (951)278-1830 FAX: (951)278-8444 www.canfab.com canfab@canfab.com

FOR: GROUP C ISO

PART NO: SEE BELOW

TABLE 3 ALLOWABLE CURB AND UNIT DIMENSION AND WEIGHT

RELATED CURBS	LCURB [IN]	WCURB [IN]	HCURB [IN]	WTCURB [LBS]	LUNIT [IN]	WUNIT [IN]	HUNIT [IN]	WTUNIT [LBS]	CG.LONG [IN]	CG.SHORT [IN]	CG.HEIGHT [IN]
1080	SEE PAGE 1	SEE PAGE 1	MIN 8	MIN 732	127.875	86.375	49.375	MAX 3261	68.7	40.9	HUNIT/2
			11	783							
			14	833							
			18	963							
			24	1232							
			MAX 36	MAX 1521							
1084	SEE PAGE 1	SEE PAGE 1	MIN 8	MIN 526	115.875	63.375	57.375	MAX 2900	57	31.5	HUNIT/2
			11	573							
			14	618							
			18	679							
			24	947							
			MAX 36	MAX 1201							
1084-XIC	SEE PAGE 1	SEE PAGE 1	MIN 8	MIN 529	115.875	63.375	57.375	MAX 2900	57	31.5	HUNIT/2
			11	576							
			14	621							
			18	682							
			24	950							
			MAX 36	MAX 1204							
1094	SEE PAGE 1	SEE PAGE 1	MIN 8	MIN 520	115.875	63.375	57.375	MAX 2729	58	32	HUNIT/2
			11	567							
			14	612							
			18	673							
			24	941							
			MAX 36	MAX 1195							
1094-XIC	SEE PAGE 1	SEE PAGE 1	MIN 8	MIN 523	115.875	63.375	57.375	MAX 2729	58	32	HUNIT/2
			11	570							
			14	615							
			18	676							
			24	944							
			MAX 36	MAX 1198							
3010	SEE PAGE 1	SEE PAGE 1	MIN 8	MIN 602	180.594	92	63	MAX 3918	85.25	45	HUNIT/2
			11	652							
			14	702							
			18	771							
			24	989							
			MAX 36	MAX 1240							

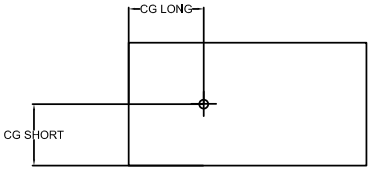
STRUCTURAL REVIEW BY:

MARTIN & associates

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GREGORY LOUIS OROZCO
No. 4957
STRUCTURAL
STATE OF CALIFORNIA

3/13/2019



PROJECT: IBC 2018 UPDATE/ CBC 2019 UPDATE DATE: 3.12.19

ENGINEER: LD DISTRIBUTOR:

DRAWING NUMBER: GROUP_C_ISO.DWG

CanFab
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FOR: GROUP C ISO

PART NO: SEE BELOW

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No. 4957
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STATE OF CALIFORNIA

3/13/2019

TABLE 3 ALLOWABLE CURB AND UNIT DIMENSION AND WEIGHT (CONTINUE)

RELATED CURBS	LCURB [IN]	WCURB [IN]	HCURB [IN]	WTCURB [LBS]	LUNIT [IN]	WUNIT [IN]	HUNIT [IN]	WTUNIT [LBS]	CG.LONG [IN]	CG.SHORT [IN]	CG.HEIGHT [IN]
6008	SEE PAGE 1	SEE PAGE 1	MIN 8	MIN 499	122.313	84.188	66.25	MAX 3195	58	36	HUNIT/2
			11	543							
			14	587							
			18	646							
			24	828							
			MAX 36	MAX 1043							
6010	SEE PAGE 1	SEE PAGE 1	MIN 8	MIN 631	122.313	84.188	66.25	MAX 3195	58	36	HUNIT/2
			11	679							
			14	727							
			18	792							
			24	999							
			MAX 36	MAX 1239							
6010-HIC	SEE PAGE 1	SEE PAGE 1	MIN 8	MIN 862	122.313	84.188	66.25	MAX 3195	58	36	HUNIT/2
			11	907							
			14	951							
			18	1010							
			24	1213							
			MAX 36	MAX 1426							

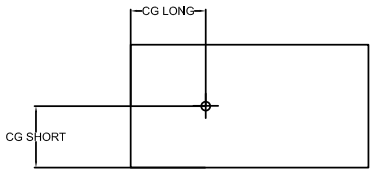


TABLE 4 TABULATED CURB AND ANCHORAGE INFORMATION PER VARYING HEIGHT

		0 < H ≤ 18"	18" < H ≤ 22"	22" < H ≤ 30"	30" < H ≤ 36"
A	CURB THICKNESS	14 GA, 12 GA FOR 6010-HIC	14 GA, 12 GA FOR 6010-HIC	12 GA	12 GA
B	EXP. ANCHOR	12	12	14	14
C	EXP. ANCHOR	8	8	8	10
D	WELD	24"	18"	18"	18"
E	SCREWS	48	50	52	56
F	SCREWS	32	34	36	38
G	DISTANCE	MAX 0.75"	MAX 0.75"	MAX 0.75"	MAX 0.75"
H	NO. OF CLIPS	12 TYPICAL, 14 FOR 3010	12 TYPICAL, 14 FOR 3010	12 TYPICAL, 14 FOR 3010	12 TYPICAL, 14 FOR 3010
I	CLIP SMS	(4) #14	(4) #14	(4) #14	(4) #14
J	CLIP SMS	(8) #14	(8) #14	(8) #14	(8) #14
K	ISO RAIL	10 GA 7.5" DEEP X 1" FLANGES			
L	NO. OF ISOLATORS	16 TYP. 17 FOR 1084-XIC AND 1094-XIC			
M	NO. OF STIFFENERS	16 TYP. 17 FOR 1084-XIC AND 1094-XIC			

PROJECT: IBC 2018 UPDATE/ CBC 2019 UPDATE DATE: 3.12.19

ENGINEER: LD DISTRIBUTOR:

DRAWING NUMBER: GROUP_C_ISO.DWG

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FOR:

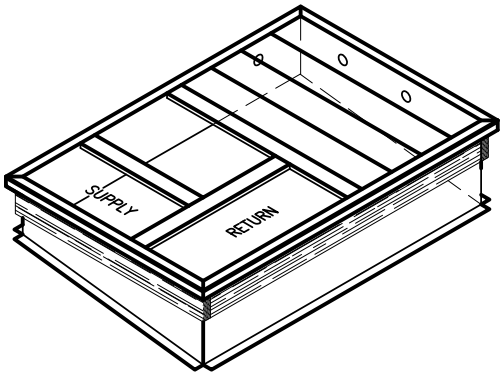
PART NO:

Pitched Roof Curb

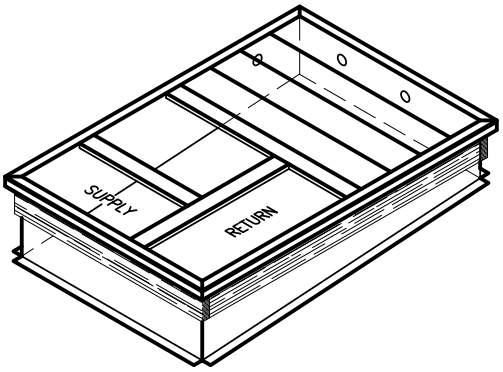
Drawing Must Accompany All Pitched Curb Orders

APPLIES TO STANDARD AND ISOLATION CURBS

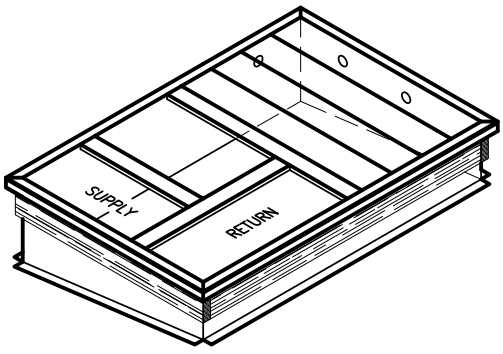
(A)



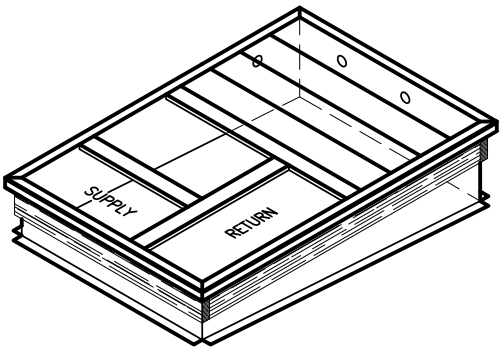
(B)



(C)



(D)



_____ On 12"

(Circle A, B, C or D To Specify Duct Placement)

PROJECT:

DATE: 01.08.19

ENGINEER:

DISTRIBUTOR:

DRAWING NUMBER:

STRUCTURAL CALCULATIONS

for

IBC 2018
Group C
6010, 6010-HIC, 1080, 1084, 1084-XIC, 1094, 1094XIC
(6010 GOVERNS)

ISOLATED CANFAB CURB

(Max Curb Height up to 36")

CURB AND ANCHORAGE WIND & SEISMIC DESIGN

Prepared for:

Cannon Fabrication, Inc. (CanFab)
182 Granite Street, Suite 101
Corona, California 92879
951.278.1830 (p)

Prepared by:

John A. Martin & Associates, Inc.
950 South Grand Avenue, 4th Floor
Los Angeles, California 90015
213.483.6490 (p)

JAMA Project No. J19022.005
PO#13121
MAR/12/2019

THE CURB HAS BEEN DESIGNED FOR SDS = 1.5G, I = 1.5 AND WIND REGION V = 175MPH. FOR HIGH SEISMIC REGIONS WITH SDS > 1.5G, I > 1.5 OR WIND REGIONS V > 175MPH, FURTHER ANALYSIS AND MODIFICATIONS TO THE CURB ARE REQUIRED PRIOR TO CONSTRUCTION

THE SUPPORTING STRUCTURE SHALL BE REVIEWED AND APPROVED BY OTHERS. BUILDING ENGINEER OF RECORD SHALL PROVIDE SUPPORT STRUCTURE AND VERIFY THE ADEQUACY OF THE STRUCTURE FOR LOADS IMPOSED ON THEM BY UNIT AS WELL AS ALL OTHER LOADS.

NO INSTALLATION SHALL TAKE PLACE UNTIL THE CURB, ANCHORAGE AND SUPPORTING STRUCTURE ARE APPROVED BY THE APPROPRIATE JURISDICTION.



3/13/2019

MARTIN & associates
JOHN A. MARTIN & ASSOCIATES, INC.
Structural Engineers
PREPARED BY: L. KIM

JOHN A. MARTIN and ASSOCIATES, INC. ☐ STRUCTURAL ENGINEERS

Architect: CANNON FABRICATION, INC. Sheet

Project: IBC 2018 Group C Job No. J13001 . 382

Date DEC/12/2018

CURB & ANCHORAGE DESIGN Engineer LK

DESIGN
for
MAX CURB HEIGHT OF 18"

950 S. GRAND AVENUE, 4TH FLOOR, LOS ANGELES, CALIFORNIA 90015 (213) 483-6490

JOHN A. MARTIN and ASSOCIATES, INC. ☐ STRUCTURAL ENGINEERS

Architect: CANNON FABRICATION, INC. Sheet

Project: IBC 2018 Group C Job No. J13001 . 382

Date DEC/12/2018

CURB & ANCHORAGE DESIGN Engineer LK

Design Wind Loads for Rooftop Equipment (ASCE 7-16 § Table 29.1-1)

$z := 60ft$ **Height above ground level**

$B := 60ft$ **Horizontal dimension of building measured normal to wind direction**

$Exp_{category} := "C"$ **Exposure Category per ASCE 7-16 § 26.7**

$Risk_{category} := "IV"$ **Risk Category per ASCE 7-16 Table 1.5-1**

$$V := \begin{cases} 0mph & \text{if } Risk_{category} = "I" \\ 0mph & \text{if } Risk_{category} = "II" \\ 175mph & \text{otherwise} \end{cases} = 175 \cdot mph$$

Basic Wind Speed per ASCE 7-16 Figure 26.5-1 A,B or C

$K_z = 1.14$ **Velocity Pressure Exposure Coefficient per ASCE 7-16 Table 29.10-1 [Exposure Category "C"]**

$K_{zt} := 1.0$ **Topographic Factor per ASCE 7-16 § 26.8, Figure 26.8-1**

$K_e := 1.0$ **Ground Elevation Factor per ASCE 7-16 § 26.9, Table 26.9-1**

$K_d := 0.85$ **Wind Directionality Factor per ASCE 7-16 § 26.6, Table 26.6-1 (Equipment)**

$q_z := 0.00256 K_z \cdot K_{zt} \cdot K_d \cdot K_e \cdot V^2 = 75.74 \cdot psf$ **Velocity pressure evaluated at height z above ground per ASCE 7-10 § 26.10.2; Eq. 26.10-1**

$GC_{r.lateral.max} := 1.9$ **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.9 for rooftop structures and equipment with Af less than (0.1Bh). (GCr) shall be permitted to be reduced linearly from 1.9 to 1.0 as the value of Af is increased from (0.1Bh) to (Bh)

$GC_{r.vertical.max} := 1.5$ **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.5 for rooftop structures and equipment with A_r less than (0.1*BL*). (GC_r) shall be permitted to be reduced linearly from 1.5 to 1.0 as the value of A_r is increased from (0.1*BL*) to (*BL*)

$P_{net} := q_z \cdot GC_{r.lateral.max} = 143.91 \cdot psf$ **Design Lateral Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-2**

$P_v := q_z \cdot GC_{r.vertical.max} = 113.61 \cdot psf$ **Design Vertical Uplift Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-3**

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Date DEC/12/2018

CURB & ANCHORAGE DESIGN Engineer LK

Seismic Demands on Nonstructural Components (ASCE 7-16 § 13.3 & 13.6):

$S_{DS} := 1.5$ **Design spectral response acceleration parameter at short periods per USGS map**

$I_p := 1.5$ **Component importance factor ASCE 7-16 § 13.1.3**

$\Omega_0 := 2.0$ **Overstrength factor ASCE 7-16 Table 13.6.1**

Vibr_Isolation = "Yes" **Placement of Unit Vibration Isolated:**

Note: Only "F_p" at seismic concrete anchor has been increased with overstrength factor "Ω_0"

$a_p := 2.5$ $R_p = 2.0$ **Seismic coefficients a_p & R_p**
Per ASCE 7-16 Table 13.6-1 for
Mechanical & Electrical Components

$z = 60\,ft$ **Height in structure of point of attachment of component with respect to the base**

$h := 60ft$ **Average roof height of structure with respect to the base**
Where for roof top equipment:

$z \div h = 1$

F_p: Horizontal Seismic Design Force per *ASCE7-16 § 13.3.1*

F_p shall be takes as $\left(\frac{0.4 \cdot a_p \cdot S_{DS} \cdot I_p}{R_p}\right) \cdot \left(1 + 2 \cdot \frac{z}{h}\right) \cdot W_p = 337.5 \cdot \% \cdot W_p$

F_p is not required to be taken as greater than $\left(1.6 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 360 \cdot \% \cdot W_p$

F_p shall not be taken as less than $\left(0.3 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 67.5 \cdot \% \cdot W_p$

Governing F_p : Horizontal Seismic Design Force $F_p = 337.5 \cdot \% \cdot W_p$

F_v: Vertical Load per ASCE7-16 § 13.3.1.2

Concurrent Vertical Seismic Force: $F_v := 0.2 \cdot S_{DS} \cdot W_p = 30 \cdot \% \cdot W_p$

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Architect: CANNON FABRICATION, INC. Sheet

Project: IBC 2018 Group C Job No. J13001 . 382

Date DEC/12/2018

CURB & ANCHORAGE DESIGN Engineer LK

Flat Roof Snow Loads (ASCE 7-16 § 7.3):

$Terrain_{CAT} := "C"$ **Terrain Category ASCE 7-16 § 26.7 & Table 7.3-1**

$Exp_{Roof} := "Partially\ Exposed"$ **Exposure of Roof ASCE 7-16 Table 7.3-1**

$C_e = 1$ **Exposure Factor ASCE 7-16 Table 7.3-1**

$Thermal_{condition} := "All\ structures\ except\ below"$ **Thermal Condition ASCE 7-16 Table 7.3-2**

$C_t = 1$ **Thermal Factor ASCE 7-16 Table 7.3-2**

$Risk_{category} = "IV"$ **Risk Category per ASCE 7-16 Table 1.5-1**

$I_s = 1.2$ **Snow Importance Factor ASCE 7-16 Table 1.5-2**

$p_g := 40psf$ **Ground Snow Loads ASCE 7-16 Figure 7.2-1**

$$p_f := \max\left(0.7 \cdot C_e \cdot C_t \cdot I_s \cdot p_g, \text{if}\left(p_g > 20psf, 20psf \cdot I_s, I_s \cdot p_g\right)\right) = 34 \cdot psf$$

Flat Roof Snow Loads ASCE 7-16 Equation 7.3-1 and § 7.3.4

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Date DEC/12/2018

CURB & ANCHORAGE DESIGN Engineer LK

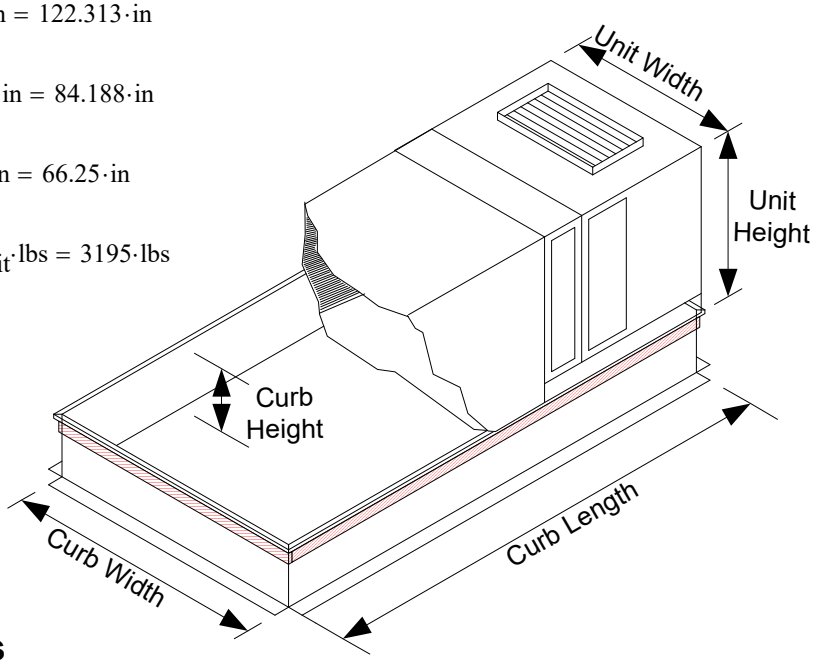
Mechanical Unit Dimensions Curb = "C-6010"

Length of Unit $L_{unit} := L_{unit} \cdot in = 122.313 \cdot in$

Width of Unit $W_{unit} := W_{unit} \cdot in = 84.188 \cdot in$

Height of Unit $H_{unit} := H_{unit} \cdot in = 66.25 \cdot in$

Weight of Unit $Wt_{unit} := Wt_{unit} \cdot lbs = 3195 \cdot lbs$



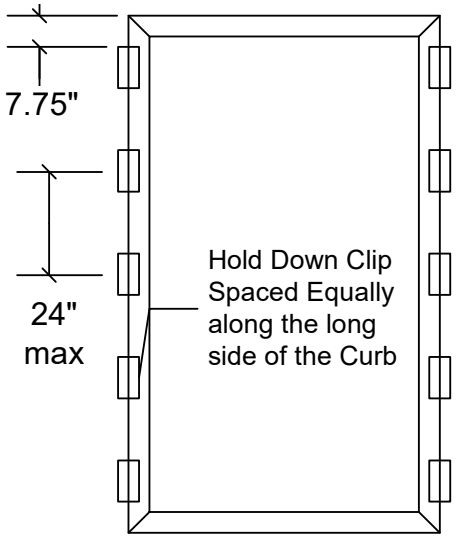
Roof Curb Dimensions

Length of Curb $L_{curb} := L_{curb} \cdot in = 113.188 \cdot in$

Width of Curb $W_{curb} := W_{curb} \cdot in = 77 \cdot in$

Height of Curb $H_{curb} := H_{curb} \cdot in = 30.5 \cdot in$

Weight of Curb $Wt_{curb} := Wt_{curb} \cdot lbs = 1239 \cdot lbs$



Curb Plan

Overall System Dimensions

Total Weight

$Wt_{tot} := Wt_{unit} + Wt_{curb} = 4402 \cdot lbs$

Total height

$H_{total} := H_{unit} + H_{curb} = 96.75 \cdot in$

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Architect: CANNON FABRICATION, INC. Sheet

Project: IBC 2018 Group C Job No. J13001 . 382

Date DEC/12/2018

CURB & ANCHORAGE DESIGN Engineer LK

Seismic Loading + Snow Loading

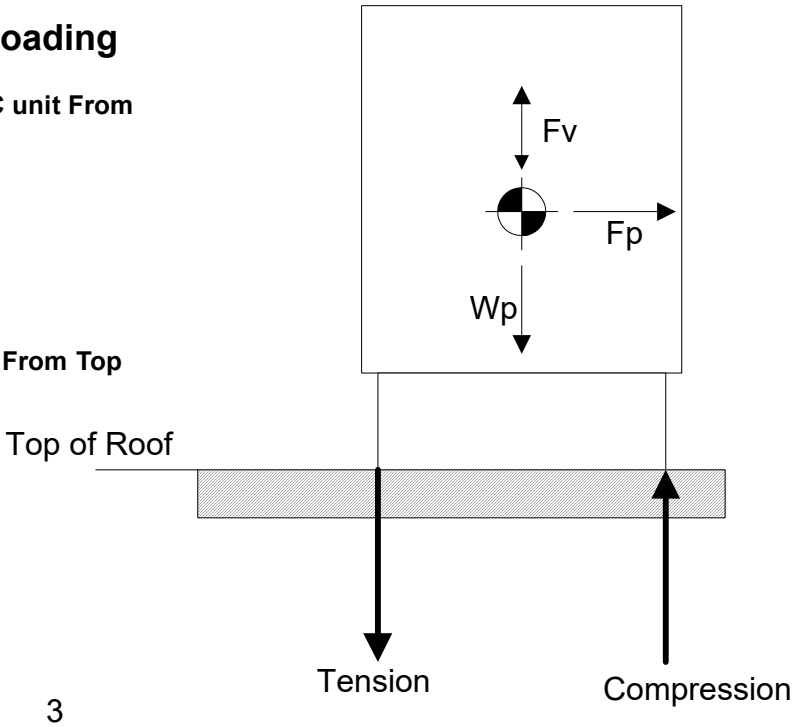
Height for Center of Gravity for HVAC unit From Top of Roof

$h_{CG.unit} := \frac{1}{2} H_{unit} = 33 \cdot in$

$h_{CG} := H_{curb} + h_{CG.unit} = 63.63 \cdot in$

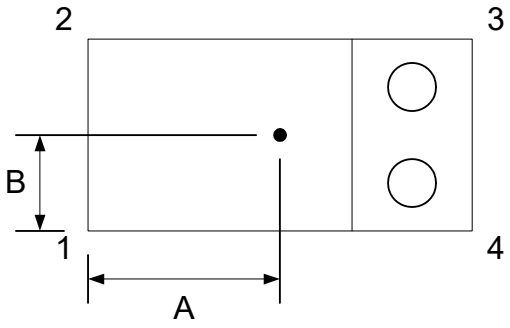
Height for Center of Gravity for Curb From Top of Roof

$h_{CG.curb} := \frac{H_{curb}}{2} = 15.25 \cdot in$



Max Seismic Base Shear

$V_{base.S} := F_p \cdot Wt_{tot} = 14857 \cdot lbs$



Unit C.G. distance in axis parallel to Curb Width $B_{ecc.width} := CG_{short} \cdot in = 36 \cdot in$

Eccentricity in axis parallel to Curb Width

$$e_{width} := \begin{cases} 0in & \text{if } B_{ecc.width} = \text{"N/A"} \\ \left| B_{ecc.width} - \frac{W_{unit}}{2} \right| & \text{otherwise} \end{cases} = 6.09 \cdot in$$

Unit C.G. distance in axis parallel to Curb Length $A_{ecc.length} := CG_{long} \cdot in = 58 \cdot in$

Eccentricity in axis parallel to Curb Length

$$e_{length} := \begin{cases} 0in & \text{if } A_{ecc.length} = \text{"N/A"} \\ \left| A_{ecc.length} - \frac{L_{unit}}{2} \right| & \text{otherwise} \end{cases} = 3.16 \cdot in$$

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Date DEC/12/2018

CURB & ANCHORAGE DESIGN Engineer LK

Max Net Tension Reaction On Each Side Due To Seismic Loads

$$T_S := \begin{bmatrix} \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{W_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{W_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} \right] \\ \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{L_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{L_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} \right] \end{bmatrix} = \begin{pmatrix} -8548 \\ -5343 \end{pmatrix}\cdot lbs$$

Max Net Compression Reaction On Each Side Due To Seismic Loads

$$C_S := \begin{bmatrix} \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{W_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \\ \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{L_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \end{bmatrix} = \begin{pmatrix} 17879 \\ 13709 \end{pmatrix}\cdot lbs$$

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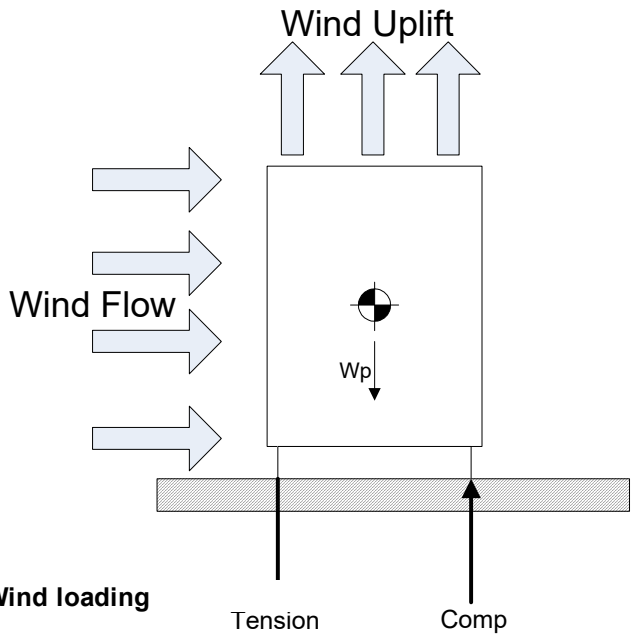
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Wind Loading + Snow Loading



Max Base Shear due to wind loading

$V_{base.W} := P_{net} \cdot L_{unit} \cdot H_{total} = 11826 \cdot lbs$

Max Uplift due to wind loading

$L_{unit.up} := L_{unit} - 0in = 122.313 \cdot in$

$P_{uplift.W} := P_v \cdot L_{unit.up} \cdot W_{unit} = 8124 \cdot lbs$

Max Net Tension Reaction On Each Side Due To Wind loading

$$T_W := \begin{pmatrix} \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} - \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \\ \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} - \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} -9739 \\ -5640 \end{pmatrix} \cdot lbs$$

Max Net Compression Reaction On Each Side Due To Wind loading

$$C_W := \begin{pmatrix} \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} + \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \\ \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} + \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} 12297 \\ 8149 \end{pmatrix} \cdot lbs$$

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Governing Loading @ Curb

Max uplift vertical load along the length of the curb

$$\omega_{x.L.vert.up} := \frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}} = 1032 \cdot plf$$

Max compressive vertical load along the length of the curb

$$\omega_{x.L.vert.comp} := \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}} = 1896 \cdot plf$$

Max vertical load along the length of the curb

$$\omega_{x.L.vert} := \max\left(\omega_{x.L.vert.up}, \omega_{x.L.vert.comp}\right) = 1896 \cdot plf$$

Max uplift vertical load along the width of the curb

$$\omega_{x.W.vert.up} := \frac{\max\left[\left|T_{S_{(1)}}\right|, \left|T_{W_{(1)}}\right|\right]}{W_{curb}} = 879 \cdot plf$$

Max compressive vertical load along the width of the curb

$$\omega_{x.W.vert.comp} := \frac{\max\left[\left|C_{S_{(1)}}\right|, \left|C_{W_{(1)}}\right|\right]}{W_{curb}} = 2136 \cdot plf$$

Max vertical loading along the width of the curb

$$\omega_{x.W.vert} := \max\left(\omega_{x.W.vert.up}, \omega_{x.W.vert.comp}\right) = 2136 \cdot plf$$

$$\begin{pmatrix} V_{base.S} \\ V_{base.W} \end{pmatrix} = \begin{pmatrix} 14857 \\ 11826 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} \left|T_S\right| \\ \left|C_S\right| \end{pmatrix} = \begin{pmatrix} 10081 \\ 22530 \end{pmatrix} \cdot lbs$$

$$\begin{pmatrix} F_v \cdot Wt_{tot} \\ P_v \cdot L_{unit} \cdot W_{unit} \end{pmatrix} = \begin{pmatrix} 1321 \\ 8124 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} \left|T_W\right| \\ \left|C_W\right| \end{pmatrix} = \begin{pmatrix} 11254 \\ 14752 \end{pmatrix} \cdot lbs$$

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Anchorage To Concrete [Expansion Anchor per ACI 318-14]

Number of connection on the long side

$N_B := 6 + 2$

Moment Arm for overturning (Short side)

$B := W_{curb} + 3in \cdot 2 = 83 \cdot in$

Number of Connection on the Short side.

$N_L := 4 + 2$

Moment Arm for over turning (Long side)

$L := L_{curb} + 3in \cdot 2 = 119 \cdot in$

Total Number of Connections

$N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 20$

Max Net Tension Reaction Due to Seismic Load, Fp

$$R_{c.EQ.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 18 \cdot lbs \qquad R_{c.EQ.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 8 \cdot lbs$$

$$R_{c.EQ} := MAX+\left[\begin{bmatrix}\left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{c.EQ.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{c.EQ.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}2139 \\ 1969\end{pmatrix} \cdot lbs$$

Max net Tension Reaction Due to Wind Load, Pnet

$$R_{c.W} := MAX+\left[\begin{bmatrix}\frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}1096 \\ 771\end{pmatrix} \cdot lbs$$

Governing Load Case:

$Govern := if\left(\left|R_{c.EQ}\right| > \left|R_{c.W}\right|, "Seismic", "Wind"\right) = "Seismic"$

Governing Tension Reaction at Each anchor Point:

$R_c := if\left(Govern = "Seismic", R_{c.EQ}, R_{c.W}\right) = \begin{pmatrix}2139 \\ 1969\end{pmatrix} \cdot lbs$

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Max Tension on anchor: $N_{ua} := \max(R_c) = 2139 \cdot lbs$

Max Shear on anchor: $V_{ua} := \frac{\max(\Omega_0 \cdot V_{base.S}, V_{base.W})}{N_t} = 1486 \cdot lbs$

Hilti Kwik Bolt TZ – Carbon Steel
5/8" Anchor with min 4" embedment
Base material: 6" thick Cracked concrete w/
Compressive strength fc' = 3000 psi
Min 6" away from the concrete edge
Evaluation Report: ICC-ESR 1917

Loading Condition:	**Seismic**

Design Tension Capacity [ϕN_n]:	3,631	[lbs]
Design Shear Capacity [ϕV_n]:	4,940	[lbs]

$\phi N_n := \phi N_n \cdot lbs = 3631 \cdot lbs$

$\phi V_n := \phi V_n \cdot lbs = 4940 \cdot lbs$

Utilization:

Tension Utilization:

$\beta_N := \frac{N_{ua}}{\phi N_n} = 59 \cdot \%$

Shear Utilization:

$\beta_V := \frac{V_{ua}}{\phi V_n} = 30 \cdot \%$

Interaction of Tensile and Shear Forces:
Per ACI 318-14 Sec. 17.6

$\beta_{NV} := \frac{(\beta_N) + (\beta_V)}{1.2} = 74 \cdot \%$

$$check\_interaction := \begin{pmatrix} if(\beta_N < 1.0, "OK", "NG") \\ if(\beta_V < 1.0, "OK", "NG") \\ if(\beta_{NV} < 1.0, "OK", "NG") \end{pmatrix} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

$$check\_interaction = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

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Anchorage To Structural Steel [Fillet Weld Conn. per AISI S100-16]

Fillet Weld 2" Long Along the Long and Short Side. Min 2 Connections per Side
Spacing: 48" O.C. for Non-Isolated Curbs; 24" for Isolated Curbs

Number of Welds on the Long Side $N_B := 5$

Moment Arm for Overturning (Short Side) $B := W_{curb} = 77 \cdot in$

Number of Welds on the Short Side. $N_L := 3$

Moment Arm for Overturning (Long Side) $L := L_{curb} = 113 \cdot in$

Total Number of Connections $N_t := \left[\left(N_B\right) + \left(N_L\right)\right] \cdot 2sides = 16$

Max Net Tension Reaction due to Seismic Load FP

$$R_{weld.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 30 \cdot lbs$$

$$R_{weld.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 18 \cdot lbs$$

$$R_{weld.EQ} := MAX+\left[\begin{bmatrix}\left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{weld.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{weld.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}1809 \\ 2056\end{pmatrix} \cdot lbs$$

Max Net Tension Reaction due to Wind Load Pnet

$$R_{weld.W} := MAX+\left[\begin{bmatrix}\frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}1792 \\ 1447\end{pmatrix} \cdot lbs$$

Tension Design Force; SRSS for Loading from Each Direction $T_{u.weld} := \max\left(\left|R_{weld.EQ}\right|, \left|R_{weld.W}\right|\right) = 2739 \cdot lbs$

Shear Load at Each Weld Connection $V_{u.weld} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{N_t} = 929 \cdot lbs$

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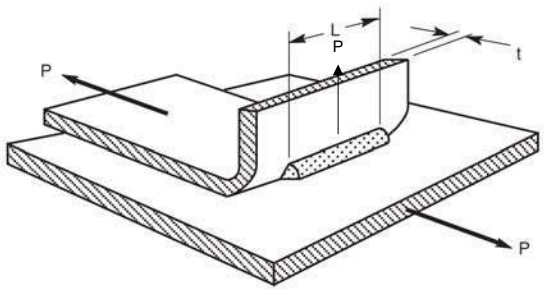
Total Demand: SRSS of V and T

$$R_{u.weld} := \sqrt{T_{u.weld}^2 + V_{u.weld}^2} = 2892 \cdot lbs$$

Fillet Weld Design per AISI S100-16 Section J2.5

Weld Length at Each Connection Point

$$L_w := 2in$$



Effective Throat Fillet Weld Size

$$t_w := \left(\frac{1}{8}in\right) \cdot 0.707 = 0.088 \cdot in$$

Thickness for the Thinnest Martial Being Welded
Min Curb Thickness = 16GA with Fu=65 ksi

$$t_1 := thick("14GA") = 0.0785 \cdot in$$

$$F_u := 65ksi$$

Min weld material strength

$$F_{exx} := 70ksi$$

For Longitudinal Loading [Parallel capacity is considered to be loading in the direction of the length of the weld] per (Eq. J2.5-1) &(Eq. J2.5-2)

$$\phi P_{long} := \begin{cases} (0.6)\left(1 - \frac{0.01 \cdot L_w}{t_1}\right) \cdot L_w \cdot t_1 \cdot F_u & \text{if } \frac{L_w}{t_1} < 25 \\ (0.5) \cdot 0.75 \cdot t_1 \cdot L_w \cdot F_u & \text{otherwise} \end{cases} = 3827 \cdot lbs$$

where $L_w \div t_1 = 25$

For Transverse Loading per (Eq. J2.5-5)

$$\phi P_{trans} := (0.65) \cdot t_1 \cdot L_w \cdot F_u = 6633 \cdot lbs$$

Strength of Weld Material per (Eq. J2.5-7)

$$\phi P_{weld} := (0.6) \cdot 0.75 \cdot t_w \cdot L_w \cdot F_{exx} = 5568 \cdot lbs$$

Design Strength of Fillet Weld

$$\phi P_n := \min\left(\phi P_{long}, \phi P_{trans}, \phi P_{weld}\right) = 3827 \cdot lbs$$

D/C Ratio for the Welded Connection

$$\beta_{NW} := \frac{R_{u.weld}}{\phi P_n} = 76 \cdot \%$$

$$weld_{check} := if\left(\beta_{NW} < 1.0, "OK", "NG"\right)$$

$weld_{check} = "OK"$

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Anchorage To Wood Member WITH Lag Screws [NDS-2018 LRFD Strength Design]

*** Use 3/8" Lag Screws along Each Side of the Curb**
*** Assume G=0.5 Douglas Fir-Larch**

Wood Lag Screw Capacity per NDS 2018 Section 11.3

Wet Service Factor: Cond := "DRY" **(e.g. CA = "DRY", AK = "WET")**

$$C_M := \begin{cases} 1.0 & \text{if Cond = "DRY"} \\ 0.7 & \text{if Cond = "WET"} \end{cases} = 1$$ **NDS 2018 Table 11.3.3**

Temperature Factor:
$$C_t := \begin{cases} 0.8 & \text{if Cond = "DRY"} \\ 0.7 & \text{if Cond = "WET"} \end{cases} = 0.8$$ **NDS 2018 Table 11.3.4**

Group Action Factor: $C_g := 0.97$ **NDS 2018 Table 11.3.6C**

Geometry Factor: $C_\Delta := 1.0$ **NDS 2018 Table 12.5.1A,B**

End Grain Factor: $C_{eg} := 1.0$ **NDS 2018 Sec. 12.5.2**

Diaphragm Factor: $C_{di} := 1.0$ **NDS 2018 Sec. 12.5.3**

Toe-Nail Factor: $C_{tn} := 1.0$ **NDS 2018 Sec. 12.5.4**

Format Conversion Factor: $K_F := 3.32$ **NDS 2018 Table 11.3.1**

Resistance Factor: $\phi := 0.65$ **NDS 2018 Table 11.3.1**

Time Effect Factor: $\lambda := 1.0$ **NDS 2018 App N.3.3**

Lateral Design Value: $Z := 130\text{lbs}$ **NDS 2018 Table 12K**

Withdrawal Design Value: $W := 305\text{lbs}$ **NDS 2018 Table 12.2A**

Lag Screw Diameter: $D_{lag} := \frac{3}{8}\text{in}$

Lag Screw Length: $L_{lag} := 4\text{in}$

Length of Tapered Tip: $E_{lag} := \frac{7}{32}\text{in}$

Lag Screw Penetration: $P_{lag} := 3.78125\text{in}$

Eff. Lag Screw Penetration for withdrawal: $P_{\omega.lag} := 2\text{in} + \frac{9}{32}\text{in} = 2.28\cdot\text{in}$ **NDS 2018 Appx. Table L2**

NDS 2018 Sec. 12.1.4.6

Minimum Penetration DCR <1.0: $DCR_{min.penetration} := \frac{4\cdot D_{lag}}{P_{\omega.lag}} = 0.66$ $DCR_{min.penetration} = \text{"OK"}$

Adj. Lateral Design Value: $Z' := Z\cdot C_M\cdot C_t\cdot C_g\cdot C_\Delta\cdot C_{eg}\cdot C_{di}\cdot C_{tn}\cdot K_F\cdot\phi\cdot\lambda = 218\cdot\text{lbs}$

Adj. Withdrawal Design Value: $W' := W\cdot C_M^{\,2}\cdot C_t\cdot C_{eg}\cdot C_{tn}\cdot K_F\cdot\phi\cdot\lambda = 527\cdot\text{lbs}$ **NDS 2018 Table 11.3.1**

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Number of Lag Screws on the Long Side $N_B := 24 + 2$

Moment Arm for Overturning (Short Side) $B := W_{curb} = 77 \cdot in$

Number of Lag Screws on the Short Side $N_L := 16 + 2$

Moment Arm for Overturning (Long Side) $L := L_{curb} = 113 \cdot in$

Total Number of Lag Screws $N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 80$

Max net Tension Reaction due to Seismic, Fp

$$R_{lag.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 6 \cdot lbs$$

$$R_{lag.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 3 \cdot lbs$$

$$R_{lag.EQ} := MAX+\left[\begin{bmatrix} \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{lag.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{lag.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 347 \\ 337 \end{pmatrix} \cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$R_{lag.W} := MAX+\left[\begin{bmatrix} \frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{L \cdot N_L \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 347 \\ 250 \end{pmatrix} \cdot lbs$$

Tension Design force; SRSS for loading from Each direction $T_{lag} := \max\left(\left|R_{lag.EQ}\right|, \left|R_{lag.W}\right|\right) = 484 \cdot lbs$

Shear load at each anchor location $V_{lag} := \frac{\max\left(V_{base.S} \cdot \sqrt{2}, V_{base.W}\right)}{N_t} = 263 \cdot lbs$

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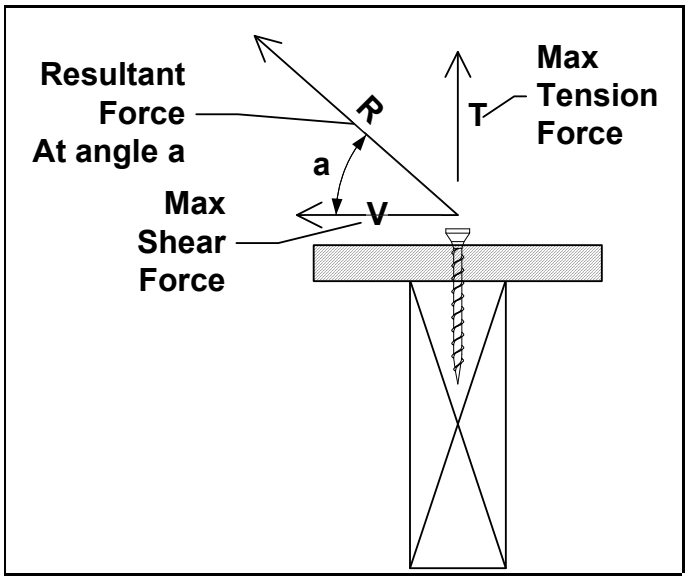
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For Lag Screws Subjected to Combined Lateral and Withdrawal Loading; Design Strength of the Lag Screw Shall Be Adjusted per Hankinson Formula as Prescribed by NDS 2018 Equation 12.4-1



Angle Between Wood Surface and Direction of Resultant Applied Load

$$(\alpha) := \operatorname{atan}\left(\frac{T_{lag}}{V_{lag}}\right) = 61\cdot\text{deg}$$

Combined Demand per Lag Screw @ Strength Level

$$R_{lag} := \sqrt{T_{lag}^{2} + V_{lag}^{2}} = 550\cdot\text{lbs}$$

Adjusted Capacity per NDS 2018 Equation 12.4-1 @ Strength Level

$$Z'_{\alpha} := \frac{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot Z'}{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot\cos(\alpha)^{2} + Z'\cdot\sin(\alpha)^{2}} = 592\cdot\text{lbs}$$

D/C Ratio for the Lag Screw connection to Wood Structure

$$\beta_{Lag} := \frac{R_{lag}}{Z'_{\alpha}} = 93\cdot\%$$

$$Lag_{Screw.Check} := \text{if}\left(\beta_{Lag} < 1.0, \text{"OK"}, \text{"NG"}\right)$$

$Lag_{Screw.Check}$ = "OK"

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Bearing and Tilting in Curb Bolted Connection AISI S100-16

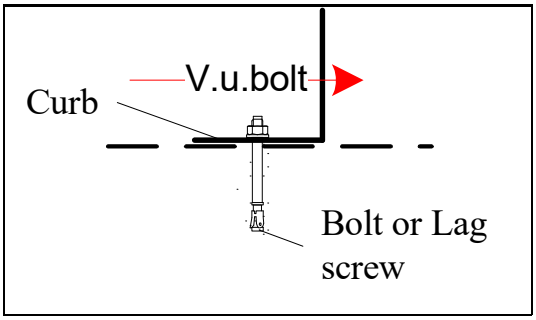
Nominal bolt diameter $d := 0.5in$

Uncoated sheet thickness $t_{curb} := thick("14GA") = 0.079 \cdot in$

Tensile strength of sheet $F_u := 65ksi$

Coefficient for conversion of units $\alpha := 1.0$

Modification Factor $m_f := 1.0$



Modification factor for type of bearing connection, per Table J3.3.1-2; For single shear connection with washers

Bearing Factor $C := \begin{cases} 3 & \text{if } \left(\frac{d}{t_{curb}} < 10\right) \wedge \left(0.024in < t_{curb} < 0.1875in\right) \\ "NG" & \text{if } \frac{d}{t_{curb}} > 10 \end{cases} = 3$

Bearing factor, which shall be determined according to Table J3.3.1-1 For d/t<10 where $d \div t_{curb} = 6$

Bearing Design Strength per AISI S100-16 Eq. J3.3.1-1

$$\phi P_{n_{(0)}} := (0.6) \cdot \left(m_f \cdot C \cdot d \cdot t_{curb} \cdot F_u\right) = 4592 \cdot lbs$$

Bolt Hole Deformation Design Strength per AISI S100-16 Eq. J3.3.2-1

$$\phi P_{n_{(1)}} := (0.65) \cdot \left[4.64 \cdot \left(\frac{\alpha}{in}\right) \cdot t_{curb} + 1.53\right] \cdot d \cdot t_{curb} \cdot F_u = 3141 \cdot lbs$$

Curb Connection Shear Capacity $\phi P_n := \min\left(\phi P_n\right) = 3141 \cdot lbs$

Loading demand at connection $V_{u.bolt} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{6} = 2476 \cdot lbs$

$Curb\_Conn\_Shear := if\left(V_{u.bolt} < \phi P_n, "OK", "NG"\right)$ Curb_Conn_Shear = "OK"

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Thickness of Curb, ISO Rail and Clip

(Per AISC Table 17-10 Galvanized)

Hold Down Clip thickness

$t_{Clip} := "12GA"$ $t_{clip} := thick(t_{Clip}) = 0.1084 \cdot in$

Roof Curb thickness

$t_{Curb} := "14GA"$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

ISO RAIL thickness

$t_{Curb.iso} := "10GA"$ $t_{curb.iso} := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Note: Iso Rail thickness is only used if the curb is isolated. Not used for non-isolated curbs

Sheet Metal Screws (SMS) Equations and References

SMS properties (ESR-2196 Table 5)

$SMS_{Table} =$

"SMS"	"Diameter"	"HeadDiameter"	"Tension"	"Shear"
"Size"	"d"	"dw"	"Pts"	"Pss"
"#8"	0.164	0.335	1000	1170
"#10"	0.19	0.399	1370	1215
"#12"	0.216	0.415	2325	1880
"#14"	0.25	0.5	4580	2440

SMS Tension Eqns

$P_{not} = 0.85 \cdot t \cdot d \cdot F_u$

$P_{nov} = 1.5 \cdot t \cdot d_w \cdot F_u$

$P_{nts} = 0.8 \cdot P_{ts}$

(AISI S100-16 J4.4.1 & J4.4.2)

FOR THE MOST CASES, PULL-OUT CAPACITY IS THE LOWEST

SMS Shearn Eqns

$P_{vnot} = 4.2 \cdot \sqrt{(d \cdot t^3)} \cdot F_u$

$P_{vnov} = 2.7 \cdot t \cdot d \cdot F_u$

$P_{vnss} = 0.8 \cdot P_{ss}$

(AISI S100-16 J4.3.1)

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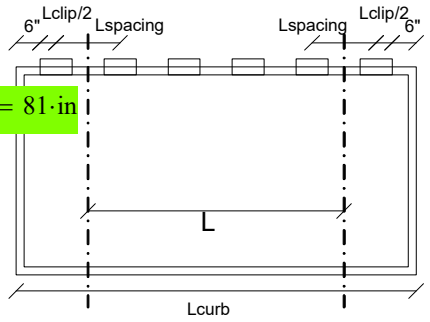
Hold Down Clip Design (Connection of the Mechanical unit to Curb)

Number of Clips on the long side $N_B := 6$

Moment Arm for overturning (Short side) $B := W_{curb} + 1.75in \cdot 2 = 81 \cdot in$

Number of Clips on the Short side. $N_L := 6$

Width of Clips $L_{clip} := 9in$



Curb Centerline Spacing (Long side)

$$L_{spacing} := \frac{L_{curb} - \left(6in + \frac{L_{clip}}{2}\right) \cdot 2}{N_B - 1} = 18.438 \cdot in$$

Moment Arm for overturning (Long side)

$$L := L_{curb} - 2 \cdot \left[6in + \frac{L_{clip}}{2} + L_{spacing} \cdot \frac{(N_L - 2)}{4}\right] = 55.313 \cdot in$$

Total Number of Clips

$$N_t := (N_B) \cdot 2sides = 12$$

Max net Tension Reaction due to Seismic, Fp

$$R_{clip.EQ} := MAX+\left[\begin{array}{l} \left[\frac{F_p \cdot Wt_{unit}}{B \cdot N_B} \cdot h_{CG.unit} + \frac{(0.9 - F_v) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B}\right] - \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} \\ \left[\frac{F_p \cdot Wt_{unit}}{L \cdot N_L} \cdot h_{CG.unit} + \frac{(0.9 - F_v) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L}\right] - \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} \end{array}\right] = \begin{pmatrix} 604 \\ 935 \end{pmatrix} \cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$R_{clip.W} := MAX+\left(\begin{array}{l} \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{unit}^2}{2}}{B \cdot N_B} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{unit}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{unit}^2}{2}}{L \cdot N_L} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{unit}}{N_t} \end{array}\right) = \begin{pmatrix} 1029 \\ 1021 \end{pmatrix} \cdot lbs$$

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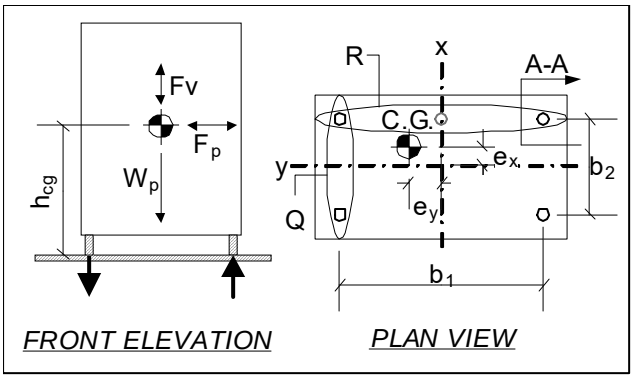
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Tensile and Shear Load calculation per ASHRAE RP-812



Eccentricity along X-X

$e_x := e_{width} = 6.094 \cdot in$

Eccentricity along Y-Y

$e_y := e_{length} = 3.157 \cdot in$

Distance between Seismic Restraints Along Y-Y

$b_1 := L_{curb} - 2 \cdot 6in = 101 \cdot in$

Distance between Seismic Restraints Along X-X

$b_2 := W_{curb} = 77 \cdot in$

Moment of Inertia about X-X

$$I_{xx} := \frac{N_t \cdot (N_t + 2) \cdot (b_1)^2}{12 \cdot (N_t - 2)} = 14335 \cdot in^2$$

Moment of Inertia about Y-Y

$$I_{yy} := \frac{N_t \cdot (b_2)^2}{4} = 17787 \cdot in^2$$

Angle about Tensile Load

$$\Theta_t := \operatorname{atan}\left[\frac{I_{yy} \cdot (b_1)}{I_{xx} \cdot (b_2)}\right] = 58 \cdot deg$$

Angle about Shear Load

$$\Theta_s := \begin{cases} \operatorname{atan}\left(\frac{e_x}{e_y}\right) & \text{if } e_y \neq 0 \\ 0deg & \text{if } e_y = 0 \end{cases} = 63 \cdot deg$$

Max Net Tensile Load Due to Seismic Load, Fp

$$T_{U.EQ.pt1} := \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} - \frac{(0.9 - F_v) \cdot Wt_{unit}}{b_1 \cdot b_2} \cdot \left(\frac{b_1}{2} \cdot e_x + \frac{b_2}{2} \cdot e_y - e_x \cdot e_y\right) = 59 \cdot lbs$$

$$T_{U.EQ.pt2} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \cos(\Theta_t) \cdot \frac{0.5 \cdot b_2}{I_{yy}} = -404 \cdot lbs$$

$$T_{U.EQ.pt3} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \sin(\Theta_t) \cdot \frac{0.5 \cdot b_1}{I_{xx}} = -1075 \cdot lbs$$

$T_{U.EQ} := T_{U.EQ.pt1} + T_{U.EQ.pt2} + T_{U.EQ.pt3} = -1420 \cdot lbs$

Max Net Shear Load Due to Seismic Load, Fp

$$V_{Ux.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\cos(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_2 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_1 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 524 \cdot lbs$$

$$V_{Uy.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\sin(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_1 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_2 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 893 \cdot lbs$$

$$V_{U.EQ} := \sqrt{V_{Ux.EQ}^2 + V_{Uy.EQ}^2} = 1035 \cdot lbs$$

Tension Design force for Hold Down Clips

$T_{clip} := \max(R_{clip.W_0}, R_{clip.W_1}, |R_{clip.EQ}|, |T_{U.EQ}|) = 1420 \cdot lbs$

$|R_{clip.EQ}| = 1113 \cdot lbs$ $|T_{U.EQ}| = 1420 \cdot lbs$

$T_{clip.EQ.max} := \max(|R_{clip.EQ}|, |T_{U.EQ}|) = 1420 \cdot lbs$

$T_{clip.W.max} := \max(R_{clip.W_0}, R_{clip.W_1}) = 1029 \cdot lbs$

Based on ASCE 7-16 Figure 29.4-1 magnitude of force coefficient,

Wind in diagonal direction to the face of equipment produces less force than that of the wind in perpendicular direction to the face of the equipment. Therefore, wind in diagonal direction does not need to be used

Shear Design force for Hold Down Clips

$$V_{clip} := \max\left(\frac{\max(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit})}{N_t}, |V_{U.EQ}|\right) = 1035 \cdot lbs$$

$F_p \cdot Wt_{unit} \cdot \frac{1}{N_t} = 899 \cdot lbs$ $|V_{U.EQ}| = 1035 \cdot lbs$

$P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t} = 675 \cdot lbs$

$V_{clip.EQ.max} := \max\left[\left(F_p \cdot Wt_{unit} \cdot \frac{1}{N_t}\right), |V_{U.EQ}|\right] = 1035 \cdot lbs$

$V_{clip.W.max} := \max\left(\left(P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t}\right)\right) = 675 \cdot lbs$

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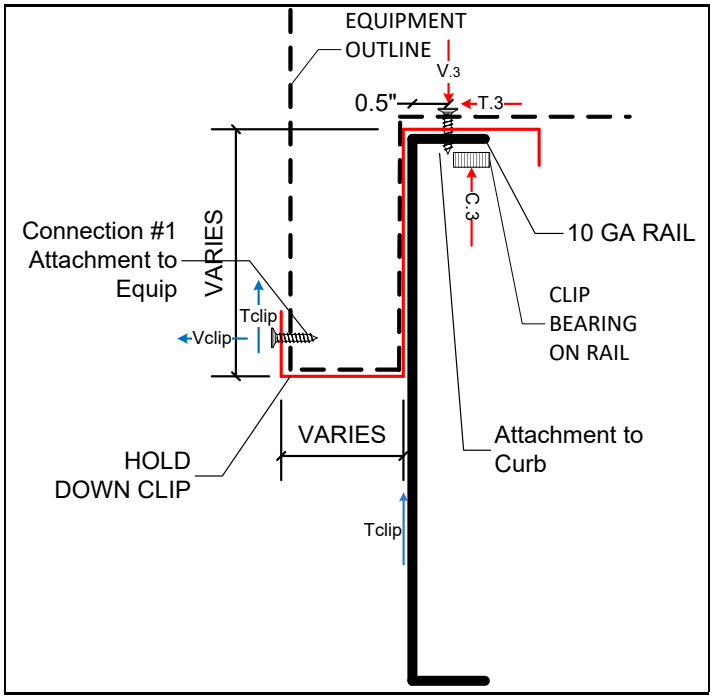
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Loading at Hold Down Clips @ Isolator Curb

$b_{return.iso} := Clip_b \cdot in = 2.125 \cdot in$

$b_{depth.iso} := Clip_c \cdot in = 6 \cdot in$



*For Reference Only

Mu Bending moment in the hold down

$M_u := T_{clip} \cdot b_{return.iso} = 3018 \cdot in \cdot lbs$

Resolve bending moment a T/C couple
Assume 0.5" bearing length
Moment Arm for T/C couple

$d_{T/C} := 1in - 0.5in = 0.5 \cdot in$

V3 is acting as shear on the screws. due to eccentricity of Tension force T

$$V_3 := \frac{T_{clip} \cdot \left[b_{return.iso} + (0) \right]}{d_{T/C}} = 6036 \cdot lbs$$

Additional load from Direct Shear acting out of plane (SRSS)

$V_3 := \sqrt{V_3^{\,2} + V_{clip}^{\,2}} = 6124 \cdot lbs$

Reaction C3 [compression force] is resisted by bearing of the hold down on the curb lip. Assume 0.5" bearing length

$C_3 := V_3 - T_{clip} = 4704 \cdot lbs$

T3 Load due to the shear acting out of plane tension on the screws.

$$T_3 := \left(\max\left(\frac{T_{clip} \cdot b_{return.iso}}{b_{depth.iso}}, V_{clip} \right) \right) = 1035 \cdot lbs$$

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Check Bending in Clip @ Isolator Curb

There are several restraints that prevents the hold down clip for iso-curb to have local bending at the bottom and transfer vertical load demand directly to the face of the curb.

- Hold down is bearing on the face of iso-rail / non-iso curb lip.
- Gasket will act as a "link" member to allow unit base rail and bottom flange to move totegther so flange can't bend unless the unit base rail bends first. However, unit base rail is not likely to bend so bottom flange won't bend

Hold Down Clip thickness

$t_{Clip} = \text{"12GA"}$ $t_{clip} := \text{thick}(t_{Clip}) = 0.1084 \cdot in$

Effective width of hold down clip

$b_c := L_{clip} = 9 \cdot in$

Yield strength of the Clip

$F_{y.c} := 50ksi$

Strength reduction for bending

$\phi_{clip} := 0.9$

Design Bending Capacity (LRFD)

$\phi M_n := \phi_{clip} \cdot F_{y.c} \left(\frac{b_c \cdot t_{clip}^2}{6} \right) = 793 \cdot in \cdot lbs$

Flexural bending demand

$M_{u.clip} := T_{clip} \cdot 0.5in = 710 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.clip}}{\phi M_n} = 0.895$

$Clip_{Bending} = \text{"OK"}$

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Check Flange Bending in Clip @ Isolator Curb

Note:
- **If the curb flange is welded to the 10GA channel and 10GA channel is welded back to the base of the curb, then both tension and compression due to equipment overturning will be taken care by the 10GA channel.**
- **Since the curb will be reinforced with 10GA channel under each isolator, it can be assumed that the loads will trasnferred down to the base structure through the channels. Therefore, flange downward bending at curb due to compressive load does not need to be checked.**

Roof Curb thickness

$t_{Curb} = \text{"14GA"}$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

Clip edge to edge distance

$$b_{edge2edge} := \frac{L_{curb} - \left(6in + \frac{L_{clip}}{2}\right) \cdot 2}{N_B - 1} - L_{clip} = 9.438 \cdot in$$

Effective width of Roof Curb

$b_{curb} := L_{clip} + b_{edge2edge} = 18.44 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\frac{b_{curb} \cdot (t_{curb})^2}{6}\right] = 852 \cdot in \cdot lbs$$

Width of Isolator

$w_{JQ.iso} := 2in$ **2 in. for CQAs**

Flexural bending demand

$$M_{u.Curb} := T_{clip} \cdot \left(\max\left(\frac{1.75in}{2} - 0.5in, \frac{w_{JQ.iso}}{2} - 1in\right)\right) = 533 \cdot in \cdot lbs$$

D/C Ratio for bending

$$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.625$$

$Curb_{Bending} = \text{"OK, Weld 10GA channel ends to curb flange"}$

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Design of Connection#1 Connection of Equipment to hold Down clip

Ultimate SMS screw connection Strength (LRFD)
Strength based on the smallest thickness of Curb and Equipment Housing (min 16 GA) [Fy = 50ksi & Fu=65ksi]

$n_{sms} := 4$ $Size_{ss} := "\#14"$

$t_{ss} := "16GA"$ $F_{u.ss} := 65ksi$

Nominal Tension Strength

$$P_{nt} := n_{sms} \cdot T_s(Size_{ss}, t_{ss}, F_{u.ss}) = 3508 \cdot lbs$$

$$P_{not} := n_{sms} \cdot T_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 3508 \cdot lbs$$

$$P_{nov} := n_{sms} \cdot T_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 12383 \cdot lbs$$

$$P_{nts} := n_{sms} \cdot T_{nts}(Size_{ss}, t_{ss}, F_{u.ss}) = 14656 \cdot lbs$$

Nominal Shear Strength

$$P_{ns} := n_{sms} \cdot V_s(Size_{ss}, t_{ss}, F_{u.ss}) = 7808 \cdot lbs$$

$$P_{vnot} := n_{sms} \cdot V_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 8737 \cdot lbs$$

$$P_{vnov} := n_{sms} \cdot V_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 11144 \cdot lbs$$

$$P_{vnss} := n_{sms} \cdot V_{nss}(Size_{ss}, t_{ss}, F_{u.ss}) = 7808 \cdot lbs$$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} V_{clip} \div (\phi_{sms} \cdot P_{nt}) \\ T_{clip} \div (\phi_{sms} \cdot P_{ns}) \end{bmatrix} = \begin{pmatrix} 59 \\ 36 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left[\begin{bmatrix} \left[\frac{T_{clip}}{P_{vnov}} + 0.71\left(\frac{V_{clip}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{T_{clip}}{P_{vnot}} + \left(\frac{V_{clip}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{T_{clip}}{P_{vnss}} + \left(\frac{V_{clip}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right] = 66 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

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Design of Connection#2 Connection of hold Down clip to Curb

Tension loads on SMS connection

$T_{s2} := V_3 = 6124 \cdot lbs$

Shear loads on SMS connection

$V_{s2} := T_3 = 1035 \cdot lbs$

Ultimate SMS screw connection Strength (LRFD)
Strength based on the smallest thickness of Curb and Equipment Housing (min 16 GA) [Fy = 50ksi & Fu=65ksi]

$n_{sms} := 8$ $Size_{ss} := "\#14"$

$t_{ss} := (t_{Curb.iso}) = "10GA"$ $F_{u.ss} := 65ksi$

Nominal Tension Strength

$P_{nt} := n_{sms} \cdot T_s(Size_{ss}, t_{ss}, F_{u.ss}) = 15271 \cdot lbs$

Note:
SMS is getting pulled up so the thicker curb iso rail is engaged for SMS capacity , rather than just the clip itself.

$P_{not} := n_{sms} \cdot T_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 15271 \cdot lbs$

$P_{nov} := n_{sms} \cdot T_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 53898 \cdot lbs$

$P_{nts} := n_{sms} \cdot T_{nts}(Size_{ss}, t_{ss}, F_{u.ss}) = 29312 \cdot lbs$

Nominal Shear Strength

$P_{ns} := n_{sms} \cdot V_s(Size_{ss}, t_{ss}, F_{u.ss}) = 15616 \cdot lbs$

$P_{vnot} := n_{sms} \cdot V_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 56103 \cdot lbs$

$P_{vnov} := n_{sms} \cdot V_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 48508 \cdot lbs$

$P_{vnss} := n_{sms} \cdot V_{nss}(Size_{ss}, t_{ss}, F_{u.ss}) = 15616 \cdot lbs$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} T_{s2} \div (\phi_{sms} \cdot P_{nt}) \\ V_{s2} \div (\phi_{sms} \cdot P_{ns}) \end{bmatrix} = \begin{pmatrix} 80 \\ 13 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left[\begin{bmatrix} \left[\frac{V_{s2}}{P_{vnov}} + 0.71\left(\frac{T_{s2}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{V_{s2}}{P_{vnot}} + \left(\frac{T_{s2}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{V_{s2}}{P_{vnss}} + \left(\frac{T_{s2}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right] = 61 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

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Hold Down clip Bending and Shear Interaction

Diameter of SMS:

$$d_{sms} := \text{vlookup}\left(Size_{ss}, SMS_{Table}, 1\right)_0 \cdot in = 0.25 \cdot in$$

Depth of flat web portion

$$h_{clip.shear} := L_{clip} - n_{sms} \cdot d_{sms} = 7 \cdot in$$

Depth-to-Thickness Ratio:

$$\frac{h_{clip.shear}}{t_{clip}} = 65 \qquad E := 29500ksi \qquad F_y := 50ksi \qquad \mu := 0.3$$

Nominal Shear Stress:
(For unreinforced web)
AISI S100-16 G2.1

$$k_v := 5.34 \qquad \sqrt{\frac{E \cdot k_v}{F_y}} = 56 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 85$$

Area of Web Element:

$$A_w := h_{clip.shear} \cdot t_{clip} = 0.759 \cdot in^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h_{clip.shear}}{t_{clip}}\right)^2} = 34.1 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} \qquad V_y := 0.6 \cdot A_w \cdot F_y = 23\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.937$$

Hole Shear Reduction Factor:
(for circular holes, AISI S100-16 Eq G3-1)

$$c := \frac{h_{clip.shear}}{2} - \frac{d_{sms}}{2.83} = 3.41 \cdot in$$

$$q_s := \begin{cases} 1.0 & \text{if } \frac{c}{t_{clip}} \geq 54 \\ \frac{c}{54 \cdot t_{clip}} & \text{if } 5 \leq \frac{c}{t_{clip}} < 54 \end{cases} = 0.583$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \leq 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \leq 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 19.792 \cdot kip$$

Design Shear Capacity with holes:

$$\phi V_{n.clip} := 0.95 \cdot V_n \cdot q_s = 11 \cdot kip$$

D/C Ratio of V and M per AISI S100-16 Eq H2-1

$$DCR_{V.M.int.clip} := \sqrt{\left(\frac{M_{u.clip}}{\phi M_n}\right)^2 + \left(\frac{\max\left(T_{clip}, V_{clip}\right)}{\phi V_{n.clip}}\right)^2} = 0.9046$$

Demand/Capacity Ratio:

$VandM_{int.clip} = \text{"OK"}$

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ISOLATOR DESIGN [PER OPM-0401-13]

OPM-0401-13 is based on allowable stress design

Number of isolators on the long side

$N_B := 8$ $N_{iso.long} := N_B = 8$

Moment Arm for overturning (Short side)

$B := W_{curb} + \frac{1.75in}{2} \cdot 2 = 79 \cdot in$

Number of isolators on the Short side.

$N_L := 6$

Isolator Centerline Spacing (Long side)

$L_{spacing.iso} := \frac{L_{curb} - (6in) \cdot 2}{N_B - 1} = 14.46 \cdot in$

Moment Arm for overturning (Long side)

$L := L_{curb} - 2 \cdot 6in - 2 \cdot L_{spacing.iso} \cdot \frac{(N_L - 2)}{4} = 72 \cdot in$

Total Number of isolators

$N_t := (N_B) \cdot 2sides = 16$

Max net Tension Reaction due to Seismic, Fp

$EQ_{ASD} := \left[0.6 - (0.7 \cdot F_v)\right] \cdot Wt_{unit} = 1.246\ kip$

$$R_{iso.EQ} := MAX+\left[\left[\left[\frac{(0.7F_p) \cdot Wt_{unit}}{B \cdot N_B} \cdot (h_{CG.unit} + 0in) + \frac{EQ_{ASD} \cdot e_{width}}{B \cdot N_B}\right] - \frac{EQ_{ASD}}{N_t}\right]\right] = \begin{pmatrix} 331 \\ 508 \end{pmatrix} \cdot lbs$$

$$\left[\left[\frac{(0.7F_p) \cdot Wt_{unit}}{L \cdot N_L} \cdot (h_{CG.unit} + 0in) + \frac{EQ_{ASD} \cdot e_{length}}{L \cdot N_L}\right] - \frac{EQ_{ASD}}{N_t}\right]$$

Max net Tension Reaction due to Wind load, Pnet

$$F_{wind.B} := \frac{P_{net} \cdot L_{unit} \cdot (H_{unit} + 0in)}{B \cdot N_B} \cdot \left(\frac{1}{2} \cdot H_{unit} + 0in\right) = 426 \cdot lbs$$

$$F_{wind.L} := \frac{P_{net} \cdot W_{unit} \cdot (H_{unit} + 0in)}{L \cdot N_L} \cdot \left(\frac{1}{2} \cdot H_{unit} + 0in\right) = 426 \cdot lbs$$

$$R_{iso.W} := (0.6) \cdot MAX+\left(\begin{pmatrix} F_{wind.B} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{Wt_{unit}}{N_t} \\ F_{wind.L} + \frac{P_v \cdot L_{unit.up} W_{unit}}{N_t} + \frac{Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{Wt_{unit}}{N_t} \end{pmatrix}\right) = \begin{pmatrix} 459 \\ 454 \end{pmatrix} \cdot lbs$$

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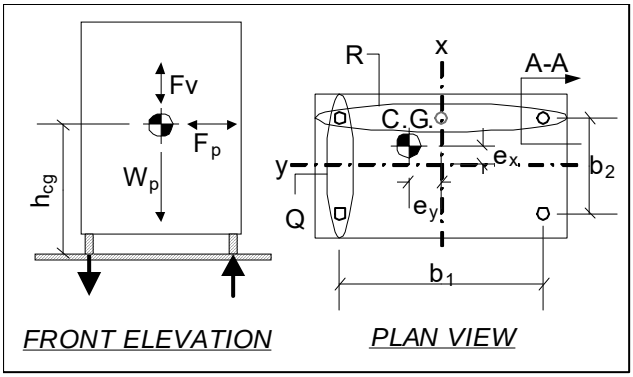
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Tensile and Shear Load calculation per ASHRAE RP-812



Eccentricity along X-X

$e_x := e_{width} = 6.09 \cdot in$

Eccentricity along Y-Y

$e_y := e_{length} = 3.16 \cdot in$

Distance between Seismic Restraints Along Y-Y

$b_1 := L_{curb} - 2 \cdot 6in = 101 \cdot in$

Distance between Seismic Restraints Along X-X

$b_2 := W_{curb} + 2 \cdot \frac{1.75in}{2} = 79 \cdot in$

Moment of Inertia about X-X

$I_{xx} := \frac{N_t \cdot (N_t + 2) \cdot (b_1)^2}{12 \cdot (N_t - 2)} = 17553 \cdot in^2$

Moment of Inertia about Y-Y

$I_{yy} := \frac{N_t \cdot (b_2)^2}{4} = 24806 \cdot in^2$

Angle about Tensile Load

$\Theta_t := \operatorname{atan}\left[\frac{I_{yy} \cdot (b_1)}{I_{xx} \cdot (b_2)}\right] = 61 \cdot deg$

Angle about Shear Load

$\Theta_s := \begin{cases} \operatorname{atan}\left(\frac{e_x}{e_y}\right) & \text{if } e_y \neq 0 \\ 0deg & \text{if } e_y = 0 \end{cases} = 63 \cdot deg$

Max Net Tensile Load Due to Seismic Load, Fp

$T_{U.EQ.pt1} := \frac{(0.6 - 0.7 \cdot F_v) \cdot Wt_{unit}}{N_t} - \frac{(0.6 - 0.7 \cdot F_v) \cdot Wt_{unit}}{b_1 \cdot b_2} \cdot \left(\frac{b_1}{2} \cdot e_x + \frac{b_2}{2} \cdot e_y - e_x \cdot e_y\right) = 13 \cdot lbs$

$T_{U.EQ.pt2} := -0.7 \cdot (F_p \cdot Wt_{unit}) \cdot (h_{CG.unit} + 0in) \cdot \cos(\Theta_t) \cdot \frac{0.5 \cdot b_2}{I_{yy}} = -191 \cdot lbs$

$T_{U.EQ.pt3} := -0.7 \cdot (F_p \cdot Wt_{unit}) \cdot (h_{CG.unit} + 0in) \cdot \sin(\Theta_t) \cdot \frac{0.5 \cdot b_1}{I_{xx}} = -631 \cdot lbs$

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$T_{U.EQ} := T_{U.EQ.pt1} + T_{U.EQ.pt2} + T_{U.EQ.pt3} = -810 \cdot lbs$

Max Net Shear Load Due to Seismic Load, Fp

$$V_{Ux.EQ} := 0.7 \cdot F_p \cdot Wt_{unit} \cdot \frac{\cos(\Theta_s)}{N_t} + \frac{0.7 \cdot F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_2 \cdot e_y + 0.7 \cdot F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_1 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 276 \cdot lbs$$

$$V_{Uy.EQ} := 0.7 \cdot F_p \cdot Wt_{unit} \cdot \frac{\sin(\Theta_s)}{N_t} + \frac{0.7 \cdot F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_1 \cdot e_y + 0.7 \cdot F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_2 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 470 \cdot lbs$$

$$V_{U.EQ} := \sqrt{V_{Ux.EQ}^2 + V_{Uy.EQ}^2} = 545 \cdot lbs$$

Tension Design force SRSS for loading from Each direction

$R_{iso.EQ.1.RP812} := \left| T_{U.EQ.pt1} + T_{U.EQ.pt3} \right| = 618 \cdot lbs$

$R_{iso.EQ.0.RP812} := \left| T_{U.EQ.pt1} + T_{U.EQ.pt2} \right| = 178 \cdot lbs$

$$R_{iso.EQ.max_1} := \max\left[\left(R_{iso.EQ.1.RP812} + 0 \cdot R_{iso.EQ.0.RP812}\right), \left(R_{iso.EQ_1} + 0 \cdot R_{iso.EQ_0}\right)\right] = 618 \cdot lbs$$

$$R_{iso.EQ.max_0} := \max\left[\left(R_{iso.EQ.0.RP812} + 0 \cdot R_{iso.EQ.1.RP812}\right), \left(R_{iso.EQ_0} + 0 \cdot R_{iso.EQ_1}\right)\right] = 331 \cdot lbs$$

For the plot:

$R_{iso.EQ.max_1} = 618 \cdot lbs$ $R_{iso.W_1} = 454 \cdot lbs$

$R_{iso.EQ.max_0} = 331 \cdot lbs$ $R_{iso.W_0} = 459 \cdot lbs$

Shear load at each anchor location

For the plot:

$$V_{iso.E} := \max\left[\left[\begin{array}{c} 1.0 \cdot V_{Ux.EQ} + 0 \cdot V_{Uy.EQ} \\ 0.3 \cdot V_{Ux.EQ} + 0 \cdot V_{Uy.EQ} \\ \left[\left(0.7F_p\right) \cdot Wt_{unit} \cdot \frac{1}{N_t}\right] \end{array}\right]\right] = 472 \cdot lbs \qquad V_{iso.W} := 0.6P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t} = 304 \cdot lbs$$

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Isolator Capacity:

$ID_{Iso} := "CQA"$

$T_{n.\Omega} := 2117lbs$ **(ASD)**

$V_{n.\Omega} := 775lbs$ **(ASD)**

Isolator Demand:

$R_{iso.max} := \max\left[\left(R_{iso.EQ.max_1}\right),\left(R_{iso.EQ.max_0}\right),\left(R_{iso.W_1}\right),\left(R_{iso.W_0}\right)\right] = 618\cdot lbs$

$V_{iso.max} := \max\left(V_{iso.E}, V_{iso.W}\right) = 472\cdot lbs$

D/C Ratio of Tension Only.:

$$DCR_{tension} := \frac{R_{iso.max}}{T_{n.\Omega}} = 0.292$$

$DCR_{tension} = "OK"$

D/C Ratio of Shear Only.:

$$DCR_{shear} := \frac{V_{iso.max}}{V_{n.\Omega}} = 0.609$$

$DCR_{shear} = "OK"$

D/C Ratio of Tension Only.:

$$DCR_{Int} := \frac{V_{iso.max}}{V_{n.\Omega}} + \frac{R_{iso.max}}{T_{n.\Omega}} = 0.901$$

$DCR_{Int} = "OK"$

ISOLATOR "SPRING" DESIGN [PER OPM-0401-13]

Factor of Safety of Spring

$FS_{spring} := 0.75$

Compressive Strength of Spring

$$C_{spring.\Omega} := \begin{cases} \left(FS_{spring}\cdot 300lbs\right) & \text{if } ID_{Iso} = "CQA" \\ \left(FS_{spring}\cdot 918lbs\right) & \text{if } ID_{Iso} = "CQB" \\ \left(FS_{spring}\cdot 918lbs\right) & \text{if } ID_{Iso} = "CQBX" \end{cases} = 225\cdot lbs$$

Rated Load per unit self-weight

$$C_{unit.rated.load} := \frac{Wt_{unit}}{N_t} = 200\cdot lbs$$

D/C Ratio of Spring Compression:

$$DCR := \frac{C_{unit.rated.load}}{C_{spring.\Omega}} = 0.888$$

$IsoSpring_{compression} = "OK"$

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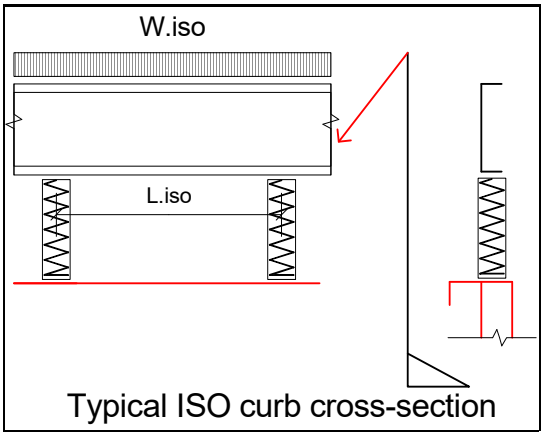
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Check ISO Rail for Bending about Strong and Weak Axis (AISI S100-16 F2.1)



Typical ISO curb cross-section

Thickness of Curb:

$t_{Curb.iso}$ = "10GA" $t := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Inside Bend Radius:

$R := R_{iso} = 0.186 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web:

$h := 7.5in - 2 \cdot (t + R) = 6.85 \cdot in$

Width of Flange:

$h_w := 1in$

Check Curb Bending of Long Side (Strong axis)

Member per CFS: $CFS_{member} :=$ "10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"

Number of Isolators on each Long Side: $N_{iso.long} = 8$

Center-to-Center Spacing of Isolators $L_{iso} := \frac{L_{curb}}{N_{iso.long} - 1} = 16 \cdot in$

Distributed Load $\omega_{iso} := \omega_{x.L.vert} = 1.896\,klf$

Moment Demand on Iso Rail $M_{cx} := \frac{\omega_{iso} \cdot L_{iso}^2}{8} = 5.163 \cdot kip \cdot in$

Curb Elastic Modulus / Yield Stress: $E := 29500ksi$ $F_y := 50ksi$

Curb Shear Modulus: $G := 11300ksi$

Poisson's Ratio $\mu := 0.3$

Section Properties from CFS: $r_x = 2.4893 \cdot in$ $r_o = 2.519 \cdot in$ $C_w = 0.595 \cdot in^6$ $S_x = 1.855 \cdot in^3$

$r_y = 0.2288 \cdot in$ $J = 0.0058 \cdot in^4$ $S_y = 0.3669 \cdot in^3$

$r_{min} := min(r_x, r_y) = 0.2288 \cdot in$

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Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Flanges*

Flat Width:

$$w := h_w - R_{curb} = 0.893 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Unstiffened"}$$

Stress at the end of the Width:

$$f_2 := 11.407ksi \quad f_1 := 11.407ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \frac{f_2}{f_1} = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 0.43$$

Critical Compressive Stress:

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t}{w}\right)^2 = 274.53 \cdot ksi$$

Stress in Compression Element:

$$f := 18ksi$$

Note: Use f from "Elastive Flexural Buckling Stress" on "Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI E2)"

Slenderness Factor:

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 0.26$$

Local reduction factor:

$$\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 0.55$$

Effective Width of the Flanges:

$$b_{eff.flange} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 0.893 \cdot in$$

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Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Web*

Flat Width: $w := h = 6.851 \cdot in$

Stiffened Web Check: $Stiffened_{check} := "Stiffened"$

Stress at the end of the Width: $f_2 := 11.407ksi$ $f_1 := 11.407ksi$

Compressive Stress Ratio (Eq. 1.1.2-1): $\Psi := \frac{f_2}{f_1} = 1$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = "Stiffened" \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = "Unstiffened" \end{cases} = 4$$

Critical Compressive Stress: $F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t}{w}\right)^2 = 43.4 \cdot ksi$

Stress in Compression Element: $f := 18ksi$

Note: Use f from "Elastive Flexural Buckling Stress" on "Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI E2)"

Slenderness Factor: $\lambda := \sqrt{\frac{f}{F_{cr}}} = 0.64$

Local reduction factor: $\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 1.022$

Effective Width of the Web:

$$b_{eff.web} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 6.851 \cdot in$$

Effective Area of the Member: $A_e := 2 \cdot \left(b_{eff.flange} \cdot t\right) + b_{eff.web} \cdot t = 1.194 \cdot in^2$

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For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. F2.1.1-4,5)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(1.0 \cdot L_{iso}\right)^2}\right] = 96 \cdot ksi$$

$$\sigma_{ey} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{iso}}{r_y}\right)^2} = 58 \cdot ksi \qquad \frac{1.0 \cdot L_{iso}}{r_y} = 71$$

KL_r = "KL/r < 200, OK"

Cb per Eq. F2.1.1-2

$$M_A := \frac{\omega_{iso} \cdot \frac{L_{iso}}{4}}{2} \cdot \left(L_{iso} - \frac{L_{iso}}{4}\right) = 3.87 \cdot kip \cdot in$$

$$M_B := M_{cx} = 5.16 \cdot kip \cdot in$$

$$M_C := \frac{\omega_{iso} \cdot \frac{3 \cdot L_{iso}}{4}}{2} \cdot \left(L_{iso} - \frac{3 \cdot L_{iso}}{4}\right) = 3.87 \cdot kip \cdot in$$

$$C_b := \min\left(1.0, \frac{12.5 \cdot M_{cx}}{2.5 \cdot M_{cx} + 3 \cdot M_A + 4 \cdot M_B + 3.M_C}\right) = 1$$

Elastic Critical Lateral-Torsional Buckling Stress per Eq. F2.1.1-1 for Singly Symmetry:

$$F_e := \frac{C_b \cdot r_o \cdot A_e}{S_x} \cdot \sqrt{\sigma_{ey} \cdot \sigma_t} = 121 \cdot ksi$$

LTB Design Stress: Eq. F2.1-3,4,5:

$$F_c := \begin{cases} F_y & \text{if } F_e \geq 2.78 \cdot F_y \\ \frac{10}{9} \cdot F_y \cdot \left(1 - \frac{10 \cdot F_y}{36 \cdot F_e}\right) & \text{if } 2.78 \cdot F_y > F_e > 0.56 \cdot F_y \\ F_e & \text{if } 0.56 \cdot F_y \geq F_e \end{cases} = 49 \cdot ksi$$

Moment Capacity Eq. F2.1-1:

$$\phi M_{nx} := 0.9 \cdot S_x \cdot \min\left(F_c, F_y\right) = 82 \cdot kip \cdot in$$

D/C Ratio of Bending:

$$DCR := \frac{M_{cx}}{\phi M_{nx}} = 0.063$$

$Iso_{Bending}$ = "OK"

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Check Curb Bending of Long Side (Weak axis)

Center-to-Center Spacing of Braces

$$L_{brace} := \frac{L_{curb}}{N_{iso.long} - 1} = 16 \cdot in$$

Note for weak-axis bracing length:
Max weak-axis span length of Iso Rail is larger than L_{brace} per cut sheet. However, the Iso Rail is braced with clip at max 24" O.C. at top and isolator at max 36" O.C. at bottom such that the actual unbraced length is as follows.

Distributed Load

$$\omega_{iso} := \frac{\max\left(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit}\right)}{L_{curb}} = 1.143\ klf$$

Moment Demand on Iso Rail

$$M_{cy} := \frac{\omega_{iso} \cdot L_{brace}^{2}}{8} = 3.114 \cdot kip \cdot in$$

Member per CFS:

$$CFS_{member} = \text{"10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"}$$

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. F2.1.1-4,5)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(1.0 \cdot L_{brace}\right)^2}\right] = 96 \cdot ksi$$

$$\sigma_{ex} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{brace}}{r_x}\right)^2} = 6900 \cdot ksi \qquad \frac{1.0 \cdot L_{brace}}{r_x} = 6$$

$$KL_r = \text{"KL/r < 200, OK"}$$

Cb per Eq. F2.1.1-2

$$M_A := \frac{\omega_{iso} \cdot \frac{L_{brace}}{4}}{2} \cdot \left(L_{brace} - \frac{L_{brace}}{4}\right) = 2.34 \cdot kip \cdot in$$

$$M_B := M_{cy} = 3.11 \cdot kip \cdot in$$

$$M_C := \frac{\omega_{iso} \cdot \frac{3 \cdot L_{brace}}{4}}{2} \cdot \left(L_{brace} - \frac{3 \cdot L_{brace}}{4}\right) = 2.34 \cdot kip \cdot in$$

$$C_b := \min\left(1.0, \frac{12.5 \cdot M_{cx}}{2.5 \cdot M_{cx} + 3 \cdot M_A + 4 \cdot M_B + 3 \cdot M_C}\right) = 1$$

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Elastic Critical Lateral-Torsional Buckling Stress per Eq. F2.1.1-1 for Singly Symmetry:

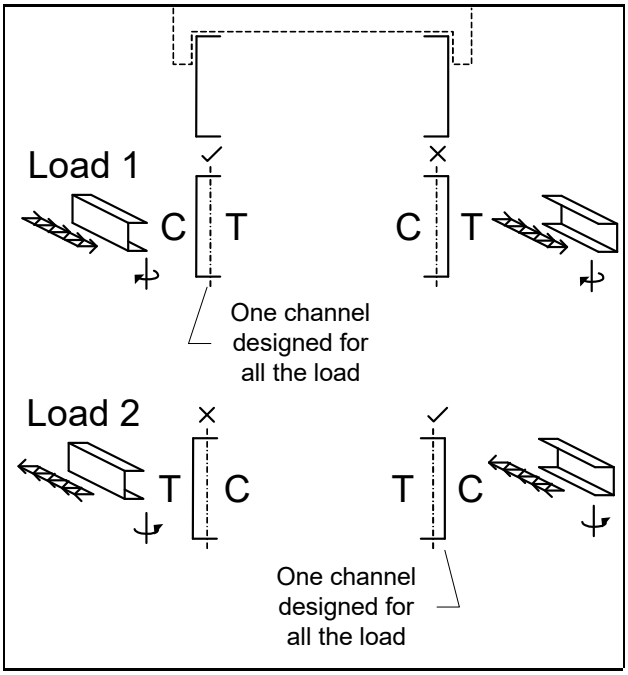
$$F_e := \frac{C_b \cdot r_o \cdot A_e}{S_y} \cdot \sqrt{\sigma_{ey} \cdot \sigma_t} = 613 \cdot ksi$$

LTB Design Stress: Eq. F2.1-3,4,5:

$$2.78 \cdot F_y = 139 \cdot ksi$$

$$0.56 \cdot F_y = 28 \cdot ksi$$

$$F_c := \begin{cases} F_y & \text{if } F_e \geq 2.78 \cdot F_y \\ \frac{10}{9} \cdot F_y \cdot \left(1 - \frac{10 \cdot F_y}{36 \cdot F_e}\right) & \text{if } 2.78 \cdot F_y > F_e > 0.56 \cdot F_y \\ F_e & \text{if } 0.56 \cdot F_y \geq F_e \end{cases} = 50 \cdot ksi$$



Note:

For ISO rail weak-axis bending capacity, rails are oriented and designed so that the stiffer side of ISO rail can take the entire bending load by itself without putting a lot of bending load to the iso rail on the other side

Moment Capacity Eq. F2.1-1:

$$\phi M_{ny} := 0.9 \cdot S_y \cdot \min(F_c, F_y) = 16.5105 \cdot kip \cdot in$$

D/C Ratio of Bending:

$$DCR := \frac{M_{cy}}{\phi M_{ny}} = 0.189$$

$$Iso_{Bending} := \text{if}(M_{cy} < \phi M_{ny}, \text{"OK"}, \text{"NG"})$$

$Iso_{Bending} = \text{"OK"}$

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Project: IBC 2018 Group C Job No. J13001 . 382

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CURB & ANCHORAGE DESIGN Engineer LK

Web Crippling of ISO Rail (AISI S100-16 G.5)

Governing Compression:

$$P_{web.crip} := \frac{\omega_{x.L.vert} \cdot L_{iso}}{2} = 1277 \cdot lbs$$

Yield Strength:

$$F_y := 50ksi$$

Bearing Length:

$N := 2in$ **2 in. for CQAs**

Thickness of Curb:

$t_{Curb.iso} = \text{"10GA"}$ $t := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Inside Bend Radius:

$R := R_{iso} = 0.186 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web:

$h = 6.85 \cdot in$

Angle btween plane of web and bearing surface:

$\theta := 90deg$

Web Crippling Limit Check (AISI Table G5-2):

$\frac{R}{t} = 1$ $\frac{h}{t} = 50$ $\frac{N}{t} = 14$ $\frac{N}{h} = 0.29$

$$LimitCheck_{webcrippling} := if\left[\left(\frac{h}{t} < 200\right) \wedge \left(\frac{N}{t} < 210\right) \wedge \left(\frac{N}{h} < 2\right) \wedge \left(\frac{R}{t} < 2\right), \text{"OK"}, \text{"NG, Need Reinf"}\right]$$

$LimitCheck_{webcrippling} = \text{"OK"}$

End Case Coefficient Single Web Channel (AISI Table G5-2):

$C := 2$ $C_R := 0.11$ $C_N := 0.37$ $C_h := 0.01$

Reduction Factor Web Crippling Strength:

$\phi_{web.end} := 0.75$

$\phi_{web.int} := 0.8$

(For Unfastened Flanges with Two-Flange Loading or Reaction. Worst Case)

Design Web Crippling Strength:

$$P_{n.end} := C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 3729 \cdot lbs$$

$$\phi P_{n.end} := \phi_{web.end} \cdot P_{n.end} = 2796 \cdot lbs$$

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Interior Case Coefficient Single Web Channel (AISI Table G5-2):

$C := 13$ $C_R := 0.47$ $C_N := 0.25$ $C_h := 0.04$

Design Web Crippling Strength:

$$P_{n.interior} := C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 7905 \cdot lbs$$

$$\phi P_{n.interior} := \left(\phi_{web.int}\right) \cdot P_{n.interior} = 6324 \cdot lbs$$

Design Strength:

$$P_{n.web.crip} := \min\left(P_{n.end}, P_{n.interior}\right) = 3729 \cdot lbs$$

$$\phi P_{n.web.crip} := \min\left(\phi P_{n.end}, \phi P_{n.interior}\right) = 2796 \cdot lbs$$

D/C Ratio of Shear:

$$DCR := \frac{P_{web.crip}}{\phi P_{n.web.crip}} = 0.457$$

Demand/Capacity Ratio:

$$Web_{crippling} := \text{if}\left[\left(P_{web.crip} < \phi P_{n.web.crip}\right) \wedge \left(\phi P_{n.end} > 0\right) \wedge \frac{h}{t} < 200, \text{"OK"}, \text{"NG, Need Reinf"}\right]$$

$Web_{crippling} = \text{"OK"}$

D/C Ratio of Interaction:
AISI Eq. H3-1b

$$DCR_{int.web} := \frac{0.91 \cdot \left(\frac{P_{web.crip}}{P_{n.web.crip}}\right) + \frac{M_{cx}}{\left(\frac{\phi M_{nx}}{0.9}\right)}}{1.33 \cdot 0.9} = 0.308$$

$Iso_{Shear} = \text{"OK"}$

$Iso_{Interaction} = \text{"OK"}$

Per AISI S100-16 H3,
Only x-axis needs to check for interaction

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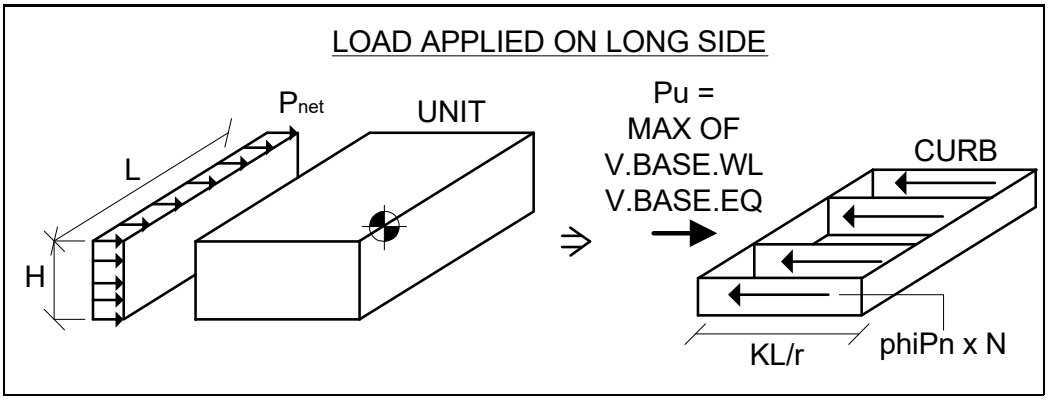
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Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI S100-16 E2)

Curb Axial Load Check due to Load on Long Side



Wind Base Shear of Unit on Long Side: $V_{base.W.L} := P_{net} \cdot L_{unit} \cdot H_{unit} = 8.1\,kip$

Seismic Base Shear of Unit on Long Side: $V_{base.S.L} := F_p \cdot Wt_{unit} = 10.8\,kip$

Max Axial: $P_u := \max(V_{base.S.L}, V_{base.W.L}) = 10783.46 \cdot lbs$

Member per CFS: $CFS_{member} =$ "10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"

Number of Curb in Length: $n_{iso} := 3$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{iso}} = 3.59\,kip$

Max Braced Length of Member: $L_{member} := W_{curb} = 77 \cdot in$

Effective Length factor: $K := 0.5$

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For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. E2.2-5, E2.2-6)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(K \cdot L_{member}\right)^2}\right] = 24 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2} = 10 \cdot ksi$$

$$\frac{K \cdot L_{member}}{r_{min}} = 168$$

KL_r = "KL/r < 200, OK"

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 7 \cdot ksi$$

Nominal Compressive Stress Capacity (Eq E2-4):

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 2.635$$

$$F_n := \begin{cases} 0.658^{\lambda_c^{\,2}} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^{\,2}}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 6.32 \cdot ksi$$

Strength reduction for Compression: $\phi_c := 0.85$

Factored Compressive Capacity: $\phi P_{n.member} := \phi_c \cdot A_e \cdot F_n = 6.41\,kip$

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.561$

$Axial_{reinf} := \text{if}\left(P_{u.EAmember} < \phi P_{n.member}, \text{"OK"}, \text{"NG"}\right)$

$Axial_{reinf}$ = "OK"

Note:
No need to check for interaction since equipment is not attached to the short side

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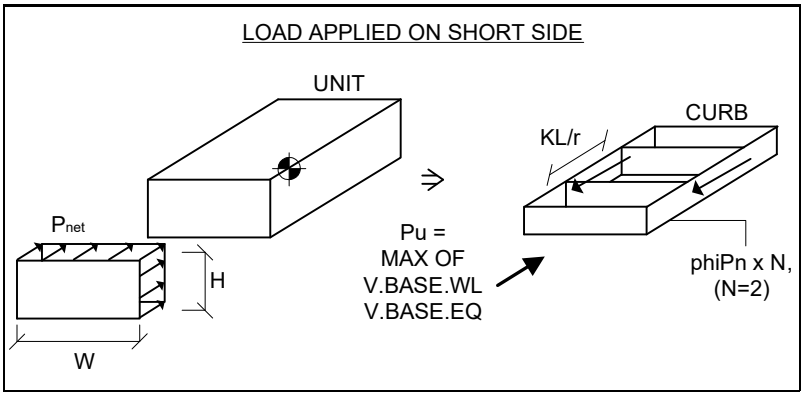
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Curb Axial Load Check due to Load on Short Side



Wind Base Shear on Short Side: $V_{base.W.H} := P_{net} \cdot W_{unit} \cdot H_{unit} = 5.6\,kip$

Seismic Base Shear of Unit on Short Side: $V_{base.S.W} := F_p \cdot Wt_{unit} = 10.8\,kip$

Max Axial: $P_u := \max\left(V_{base.S.W}, V_{base.W.H}\right) = 10783.46 \cdot lbs$

Member per CFS: $CFS_{member} = \text{"10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"}$

Number of Curb in Length: $n_{curb} := 2$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{curb}} = 5.39\,kip$

Max Braced Length of Member: $L_{member} := \frac{L_{curb}}{n_{iso} - 1} = 57 \cdot in$

Effective Length factor: $K := 0.5$

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. E2.2-5, E2.2-6)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(K \cdot L_{member}\right)^2}\right] = 37 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2} = 19 \cdot ksi \qquad \frac{K \cdot L_{member}}{r_{min}} = 124$$

$KL_r = \text{"KL/r < 200, OK"}$

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 13 \cdot ksi$$

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Nominal Compressive Stress Capacity (Eq E2-4):

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 1.993$$

$$F_n := \begin{cases} 0.658^{\lambda_c^2} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^2}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 11.04 \cdot \text{ksi}$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot A_e \cdot F_n = 11.2\,\text{kip}$$

D/C Ratio of Compression:

$$DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.481$$

$$Axial_{reinf} := \text{if}\left(P_{u.EAmember} < \phi P_{n.member}, \text{"OK"}, \text{"NG"}\right)$$

$Axial_{reinf} = \text{"OK"}$

Note:
If the load direction is in perpedicular plane to the short side of the equipment, the channels will only experience axial load and no bending will occur at the channel. Therefore, no need to check for interaction since the channels

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Shear of ISO Rail Webs without Holes (AISI S100-16 G2)

Note: The connection holes are not centered at mid-depth of isolated curb rail so AISI G2 shall be used

Deeper Section (h = depth)

Thickness of Curb: $t := \text{thick}(t_{Curb.iso}) = 0.138 \cdot in$

Depth-to-Thickness Ratio: $\frac{h}{t} = 50$

Curb Elastic Modulus: $E := 29500ksi$

Clear distance b/w transverse stiffeners of reinforced web: $a := L_{iso} = 16 \cdot in$

Clear Distance-to-Thickness Ratio: $\frac{a}{h} = 2.36$

Nominal Shear Stress:

$$k_v := \begin{cases} 5.34 \text{ if } a = L_{iso} \\ 4.00 + \frac{5.34}{\left(\frac{a}{h}\right)^2} \text{ if } \left(\frac{a}{h} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \frac{4.00}{\left(\frac{a}{h}\right)^2} \text{ if } \left(\frac{a}{h} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 6.06$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 60 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 90$$

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Curb Shear Check due to Load on Longer Side

Area of Web Element:

$$A_w := h \cdot t = 0.947 \cdot in^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 65.7 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} = 62\,kip \qquad V_y := 0.6 \cdot A_w \cdot F_y = 28\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.676$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 28.404 \cdot kip$$

Number of Members within Length: $n := 1$ **(Per Curb Design)**

Design Shear Capacity:

$$\phi V_{n.h} := 0.95 \cdot n \cdot V_n = 26.98 \cdot kip$$

Design Shear Demand:

$$V_{u.h} := \frac{\omega_{x.L.vert} \cdot L_{iso}}{2} = 1277.1 \cdot lbs$$

D/C Ratio of Shear:

$$DCR := \frac{V_{u.h}}{\phi V_{n.h}} = 0.047$$

Demand/Capacity Ratio:

$Shear_{in.plane} = \text{"OK"}$

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Shallower Section (h.w = Width)

Thickness of Curb: $t := thick(t_{Curb.iso}) = 0.138 \cdot in$

Depth-to-Thickness Ratio: $\frac{h_w}{t} = 7$

Curb Elastic Modulus: $E := 29500ksi$

Clear distance b/w transverse stiffeners of reinforced web: $a := L_{brace} = 16 \cdot in$

Clear Distance-to-Thickness Ratio: $\frac{a}{h_w} = 16.17$

Nominal Shear Stress:

$$k_v := \begin{cases} 5.34 & \text{if } a = L_{brace} \\ 4.00 + \frac{5.34}{\left(\frac{a}{h_w}\right)^2} & \text{if } \left(\frac{a}{h_w} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \frac{4.00}{\left(\frac{a}{h_w}\right)^2} & \text{if } \left(\frac{a}{h_w} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 5.36$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 56 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 85$$

Curb Shear Check due to Load on Longer Side

Area of Web Element: $A_w := h_w \cdot t = 0.1382 \cdot in^2$

Number of Members within Length: $n := 1$ **(Per Curb Design)**

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 58.1 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} = 8\,kip \qquad V_y := 0.6 \cdot A_w \cdot F_y = 4\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.719$$

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$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 4.146 \cdot \text{kip}$$

Design Shear Capacity:

$$\phi V_{n.hw} := 0.95 \cdot n \cdot V_n = 3.9 \cdot \text{kip}$$

Design Shear Demand:

$$V_{u.hw} := \frac{\left(\frac{\max\left(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit}\right)}{L_{curb}} \right) \cdot L_{brace}}{2} = 770.2 \cdot \text{lbs}$$

D/C Ratio of Shear:

$$DCR := \frac{V_{u.hw}}{\phi V_{n.hw}} = 0.196$$

Demand/Capacity Ratio:

$Shear_{in.plane}$ = "OK"

D/C Ratio of Vx and Mx:

$$DCR_{V.M.int} := \begin{cases} \left(0.6 \cdot \frac{M_{cx}}{\phi M_{nx}} + \frac{V_{u.h}}{\phi V_{n.h}}\right) \cdot \frac{1}{1.3} & \text{if } \frac{M_{cx}}{\phi M_{nx}} > 0.5 \wedge \frac{V_{u.h}}{\phi V_{n.h}} > 0.7 \\ \sqrt{\left(\frac{M_{cx}}{\phi M_{nx}}\right)^2 + \left(\frac{V_{u.h}}{\phi V_{n.h}}\right)^2} & \text{otherwise} \end{cases} = 0.079$$

Demand/Capacity Ratio:

$VandMx_{int}$ = "OK"

D/C Ratio of Vy and My:

$$DCR_{V.M.int} := \begin{cases} \left(0.6 \cdot \frac{M_{cy}}{\phi M_{ny}} + \frac{V_{u.hw}}{\phi V_{n.hw}}\right) \cdot \frac{1}{1.3} & \text{if } \frac{M_{cy}}{\phi M_{ny}} > 0.5 \wedge \frac{V_{u.hw}}{\phi V_{n.hw}} > 0.7 \\ \sqrt{\left(\frac{M_{cy}}{\phi M_{ny}}\right)^2 + \left(\frac{V_{u.hw}}{\phi V_{n.hw}}\right)^2} & \text{otherwise} \end{cases} = 0.272$$

Demand/Capacity Ratio:

$VandMy_{int}$ = "OK"

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Web Crippling/Compression of Non-iso CanFab Curb (AISI S100-16 G5)

Governing Compression for Non-Isolated Curb:

$$P_{web.crip.int} := \max\left[\frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}}, \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}}\right] \cdot L_{spacing.non.iso} = 4854 \cdot lbs$$

$$P_{web.crip.end} := 0.5 \cdot P_{web.crip.int} = 2427 \cdot lbs$$

Yield Strength: $F_y := 50ksi$

Bearing Length: $N_{bearing} := L_{spacing.non.iso} = 31 \cdot in$

Thickness of Curb: $t_{Curb} = \text{"14GA"}$ $t := thick(t_{Curb}) = 0.0785 \cdot in$

Inside Bend Radius: $R := R_{curb} = 0.107 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web: $h := 18in - 2 \cdot (t + R) = 17.63 \cdot in$

Angle btween plane of web and bearing surface: $\theta := 90deg$

Web Crippling Limit Check (AISI Table G5-2): $\frac{R}{t} = 1$ $\frac{h}{t} = 225$ $\frac{N_{bearing}}{t} = 391$ $\frac{N_{bearing}}{h} = 1.74$

End Case Coefficient Single Web Channel (AISI Table G5-2): $C := 13$ $C_R := 0.32$ $C_N := 0.05$ $C_h := 0.04$

Reduction Factor Web Crippling Strength: $\phi_{web.end} := 0.9$ $\phi_{web.int} := 0.8$ **(For Unfastened partially Stiffened Flanges with Two-Flange Loading or Reaction.)**

Design Web Crippling Strength:

$$\phi P_{n.end} := \left(\phi_{web.end}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 1800 \cdot lbs$$

Interior Case Coefficient Single Web Channel (AISI Table G5-2): $C := 24$ $C_R := 0.52$ $C_N := 0.15$ $C_h := 0.001$

Design Web Crippling Strength:

$$\phi P_{n.interior} := \left(\phi_{web.int}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 9091 \cdot lbs$$

D/C Ratio of Shear: $DCR_{end} := \frac{P_{web.crip.end}}{2 \cdot \phi P_{n.end}} = 0.674$ $DCR_{int} := \frac{P_{web.crip.int}}{\phi P_{n.interior}} = 0.534$

Demand/Capacity Ratio: **Note: Factor of 2 for two ends connected together at the end**

$Web_{crippling} = \text{"OK"}$

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Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Length

Roof Curb thickness

$t_{Curb} = \text{"14GA"}$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

Min width of Roof Curb

$b_{curb} := L_{curb} + \frac{W_{curb}}{2} \cdot 2 + 3in \cdot 2 \cdot 2 = 202.19 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := L_{curb} + \min\left(\frac{W_{curb}}{2} \cdot 2, \frac{L_{curb}}{2}\right) = 170 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{array}{c} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{array} \right] \right] = 9344 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.L.vert.up} \cdot L_{curb}) \cdot (0.75in) = 7304 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.782$

$Curb_{BotFlangeBending} = \text{"OK"}$

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Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Width

Roof Curb thickness

$t_{Curb} = \text{"14GA"}$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

Min width of Roof Curb

$b_{curb} := W_{curb} + \frac{L_{curb}}{4} \cdot 2 + 3in \cdot 2 = 139.59 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := W_{curb} + \min\left(\frac{L_{curb}}{6} \cdot 2, W_{curb}\right) = 115 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{array}{c} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{array} \right] \right] = 6452 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.W.vert.up} \cdot W_{curb}) \cdot (0.75in) = 4230 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.656$

$Curb_{BotFlangeBending} = \text{"OK"}$

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Web Crippling/Compression of Iso CanFab Curb (AISI S100-16 G5)

Note: Curb stiffeners directly transfer the compressive load from isolator to the base. Therefore, curb web crippling is prevented.

Curb Web with Reinforcement

Max Compression: $Comp_{maxtot} := \max(|C_S|, |C_W|) = 22530.11 \cdot lbs$

Reinforcement per CFS: $CFS_{reinf} :=$ "Single Stiffener 10GA 1"x7"x1" Fy=50ksi 18" Tall on min. 16GA "

Note: min. of 10 GA channel and min. 16 GA curb web

Number of Reinforcement in Length: $n_{reinf} := N_{iso.long} = 8$

Max Compression per Reinf: $Comp_{per.reinf} := \frac{Comp_{maxtot}}{n_{reinf}} = 2.816\,kip$

Spacing: $Spacing := \frac{L_{curb}}{n_{reinf}} = 14 \cdot in$ $KL_r := \frac{1.0 \cdot (H_{curb} - 12.5in)}{0.2339in} = 77$

Factored Nominal Comp. Capacity per reinforcement: $\phi P_{n.reinf} = 21.066 \cdot kip$ **(See attached CFS)**

Total Factored nominal Comp Capacity: $\phi P_{n.tot} := n_{reinf} \cdot \phi P_{n.reinf} = 169 \cdot kip$

D/C Ratio of Compression: $DCR := \frac{Comp_{maxtot}}{\phi P_{n.tot}} = 0.13$

$Comp_{reinf} := if(Comp_{maxtot} < \phi P_{n.tot}, "OK", "NG")$ $Comp_{reinf} = "OK"$

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Check CanFab Curb for Compressive Force due to T/C Coupling of Overturning

Note:
-Since the equipment is only attached to the longer sides of the CanFab Curb, most likely there will be compressive force onto the curb due to T/C coupling.
- Rectangular CanFab Curb will be considered as "Channel" to resist the compressive force.

Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Flanges*

Flat Width:

$$w := \frac{W_{curb}}{2} - R_{curb} = 38.393 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Unstiffened"}$$

Stress at the end of the Width:

$$f_2 := 50ksi \qquad f_1 := 50ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \left| \frac{f_2}{f_1} \right| = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 0.43$$

Critical Compressive Stress (Eq 1.1-4):

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w}\right)^2 = 0.05 \cdot ksi$$

Stress in Compression Element:

$$f := F_y = 50 \cdot ksi \qquad \textbf{(Assume f = Fy)}$$

Slenderness Factor (Eq 1.1-3):

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 32.3$$

Local reduction factor (Eq 1.1-2):

$$\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 0.031$$

Effective Width of the Flanges:

$$b_{eff.flange} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 1.181 \cdot in$$

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Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Web*

Flat Width:

$$w := L_{curb} - R_{curb} \cdot 2 = 112.974 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Stiffened"}$$

Stress at the end of the Width:

$$f_2 := 50ksi \qquad f_1 := 50ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \left| \frac{f_2}{f_1} \right| = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 4$$

Critical Compressive Stress (Eq 1.1-4):

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w} \right)^2 = 0.05 \cdot ksi$$

Stress in Compression Element:

$$f := F_y = 50 \cdot ksi \qquad \textbf{(Assume f = Fy)}$$

Slenderness Factor (Eq 1.1-3):

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 31.16$$

Local reduction factor (Eq 1.1-2):

$$\rho := \left(1 - \frac{0.22}{\lambda}\right) \frac{1}{\lambda} = 0.032$$

Effective Width of the Web:

$$b_{eff.web} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 3.6 \cdot in$$

Effective Area of the Member:

$$A_e := 2 \cdot \left(b_{eff.flange} \cdot t_{curb} \right) + b_{eff.web} \cdot t_{curb} = 0.468 \cdot in^2$$

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Length of the Compressive Member: $L_{curb.web} := h = 17.629 \cdot in$

Young's Modulus for Cold Form Steel: $E := 29500ksi$

Curb Shear Modulus: $G := 11300ksi$

Poisson's Ratio $\mu := 0.3$

Section Properties of the Member (From Section Properties Calculator):

$A_{half.curb} := 13.599in^2$ $r_o := 50.187in$ $I_x := 26250.724in^4$ $I_y := 1949.977in^4$

$J := 0.023in^4$ $r_x := \sqrt{\frac{I_x}{A_{half.curb}}} = 43.936 \cdot in$ $r_y := \sqrt{\frac{I_y}{A_{half.curb}}} = 11.975 \cdot in$

$C_w := 4.431 \cdot 10^6 \cdot in^6$ $r_{min} := \min(r_x, r_y) = 11.975 \cdot in$

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^2}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{(1.0 \cdot L_{curb.web})^2}\right] = 3521946.764 \cdot ksi$$

$$\sigma_{e.y} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_y}\right)^2} = 134331.872 \cdot ksi \qquad \sigma_{e.x} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_x}\right)^2} = 1808384.866 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2} = 134331.872 \cdot ksi$$

$$\frac{1.0 \cdot L_{curb.web}}{r_{min}} = 1.47$$

$KL_r = \text{"KL/r < 200, OK"}$

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 129396.512 \cdot ksi$$

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Nominal Compressive Stress Capacity: (Eq E2-4)

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 0.02$$

$$F_n := \begin{cases} 0.658^{\lambda_c^2} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^2}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 49.99 \cdot \text{ksi}$$

Compressive Capacity:

$$P_{n.member} := A_e \cdot F_n = 23.39 \cdot \text{kip}$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot P_{n.member} = 19.88 \cdot \text{kip}$$

Factored Max Compressive Force:

$$P_{comp.max} := \max\left(\left|C_S\right|, \left|C_W\right|\right) = 22.53 \text{ kip}$$

D/C Ratio of Compression:

$$DCR := \frac{P_{comp.max}}{\phi P_{n.member}} = 1.133$$

$$Axial_{curb.comp} := \text{if}\left(P_{comp.max} < \phi P_{n.member}, \text{"OK"}, \text{"Provide Channel from above as Web Stiffener"}\right)$$

$Axial_{curb.comp}$ = "Provide Channel from above as Web Stiffener"

Note: No need to check for interaction since the curb is only subjected to the compressive force.

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Shear of CanFab Curb Webs without Holes (AISI S100-16 G2)

Note: Since the unit is stiffer than the curb and the curb is firmly attached to the unit and to the base structure, curbs will mainly take the lateral forces as shear and axial load rather than bending.

Thickness of Curb:

$$t := thick(t_{Curb}) = 0.079 \cdot in$$

Depth-to-Thickness Ratio:

$$\frac{h}{t} = 225$$

Curb Elastic Modulus:

$$E := 29500ksi$$

Clear distance b/w transverse stiffeners of reinforced web:

$$a := \max\left(\frac{L_{curb}}{2}, W_{curb}\right) = 77 \cdot in \qquad \frac{a}{h} = 4.37$$

$$k_v := \begin{cases} 5.34 & \text{if } a = L_{curb} \\ 4.00 + \dfrac{5.34}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \dfrac{4.00}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 5.55$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 57 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 86$$

Curb Shear Check due to Load on Longer Side

Area of Web Element:

$$A_w := W_{curb} \cdot t = 6 \cdot in^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 2.9 \cdot ksi$$

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$V_{cr} := A_w \cdot F_{cr} = 18\,kip \quad V_y := 0.6 \cdot A_w \cdot F_y = 181\,kip \quad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 3.198$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 17.734 \cdot kip$$

Number of Members within Length: $n := 2$ **(Per Curb Design)**

Design Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 33694.2 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.H} := P_{net} \cdot L_{unit} \cdot H_{total} = 11826.3 \cdot lbs$

Design Shear Demand: $V_u := \max(V_{base.S}, V_{base.W.H}) = 14857.1 \cdot lbs$

D/C Ratio of Shear: $DCR := \frac{V_u}{\phi V_n} = 0.441$

Demand/Capacity Ratio:

$Shear_{in.plane} := \text{if}(V_u < \phi V_n, \text{"OK"}, \text{"NG"})$

$Shear_{in.plane} = \text{"OK"}$

Curb Shear Check due to Load on Shorter Side

Area of Web Element: $A_w := L_{curb} \cdot t = 9 \cdot in^2$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot (1 - \mu^2) \cdot \left(\frac{h}{t}\right)^2} = 2.9 \cdot ksi$$

$V_{cr} := A_w \cdot F_{cr} = 26\,kip \quad V_y := 0.6 \cdot A_w \cdot F_y = 267\,kip \quad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 3.198$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 26.068 \cdot kip$$

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Number of Members within Length: $n := 2$ **(Per Curb Design)**

Factored Nominal Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 49529.5 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot W_{unit} \cdot H_{total} = 8140 \cdot lbs$

Factored Shear Demand: $V_u := \max(V_{base.S}, V_{base.W.L}) = 14857.1 \cdot lbs$

D/C Ratio of Shear: $DCR := \frac{V_u}{\phi V_n} = 0.3$

Demand/Capacity Ratio:

$Shear_{in.plane} := if(V_u < \phi V_n, "OK", "NG")$

$Shear_{in.plane} = "OK"$

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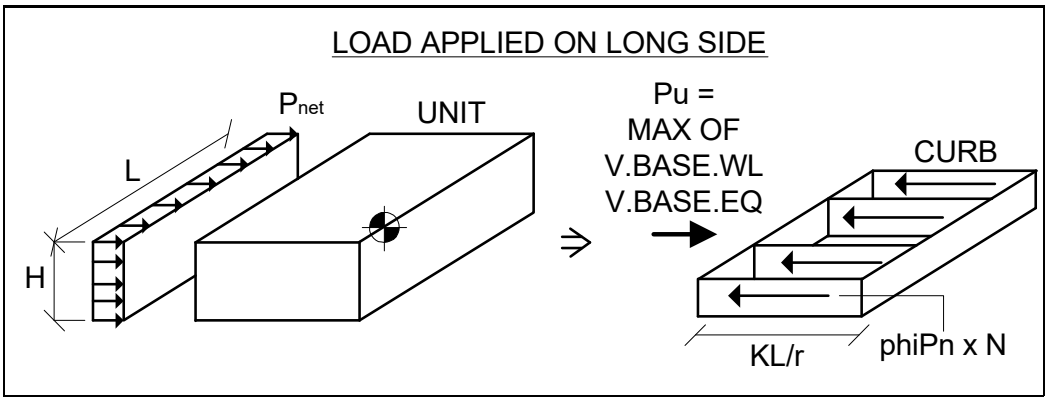
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Check CanFab Curb for In-Plane Axial due to EQ and Wind (AISI S100-16 E2)

Curb Axial Load Check due to Load on Long Side



Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot L_{unit} \cdot H_{total} = 11.8\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.L}) = 14857.09 \cdot lbs$

Member per CFS: $CFS_{member} :=$ "14GA Custom Curb 18" Tall L.b = 63in"

Max Braced Length of Member: $L_{member} := 48in$ **Conservative since the max anchor spacing is 24"**

Number of Curb in Length: $n_{curb.long} := 3$

Radius of gyration in y-axis: $r_{y.curb} := 0.671\,in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{2} = 7.43\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 72$ $KL_r =$ "KL/r < 200, OK"

Spacing: $Spacing := \frac{L_{curb}}{n_{curb.long}} = 38 \cdot in$

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 11.417 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.651$

$Axial_{short.curb} =$ "OK"

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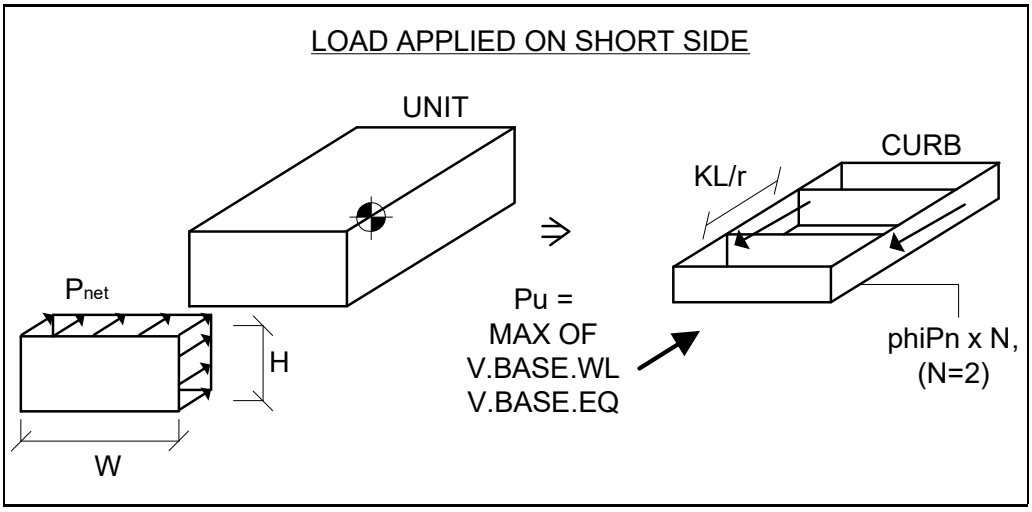
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Curb Axial Load Check due to Load on Short Side



Wind Base Shear on Short Side: $V_{base.W.H} := P_{net} \cdot W_{unit} \cdot H_{total} = 8.1\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.H}) = 14857.09 \cdot lbs$

Member per CFS: CFS_{member} = "14GA Custom Curb 18" Tall L.b = 63in"

Max Braced Length of Member: $L_{member} := \frac{L_{curb}}{n_{curb.long} - 1} = 57 \cdot in$

Number of Curb in Length: $n_{curb} := 2$

Radius of gyration in y-axis: $r_{y.curb} := 0.671\,in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{curb}} = 7.43\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 84$ KL_r = "KL/r < 200, OK"

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 11.417 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.651$

$Axial_{long.curb}$ = "OK"

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for
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Design Wind Loads for Rooftop Equipment (ASCE 7-16 § Table 29.1-1)

$z := 60ft$ **Height above ground level**

$B := 60ft$ **Horizontal dimension of building measured normal to wind direction**

$Exp_{category} := "C"$ **Exposure Category per ASCE 7-16 § 26.7**

$Risk_{category} := "IV"$ **Risk Category per ASCE 7-16 Table 1.5-1**

$$V := \begin{cases} 0mph & \text{if } Risk_{category} = "I" \\ 0mph & \text{if } Risk_{category} = "II" \\ 175mph & \text{otherwise} \end{cases} = 175 \cdot mph$$

Basic Wind Speed per ASCE 7-16 Figure 26.5-1 A,B or C

$K_z = 1.14$ **Velocity Pressure Exposure Coefficient per ASCE 7-16 Table 29.10-1 [Exposure Category "C"]**

$K_{zt} := 1.0$ **Topographic Factor per ASCE 7-16 § 26.8, Figure 26.8-1**

$K_e := 1.0$ **Ground Elevation Factor per ASCE 7-16 § 26.9, Table 26.9-1**

$K_d := 0.85$ **Wind Directionality Factor per ASCE 7-16 § 26.6, Table 26.6-1 (Equipment)**

$q_z := 0.00256 K_z \cdot K_{zt} \cdot K_d \cdot K_e \cdot V^2 = 75.74 \cdot psf$ **Velocity pressure evaluated at height z above ground per ASCE 7-10 § 26.10.2; Eq. 26.10-1**

$GC_{r.lateral.max} := 1.9$ **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.9 for rooftop structures and equipment with Af less than (0.1Bh). (GCr) shall be permitted to be reduced linearly from 1.9 to 1.0 as the value of Af is increased from (0.1Bh) to (Bh)

$GC_{r.vertical.max} := 1.5$ **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.5 for rooftop structures and equipment with A_r less than (0.1*BL*). (GC_r) shall be permitted to be reduced linearly from 1.5 to 1.0 as the value of A_r is increased from (0.1*BL*) to (*BL*)

$P_{net} := q_z \cdot GC_{r.lateral.max} = 143.91 \cdot psf$ **Design Lateral Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-2**

$P_v := q_z \cdot GC_{r.vertical.max} = 113.61 \cdot psf$ **Design Vertical Uplift Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-3**

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Seismic Demands on Nonstructural Components (ASCE 7-16 § 13.3 & 13.6):

$S_{DS} := 1.5$ **Design spectral response acceleration parameter at short periods per USGS map**

$I_p := 1.5$ **Component importance factor ASCE 7-16 § 13.1.3**

$\Omega_0 := 2.0$ **Overstrength factor ASCE 7-16 Table 13.6.1**

Vibr_Isolation = "Yes" **Placement of Unit Vibration Isolated:**

Note: Only "F_p" at seismic concrete anchor has been increased with overstrength factor "Ω_0"

$a_p := 2.5$ $R_p = 2.0$ **Seismic coefficients a_p & R_p**
Per ASCE 7-16 Table 13.6-1 for
Mechanical & Electrical Components

$z = 60\,ft$ **Height in structure of point of attachment of component with respect to the base**

$h := 60ft$ **Average roof height of structure with respect to the base**
Where for roof top equipment:

$z \div h = 1$

F_p: Horizontal Seismic Design Force per *ASCE7-16 § 13.3.1*

F_p shall be takes as $\left(\frac{0.4 \cdot a_p \cdot S_{DS} \cdot I_p}{R_p}\right) \cdot \left(1 + 2 \cdot \frac{z}{h}\right) \cdot W_p = 337.5 \cdot \%_{\cdot} W_p$

F_p is not required to be taken as greater than $\left(1.6 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 360 \cdot \%_{\cdot} W_p$

F_p shall not be taken as less than $\left(0.3 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 67.5 \cdot \%_{\cdot} W_p$

Governing F_p : Horizontal Seismic Design Force $F_p = 337.5 \cdot \%_{\cdot} W_p$

F_v: Vertical Load per ASCE7-16 § 13.3.1.2

Concurrent Vertical Seismic Force: $F_v := 0.2 \cdot S_{DS} \cdot W_p = 30 \cdot \%_{\cdot} W_p$

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Flat Roof Snow Loads (ASCE 7-16 § 7.3):

$Terrain_{CAT} := "C"$ **Terrain Category ASCE 7-16 § 26.7 & Table 7.3-1**

$Exp_{Roof} := "Partially Exposed"$ **Exposure of Roof ASCE 7-16 Table 7.3-1**

$C_e = 1$ **Exposure Factor ASCE 7-16 Table 7.3-1**

$Thermal_{condition} := "All structures except below"$ **Thermal Condition ASCE 7-16 Table 7.3-2**

$C_t = 1$ **Thermal Factor ASCE 7-16 Table 7.3-2**

$Risk_{category} = "IV"$ **Risk Category per ASCE 7-16 Table 1.5-1**

$I_s = 1.2$ **Snow Importance Factor ASCE 7-16 Table 1.5-2**

$p_g := 40psf$ **Ground Snow Loads ASCE 7-16 Figure 7.2-1**

$$p_f := \max\left(0.7 \cdot C_e \cdot C_t \cdot I_s \cdot p_g, \text{if}\left(p_g > 20psf, 20psf \cdot I_s, I_s \cdot p_g\right)\right) = 34 \cdot psf$$

Flat Roof Snow Loads ASCE 7-16 Equation 7.3-1 and § 7.3.4

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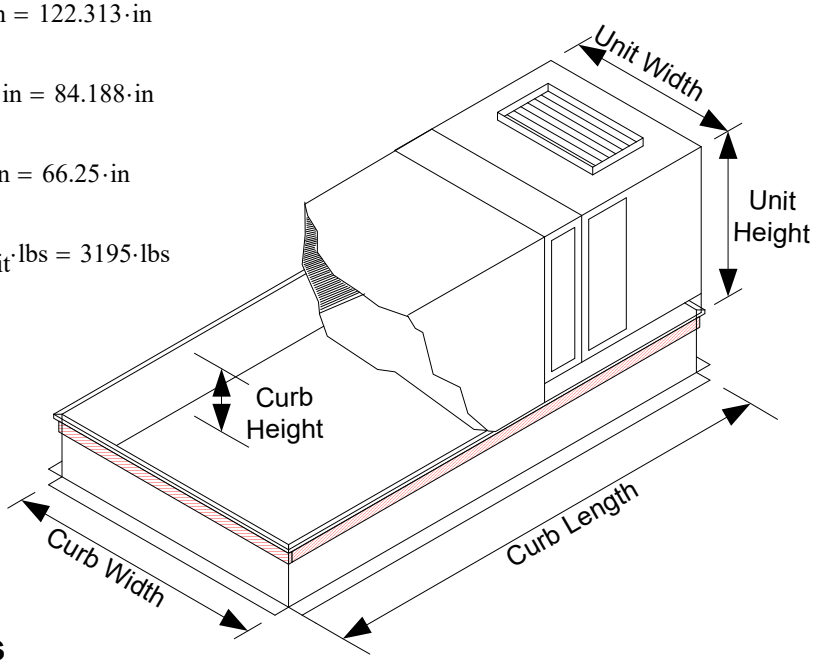
Mechanical Unit Dimensions Curb = "C-6010"

Length of Unit $L_{unit} := L_{unit} \cdot in = 122.313 \cdot in$

Width of Unit $W_{unit} := W_{unit} \cdot in = 84.188 \cdot in$

Height of Unit $H_{unit} := H_{unit} \cdot in = 66.25 \cdot in$

Weight of Unit $Wt_{unit} := Wt_{unit} \cdot lbs = 3195 \cdot lbs$



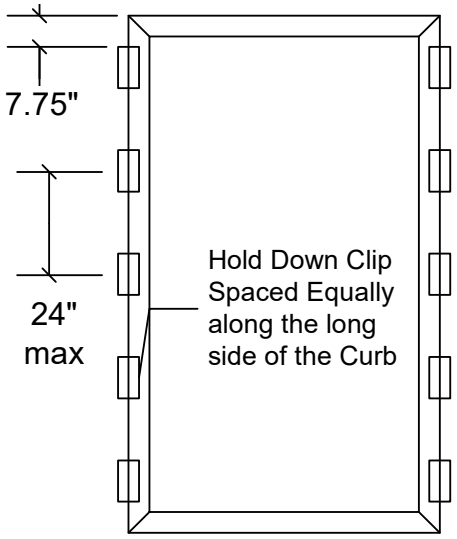
Roof Curb Dimensions

Length of Curb $L_{curb} := L_{curb} \cdot in = 113.188 \cdot in$

Width of Curb $W_{curb} := W_{curb} \cdot in = 77 \cdot in$

Height of Curb $H_{curb} := H_{curb} \cdot in = 34.5 \cdot in$

Weight of Curb $Wt_{curb} := Wt_{curb} \cdot lbs = 1239 \cdot lbs$



Curb Plan

Overall System Dimensions

Total Weight

$Wt_{tot} := Wt_{unit} + Wt_{curb} = 4402 \cdot lbs$

Total height

$H_{total} := H_{unit} + H_{curb} = 100.75 \cdot in$

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Seismic Loading + Snow Loading

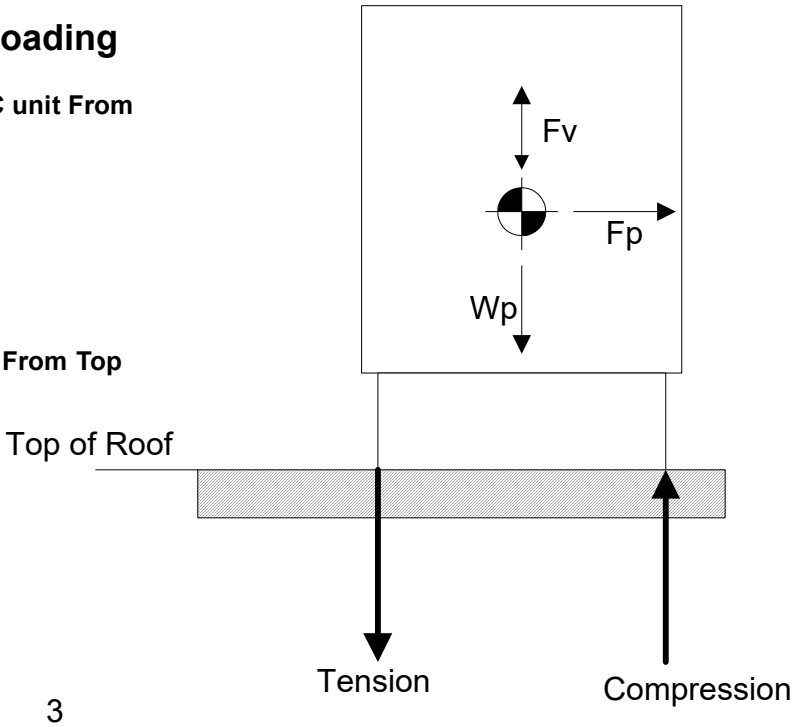
Height for Center of Gravity for HVAC unit From Top of Roof

$h_{CG.unit} := \frac{1}{2} H_{unit} = 33 \cdot in$

$h_{CG} := H_{curb} + h_{CG.unit} = 67.63 \cdot in$

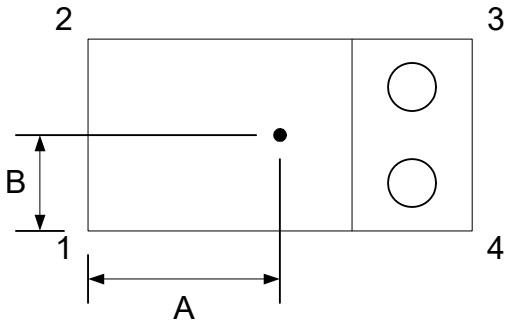
Height for Center of Gravity for Curb From Top of Roof

$h_{CG.curb} := \frac{H_{curb}}{2} = 17.25 \cdot in$



Max Seismic Base Shear

$V_{base.S} := F_p \cdot Wt_{tot} = 14857 \cdot lbs$



Unit C.G. distance in axis parallel to Curb Width $B_{ecc.width} := CG_{short} \cdot in = 36 \cdot in$

Eccentricity in axis parallel to Curb Width

$$e_{width} := \begin{cases} 0in & \text{if } B_{ecc.width} = \text{"N/A"} \\ \left| B_{ecc.width} - \frac{W_{unit}}{2} \right| & \text{otherwise} \end{cases} = 6.09 \cdot in$$

Unit C.G. distance in axis parallel to Curb Length $A_{ecc.length} := CG_{long} \cdot in = 58 \cdot in$

Eccentricity in axis parallel to Curb Length

$$e_{length} := \begin{cases} 0in & \text{if } A_{ecc.length} = \text{"N/A"} \\ \left| A_{ecc.length} - \frac{L_{unit}}{2} \right| & \text{otherwise} \end{cases} = 3.16 \cdot in$$

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Max Net Tension Reaction On Each Side Due To Seismic Loads

$$T_S := \begin{bmatrix} \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{W_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{W_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} \right] \\ \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{L_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{L_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} \right] \end{bmatrix} = \begin{pmatrix} -9214 \\ -5796 \end{pmatrix}\cdot lbs$$

Max Net Compression Reaction On Each Side Due To Seismic Loads

$$C_S := \begin{bmatrix} \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{W_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \\ \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{L_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \end{bmatrix} = \begin{pmatrix} 18651 \\ 14234 \end{pmatrix}\cdot lbs$$

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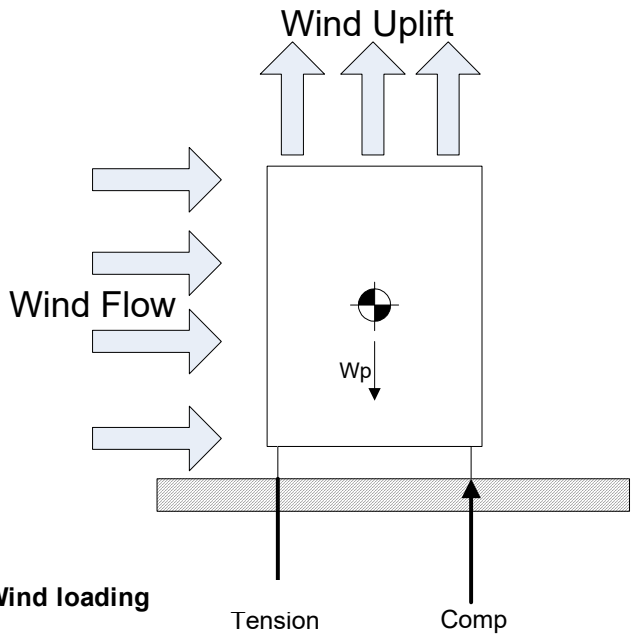
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Wind Loading + Snow Loading



Max Base Shear due to wind loading

$V_{base.W} := P_{net} \cdot L_{unit} \cdot H_{total} = 12315 \cdot lbs$

Max Uplift due to wind loading

$L_{unit.up} := L_{unit} - 0in = 122.313 \cdot in$

$P_{uplift.W} := P_v \cdot L_{unit.up} \cdot W_{unit} = 8124 \cdot lbs$

Max Net Tension Reaction On Each Side Due To Wind loading

$$T_W := \begin{pmatrix} \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} - \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \\ \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} - \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} -10366 \\ -5934 \end{pmatrix} \cdot lbs$$

Max Net Compression Reaction On Each Side Due To Wind loading

$$C_W := \begin{pmatrix} \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} + \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \\ \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} + \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} 12924 \\ 8443 \end{pmatrix} \cdot lbs$$

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Governing Loading @ Curb

Max uplift vertical load along the length of the curb

$$\omega_{x.L.vert.up} := \frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}} = 1099 \cdot plf$$

Max compressive vertical load along the length of the curb

$$\omega_{x.L.vert.comp} := \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}} = 1977 \cdot plf$$

Max vertical load along the length of the curb

$$\omega_{x.L.vert} := \max\left(\omega_{x.L.vert.up}, \omega_{x.L.vert.comp}\right) = 1977 \cdot plf$$

Max uplift vertical load along the width of the curb

$$\omega_{x.W.vert.up} := \frac{\max\left[\left|T_{S_{(1)}}\right|, \left|T_{W_{(1)}}\right|\right]}{W_{curb}} = 925 \cdot plf$$

Max compressive vertical load along the width of the curb

$$\omega_{x.W.vert.comp} := \frac{\max\left[\left|C_{S_{(1)}}\right|, \left|C_{W_{(1)}}\right|\right]}{W_{curb}} = 2218 \cdot plf$$

Max vertical loading along the width of the curb

$$\omega_{x.W.vert} := \max\left(\omega_{x.W.vert.up}, \omega_{x.W.vert.comp}\right) = 2218 \cdot plf$$

$$\begin{pmatrix} V_{base.S} \\ V_{base.W} \end{pmatrix} = \begin{pmatrix} 14857 \\ 12315 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} \left|T_S\right| \\ \left|C_S\right| \end{pmatrix} = \begin{pmatrix} 10886 \\ 23462 \end{pmatrix} \cdot lbs$$

$$\begin{pmatrix} F_v \cdot Wt_{tot} \\ P_v \cdot L_{unit} \cdot W_{unit} \end{pmatrix} = \begin{pmatrix} 1321 \\ 8124 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} \left|T_W\right| \\ \left|C_W\right| \end{pmatrix} = \begin{pmatrix} 11944 \\ 15437 \end{pmatrix} \cdot lbs$$

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Anchorage To Concrete [Expansion Anchor per ACI 318-14]

Number of connection on the long side

$N_B := 6 + 2$

Moment Arm for overturning (Short side)

$B := W_{curb} + 3in \cdot 2 = 83 \cdot in$

Number of Connection on the Short side.

$N_L := 4 + 2$

Moment Arm for over turning (Long side)

$L := L_{curb} + 3in \cdot 2 = 119 \cdot in$

Total Number of Connections

$N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 20$

Max Net Tension Reaction Due to Seismic Load, Fp

$$R_{c.EQ.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 18 \cdot lbs \qquad R_{c.EQ.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 8 \cdot lbs$$

$$R_{c.EQ} := MAX+\left[\begin{bmatrix}\left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{c.EQ.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{c.EQ.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}2294 \\ 2112\end{pmatrix} \cdot lbs$$

Max net Tension Reaction Due to Wind Load, Pnet

$$R_{c.W} := MAX+\left[\begin{bmatrix}\frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}1169 \\ 818\end{pmatrix} \cdot lbs$$

Governing Load Case:

$Govern := if\left(\left|R_{c.EQ}\right| > \left|R_{c.W}\right|, "Seismic", "Wind"\right) = "Seismic"$

Governing Tension Reaction at Each anchor Point:

$R_c := if\left(Govern = "Seismic", R_{c.EQ}, R_{c.W}\right) = \begin{pmatrix}2294 \\ 2112\end{pmatrix} \cdot lbs$

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Max Tension on anchor: $N_{ua} := \max(R_c) = 2294 \cdot lbs$

Max Shear on anchor: $V_{ua} := \frac{\max(\Omega_0 \cdot V_{base.S}, V_{base.W})}{N_t} = 1486 \cdot lbs$

Hilti Kwik Bolt TZ – Carbon Steel
5/8" Anchor with min 4" embedment
Base material: 6" thick Cracked concrete w/
Compressive strength fc' = 3000 psi
Min 6" away from the concrete edge
Evaluation Report: ICC-ESR 1917

Loading Condition:	**Seismic**

Design Tension Capacity [ϕN_n]:	3,631	[lbs]
Design Shear Capacity [ϕV_n]:	4,940	[lbs]

$\phi N_n := \phi N_n \cdot lbs = 3631 \cdot lbs$

$\phi V_n := \phi V_n \cdot lbs = 4940 \cdot lbs$

Utilization:

Tension Utilization:

$\beta_N := \frac{N_{ua}}{\phi N_n} = 63 \cdot \%$

Shear Utilization:

$\beta_V := \frac{V_{ua}}{\phi V_n} = 30 \cdot \%$

Interaction of Tensile and Shear Forces:
Per ACI 318-14 Sec. 17.6

$\beta_{NV} := \frac{(\beta_N) + (\beta_V)}{1.2} = 78 \cdot \%$

$$check\_interaction := \begin{pmatrix} if(\beta_N < 1.0, "OK", "NG") \\ if(\beta_V < 1.0, "OK", "NG") \\ if(\beta_{NV} < 1.0, "OK", "NG") \end{pmatrix} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

$$check\_interaction = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

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Anchorage To Structural Steel [Fillet Weld Conn. per AISI S100-16]

Fillet Weld 2" Long Along the Long and Short Side. Min 2 Connections per Side
Spacing: 48" O.C. for Non-Isolated Curbs; 24" for Isolated Curbs

Number of Welds on the Long Side $N_B := 6$

Moment Arm for Overturning (Short Side) $B := W_{curb} = 77 \cdot in$

Number of Welds on the Short Side. $N_L := 4$

Moment Arm for Overturning (Long Side) $L := L_{curb} = 113 \cdot in$

Total Number of Connections $N_t := \left[\left(N_B\right) + \left(N_L\right)\right] \cdot 2sides = 20$

Max Net Tension Reaction due to Seismic Load FP

$$R_{weld.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 25 \cdot lbs$$

$$R_{weld.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 13 \cdot lbs$$

$$R_{weld.EQ} := MAX+\left[\begin{bmatrix}\left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{weld.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{weld.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}1624 \\ 1647\end{pmatrix} \cdot lbs$$

Max Net Tension Reaction due to Wind Load Pnet

$$R_{weld.W} := MAX+\left[\begin{bmatrix}\frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}1589 \\ 1171\end{pmatrix} \cdot lbs$$

Tension Design Force; SRSS for Loading from Each Direction $T_{u.weld} := \max\left(\left|R_{weld.EQ}\right|, \left|R_{weld.W}\right|\right) = 2313 \cdot lbs$

Shear Load at Each Weld Connection $V_{u.weld} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{N_t} = 743 \cdot lbs$

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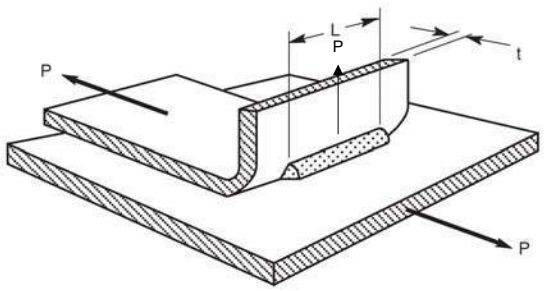
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Total Demand: SRSS of V and T

$$R_{u.weld} := \sqrt{T_{u.weld}^2 + V_{u.weld}^2} = 2429 \cdot lbs$$

Fillet Weld Design per AISI S100-16 Section J2.5

Weld Length at Each Connection Point $L_w := 2in$



Effective Throat Fillet Weld Size

$$t_w := \left(\frac{1}{8}in\right) \cdot 0.707 = 0.088 \cdot in$$

Thickness for the Thinnest Martial Being Welded
Min Curb Thickness = 16GA with Fu=65 ksi

$t_1 := thick("14GA") = 0.0785 \cdot in$

$F_u := 65ksi$

Min weld material strength

$F_{exx} := 70ksi$

For Longitudinal Loading [Parallel capacity is considered to be loading in the direction of the length of the weld] per (Eq. J2.5-1) &(Eq. J2.5-2)

$$\phi P_{long} := \begin{cases} (0.6)\left(1 - \frac{0.01 \cdot L_w}{t_1}\right) \cdot L_w \cdot t_1 \cdot F_u & \text{if } \frac{L_w}{t_1} < 25 \\ (0.5) \cdot 0.75 \cdot t_1 \cdot L_w \cdot F_u & \text{otherwise} \end{cases} = 3827 \cdot lbs$$

where $L_w \div t_1 = 25$

For Transverse Loading per (Eq. J2.5-5)

$$\phi P_{trans} := (0.65) \cdot t_1 \cdot L_w \cdot F_u = 6633 \cdot lbs$$

Strength of Weld Material per (Eq. J2.5-7)

$$\phi P_{weld} := (0.6) \cdot 0.75 \cdot t_w \cdot L_w \cdot F_{exx} = 5568 \cdot lbs$$

Design Strength of Fillet Weld

$$\phi P_n := \min\left(\phi P_{long}, \phi P_{trans}, \phi P_{weld}\right) = 3827 \cdot lbs$$

D/C Ratio for the Welded Connection

$$\beta_{NW} := \frac{R_{u.weld}}{\phi P_n} = 63 \cdot \%$$

$weld_{check} := if\left(\beta_{NW} < 1.0, "OK", "NG"\right)$

$weld_{check} = "OK"$

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Anchorage To Wood Member WITH Lag Screws [NDS-2018 LRFD Strength Design]

*** Use 3/8" Lag Screws along Each Side of the Curb**
*** Assume G=0.5 Douglas Fir-Larch**

Wood Lag Screw Capacity per NDS 2018 Section 11.3

Wet Service Factor: $Cond := "DRY"$ **(e.g. CA = "DRY", AK = "WET")**

$$C_M := \begin{cases} 1.0 & \text{if } Cond = "DRY" \\ 0.7 & \text{if } Cond = "WET" \end{cases} = 1$$ **NDS 2018 Table 11.3.3**

Temperature Factor:
$$C_t := \begin{cases} 0.8 & \text{if } Cond = "DRY" \\ 0.7 & \text{if } Cond = "WET" \end{cases} = 0.8$$ **NDS 2018 Table 11.3.4**

Group Action Factor: $C_g := 0.97$ **NDS 2018 Table 11.3.6C**

Geometry Factor: $C_\Delta := 1.0$ **NDS 2018 Table 12.5.1A,B**

End Grain Factor: $C_{eg} := 1.0$ **NDS 2018 Sec. 12.5.2**

Diaphragm Factor: $C_{di} := 1.0$ **NDS 2018 Sec. 12.5.3**

Toe-Nail Factor: $C_{tn} := 1.0$ **NDS 2018 Sec. 12.5.4**

Format Conversion Factor: $K_F := 3.32$ **NDS 2018 Table 11.3.1**

Resistance Factor: $\phi := 0.65$ **NDS 2018 Table 11.3.1**

Time Effect Factor: $\lambda := 1.0$ **NDS 2018 App N.3.3**

Lateral Design Value: $Z := 130lbs$ **NDS 2018 Table 12K**

Withdrawal Design Value: $W := 305lbs$ **NDS 2018 Table 12.2A**

Lag Screw Diameter: $D_{lag} := \frac{3}{8}in$

Lag Screw Length: $L_{lag} := 4in$

Length of Tapered Tip: $E_{lag} := \frac{7}{32}in$

Lag Screw Penetration: $P_{lag} := 3.78125in$

Eff. Lag Screw Penetration for withdrawal: $P_{\omega.lag} := 2in + \frac{9}{32}in = 2.28 \cdot in$ **NDS 2018 Appx. Table L2**

NDS 2018 Sec. 12.1.4.6

Minimum Penetration DCR <1.0: $DCR_{min.penetration} := \frac{4 \cdot D_{lag}}{P_{\omega.lag}} = 0.66$ $DCR_{min.penetration} = "OK"$

Adj. Lateral Design Value: $Z' := Z \cdot C_M \cdot C_t \cdot C_g \cdot C_\Delta \cdot C_{eg} \cdot C_{di} \cdot C_{tn} \cdot K_F \cdot \phi \cdot \lambda = 218 \cdot lbs$

Adj. Withdrawal Design Value: $W' := W \cdot C_M^{\,2} \cdot C_t \cdot C_{eg} \cdot C_{tn} \cdot K_F \cdot \phi \cdot \lambda = 527 \cdot lbs$ **NDS 2018 Table 11.3.1**

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Number of Lag Screws on the Long Side $N_B := 25 + 2$

Moment Arm for Overturning (Short Side) $B := W_{curb} = 77 \cdot in$

Number of Lag Screws on the Short Side $N_L := 17 + 2$

Moment Arm for Overturning (Long Side) $L := L_{curb} = 113 \cdot in$

Total Number of Lag Screws $N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 84$

Max net Tension Reaction due to Seismic, Fp

$$R_{lag.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 6 \cdot lbs$$

$$R_{lag.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 3 \cdot lbs$$

$$R_{lag.EQ} := MAX+\left[\begin{bmatrix} \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{lag.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{lag.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 359 \\ 343 \end{pmatrix} \cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$R_{lag.W} := MAX+\left[\begin{bmatrix} \frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{L \cdot N_L \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 356 \\ 252 \end{pmatrix} \cdot lbs$$

Tension Design force; SRSS for loading from Each direction $T_{lag} := \max\left(\left|R_{lag.EQ}\right|, \left|R_{lag.W}\right|\right) = 496 \cdot lbs$

Shear load at each anchor location $V_{lag} := \frac{\max\left(V_{base.S} \cdot \sqrt{2}, V_{base.W}\right)}{N_t} = 250 \cdot lbs$

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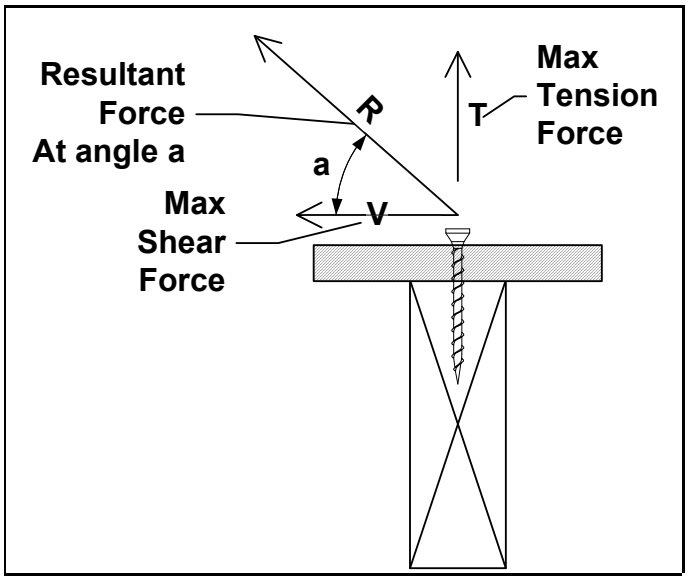
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For Lag Screws Subjected to Combined Lateral and Withdrawal Loading; Design Strength of the Lag Screw Shall Be Adjusted per Hankinson Formula as Prescribed by NDS 2018 Equation 12.4-1



Angle Between Wood Surface and Direction of Resultant Applied Load

$$(\alpha) := \operatorname{atan}\left(\frac{T_{lag}}{V_{lag}}\right) = 63\cdot deg$$

Combined Demand per Lag Screw @ Strength Level

$$R_{lag} := \sqrt{T_{lag}^{2} + V_{lag}^{2}} = 556\cdot lbs$$

Adjusted Capacity per NDS 2018 Equation 12.4-1 @ Strength Level

$$Z'_{\alpha} := \frac{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot Z'}{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot\cos(\alpha)^{2} + Z'\cdot\sin(\alpha)^{2}} = 627\cdot lbs$$

D/C Ratio for the Lag Screw connection to Wood Structure

$$\beta_{Lag} := \frac{R_{lag}}{Z'_{\alpha}} = 89\cdot\%$$

$$Lag_{Screw.Check} := \text{if}\left(\beta_{Lag} < 1.0, \text{"OK"}, \text{"NG"}\right)$$

$Lag_{Screw.Check}$ = "OK"

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Bearing and Tilting in Curb Bolted Connection AISI S100-16

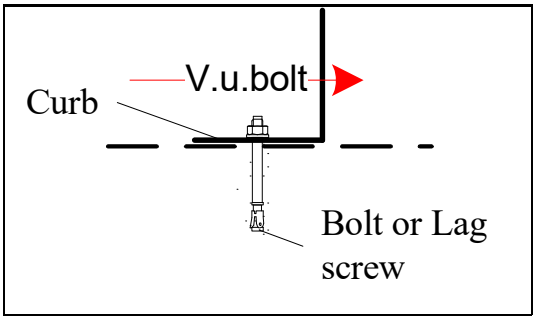
Nominal bolt diameter $d := 0.5in$

Uncoated sheet thickness $t_{curb} := thick("14GA") = 0.079 \cdot in$

Tensile strength of sheet $F_u := 65ksi$

Coefficient for conversion of units $\alpha := 1.0$

Modification Factor $m_f := 1.0$



Modification factor for type of bearing connection, per Table J3.3.1-2; For single shear connection with washers

Bearing Factor $C := \begin{cases} 3 & \text{if } \left(\frac{d}{t_{curb}} < 10\right) \wedge \left(0.024in < t_{curb} < 0.1875in\right) \\ "NG" & \text{if } \frac{d}{t_{curb}} > 10 \end{cases} = 3$

Bearing factor, which shall be determined according to Table J3.3.1-1 For d/t<10 where $d \div t_{curb} = 6$

Bearing Design Strength per AISI S100-16 Eq. J3.3.1-1

$$\phi P_{n_{(0)}} := (0.6) \cdot \left(m_f \cdot C \cdot d \cdot t_{curb} \cdot F_u\right) = 4592 \cdot lbs$$

Bolt Hole Deformation Design Strength per AISI S100-16 Eq. J3.3.2-1

$$\phi P_{n_{(1)}} := (0.65) \cdot \left[4.64 \cdot \left(\frac{\alpha}{in}\right) \cdot t_{curb} + 1.53\right] \cdot d \cdot t_{curb} \cdot F_u = 3141 \cdot lbs$$

Curb Connection Shear Capacity $\phi P_n := \min\left(\phi P_n\right) = 3141 \cdot lbs$

Loading demand at connection $V_{u.bolt} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{6} = 2476 \cdot lbs$

$Curb\_Conn\_Shear := if\left(V_{u.bolt} < \phi P_n, "OK", "NG"\right)$ Curb_Conn_Shear = "OK"

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Thickness of Curb, ISO Rail and Clip

(Per AISC Table 17-10 Galvanized)

Hold Down Clip thickness $t_{Clip} := "12GA"$ $t_{clip} := thick(t_{Clip}) = 0.1084 \cdot in$

Roof Curb thickness $t_{Curb} := "14GA"$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

ISO RAIL thickness $t_{Curb.iso} := "10GA"$ $t_{curb.iso} := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Note: Iso Rail thickness is only used if the curb is isolated. Not used for non-isolated curbs

Sheet Metal Screws (SMS) Equations and References

SMS properties (ESR-2196 Table 5)

$$SMS_{Table} = \begin{pmatrix} "SMS" & "Diameter" & "HeadDiameter" & "Tension" & "Shear" \\ "Size" & "d" & "dw" & "Pts" & "Pss" \\ "\#8" & 0.164 & 0.335 & 1000 & 1170 \\ "\#10" & 0.19 & 0.399 & 1370 & 1215 \\ "\#12" & 0.216 & 0.415 & 2325 & 1880 \\ "\#14" & 0.25 & 0.5 & 4580 & 2440 \end{pmatrix}$$

SMS Tension Eqns

$P_{not} = 0.85 \cdot t \cdot d \cdot F_u$

$P_{nov} = 1.5 \cdot t \cdot d_w \cdot F_u$

$P_{nts} = 0.8 \cdot P_{ts}$

(AISI S100-16 J4.4.1 & J4.4.2)

FOR THE MOST CASES, PULL-OUT CAPACITY IS THE LOWEST

SMS Shearn Eqns

$P_{vnot} = 4.2 \cdot \sqrt{(d \cdot t^3)} \cdot F_u$

$P_{vnov} = 2.7 \cdot t \cdot d \cdot F_u$

$P_{vnss} = 0.8 \cdot P_{ss}$

(AISI S100-16 J4.3.1)

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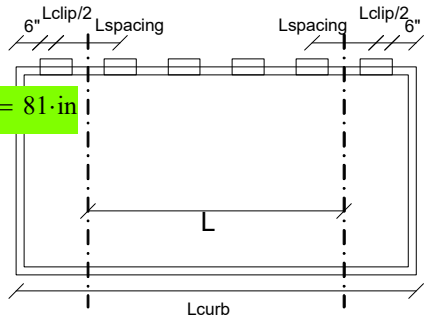
Hold Down Clip Design (Connection of the Mechanical unit to Curb)

Number of Clips on the long side $N_B := 6$

Moment Arm for overturning (Short side) $B := W_{curb} + 1.75in \cdot 2 = 81 \cdot in$

Number of Clips on the Short side. $N_L := 6$

Width of Clips $L_{clip} := 9in$



Curb Centerline Spacing (Long side)

$$L_{spacing} := \frac{L_{curb} - \left(6in + \frac{L_{clip}}{2}\right)\cdot 2}{N_B - 1} = 18.438 \cdot in$$

Moment Arm for overturning (Long side)

$$L := L_{curb} - 2\cdot\left[6in + \frac{L_{clip}}{2} + L_{spacing}\cdot\frac{(N_L - 2)}{4}\right] = 55.313 \cdot in$$

Total Number of Clips

$$N_t := (N_B)\cdot 2sides = 12$$

Max net Tension Reaction due to Seismic, Fp

$$R_{clip.EQ} := MAX+\left[\begin{array}{l}\left[\frac{F_p \cdot Wt_{unit}}{B \cdot N_B}\cdot h_{CG.unit} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{width}}{B \cdot N_B}\right] - \frac{(0.9 - F_v)\cdot Wt_{unit}}{N_t} \\ \left[\frac{F_p \cdot Wt_{unit}}{L \cdot N_L}\cdot h_{CG.unit} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{length}}{L \cdot N_L}\right] - \frac{(0.9 - F_v)\cdot Wt_{unit}}{N_t}\end{array}\right] = \begin{pmatrix}604\\935\end{pmatrix}\cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$R_{clip.W} := MAX+\left(\begin{array}{l}\frac{P_{net}\cdot L_{unit}\cdot\frac{H_{unit}^{\,2}}{2}}{B \cdot N_B} + \frac{P_v \cdot L_{unit.up}\cdot W_{unit}}{N_t} + \frac{0.9\cdot Wt_{unit}\cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{unit}}{N_t} \\ \frac{P_{net}\cdot W_{unit}\cdot\frac{H_{unit}^{\,2}}{2}}{L \cdot N_L} + \frac{P_v \cdot L_{unit.up}\cdot W_{unit}}{N_t} + \frac{0.9\cdot Wt_{unit}\cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{unit}}{N_t}\end{array}\right) = \begin{pmatrix}1029\\1021\end{pmatrix}\cdot lbs$$

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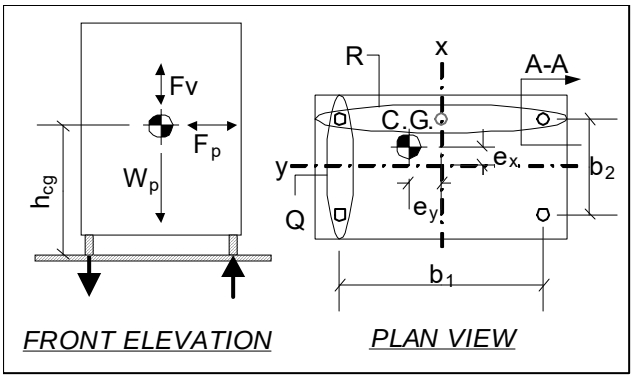
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Tensile and Shear Load calculation per ASHRAE RP-812



Eccentricity along X-X

$e_x := e_{width} = 6.094 \cdot in$

Eccentricity along Y-Y

$e_y := e_{length} = 3.157 \cdot in$

Distance between Seismic Restraints Along Y-Y

$b_1 := L_{curb} - 2 \cdot 6in = 101 \cdot in$

Distance between Seismic Restraints Along X-X

$b_2 := W_{curb} = 77 \cdot in$

Moment of Inertia about X-X

$$I_{xx} := \frac{N_t \cdot (N_t + 2) \cdot (b_1)^2}{12 \cdot (N_t - 2)} = 14335 \cdot in^2$$

Moment of Inertia about Y-Y

$$I_{yy} := \frac{N_t \cdot (b_2)^2}{4} = 17787 \cdot in^2$$

Angle about Tensile Load

$$\Theta_t := \operatorname{atan}\left[\frac{I_{yy} \cdot (b_1)}{I_{xx} \cdot (b_2)}\right] = 58 \cdot deg$$

Angle about Shear Load

$$\Theta_s := \begin{cases} \operatorname{atan}\left(\frac{e_x}{e_y}\right) & \text{if } e_y \neq 0 \\ 0deg & \text{if } e_y = 0 \end{cases} = 63 \cdot deg$$

Max Net Tensile Load Due to Seismic Load, Fp

$$T_{U.EQ.pt1} := \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} - \frac{(0.9 - F_v) \cdot Wt_{unit}}{b_1 \cdot b_2} \cdot \left(\frac{b_1}{2} \cdot e_x + \frac{b_2}{2} \cdot e_y - e_x \cdot e_y\right) = 59 \cdot lbs$$

$$T_{U.EQ.pt2} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \cos(\Theta_t) \cdot \frac{0.5 \cdot b_2}{I_{yy}} = -404 \cdot lbs$$

$$T_{U.EQ.pt3} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \sin(\Theta_t) \cdot \frac{0.5 \cdot b_1}{I_{xx}} = -1075 \cdot lbs$$

$T_{U.EQ} := T_{U.EQ.pt1} + T_{U.EQ.pt2} + T_{U.EQ.pt3} = -1420 \cdot lbs$

Max Net Shear Load Due to Seismic Load, Fp

$$V_{Ux.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\cos(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_2 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_1 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 524 \cdot lbs$$

$$V_{Uy.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\sin(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_1 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_2 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 893 \cdot lbs$$

$$V_{U.EQ} := \sqrt{V_{Ux.EQ}^2 + V_{Uy.EQ}^2} = 1035 \cdot lbs$$

Tension Design force for Hold Down Clips

$T_{clip} := \max(R_{clip.W_0}, R_{clip.W_1}, |R_{clip.EQ}|, |T_{U.EQ}|) = 1420 \cdot lbs$

$|R_{clip.EQ}| = 1113 \cdot lbs$ $|T_{U.EQ}| = 1420 \cdot lbs$

$T_{clip.EQ.max} := \max(|R_{clip.EQ}|, |T_{U.EQ}|) = 1420 \cdot lbs$

$T_{clip.W.max} := \max(R_{clip.W_0}, R_{clip.W_1}) = 1029 \cdot lbs$

Based on ASCE 7-16 Figure 29.4-1 magnitude of force coefficient,

Wind in diagonal direction to the face of equipment produces less force than that of the wind in perpendicular direction to the face of the equipment. Therefore, wind in diagonal direction does not need to be used

Shear Design force for Hold Down Clips

$$V_{clip} := \max\left(\frac{\max(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit})}{N_t}, |V_{U.EQ}|\right) = 1035 \cdot lbs$$

$F_p \cdot Wt_{unit} \cdot \frac{1}{N_t} = 899 \cdot lbs$ $|V_{U.EQ}| = 1035 \cdot lbs$

$P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t} = 675 \cdot lbs$

$V_{clip.EQ.max} := \max\left[\left(F_p \cdot Wt_{unit} \cdot \frac{1}{N_t}\right), |V_{U.EQ}|\right] = 1035 \cdot lbs$

$V_{clip.W.max} := \max\left(\left(P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t}\right)\right) = 675 \cdot lbs$

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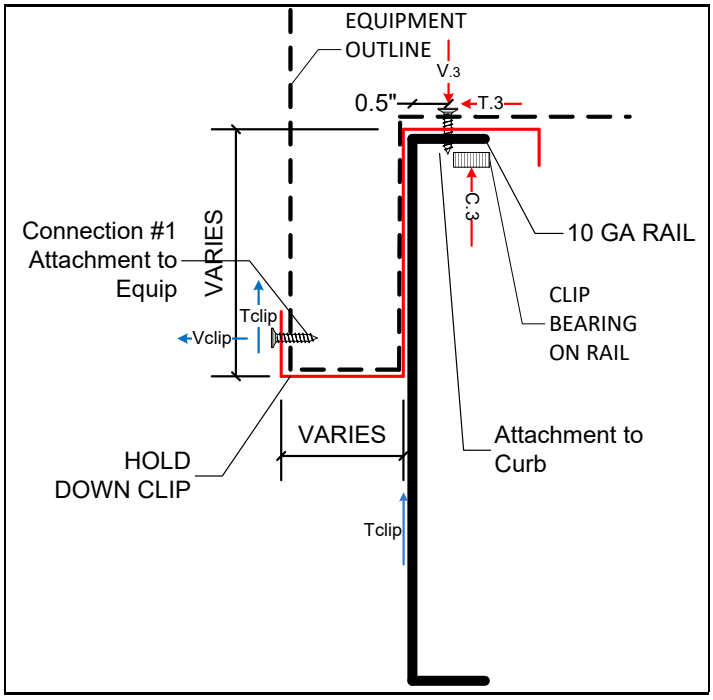
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Loading at Hold Down Clips @ Isolator Curb

$b_{return.iso} := Clip_b \cdot in = 2.125 \cdot in$

$b_{depth.iso} := Clip_c \cdot in = 6 \cdot in$



*For Reference Only

Mu Bending moment in the hold down

$M_u := T_{clip} \cdot b_{return.iso} = 3018 \cdot in \cdot lbs$

Resolve bending moment a T/C couple
Assume 0.5" bearing length
Moment Arm for T/C couple

$d_{T/C} := 1in - 0.5in = 0.5 \cdot in$

V3 is acting as shear on the screws. due to eccentricity of Tension force T

$$V_3 := \frac{T_{clip} \cdot \left[b_{return.iso} + (0) \right]}{d_{T/C}} = 6036 \cdot lbs$$

Additional load from Direct Shear acting out of plane (SRSS)

$V_3 := \sqrt{V_3^{\,2} + V_{clip}^{\,2}} = 6124 \cdot lbs$

Reaction C3 [compression force] is resisted by bearing of the hold down on the curb lip. Assume 0.5" bearing length

$C_3 := V_3 - T_{clip} = 4704 \cdot lbs$

T3 Load due to the shear acting out of plane tension on the screws.

$$T_3 := \left(\max\left(\frac{T_{clip} \cdot b_{return.iso}}{b_{depth.iso}}, V_{clip} \right) \right) = 1035 \cdot lbs$$

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Check Bending in Clip @ Isolator Curb

There are several restraints that prevents the hold down clip for iso-curb to have local bending at the bottom and transfer vertical load demand directly to the face of the curb.

- Hold down is bearing on the face of iso-rail / non-iso curb lip.
- Gasket will act as a "link" member to allow unit base rail and bottom flange to move totegther so flange can't bend unless the unit base rail bends first. However, unit base rail is not likely to bend so bottom flange won't bend

Hold Down Clip thickness

$t_{Clip} = \text{"12GA"}$ $t_{clip} := \text{thick}(t_{Clip}) = 0.1084 \cdot in$

Effective width of hold down clip

$b_c := L_{clip} = 9 \cdot in$

Yield strength of the Clip

$F_{y.c} := 50ksi$

Strength reduction for bending

$\phi_{clip} := 0.9$

Design Bending Capacity (LRFD)

$\phi M_n := \phi_{clip} \cdot F_{y.c} \left(\frac{b_c \cdot t_{clip}^2}{6} \right) = 793 \cdot in \cdot lbs$

Flexural bending demand

$M_{u.clip} := T_{clip} \cdot 0.5in = 710 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.clip}}{\phi M_n} = 0.895$

$Clip_{Bending} = \text{"OK"}$

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Check Flange Bending in Clip @ Isolator Curb

Note:
- **If the curb flange is welded to the 10GA channel and 10GA channel is welded back to the base of the curb, then both tension and compression due to equipment overturning will be taken care by the 10GA channel.**
- **Since the curb will be reinforced with 10GA channel under each isolator, it can be assumed that the loads will trasnferred down to the base structure through the channels. Therefore, flange downward bending at curb due to compressive load does not need to be checked.**

Roof Curb thickness

$t_{Curb} = \text{"14GA"}$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

Clip edge to edge distance

$$b_{edge2edge} := \frac{L_{curb} - \left(6in + \frac{L_{clip}}{2}\right) \cdot 2}{N_B - 1} - L_{clip} = 9.438 \cdot in$$

Effective width of Roof Curb

$b_{curb} := L_{clip} + b_{edge2edge} = 18.44 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\frac{b_{curb} \cdot (t_{curb})^2}{6}\right] = 852 \cdot in \cdot lbs$$

Width of Isolator

$w_{JQ.iso} := 2in$ **2 in. for CQAs**

Flexural bending demand

$$M_{u.Curb} := T_{clip} \cdot \left(\max\left(\frac{1.75in}{2} - 0.5in, \frac{w_{JQ.iso}}{2} - 1in\right)\right) = 533 \cdot in \cdot lbs$$

D/C Ratio for bending

$$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.625$$

$Curb_{Bending} = \text{"OK, Weld 10GA channel ends to curb flange"}$

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Design of Connection#1 Connection of Equipment to hold Down clip

Ultimate SMS screw connection Strength (LRFD)
Strength based on the smallest thickness of Curb and Equipment Housing (min 16 GA) [Fy = 50ksi & Fu=65ksi]

$n_{sms} := 4$ $Size_{ss} := "\#14"$

$t_{ss} := "16GA"$ $F_{u.ss} := 65ksi$

Nominal Tension Strength

$P_{nt} := n_{sms} \cdot T_s(Size_{ss}, t_{ss}, F_{u.ss}) = 3508 \cdot lbs$

$P_{not} := n_{sms} \cdot T_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 3508 \cdot lbs$

$P_{nov} := n_{sms} \cdot T_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 12383 \cdot lbs$

$P_{nts} := n_{sms} \cdot T_{nts}(Size_{ss}, t_{ss}, F_{u.ss}) = 14656 \cdot lbs$

Nominal Shear Strength

$P_{ns} := n_{sms} \cdot V_s(Size_{ss}, t_{ss}, F_{u.ss}) = 7808 \cdot lbs$

$P_{vnot} := n_{sms} \cdot V_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 8737 \cdot lbs$

$P_{vnov} := n_{sms} \cdot V_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 11144 \cdot lbs$

$P_{vnss} := n_{sms} \cdot V_{nss}(Size_{ss}, t_{ss}, F_{u.ss}) = 7808 \cdot lbs$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} V_{clip} \div (\phi_{sms} \cdot P_{nt}) \\ T_{clip} \div (\phi_{sms} \cdot P_{ns}) \end{bmatrix} = \begin{pmatrix} 59 \\ 36 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left[\begin{bmatrix} \left[\frac{T_{clip}}{P_{vnov}} + 0.71\left(\frac{V_{clip}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{T_{clip}}{P_{vnot}} + \left(\frac{V_{clip}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{T_{clip}}{P_{vnss}} + \left(\frac{V_{clip}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right] = 66 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

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Design of Connection#2 Connection of hold Down clip to Curb

Tension loads on SMS connection

$T_{s2} := V_3 = 6124 \cdot lbs$

Shear loads on SMS connection

$V_{s2} := T_3 = 1035 \cdot lbs$

Ultimate SMS screw connection Strength (LRFD)
Strength based on the smallest thickness of Curb and Equipment Housing (min 16 GA) [Fy = 50ksi & Fu=65ksi]

$n_{sms} := 8$ $Size_{ss} := "\#14"$

$t_{ss} := (t_{Curb.iso}) = "10GA"$ $F_{u.ss} := 65ksi$

Nominal Tension Strength

$P_{nt} := n_{sms} \cdot T_s(Size_{ss}, t_{ss}, F_{u.ss}) = 15271 \cdot lbs$

Note:
SMS is getting pulled up so the thicker curb iso rail is engaged for SMS capacity , rather than just the clip itself.

$P_{not} := n_{sms} \cdot T_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 15271 \cdot lbs$

$P_{nov} := n_{sms} \cdot T_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 53898 \cdot lbs$

$P_{nts} := n_{sms} \cdot T_{nts}(Size_{ss}, t_{ss}, F_{u.ss}) = 29312 \cdot lbs$

Nominal Shear Strength

$P_{ns} := n_{sms} \cdot V_s(Size_{ss}, t_{ss}, F_{u.ss}) = 15616 \cdot lbs$

$P_{vnot} := n_{sms} \cdot V_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 56103 \cdot lbs$

$P_{vnov} := n_{sms} \cdot V_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 48508 \cdot lbs$

$P_{vnss} := n_{sms} \cdot V_{nss}(Size_{ss}, t_{ss}, F_{u.ss}) = 15616 \cdot lbs$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} T_{s2} \div (\phi_{sms} \cdot P_{nt}) \\ V_{s2} \div (\phi_{sms} \cdot P_{ns}) \end{bmatrix} = \begin{pmatrix} 80 \\ 13 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left[\begin{bmatrix} \left[\frac{V_{s2}}{P_{vnov}} + 0.71\left(\frac{T_{s2}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{V_{s2}}{P_{vnot}} + \left(\frac{T_{s2}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{V_{s2}}{P_{vnss}} + \left(\frac{T_{s2}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right] = 61 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

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Hold Down clip Bending and Shear Interaction

Diameter of SMS:

$$d_{sms} := \text{vlookup}\left(Size_{ss}, SMS_{Table}, 1\right)_0 \cdot in = 0.25 \cdot in$$

Depth of flat web portion

$$h_{clip.shear} := L_{clip} - n_{sms} \cdot d_{sms} = 7 \cdot in$$

Depth-to-Thickness Ratio:

$$\frac{h_{clip.shear}}{t_{clip}} = 65 \qquad E := 29500ksi \qquad F_y := 50ksi \qquad \mu := 0.3$$

Nominal Shear Stress:
(For unreinforced web)
AISI S100-16 G2.1

$$k_v := 5.34 \qquad \sqrt{\frac{E \cdot k_v}{F_y}} = 56 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 85$$

Area of Web Element:

$$A_w := h_{clip.shear} \cdot t_{clip} = 0.759 \cdot in^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h_{clip.shear}}{t_{clip}}\right)^2} = 34.1 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} \qquad V_y := 0.6 \cdot A_w \cdot F_y = 23\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.937$$

Hole Shear Reduction Factor:
(for circular holes, AISI S100-16 Eq G3-1)

$$c := \frac{h_{clip.shear}}{2} - \frac{d_{sms}}{2.83} = 3.41 \cdot in$$

$$q_s := \begin{cases} 1.0 & \text{if } \frac{c}{t_{clip}} \geq 54 \\ \frac{c}{54 \cdot t_{clip}} & \text{if } 5 \leq \frac{c}{t_{clip}} < 54 \end{cases} = 0.583$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \leq 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \leq 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 19.792 \cdot kip$$

Design Shear Capacity with holes:

$$\phi V_{n.clip} := 0.95 \cdot V_n \cdot q_s = 11 \cdot kip$$

D/C Ratio of V and M per AISI S100-16 Eq H2-1

$$DCR_{V.M.int.clip} := \sqrt{\left(\frac{M_{u.clip}}{\phi M_n}\right)^2 + \left(\frac{\max\left(T_{clip}, V_{clip}\right)}{\phi V_{n.clip}}\right)^2} = 0.9046$$

Demand/Capacity Ratio:

$$VandM_{int.clip} = \text{"OK"}$$

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ISOLATOR DESIGN [PER OPM-0401-13]

OPM-0401-13 is based on allowable stress design

Number of isolators on the long side

$N_B := 8$ $N_{iso.long} := N_B = 8$

Moment Arm for overturning (Short side)

$B := W_{curb} + \frac{1.75in}{2} \cdot 2 = 79 \cdot in$

Number of isolators on the Short side.

$N_L := 6$

Isolator Centerline Spacing (Long side)

$L_{spacing.iso} := \frac{L_{curb} - (6in) \cdot 2}{N_B - 1} = 14.46 \cdot in$

Moment Arm for overturning (Long side)

$L := L_{curb} - 2 \cdot 6in - 2 \cdot L_{spacing.iso} \cdot \frac{(N_L - 2)}{4} = 72 \cdot in$

Total Number of isolators

$N_t := (N_B) \cdot 2sides = 16$

Max net Tension Reaction due to Seismic, Fp

$EQ_{ASD} := \left[0.6 - (0.7 \cdot F_v)\right] \cdot Wt_{unit} = 1.246\ kip$

$$R_{iso.EQ} := MAX+\left[\left[\left[\frac{(0.7F_p) \cdot Wt_{unit}}{B \cdot N_B} \cdot (h_{CG.unit} + 0in) + \frac{EQ_{ASD} \cdot e_{width}}{B \cdot N_B}\right] - \frac{EQ_{ASD}}{N_t}\right]\right] = \begin{pmatrix} 331 \\ 508 \end{pmatrix} \cdot lbs$$

$$\left[\left[\frac{(0.7F_p) \cdot Wt_{unit}}{L \cdot N_L} \cdot (h_{CG.unit} + 0in) + \frac{EQ_{ASD} \cdot e_{length}}{L \cdot N_L}\right] - \frac{EQ_{ASD}}{N_t}\right]$$

Max net Tension Reaction due to Wind load, Pnet

$$F_{wind.B} := \frac{P_{net} \cdot L_{unit} \cdot (H_{unit} + 0in)}{B \cdot N_B} \cdot \left(\frac{1}{2} \cdot H_{unit} + 0in\right) = 426 \cdot lbs$$

$$F_{wind.L} := \frac{P_{net} \cdot W_{unit} \cdot (H_{unit} + 0in)}{L \cdot N_L} \cdot \left(\frac{1}{2} \cdot H_{unit} + 0in\right) = 426 \cdot lbs$$

$$R_{iso.W} := (0.6) \cdot MAX+\left(\begin{pmatrix} F_{wind.B} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{Wt_{unit}}{N_t} \\ F_{wind.L} + \frac{P_v \cdot L_{unit.up} W_{unit}}{N_t} + \frac{Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{Wt_{unit}}{N_t} \end{pmatrix}\right) = \begin{pmatrix} 459 \\ 454 \end{pmatrix} \cdot lbs$$

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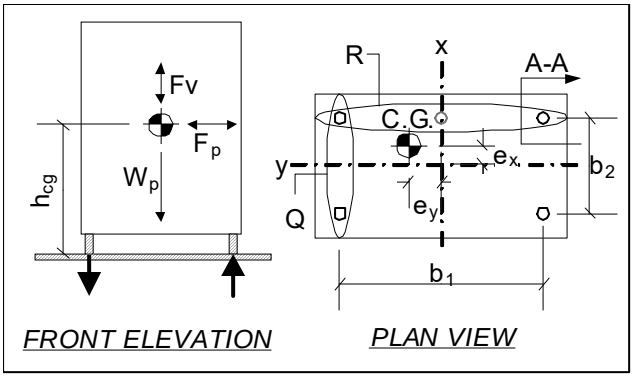
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Tensile and Shear Load calculation per ASHRAE RP-812



Eccentricity along X-X

$e_x := e_{width} = 6.09 \cdot in$

Eccentricity along Y-Y

$e_y := e_{length} = 3.16 \cdot in$

Distance between Seismic Restraints Along Y-Y

$b_1 := L_{curb} - 2 \cdot 6in = 101 \cdot in$

Distance between Seismic Restraints Along X-X

$b_2 := W_{curb} + 2 \cdot \frac{1.75in}{2} = 79 \cdot in$

Moment of Inertia about X-X

$I_{xx} := \frac{N_t \cdot (N_t + 2) \cdot (b_1)^2}{12 \cdot (N_t - 2)} = 17553 \cdot in^2$

Moment of Inertia about Y-Y

$I_{yy} := \frac{N_t \cdot (b_2)^2}{4} = 24806 \cdot in^2$

Angle about Tensile Load

$\Theta_t := \operatorname{atan}\left[\frac{I_{yy} \cdot (b_1)}{I_{xx} \cdot (b_2)}\right] = 61 \cdot deg$

Angle about Shear Load

$$\Theta_s := \begin{cases} \operatorname{atan}\left(\frac{e_x}{e_y}\right) & \text{if } e_y \neq 0 \\ 0deg & \text{if } e_y = 0 \end{cases} = 63 \cdot deg$$

Max Net Tensile Load Due to Seismic Load, Fp

$$T_{U.EQ.pt1} := \frac{(0.6 - 0.7 \cdot F_v) \cdot Wt_{unit}}{N_t} - \frac{(0.6 - 0.7 \cdot F_v) \cdot Wt_{unit}}{b_1 \cdot b_2} \cdot \left(\frac{b_1}{2} \cdot e_x + \frac{b_2}{2} \cdot e_y - e_x \cdot e_y\right) = 13 \cdot lbs$$

$$T_{U.EQ.pt2} := -0.7 \cdot (F_p \cdot Wt_{unit}) \cdot (h_{CG.unit} + 0in) \cdot \cos(\Theta_t) \cdot \frac{0.5 \cdot b_2}{I_{yy}} = -191 \cdot lbs$$

$$T_{U.EQ.pt3} := -0.7 \cdot (F_p \cdot Wt_{unit}) \cdot (h_{CG.unit} + 0in) \cdot \sin(\Theta_t) \cdot \frac{0.5 \cdot b_1}{I_{xx}} = -631 \cdot lbs$$

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$T_{U.EQ} := T_{U.EQ.pt1} + T_{U.EQ.pt2} + T_{U.EQ.pt3} = -810 \cdot lbs$

Max Net Shear Load Due to Seismic Load, Fp

$$V_{Ux.EQ} := 0.7 \cdot F_p \cdot Wt_{unit} \cdot \frac{\cos(\Theta_s)}{N_t} + \frac{0.7 \cdot F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_2 \cdot e_y + 0.7 \cdot F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_1 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 276 \cdot lbs$$

$$V_{Uy.EQ} := 0.7 \cdot F_p \cdot Wt_{unit} \cdot \frac{\sin(\Theta_s)}{N_t} + \frac{0.7 \cdot F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_1 \cdot e_y + 0.7 \cdot F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_2 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 470 \cdot lbs$$

$$V_{U.EQ} := \sqrt{V_{Ux.EQ}^2 + V_{Uy.EQ}^2} = 545 \cdot lbs$$

Tension Design force SRSS for loading from Each direction

$R_{iso.EQ.1.RP812} := \left| T_{U.EQ.pt1} + T_{U.EQ.pt3} \right| = 618 \cdot lbs$

$R_{iso.EQ.0.RP812} := \left| T_{U.EQ.pt1} + T_{U.EQ.pt2} \right| = 178 \cdot lbs$

$$R_{iso.EQ.max_1} := \max\left[\left(R_{iso.EQ.1.RP812} + 0 \cdot R_{iso.EQ.0.RP812}\right), \left(R_{iso.EQ_1} + 0 \cdot R_{iso.EQ_0}\right)\right] = 618 \cdot lbs$$

$$R_{iso.EQ.max_0} := \max\left[\left(R_{iso.EQ.0.RP812} + 0 \cdot R_{iso.EQ.1.RP812}\right), \left(R_{iso.EQ_0} + 0 \cdot R_{iso.EQ_1}\right)\right] = 331 \cdot lbs$$

For the plot:

$R_{iso.EQ.max_1} = 618 \cdot lbs$ $R_{iso.W_1} = 454 \cdot lbs$

$R_{iso.EQ.max_0} = 331 \cdot lbs$ $R_{iso.W_0} = 459 \cdot lbs$

Shear load at each anchor location

For the plot:

$$V_{iso.E} := \max\left[\left[\begin{array}{c} 1.0 \cdot V_{Ux.EQ} + 0 \cdot V_{Uy.EQ} \\ 0.3 \cdot V_{Ux.EQ} + 0 \cdot V_{Uy.EQ} \\ \left[\left(0.7F_p\right) \cdot Wt_{unit} \cdot \frac{1}{N_t}\right] \end{array}\right]\right] = 472 \cdot lbs \qquad V_{iso.W} := 0.6P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t} = 304 \cdot lbs$$

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Isolator Capacity:

$ID_{Iso} := "CQA"$

$T_{n.\Omega} := 2117lbs$ **(ASD)**

$V_{n.\Omega} := 775lbs$ **(ASD)**

Isolator Demand:

$R_{iso.max} := \max\left[\left(R_{iso.EQ.max_1}\right),\left(R_{iso.EQ.max_0}\right),\left(R_{iso.W_1}\right),\left(R_{iso.W_0}\right)\right] = 618\cdot lbs$

$V_{iso.max} := \max\left(V_{iso.E}, V_{iso.W}\right) = 472\cdot lbs$

D/C Ratio of Tension Only.:

$$DCR_{tension} := \frac{R_{iso.max}}{T_{n.\Omega}} = 0.292$$

$DCR_{tension} = "OK"$

D/C Ratio of Shear Only.:

$$DCR_{shear} := \frac{V_{iso.max}}{V_{n.\Omega}} = 0.609$$

$DCR_{shear} = "OK"$

D/C Ratio of Tension Only.:

$$DCR_{Int} := \frac{V_{iso.max}}{V_{n.\Omega}} + \frac{R_{iso.max}}{T_{n.\Omega}} = 0.901$$

$DCR_{Int} = "OK"$

ISOLATOR "SPRING" DESIGN [PER OPM-0401-13]

Factor of Safety of Spring

$FS_{spring} := 0.75$

Compressive Strength of Spring

$$C_{spring.\Omega} := \begin{cases} \left(FS_{spring}\cdot 300lbs\right) & \text{if } ID_{Iso} = "CQA" \\ \left(FS_{spring}\cdot 918lbs\right) & \text{if } ID_{Iso} = "CQB" \\ \left(FS_{spring}\cdot 918lbs\right) & \text{if } ID_{Iso} = "CQBX" \end{cases} = 225\cdot lbs$$

Rated Load per unit self-weight

$$C_{unit.rated.load} := \frac{Wt_{unit}}{N_t} = 200\cdot lbs$$

D/C Ratio of Spring Compression:

$$DCR := \frac{C_{unit.rated.load}}{C_{spring.\Omega}} = 0.888$$

$IsoSpring_{compression} = "OK"$

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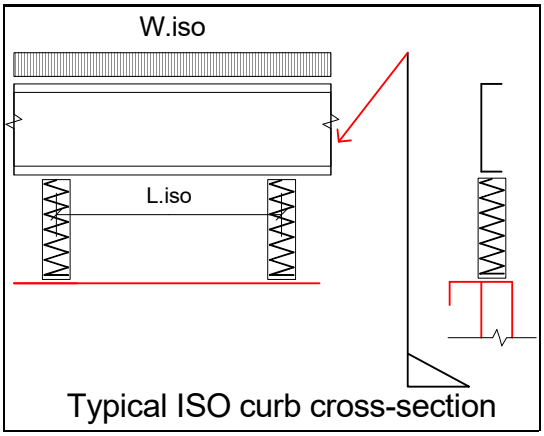
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Check ISO Rail for Bending about Strong and Weak Axis (AISI S100-16 F2.1)



Typical ISO curb cross-section

Thickness of Curb:

$t_{Curb.iso}$ = "10GA" $t := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Inside Bend Radius:

$R := R_{iso} = 0.186 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web:

$h := 7.5in - 2 \cdot (t + R) = 6.85 \cdot in$

Width of Flange:

$h_w := 1in$

Check Curb Bending of Long Side (Strong axis)

Member per CFS: $CFS_{member} :=$ "10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"

Number of Isolators on each Long Side: $N_{iso.long} = 8$

Center-to-Center Spacing of Isolators $L_{iso} := \frac{L_{curb}}{N_{iso.long} - 1} = 16 \cdot in$

Distributed Load $\omega_{iso} := \omega_{x.L.vert} = 1.977\,klf$

Moment Demand on Iso Rail $M_{cx} := \frac{\omega_{iso} \cdot L_{iso}^2}{8} = 5.385 \cdot kip \cdot in$

Curb Elastic Modulus / Yield Stress: $E := 29500ksi$ $F_y := 50ksi$

Curb Shear Modulus: $G := 11300ksi$

Poisson's Ratio $\mu := 0.3$

Section Properties from CFS: $r_x = 2.4893 \cdot in$ $r_o = 2.519 \cdot in$ $C_w = 0.595 \cdot in^6$ $S_x = 1.855 \cdot in^3$

$r_y = 0.2288 \cdot in$ $J = 0.0058 \cdot in^4$ $S_y = 0.3669 \cdot in^3$

$r_{min} := min(r_x, r_y) = 0.2288 \cdot in$

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Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Flanges*

Flat Width:

$$w := h_w - R_{curb} = 0.893 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Unstiffened"}$$

Stress at the end of the Width:

$$f_2 := 11.407ksi \quad f_1 := 11.407ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \frac{f_2}{f_1} = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 0.43$$

Critical Compressive Stress:

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t}{w}\right)^2 = 274.53 \cdot ksi$$

Stress in Compression Element:

$$f := 18ksi$$

Note: Use f from "Elastive Flexural Buckling Stress" on "Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI E2)"

Slenderness Factor:

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 0.26$$

Local reduction factor:

$$\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 0.55$$

Effective Width of the Flanges:

$$b_{eff.flange} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 0.893 \cdot in$$

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Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Web*

Flat Width: $w := h = 6.851 \cdot in$

Stiffened Web Check: $Stiffened_{check} := "Stiffened"$

Stress at the end of the Width: $f_2 := 11.407ksi$ $f_1 := 11.407ksi$

Compressive Stress Ratio (Eq. 1.1.2-1): $\Psi := \frac{f_2}{f_1} = 1$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = "Stiffened" \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = "Unstiffened" \end{cases} = 4$$

Critical Compressive Stress: $F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t}{w}\right)^2 = 43.4 \cdot ksi$

Stress in Compression Element: $f := 18ksi$

Note: Use f from "Elastive Flexural Buckling Stress" on "Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI E2)"

Slenderness Factor: $\lambda := \sqrt{\frac{f}{F_{cr}}} = 0.64$

Local reduction factor: $\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 1.022$

Effective Width of the Web:

$$b_{eff.web} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 6.851 \cdot in$$

Effective Area of the Member: $A_e := 2 \cdot \left(b_{eff.flange} \cdot t\right) + b_{eff.web} \cdot t = 1.194 \cdot in^2$

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For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. F2.1.1-4,5)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(1.0 \cdot L_{iso}\right)^2}\right] = 96 \cdot ksi$$

$$\sigma_{ey} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{iso}}{r_y}\right)^2} = 58 \cdot ksi \qquad \frac{1.0 \cdot L_{iso}}{r_y} = 71$$

KL_r = "KL/r < 200, OK"

Cb per Eq. F2.1.1-2

$$M_A := \frac{\omega_{iso} \cdot \frac{L_{iso}}{4}}{2} \cdot \left(L_{iso} - \frac{L_{iso}}{4}\right) = 4.04 \cdot kip \cdot in$$

$$M_B := M_{cx} = 5.39 \cdot kip \cdot in$$

$$M_C := \frac{\omega_{iso} \cdot \frac{3 \cdot L_{iso}}{4}}{2} \cdot \left(L_{iso} - \frac{3 \cdot L_{iso}}{4}\right) = 4.04 \cdot kip \cdot in$$

$$C_b := \min\left(1.0, \frac{12.5 \cdot M_{cx}}{2.5 \cdot M_{cx} + 3 \cdot M_A + 4 \cdot M_B + 3.M_C}\right) = 1$$

Elastic Critical Lateral-Torsional Buckling Stress per Eq. F2.1.1-1 for Singly Symmetry:

$$F_e := \frac{C_b \cdot r_o \cdot A_e}{S_x} \cdot \sqrt{\sigma_{ey} \cdot \sigma_t} = 121 \cdot ksi$$

LTB Design Stress: Eq. F2.1-3,4,5:

$$F_c := \begin{cases} F_y & \text{if } F_e \geq 2.78 \cdot F_y \\ \frac{10}{9} \cdot F_y \cdot \left(1 - \frac{10 \cdot F_y}{36 \cdot F_e}\right) & \text{if } 2.78 \cdot F_y > F_e > 0.56 \cdot F_y \\ F_e & \text{if } 0.56 \cdot F_y \geq F_e \end{cases} = 49 \cdot ksi$$

Moment Capacity Eq. F2.1-1:

$$\phi M_{nx} := 0.9 \cdot S_x \cdot \min\left(F_c, F_y\right) = 82 \cdot kip \cdot in$$

D/C Ratio of Bending:

$$DCR := \frac{M_{cx}}{\phi M_{nx}} = 0.066$$

$Iso_{Bending}$ = "OK"

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Check Curb Bending of Long Side (Weak axis)

Center-to-Center Spacing of Braces

$$L_{brace} := \frac{L_{curb}}{N_{iso.long} - 1} = 16 \cdot in$$

Note for weak-axis bracing length:
Max weak-axis span length of Iso Rail is larger than L_{brace} per cut sheet. However, the Iso Rail is braced with clip at max 24" O.C. at top and isolator at max 36" O.C. at bottom such that the actual unbraced length is as follows.

Distributed Load

$$\omega_{iso} := \frac{\max\left(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit}\right)}{L_{curb}} = 1.143\ klf$$

Moment Demand on Iso Rail

$$M_{cy} := \frac{\omega_{iso} \cdot L_{brace}^{2}}{8} = 3.114 \cdot kip \cdot in$$

Member per CFS:

$$CFS_{member} = \text{"10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"}$$

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. F2.1.1-4,5)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(1.0 \cdot L_{brace}\right)^2}\right] = 96 \cdot ksi$$

$$\sigma_{ex} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{brace}}{r_x}\right)^2} = 6900 \cdot ksi \qquad \frac{1.0 \cdot L_{brace}}{r_x} = 6$$

$$KL_r = \text{"KL/r < 200, OK"}$$

Cb per Eq. F2.1.1-2

$$M_A := \frac{\omega_{iso} \cdot \frac{L_{brace}}{4}}{2} \cdot \left(L_{brace} - \frac{L_{brace}}{4}\right) = 2.34 \cdot kip \cdot in$$

$$M_B := M_{cy} = 3.11 \cdot kip \cdot in$$

$$M_C := \frac{\omega_{iso} \cdot \frac{3 \cdot L_{brace}}{4}}{2} \cdot \left(L_{brace} - \frac{3 \cdot L_{brace}}{4}\right) = 2.34 \cdot kip \cdot in$$

$$C_b := \min\left(1.0, \frac{12.5 \cdot M_{cx}}{2.5 \cdot M_{cx} + 3 \cdot M_A + 4 \cdot M_B + 3 \cdot M_C}\right) = 1$$

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Elastic Critical Lateral-Torsional Buckling Stress per Eq. F2.1.1-1 for Singly Symmetry:

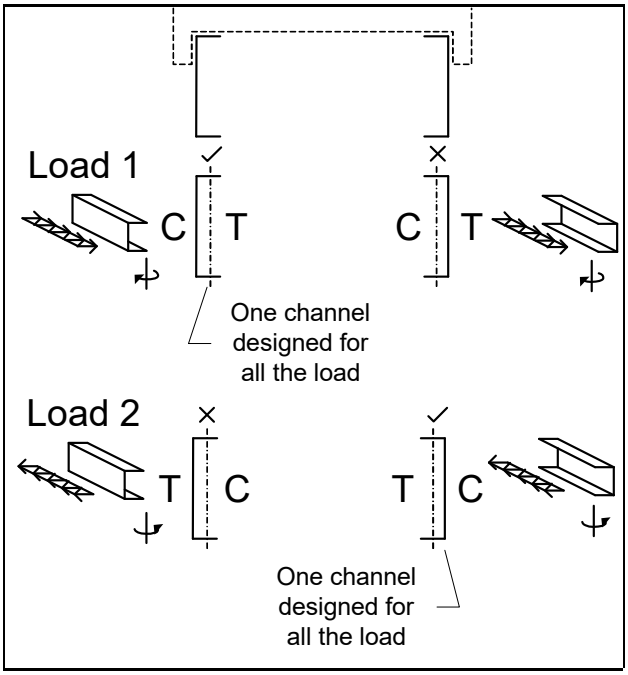
$$F_e := \frac{C_b \cdot r_o \cdot A_e}{S_y} \cdot \sqrt{\sigma_{ey} \cdot \sigma_t} = 613 \cdot ksi$$

LTB Design Stress: Eq. F2.1-3,4,5:

$$2.78 \cdot F_y = 139 \cdot ksi$$

$$0.56 \cdot F_y = 28 \cdot ksi$$

$$F_c := \begin{cases} F_y & \text{if } F_e \geq 2.78 \cdot F_y \\ \frac{10}{9} \cdot F_y \cdot \left(1 - \frac{10 \cdot F_y}{36 \cdot F_e}\right) & \text{if } 2.78 \cdot F_y > F_e > 0.56 \cdot F_y \\ F_e & \text{if } 0.56 \cdot F_y \geq F_e \end{cases} = 50 \cdot ksi$$



Note:

For ISO rail weak-axis bending capacity, rails are oriented and designed so that the stiffer side of ISO rail can take the entire bending load by itself without putting a lot of bending load to the iso rail on the other side

Moment Capacity Eq. F2.1-1:

$$\phi M_{ny} := 0.9 \cdot S_y \cdot \min\left(F_c, F_y\right) = 16.5105 \cdot kip \cdot in$$

D/C Ratio of Bending:

$$DCR := \frac{M_{cy}}{\phi M_{ny}} = 0.189$$

$$Iso_{Bending} := \text{if}\left(M_{cy} < \phi M_{ny}, \text{"OK"}, \text{"NG"}\right)$$

$Iso_{Bending} = \text{"OK"}$

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Web Crippling of ISO Rail (AISI S100-16 G.5)

Governing Compression:

$$P_{web.crip} := \frac{\omega_{x.L.vert} \cdot L_{iso}}{2} = 1332 \cdot lbs$$

Yield Strength:

$$F_y := 50ksi$$

Bearing Length:

$N := 2in$ **2 in. for CQAs**

Thickness of Curb:

$t_{Curb.iso} = \text{"10GA"}$ $t := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Inside Bend Radius:

$R := R_{iso} = 0.186 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web:

$h = 6.85 \cdot in$

Angle btween plane of web and bearing surface:

$\theta := 90deg$

Web Crippling Limit Check (AISI Table G5-2):

$\frac{R}{t} = 1$ $\frac{h}{t} = 50$ $\frac{N}{t} = 14$ $\frac{N}{h} = 0.29$

$$LimitCheck_{webcrippling} := if\left[\left(\frac{h}{t} < 200\right) \wedge \left(\frac{N}{t} < 210\right) \wedge \left(\frac{N}{h} < 2\right) \wedge \left(\frac{R}{t} < 2\right), \text{"OK"}, \text{"NG, Need Reinf"}\right]$$

$LimitCheck_{webcrippling} = \text{"OK"}$

End Case Coefficient Single Web Channel (AISI Table G5-2):

$C := 2$ $C_R := 0.11$ $C_N := 0.37$ $C_h := 0.01$

Reduction Factor Web Crippling Strength:

$\phi_{web.end} := 0.75$

$\phi_{web.int} := 0.8$

(For Unfastened Flanges with Two-Flange Loading or Reaction. Worst Case)

Design Web Crippling Strength:

$$P_{n.end} := C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 3729 \cdot lbs$$

$$\phi P_{n.end} := \phi_{web.end} \cdot P_{n.end} = 2796 \cdot lbs$$

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Interior Case Coefficient Single Web Channel (AISI Table G5-2):

$C := 13$ $C_R := 0.47$ $C_N := 0.25$ $C_h := 0.04$

Design Web Crippling Strength:

$$P_{n.interior} := C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 7905 \cdot lbs$$

$$\phi P_{n.interior} := \left(\phi_{web.int}\right) \cdot P_{n.interior} = 6324 \cdot lbs$$

Design Strength:

$$P_{n.web.crip} := \min\left(P_{n.end}, P_{n.interior}\right) = 3729 \cdot lbs$$

$$\phi P_{n.web.crip} := \min\left(\phi P_{n.end}, \phi P_{n.interior}\right) = 2796 \cdot lbs$$

D/C Ratio of Shear:

$$DCR := \frac{P_{web.crip}}{\phi P_{n.web.crip}} = 0.476$$

Demand/Capacity Ratio:

$$Web_{crippling} := \text{if}\left[\left(P_{web.crip} < \phi P_{n.web.crip}\right) \wedge \left(\phi P_{n.end} > 0\right) \wedge \frac{h}{t} < 200, \text{"OK"}, \text{"NG, Need Reinf"}\right]$$

$Web_{crippling} = \text{"OK"}$

D/C Ratio of Interaction:
AISI Eq. H3-1b

$$DCR_{int.web} := \frac{0.91 \cdot \left(\frac{P_{web.crip}}{P_{n.web.crip}}\right) + \frac{M_{cx}}{\left(\frac{\phi M_{nx}}{0.9}\right)}}{1.33 \cdot 0.9} = 0.321$$

$Iso_{Shear} = \text{"OK"}$

$Iso_{Interaction} = \text{"OK"}$

Per AISI S100-16 H3,
Only x-axis needs to check for interaction

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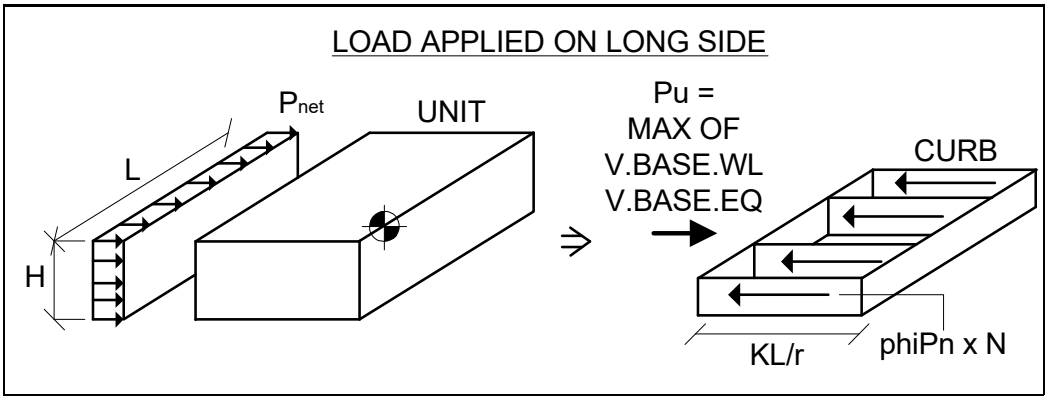
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Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI S100-16 E2)

Curb Axial Load Check due to Load on Long Side



Wind Base Shear of Unit on Long Side: $V_{base.W.L} := P_{net} \cdot L_{unit} \cdot H_{unit} = 8.1\,kip$

Seismic Base Shear of Unit on Long Side: $V_{base.S.L} := F_p \cdot Wt_{unit} = 10.8\,kip$

Max Axial: $P_u := \max\left(V_{base.S.L}, V_{base.W.L}\right) = 10783.46 \cdot lbs$

Member per CFS: $CFS_{member} =$ "10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"

Number of Curb in Length: $n_{iso} := 3$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{iso}} = 3.59\,kip$

Max Braced Length of Member: $L_{member} := W_{curb} = 77 \cdot in$

Effective Length factor: $K := 0.5$

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For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. E2.2-5, E2.2-6)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(K \cdot L_{member}\right)^2}\right] = 24 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2} = 10 \cdot ksi$$

$$\frac{K \cdot L_{member}}{r_{min}} = 168$$

KL_r = "KL/r < 200, OK"

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 7 \cdot ksi$$

Nominal Compressive Stress Capacity (Eq E2-4):

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 2.635$$

$$F_n := \begin{cases} 0.658^{\lambda_c^{\,2}} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^{\,2}}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 6.32 \cdot ksi$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot A_e \cdot F_n = 6.41\,kip$$

D/C Ratio of Compression:

$$DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.561$$

$$Axial_{reinf} := \text{if}\left(P_{u.EAmember} < \phi P_{n.member}, \text{"OK"}, \text{"NG"}\right)$$

$Axial_{reinf}$ = "OK"

Note:
No need to check for interaction since equipment is not attached to the short side

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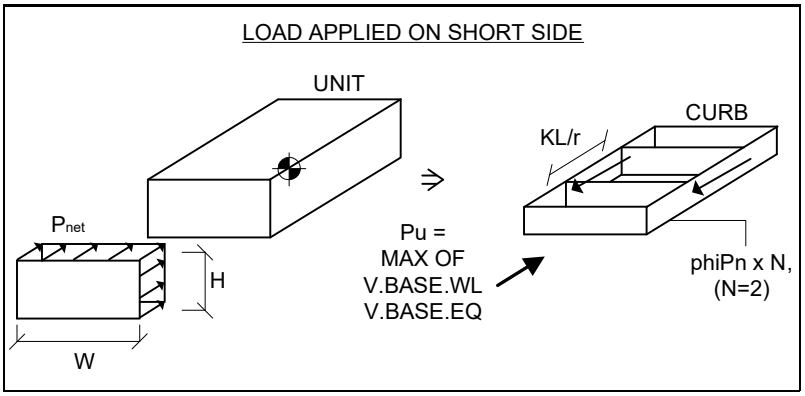
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Curb Axial Load Check due to Load on Short Side



Wind Base Shear on Short Side: $V_{base.W.H} := P_{net} \cdot W_{unit} \cdot H_{unit} = 5.6\,kip$

Seismic Base Shear of Unit on Short Side: $V_{base.S.W} := F_p \cdot Wt_{unit} = 10.8\,kip$

Max Axial: $P_u := \max\left(V_{base.S.W}, V_{base.W.H}\right) = 10783.46 \cdot lbs$

Member per CFS: $CFS_{member} = \text{"10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"}$

Number of Curb in Length: $n_{curb} := 2$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{curb}} = 5.39\,kip$

Max Braced Length of Member: $L_{member} := \frac{L_{curb}}{n_{iso} - 1} = 57 \cdot in$

Effective Length factor: $K := 0.5$

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. E2.2-5, E2.2-6)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(K \cdot L_{member}\right)^2}\right] = 37 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2} = 19 \cdot ksi \qquad \frac{K \cdot L_{member}}{r_{min}} = 124$$

$KL_r = \text{"KL/r < 200, OK"}$

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 13 \cdot ksi$$

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Nominal Compressive Stress Capacity (Eq E2-4):

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 1.993$$

$$F_n := \begin{cases} 0.658^{\lambda_c^2} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^2}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 11.04 \cdot \text{ksi}$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot A_e \cdot F_n = 11.2\,\text{kip}$$

D/C Ratio of Compression:

$$DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.481$$

$$Axial_{reinf} := \text{if}\left(P_{u.EAmember} < \phi P_{n.member}, \text{"OK"}, \text{"NG"}\right)$$

$Axial_{reinf} = \text{"OK"}$

Note:
If the load direction is in perpedicular plane to the short side of the equipment, the channels will only experience axial load and no bending will occur at the channel. Therefore, no need to check for interaction since the channels

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Shear of ISO Rail Webs without Holes (AISI S100-16 G2)

Note: The connection holes are not centered at mid-depth of isolated curb rail so AISI G2 shall be used

Deeper Section (h = depth)

Thickness of Curb: $t := \text{thick}(t_{Curb.iso}) = 0.138 \cdot in$

Depth-to-Thickness Ratio: $\frac{h}{t} = 50$

Curb Elastic Modulus: $E := 29500ksi$

Clear distance b/w transverse stiffeners of reinforced web: $a := L_{iso} = 16 \cdot in$

Clear Distance-to-Thickness Ratio: $\frac{a}{h} = 2.36$

Nominal Shear Stress:

$$k_v := \begin{cases} 5.34 \text{ if } a = L_{iso} \\ 4.00 + \frac{5.34}{\left(\frac{a}{h}\right)^2} \text{ if } \left(\frac{a}{h} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \frac{4.00}{\left(\frac{a}{h}\right)^2} \text{ if } \left(\frac{a}{h} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 6.06$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 60 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 90$$

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Curb Shear Check due to Load on Longer Side

Area of Web Element:

$$A_w := h \cdot t = 0.947 \cdot in^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 65.7 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} = 62\,kip \qquad V_y := 0.6 \cdot A_w \cdot F_y = 28\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.676$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 28.404 \cdot kip$$

Number of Members within Length: $n := 1$ **(Per Curb Design)**

Design Shear Capacity:

$$\phi V_{n.h} := 0.95 \cdot n \cdot V_n = 26.98 \cdot kip$$

Design Shear Demand:

$$V_{u.h} := \frac{\omega_{x.L.vert} \cdot L_{iso}}{2} = 1332.2 \cdot lbs$$

D/C Ratio of Shear:

$$DCR := \frac{V_{u.h}}{\phi V_{n.h}} = 0.049$$

Demand/Capacity Ratio:

$Shear_{in.plane} = \text{"OK"}$

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Shallower Section (h.w = Width)

Thickness of Curb: $t := \text{thick}(t_{Curb.iso}) = 0.138 \cdot in$

Depth-to-Thickness Ratio: $\frac{h_w}{t} = 7$

Curb Elastic Modulus: $E := 29500ksi$

Clear distance b/w transverse stiffeners of reinforced web: $a := L_{brace} = 16 \cdot in$

Clear Distance-to-Thickness Ratio: $\frac{a}{h_w} = 16.17$

Nominal Shear Stress:

$$k_v := \begin{cases} 5.34 & \text{if } a = L_{brace} \\ 4.00 + \frac{5.34}{\left(\frac{a}{h_w}\right)^2} & \text{if } \left(\frac{a}{h_w} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \frac{4.00}{\left(\frac{a}{h_w}\right)^2} & \text{if } \left(\frac{a}{h_w} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 5.36$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 56 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 85$$

Curb Shear Check due to Load on Longer Side

Area of Web Element: $A_w := h_w \cdot t = 0.1382 \cdot in^2$

Number of Members within Length: $n := 1$ **(Per Curb Design)**

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 58.1 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} = 8\,kip \qquad V_y := 0.6 \cdot A_w \cdot F_y = 4\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.719$$

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$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 4.146 \cdot \text{kip}$$

Design Shear Capacity:

$$\phi V_{n.hw} := 0.95 \cdot n \cdot V_n = 3.9 \cdot \text{kip}$$

Design Shear Demand:

$$V_{u.hw} := \frac{\left(\frac{\max\left(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit}\right)}{L_{curb}} \right) \cdot L_{brace}}{2} = 770.2 \cdot \text{lbs}$$

D/C Ratio of Shear:

$$DCR := \frac{V_{u.hw}}{\phi V_{n.hw}} = 0.196$$

Demand/Capacity Ratio:

$Shear_{in.plane}$ = "OK"

D/C Ratio of Vx and Mx:

$$DCR_{V.M.int} := \begin{cases} \left(0.6 \cdot \frac{M_{cx}}{\phi M_{nx}} + \frac{V_{u.h}}{\phi V_{n.h}}\right) \cdot \frac{1}{1.3} & \text{if } \frac{M_{cx}}{\phi M_{nx}} > 0.5 \wedge \frac{V_{u.h}}{\phi V_{n.h}} > 0.7 \\ \sqrt{\left(\frac{M_{cx}}{\phi M_{nx}}\right)^2 + \left(\frac{V_{u.h}}{\phi V_{n.h}}\right)^2} & \text{otherwise} \end{cases} = 0.082$$

Demand/Capacity Ratio:

$VandMx_{int}$ = "OK"

D/C Ratio of Vy and My:

$$DCR_{V.M.int} := \begin{cases} \left(0.6 \cdot \frac{M_{cy}}{\phi M_{ny}} + \frac{V_{u.hw}}{\phi V_{n.hw}}\right) \cdot \frac{1}{1.3} & \text{if } \frac{M_{cy}}{\phi M_{ny}} > 0.5 \wedge \frac{V_{u.hw}}{\phi V_{n.hw}} > 0.7 \\ \sqrt{\left(\frac{M_{cy}}{\phi M_{ny}}\right)^2 + \left(\frac{V_{u.hw}}{\phi V_{n.hw}}\right)^2} & \text{otherwise} \end{cases} = 0.272$$

Demand/Capacity Ratio:

$VandMy_{int}$ = "OK"

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Web Crippling/Compression of Non-iso CanFab Curb (AISI S100-16 G5)

Governing Compression for Non-Isolated Curb:

$$P_{web.crip.int} := \max\left[\frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}}, \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}}\right] \cdot L_{spacing.non.iso} = 5064 \cdot lbs$$

$$P_{web.crip.end} := 0.5 \cdot P_{web.crip.int} = 2532 \cdot lbs$$

Yield Strength: $F_y := 50ksi$

Bearing Length: $N_{bearing} := L_{spacing.non.iso} = 31 \cdot in$

Thickness of Curb: $t_{Curb} = \text{"14GA"}$ $t := thick(t_{Curb}) = 0.0785 \cdot in$

Inside Bend Radius: $R := R_{curb} = 0.107 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web: $h := 22in - 2 \cdot (t + R) = 21.63 \cdot in$

Angle btween plane of web and bearing surface: $\theta := 90deg$

Web Crippling Limit Check (AISI Table G5-2): $\frac{R}{t} = 1$ $\frac{h}{t} = 276$ $\frac{N_{bearing}}{t} = 391$ $\frac{N_{bearing}}{h} = 1.42$

End Case Coefficient Single Web Channel (AISI Table G5-2): $C := 13$ $C_R := 0.32$ $C_N := 0.05$ $C_h := 0.04$

Reduction Factor Web Crippling Strength: $\phi_{web.end} := 0.9$ $\phi_{web.int} := 0.8$ **(For Unfastened partially Stiffened Flanges with Two-Flange Loading or Reaction.)**

Design Web Crippling Strength:

$$\phi P_{n.end} := \left(\phi_{web.end}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 1510 \cdot lbs$$

Interior Case Coefficient Single Web Channel (AISI Table G5-2): $C := 24$ $C_R := 0.52$ $C_N := 0.15$ $C_h := 0.001$

Design Web Crippling Strength:

$$\phi P_{n.interior} := \left(\phi_{web.int}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 9076 \cdot lbs$$

D/C Ratio of Shear: $DCR_{end} := \frac{P_{web.crip.end}}{2 \cdot \phi P_{n.end}} = 0.838$ $DCR_{int} := \frac{P_{web.crip.int}}{\phi P_{n.interior}} = 0.558$

Demand/Capacity Ratio: **Note: Factor of 2 for two ends connected together at the end**

$Web_{crippling} = \text{"OK"}$

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Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Length

Roof Curb thickness

$t_{Curb} = \text{"14GA"}$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

Min width of Roof Curb

$b_{curb} := L_{curb} + W_{curb} \cdot 2 = 267.19 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := L_{curb} + \min\left(\frac{W_{curb}}{2} \cdot 2, \frac{L_{curb}}{2}\right) = 170 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{array}{c} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{array} \right] \right] = 12349 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.L.vert.up} \cdot L_{curb}) \cdot (0.75in) = 7774 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.63$

$Curb_{BotFlangeBending} = \text{"OK"}$

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Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Width

Roof Curb thickness

$t_{Curb} = \text{"14GA"}$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

Min width of Roof Curb

$b_{curb} := W_{curb} + \frac{L_{curb}}{4} \cdot 2 + 3in \cdot 2 = 139.59 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := W_{curb} + \min\left(\frac{L_{curb}}{6} \cdot 2, W_{curb}\right) = 115 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{matrix} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{matrix} \right] \right] = 6452 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.W.vert.up} \cdot W_{curb}) \cdot (0.75in) = 4450 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.69$

$Curb_{BotFlangeBending} = \text{"OK"}$

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Web Crippling/Compression of Iso CanFab Curb (AISI S100-16 G5)

Note: Curb stiffeners directly transfer the compressive load from isolator to the base. Therefore, curb web crippling is prevented.

Curb Web with Reinforcement

Max Compression: $Comp_{maxtot} := \max(|C_S|, |C_W|) = 23462.12 \cdot lbs$

Reinforcement per CFS: $CFS_{reinf} :=$ "Single Stiffener 10GA 1"x7"x1" Fy=50ksi 18" Tall on min. 16GA "

Note: min. of 10 GA channel and min. 16 GA curb web

Number of Reinforcement in Length: $n_{reinf} := N_{iso.long} = 8$

Max Compression per Reinf: $Comp_{per.reinf} := \frac{Comp_{maxtot}}{n_{reinf}} = 2.933\ kip$

Spacing: $Spacing := \frac{L_{curb}}{n_{reinf}} = 14 \cdot in$ $KL_r := \frac{1.0 \cdot (H_{curb} - 12.5in)}{0.2339in} = 94$

Factored Nominal Comp. Capacity per reinforcement: $\phi P_{n.reinf} = 21.066 \cdot kip$ **(See attached CFS)**

Total Factored nominal Comp Capacity: $\phi P_{n.tot} := n_{reinf} \cdot \phi P_{n.reinf} = 169 \cdot kip$

D/C Ratio of Compression: $DCR := \frac{Comp_{maxtot}}{\phi P_{n.tot}} = 0.14$

$Comp_{reinf} := if(Comp_{maxtot} < \phi P_{n.tot}, "OK", "NG")$ $Comp_{reinf} = "OK"$

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Check CanFab Curb for Compressive Force due to T/C Coupling of Overturning

Note:
-Since the equipment is only attached to the longer sides of the CanFab Curb, most likely there will be compressive force onto the curb due to T/C coupling.
- Rectangular CanFab Curb will be considered as "Channel" to resist the compressive force.

Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Flanges*

Flat Width:

$$w := \frac{W_{curb}}{2} - R_{curb} = 38.393 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Unstiffened"}$$

Stress at the end of the Width:

$$f_2 := 50ksi \qquad f_1 := 50ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \left| \frac{f_2}{f_1} \right| = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 0.43$$

Critical Compressive Stress (Eq 1.1-4):

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w}\right)^2 = 0.05 \cdot ksi$$

Stress in Compression Element:

$$f := F_y = 50 \cdot ksi \qquad \textbf{(Assume f = Fy)}$$

Slenderness Factor (Eq 1.1-3):

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 32.3$$

Local reduction factor (Eq 1.1-2):

$$\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 0.031$$

Effective Width of the Flanges:

$$b_{eff.flange} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 1.181 \cdot in$$

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Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Web*

Flat Width:

$$w := L_{curb} - R_{curb} \cdot 2 = 112.974 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Stiffened"}$$

Stress at the end of the Width:

$$f_2 := 50ksi \qquad f_1 := 50ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \left| \frac{f_2}{f_1} \right| = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 4$$

Critical Compressive Stress (Eq 1.1-4):

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w} \right)^2 = 0.05 \cdot ksi$$

Stress in Compression Element:

$$f := F_y = 50 \cdot ksi \qquad \textbf{(Assume f = Fy)}$$

Slenderness Factor (Eq 1.1-3):

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 31.16$$

Local reduction factor (Eq 1.1-2):

$$\rho := \left(1 - \frac{0.22}{\lambda}\right) \frac{1}{\lambda} = 0.032$$

Effective Width of the Web:

$$b_{eff.web} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 3.6 \cdot in$$

Effective Area of the Member:

$$A_e := 2 \cdot \left(b_{eff.flange} \cdot t_{curb} \right) + b_{eff.web} \cdot t_{curb} = 0.468 \cdot in^2$$

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Length of the Compressive Member: $L_{curb.web} := h = 21.629 \cdot in$

Young's Modulus for Cold Form Steel: $E := 29500ksi$

Curb Shear Modulus: $G := 11300ksi$

Poisson's Ratio $\mu := 0.3$

Section Properties of the Member (From Section Properties Calculator):

$A_{half.curb} := 13.599in^2$ $r_o := 50.187in$ $I_x := 26250.724in^4$ $I_y := 1949.977in^4$

$J := 0.023in^4$ $r_x := \sqrt{\frac{I_x}{A_{half.curb}}} = 43.936 \cdot in$ $r_y := \sqrt{\frac{I_y}{A_{half.curb}}} = 11.975 \cdot in$

$C_w := 4.431 \cdot 10^6 \cdot in^6$ $r_{min} := \min(r_x, r_y) = 11.975 \cdot in$

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^2}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{(1.0 \cdot L_{curb.web})^2}\right] = 2339737.294 \cdot ksi$$

$$\sigma_{e.y} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_y}\right)^2} = 89240.781 \cdot ksi \qquad \sigma_{e.x} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_x}\right)^2} = 1201365.512 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2} = 89240.781 \cdot ksi$$

$$\frac{1.0 \cdot L_{curb.web}}{r_{min}} = 1.81$$

$KL_r = \text{"KL/r < 200, OK"}$

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 85962.07 \cdot ksi$$

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Nominal Compressive Stress Capacity: (Eq E2-4)

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 0.024$$

$$F_n := \begin{cases} 0.658^{\lambda_c^2} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^2}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 49.99 \cdot \text{ksi}$$

Compressive Capacity:

$$P_{n.member} := A_e \cdot F_n = 23.39 \cdot \text{kip}$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot P_{n.member} = 19.88 \cdot \text{kip}$$

Factored Max Compressive Force:

$$P_{comp.max} := \max\left(\left|C_S\right|, \left|C_W\right|\right) = 23.462\ \text{kip}$$

D/C Ratio of Compression:

$$DCR := \frac{P_{comp.max}}{\phi P_{n.member}} = 1.18$$

$$Axial_{curb.comp} := \text{if}\left(P_{comp.max} < \phi P_{n.member}, \text{"OK"}, \text{"Provide Channel from above as Web Stiffener"}\right)$$

$Axial_{curb.comp}$ = "Provide Channel from above as Web Stiffener"

Note: No need to check for interaction since the curb is only subjected to the compressive force.

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Shear of CanFab Curb Webs without Holes (AISI S100-16 G2)

Note: Since the unit is stiffer than the curb and the curb is firmly attached to the unit and to the base structure, curbs will mainly take the lateral forces as shear and axial load rather than bending.

Thickness of Curb:

$$t := \text{thick}(t_{Curb}) = 0.079 \cdot \text{in}$$

Depth-to-Thickness Ratio:

$$\frac{h}{t} = 276$$

Curb Elastic Modulus:

$$E := 29500\text{ksi}$$

Clear distance b/w transverse stiffeners of reinforced web:

$$a := \max\left(\frac{L_{curb}}{2}, W_{curb}\right) = 77 \cdot \text{in} \qquad \frac{a}{h} = 3.56$$

$$k_v := \begin{cases} 5.34 & \text{if } a = L_{curb} \\ 4.00 + \dfrac{5.34}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \dfrac{4.00}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 5.66$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 58 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 87$$

Curb Shear Check due to Load on Longer Side

Area of Web Element:

$$A_w := W_{curb} \cdot t = 6 \cdot \text{in}^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 2 \cdot \text{ksi}$$

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$V_{cr} := A_w \cdot F_{cr} = 12\,kip$ $V_y := 0.6 \cdot A_w \cdot F_y = 181\,kip$ $\lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 3.886$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 12.006 \cdot kip$$

Number of Members within Length: $n := 2$ **(Per Curb Design)**

Design Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 22811.4 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.H} := P_{net} \cdot L_{unit} \cdot H_{total} = 12315.2 \cdot lbs$

Design Shear Demand: $V_u := \max(V_{base.S}, V_{base.W.H}) = 14857.1 \cdot lbs$

D/C Ratio of Shear: $DCR := \frac{V_u}{\phi V_n} = 0.651$

Demand/Capacity Ratio:

$Shear_{in.plane} := \text{if}(V_u < \phi V_n, \text{"OK"}, \text{"NG"})$

$Shear_{in.plane} = \text{"OK"}$

Curb Shear Check due to Load on Shorter Side

Area of Web Element: $A_w := L_{curb} \cdot t = 9 \cdot in^2$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot (1 - \mu^2) \cdot \left(\frac{h}{t}\right)^2} = 2 \cdot ksi$$

$V_{cr} := A_w \cdot F_{cr} = 18\,kip$ $V_y := 0.6 \cdot A_w \cdot F_y = 267\,kip$ $\lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 3.886$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 17.648 \cdot kip$$

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Number of Members within Length: $n := 2$ **(Per Curb Design)**

Factored Nominal Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 33532.1 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot W_{unit} \cdot H_{total} = 8476.6 \cdot lbs$

Factored Shear Demand: $V_u := \max(V_{base.S}, V_{base.W.L}) = 14857.1 \cdot lbs$

D/C Ratio of Shear: $DCR := \frac{V_u}{\phi V_n} = 0.443$

Demand/Capacity Ratio:

$Shear_{in.plane} := \text{if}(V_u < \phi V_n, \text{"OK"}, \text{"NG"})$

$Shear_{in.plane} = \text{"OK"}$

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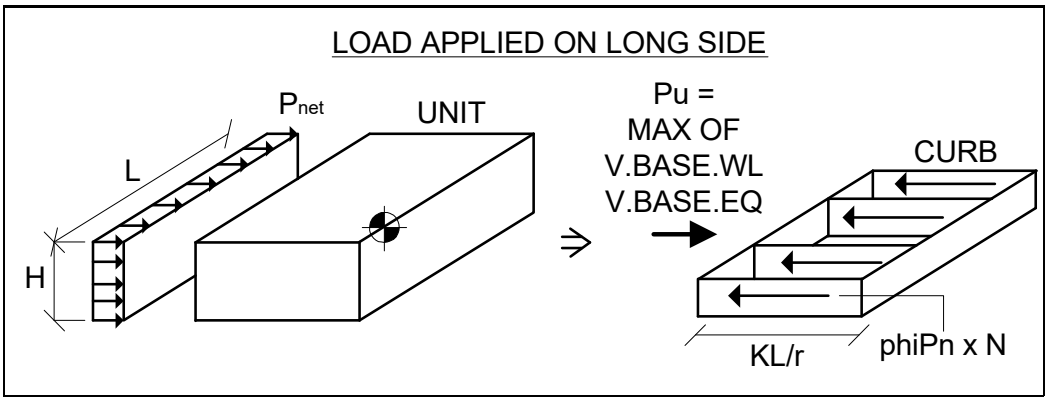
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Check CanFab Curb for In-Plane Axial due to EQ and Wind (AISI S100-16 E2)

Curb Axial Load Check due to Load on Long Side



Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot L_{unit} \cdot H_{total} = 12.3\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.L}) = 14857.09 \cdot lbs$

Member per CFS: $CFS_{member} :=$ "14GA Custom Curb 22" Tall L.b = 63in"

Max Braced Length of Member: $L_{member} := 48in$ **Conservative since the max anchor spacing is 24"**

Number of Curb in Length: $n_{curb.long} := 3$

Radius of gyration in y-axis: $r_{y.curb} := 0.630in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{2} = 7.43\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 76$ $KL_r =$ "KL/r < 200, OK"

Spacing: $Spacing := \frac{L_{curb}}{n_{curb.long}} = 38 \cdot in$

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 9.556 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.777$

$Axial_{short.curb} =$ "OK"

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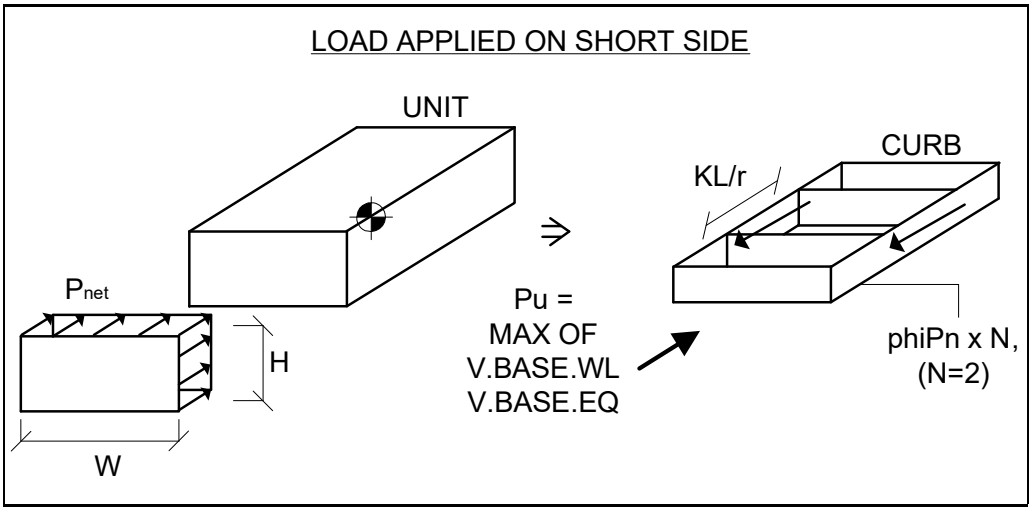
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Curb Axial Load Check due to Load on Short Side



Wind Base Shear on Short Side: $V_{base.W.H} := P_{net} \cdot W_{unit} \cdot H_{total} = 8.5\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.H}) = 14857.09 \cdot lbs$

Member per CFS: CFS_{member} = "14GA Custom Curb 22" Tall L.b = 63in"

Max Braced Length of Member: $L_{member} := \frac{L_{curb}}{n_{curb.long} - 1} = 57 \cdot in$

Number of Curb in Length: $n_{curb} := 2$

Radius of gyration in y-axis: $r_{y.curb} := 0.630\,in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{curb}} = 7.43\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 90$ KL_r = "KL/r < 200, OK"

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 9.556 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.777$

$Axial_{long.curb}$ = "OK"

A121

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Project: IBC 2018 Group C Job No. J13001 . 382

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CURB & ANCHORAGE DESIGN Engineer LK

DESIGN
for
MAX CURB HEIGHT OF 30"

950 S. GRAND AVENUE, 4TH FLOOR, LOS ANGELES, CALIFORNIA 90015 (213) 483-6490

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Design Wind Loads for Rooftop Equipment (ASCE 7-16 § Table 29.1-1)

$z := 60ft$ **Height above ground level**

$B := 60ft$ **Horizontal dimension of building measured normal to wind direction**

$Exp_{category} := "C"$ **Exposure Category per ASCE 7-16 § 26.7**

$Risk_{category} := "IV"$ **Risk Category per ASCE 7-16 Table 1.5-1**

$$V := \begin{cases} 0mph & \text{if } Risk_{category} = "I" \\ 0mph & \text{if } Risk_{category} = "II" \\ 175mph & \text{otherwise} \end{cases} = 175 \cdot mph$$

Basic Wind Speed per ASCE 7-16 Figure 26.5-1 A,B or C

$K_z = 1.14$ **Velocity Pressure Exposure Coefficient per ASCE 7-16 Table 29.10-1 [Exposure Category "C"]**

$K_{zt} := 1.0$ **Topographic Factor per ASCE 7-16 § 26.8, Figure 26.8-1**

$K_e := 1.0$ **Ground Elevation Factor per ASCE 7-16 § 26.9, Table 26.9-1**

$K_d := 0.85$ **Wind Directionality Factor per ASCE 7-16 § 26.6, Table 26.6-1 (Equipment)**

$q_z := 0.00256 K_z \cdot K_{zt} \cdot K_d \cdot K_e \cdot V^2 = 75.74 \cdot psf$ **Velocity pressure evaluated at height z above ground per ASCE 7-10 § 26.10.2; Eq. 26.10-1**

$GC_{r.lateral.max} := 1.9$ **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.9 for rooftop structures and equipment with Af less than (0.1Bh). (GCr) shall be permitted to be reduced linearly from 1.9 to 1.0 as the value of Af is increased from (0.1Bh) to (Bh)

$GC_{r.vertical.max} := 1.5$ **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.5 for rooftop structures and equipment with A_r less than (0.1*BL*). (GC_r) shall be permitted to be reduced linearly from 1.5 to 1.0 as the value of A_r is increased from (0.1*BL*) to (*BL*)

$P_{net} := q_z \cdot GC_{r.lateral.max} = 143.91 \cdot psf$ **Design Lateral Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-2**

$P_v := q_z \cdot GC_{r.vertical.max} = 113.61 \cdot psf$ **Design Vertical Uplift Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-3**

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Seismic Demands on Nonstructural Components (ASCE 7-16 § 13.3 & 13.6):

$S_{DS} := 1.5$ **Design spectral response acceleration parameter at short periods per USGS map**

$I_p := 1.5$ **Component importance factor ASCE 7-16 § 13.1.3**

$\Omega_0 := 2.0$ **Overstrength factor ASCE 7-16 Table 13.6.1**

Vibr_Isolation = "Yes" **Placement of Unit Vibration Isolated:**

Note: Only "F_p" at seismic concrete anchor has been increased with overstrength factor "Ω_0"

$a_p := 2.5$ $R_p = 2.0$ **Seismic coefficients a_p & R_p**
Per ASCE 7-16 Table 13.6-1 for
Mechanical & Electrical Components

$z = 60\,ft$ **Height in structure of point of attachment of component with respect to the base**

$h := 60ft$ **Average roof height of structure with respect to the base**
Where for roof top equipment:

$z \div h = 1$

F_p: Horizontal Seismic Design Force per *ASCE7-16 § 13.3.1*

F_p shall be takes as $\left(\frac{0.4 \cdot a_p \cdot S_{DS} \cdot I_p}{R_p}\right) \cdot \left(1 + 2 \cdot \frac{z}{h}\right) \cdot W_p = 337.5 \cdot \% \cdot W_p$

F_p is not required to be taken as greater than $\left(1.6 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 360 \cdot \% \cdot W_p$

F_p shall not be taken as less than $\left(0.3 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 67.5 \cdot \% \cdot W_p$

Governing F_p : Horizontal Seismic Design Force $F_p = 337.5 \cdot \% \cdot W_p$

F_v: Vertical Load per ASCE7-16 § 13.3.1.2

Concurrent Vertical Seismic Force: $F_v := 0.2 \cdot S_{DS} \cdot W_p = 30 \cdot \% \cdot W_p$

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Flat Roof Snow Loads (ASCE 7-16 § 7.3):

$Terrain_{CAT} := "C"$ **Terrain Category ASCE 7-16 § 26.7 & Table 7.3-1**

$Exp_{Roof} := "Partially\ Exposed"$ **Exposure of Roof ASCE 7-16 Table 7.3-1**

$C_e = 1$ **Exposure Factor ASCE 7-16 Table 7.3-1**

$Thermal_{condition} := "All\ structures\ except\ below"$ **Thermal Condition ASCE 7-16 Table 7.3-2**

$C_t = 1$ **Thermal Factor ASCE 7-16 Table 7.3-2**

$Risk_{category} = "IV"$ **Risk Category per ASCE 7-16 Table 1.5-1**

$I_s = 1.2$ **Snow Importance Factor ASCE 7-16 Table 1.5-2**

$p_g := 40psf$ **Ground Snow Loads ASCE 7-16 Figure 7.2-1**

$$p_f := \max\left(0.7 \cdot C_e \cdot C_t \cdot I_s \cdot p_g, \text{if}\left(p_g > 20psf, 20psf \cdot I_s, I_s \cdot p_g\right)\right) = 34 \cdot psf$$

Flat Roof Snow Loads ASCE 7-16 Equation 7.3-1 and § 7.3.4

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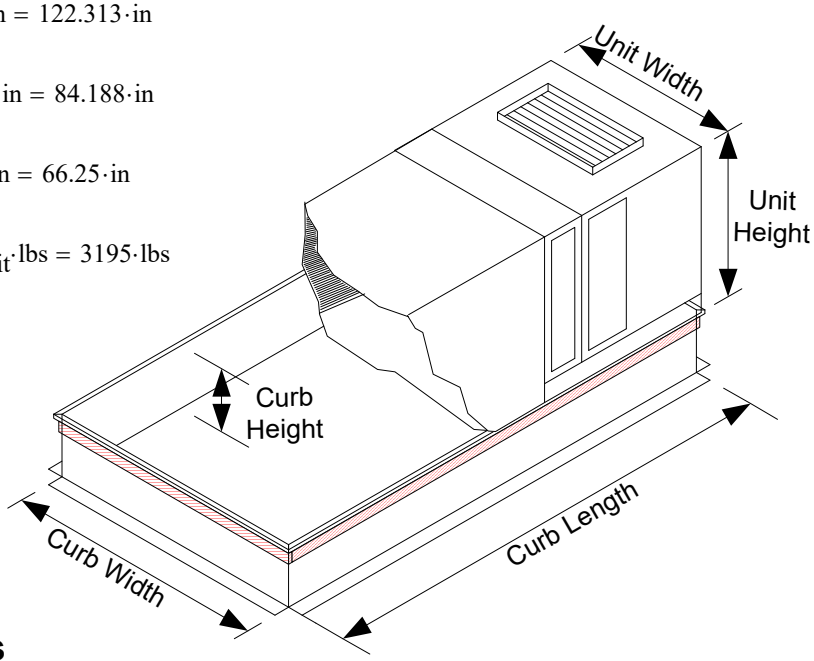
Mechanical Unit Dimensions Curb = "C-6010"

Length of Unit $L_{unit} := L_{unit} \cdot in = 122.313 \cdot in$

Width of Unit $W_{unit} := W_{unit} \cdot in = 84.188 \cdot in$

Height of Unit $H_{unit} := H_{unit} \cdot in = 66.25 \cdot in$

Weight of Unit $Wt_{unit} := Wt_{unit} \cdot lbs = 3195 \cdot lbs$



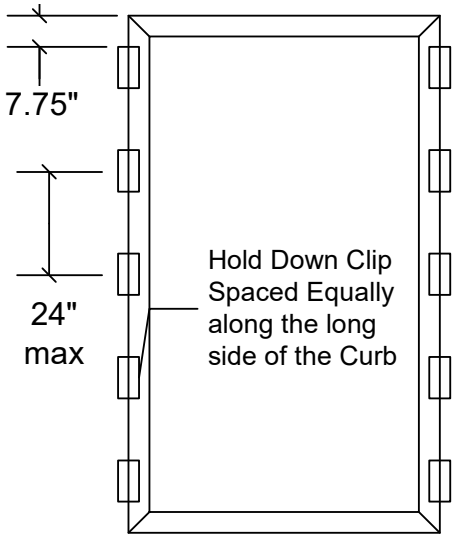
Roof Curb Dimensions

Length of Curb $L_{curb} := L_{curb} \cdot in = 113.188 \cdot in$

Width of Curb $W_{curb} := W_{curb} \cdot in = 77 \cdot in$

Height of Curb $H_{curb} := H_{curb} \cdot in = 42.5 \cdot in$

Weight of Curb $Wt_{curb} := Wt_{curb} \cdot lbs = 1239 \cdot lbs$



Curb Plan

Overall System Dimensions

Total Weight

$Wt_{tot} := Wt_{unit} + Wt_{curb} = 4402 \cdot lbs$

Total height

$H_{total} := H_{unit} + H_{curb} = 108.75 \cdot in$

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Seismic Loading + Snow Loading

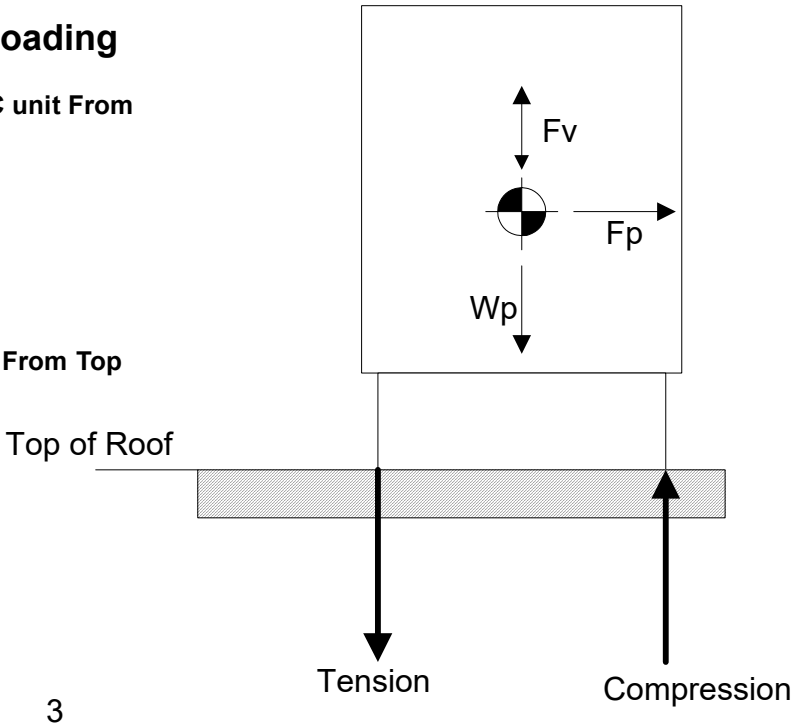
Height for Center of Gravity for HVAC unit From Top of Roof

$h_{CG.unit} := \frac{1}{2} H_{unit} = 33 \cdot in$

$h_{CG} := H_{curb} + h_{CG.unit} = 75.63 \cdot in$

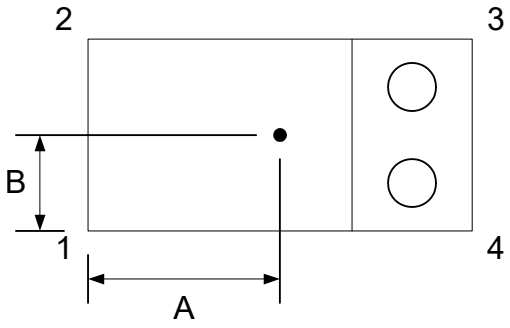
Height for Center of Gravity for Curb From Top of Roof

$h_{CG.curb} := \frac{H_{curb}}{2} = 21.25 \cdot in$



Max Seismic Base Shear

$V_{base.S} := F_p \cdot Wt_{tot} = 14857 \cdot lbs$



Unit C.G. distance in axis parallel to Curb Width $B_{ecc.width} := CG_{short} \cdot in = 36 \cdot in$

Eccentricity in axis parallel to Curb Width

$$e_{width} := \begin{cases} 0in & \text{if } B_{ecc.width} = \text{"N/A"} \\ \left| B_{ecc.width} - \frac{W_{unit}}{2} \right| & \text{otherwise} \end{cases} = 6.09 \cdot in$$

Unit C.G. distance in axis parallel to Curb Length $A_{ecc.length} := CG_{long} \cdot in = 58 \cdot in$

Eccentricity in axis parallel to Curb Length

$$e_{length} := \begin{cases} 0in & \text{if } A_{ecc.length} = \text{"N/A"} \\ \left| A_{ecc.length} - \frac{L_{unit}}{2} \right| & \text{otherwise} \end{cases} = 3.16 \cdot in$$

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Max Net Tension Reaction On Each Side Due To Seismic Loads

$$T_S := \begin{bmatrix} \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{W_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{W_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} \right] \\ \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{L_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{L_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} \right] \end{bmatrix} = \begin{pmatrix} -10546 \\ -6702 \end{pmatrix}\cdot lbs$$

Max Net Compression Reaction On Each Side Due To Seismic Loads

$$C_S := \begin{bmatrix} \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{W_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \\ \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{L_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \end{bmatrix} = \begin{pmatrix} 20195 \\ 15284 \end{pmatrix}\cdot lbs$$

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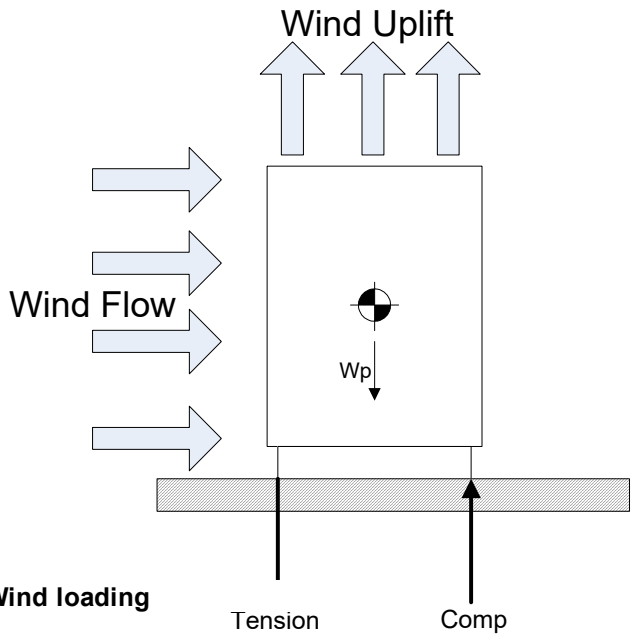
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Wind Loading + Snow Loading



Max Base Shear due to wind loading

$V_{base.W} := P_{net} \cdot L_{unit} \cdot H_{total} = 13293 \cdot lbs$

Max Uplift due to wind loading

$L_{unit.up} := L_{unit} - 0in = 122.313 \cdot in$

$P_{uplift.W} := P_v \cdot L_{unit.up} \cdot W_{unit} = 8124 \cdot lbs$

Max Net Tension Reaction On Each Side Due To Wind loading

$$T_W := \begin{pmatrix} \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} - \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \\ \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} - \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} -11696 \\ -6557 \end{pmatrix} \cdot lbs$$

Max Net Compression Reaction On Each Side Due To Wind loading

$$C_W := \begin{pmatrix} \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} + \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \\ \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} + \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} 14254 \\ 9066 \end{pmatrix} \cdot lbs$$

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Governing Loading @ Curb

Max uplift vertical load along the length of the curb

$$\omega_{x.L.vert.up} := \frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}} = 1240 \cdot plf$$

Max compressive vertical load along the length of the curb

$$\omega_{x.L.vert.comp} := \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}} = 2141 \cdot plf$$

Max vertical load along the length of the curb

$$\omega_{x.L.vert} := \max\left(\omega_{x.L.vert.up}, \omega_{x.L.vert.comp}\right) = 2141 \cdot plf$$

Max uplift vertical load along the width of the curb

$$\omega_{x.W.vert.up} := \frac{\max\left[\left|T_{S_{(1)}}\right|, \left|T_{W_{(1)}}\right|\right]}{W_{curb}} = 1045 \cdot plf$$

Max compressive vertical load along the width of the curb

$$\omega_{x.W.vert.comp} := \frac{\max\left[\left|C_{S_{(1)}}\right|, \left|C_{W_{(1)}}\right|\right]}{W_{curb}} = 2382 \cdot plf$$

Max vertical loading along the width of the curb

$$\omega_{x.W.vert} := \max\left(\omega_{x.W.vert.up}, \omega_{x.W.vert.comp}\right) = 2382 \cdot plf$$

$$\begin{pmatrix} V_{base.S} \\ V_{base.W} \end{pmatrix} = \begin{pmatrix} 14857 \\ 13293 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} \left|T_S\right| \\ \left|C_S\right| \end{pmatrix} = \begin{pmatrix} 12496 \\ 25326 \end{pmatrix} \cdot lbs$$

$$\begin{pmatrix} F_v \cdot Wt_{tot} \\ P_v \cdot L_{unit} \cdot W_{unit} \end{pmatrix} = \begin{pmatrix} 1321 \\ 8124 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} \left|T_W\right| \\ \left|C_W\right| \end{pmatrix} = \begin{pmatrix} 13408 \\ 16893 \end{pmatrix} \cdot lbs$$

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Anchorage To Concrete [Expansion Anchor per ACI 318-14]

Number of connection on the long side

$N_B := 7 + 2$

Moment Arm for overturning (Short side)

$B := W_{curb} + 3in \cdot 2 = 83 \cdot in$

Number of Connection on the Short side.

$N_L := 4 + 2$

Moment Arm for over turning (Long side)

$L := L_{curb} + 3in \cdot 2 = 119 \cdot in$

Total Number of Connections

$N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 22$

Max Net Tension Reaction Due to Seismic Load, Fp

$$R_{c.EQ.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 16 \cdot lbs \qquad R_{c.EQ.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 8 \cdot lbs$$

$$R_{c.EQ} := MAX+\left[\left[\left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{c.EQ.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t}\right]\right] = \begin{pmatrix} 2311 \\ 2411 \end{pmatrix} \cdot lbs$$

$$\left[\left[\left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{c.EQ.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t}\right]\right]$$

Max net Tension Reaction Due to Wind Load, Pnet

$$R_{c.W} := MAX+\left[\left[\begin{array}{l} \frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t} \end{array}\right]\right] = \begin{pmatrix} 1180 \\ 898 \end{pmatrix} \cdot lbs$$

Governing Load Case:

$Govern := if\left(\left|R_{c.EQ}\right| > \left|R_{c.W}\right|, "Seismic", "Wind"\right) = "Seismic"$

Governing Tension Reaction at Each anchor Point:

$R_c := if\left(Govern = "Seismic", R_{c.EQ}, R_{c.W}\right) = \begin{pmatrix} 2311 \\ 2411 \end{pmatrix} \cdot lbs$

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Max Tension on anchor: $N_{ua} := \max(R_c) = 2411 \cdot lbs$

Max Shear on anchor: $V_{ua} := \frac{\max(\Omega_0 \cdot V_{base.S}, V_{base.W})}{N_t} = 1351 \cdot lbs$

Hilti Kwik Bolt TZ – Carbon Steel
5/8" Anchor with min 4" embedment
Base material: 6" thick Cracked concrete w/
Compressive strength fc' = 3000 psi
Min 6" away from the concrete edge
Evaluation Report: ICC-ESR 1917

Loading Condition:	**Seismic**

Design Tension Capacity [ϕN_n]:	3,631	[lbs]
Design Shear Capacity [ϕV_n]:	4,940	[lbs]

$\phi N_n := \phi N_n \cdot lbs = 3631 \cdot lbs$

$\phi V_n := \phi V_n \cdot lbs = 4940 \cdot lbs$

Utilization:

Tension Utilization:

$\beta_N := \frac{N_{ua}}{\phi N_n} = 66 \cdot \%$

Shear Utilization:

$\beta_V := \frac{V_{ua}}{\phi V_n} = 27 \cdot \%$

Interaction of Tensile and Shear Forces:
Per ACI 318-14 Sec. 17.6

$\beta_{NV} := \frac{(\beta_N) + (\beta_V)}{1.2} = 78 \cdot \%$

$$check\_interaction := \begin{pmatrix} if(\beta_N < 1.0, "OK", "NG") \\ if(\beta_V < 1.0, "OK", "NG") \\ if(\beta_{NV} < 1.0, "OK", "NG") \end{pmatrix} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

$$check\_interaction = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

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Anchorage To Structural Steel [Fillet Weld Conn. per AISI S100-16]

Fillet Weld 2" Long Along the Long and Short Side. Min 2 Connections per Side
Spacing: 48" O.C. for Non-Isolated Curbs; 24" for Isolated Curbs

Number of Welds on the Long Side $N_B := 6$

Moment Arm for Overturning (Short Side) $B := W_{curb} = 77 \cdot in$

Number of Welds on the Short Side. $N_L := 4$

Moment Arm for Overturning (Long Side) $L := L_{curb} = 113 \cdot in$

Total Number of Connections $N_t := \left[\left(N_B\right) + \left(N_L\right)\right] \cdot 2sides = 20$

Max Net Tension Reaction due to Seismic Load FP

$$R_{weld.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 25 \cdot lbs$$

$$R_{weld.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 13 \cdot lbs$$

$$R_{weld.EQ} := MAX+\left[\begin{bmatrix}\left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{weld.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{weld.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}1846 \\ 1874\end{pmatrix} \cdot lbs$$

Max Net Tension Reaction due to Wind Load Pnet

$$R_{weld.W} := MAX+\left[\begin{bmatrix}\frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}1811 \\ 1327\end{pmatrix} \cdot lbs$$

Tension Design Force; SRSS for Loading from Each Direction $T_{u.weld} := \max\left(\left|R_{weld.EQ}\right|, \left|R_{weld.W}\right|\right) = 2630 \cdot lbs$

Shear Load at Each Weld Connection $V_{u.weld} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{N_t} = 743 \cdot lbs$

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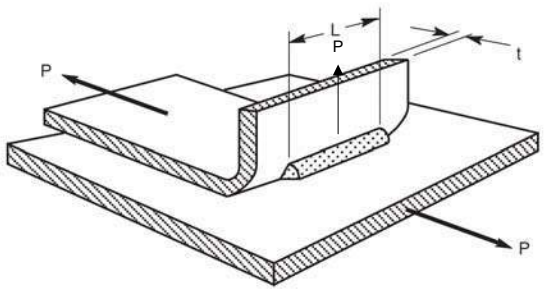
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Total Demand: SRSS of V and T

$$R_{u.weld} := \sqrt{T_{u.weld}^2 + V_{u.weld}^2} = 2733 \cdot lbs$$

Fillet Weld Design per AISI S100-16 Section J2.5

Weld Length at Each Connection Point $L_w := 2in$



Effective Throat Fillet Weld Size

$$t_w := \left(\frac{1}{8}in\right) \cdot 0.707 = 0.088 \cdot in$$

Thickness for the Thinnest Martial Being Welded
Min Curb Thickness = 16GA with Fu=65 ksi

$t_1 := thick("12GA") = 0.1084 \cdot in$

$F_u := 65ksi$

Min weld material strength

$F_{exx} := 70ksi$

For Longitudinal Loading [Parallel capacity is considered to be loading in the direction of the length of the weld] per (Eq. J2.5-1) &(Eq. J2.5-2)

$$\phi P_{long} := \begin{cases} (0.6)\left(1 - \frac{0.01 \cdot L_w}{t_1}\right) \cdot L_w \cdot t_1 \cdot F_u & \text{if } \frac{L_w}{t_1} < 25 \\ (0.5) \cdot 0.75 \cdot t_1 \cdot L_w \cdot F_u & \text{otherwise} \end{cases} = 6895 \cdot lbs$$

where $L_w \div t_1 = 18$

For Transverse Loading per (Eq. J2.5-5)

$$\phi P_{trans} := (0.65) \cdot t_1 \cdot L_w \cdot F_u = 9160 \cdot lbs$$

Strength of Weld Material per (Eq. J2.5-7)

$$\phi P_{weld} := (0.6) \cdot 0.75 \cdot t_w \cdot L_w \cdot F_{exx} = 5568 \cdot lbs$$

Design Strength of Fillet Weld

$$\phi P_n := \min\left(\phi P_{long}, \phi P_{trans}, \phi P_{weld}\right) = 5568 \cdot lbs$$

D/C Ratio for the Welded Connection

$$\beta_{NW} := \frac{R_{u.weld}}{\phi P_n} = 49 \cdot \%$$

$weld_{check} := if\left(\beta_{NW} < 1.0, "OK", "NG"\right)$

$weld_{check} = "OK"$

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Anchorage To Wood Member WITH Lag Screws [NDS-2018 LRFD Strength Design]

*** Use 3/8" Lag Screws along Each Side of the Curb**
*** Assume G=0.5 Douglas Fir-Larch**

Wood Lag Screw Capacity per NDS 2018 Section 11.3

Wet Service Factor: $Cond := "DRY"$ **(e.g. CA = "DRY", AK = "WET")**

$$C_M := \begin{cases} 1.0 & \text{if } Cond = "DRY" \\ 0.7 & \text{if } Cond = "WET" \end{cases} = 1$$ **NDS 2018 Table 11.3.3**

Temperature Factor:
$$C_t := \begin{cases} 0.8 & \text{if } Cond = "DRY" \\ 0.7 & \text{if } Cond = "WET" \end{cases} = 0.8$$ **NDS 2018 Table 11.3.4**

Group Action Factor: $C_g := 0.97$ **NDS 2018 Table 11.3.6C**

Geometry Factor: $C_\Delta := 1.0$ **NDS 2018 Table 12.5.1A,B**

End Grain Factor: $C_{eg} := 1.0$ **NDS 2018 Sec. 12.5.2**

Diaphragm Factor: $C_{di} := 1.0$ **NDS 2018 Sec. 12.5.3**

Toe-Nail Factor: $C_{tn} := 1.0$ **NDS 2018 Sec. 12.5.4**

Format Conversion Factor: $K_F := 3.32$ **NDS 2018 Table 11.3.1**

Resistance Factor: $\phi := 0.65$ **NDS 2018 Table 11.3.1**

Time Effect Factor: $\lambda := 1.0$ **NDS 2018 App N.3.3**

Lateral Design Value: $Z := 130lbs$ **NDS 2018 Table 12K**

Withdrawal Design Value: $W := 305lbs$ **NDS 2018 Table 12.2A**

Lag Screw Diameter: $D_{lag} := \frac{3}{8}in$

Lag Screw Length: $L_{lag} := 4in$

Length of Tapered Tip: $E_{lag} := \frac{7}{32}in$

Lag Screw Penetration: $P_{lag} := 3.78125in$

Eff. Lag Screw Penetration for withdrawal: $P_{\omega.lag} := 2in + \frac{9}{32}in = 2.28 \cdot in$ **NDS 2018 Appx. Table L2**

NDS 2018 Sec. 12.1.4.6

Minimum Penetration DCR <1.0: $DCR_{min.penetration} := \frac{4 \cdot D_{lag}}{P_{\omega.lag}} = 0.66$ $DCR_{min.penetration} = "OK"$

Adj. Lateral Design Value: $Z' := Z \cdot C_M \cdot C_t \cdot C_g \cdot C_\Delta \cdot C_{eg} \cdot C_{di} \cdot C_{tn} \cdot K_F \cdot \phi \cdot \lambda = 218 \cdot lbs$

Adj. Withdrawal Design Value: $W' := W \cdot C_M^{\,2} \cdot C_t \cdot C_{eg} \cdot C_{tn} \cdot K_F \cdot \phi \cdot \lambda = 527 \cdot lbs$ **NDS 2018 Table 11.3.1**

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Number of Lag Screws on the Long Side $N_B := 26 + 2$

Moment Arm for Overturning (Short Side) $B := W_{curb} = 77 \cdot in$

Number of Lag Screws on the Short Side $N_L := 18 + 2$

Moment Arm for Overturning (Long Side) $L := L_{curb} = 113 \cdot in$

Total Number of Lag Screws $N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 88$

Max net Tension Reaction due to Seismic, Fp

$$R_{lag.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 5 \cdot lbs$$

$$R_{lag.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 3 \cdot lbs$$

$$R_{lag.EQ} := MAX+\left[\begin{bmatrix} \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{lag.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{lag.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 394 \\ 371 \end{pmatrix} \cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$R_{lag.W} := MAX+\left[\begin{bmatrix} \frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{L \cdot N_L \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 391 \\ 271 \end{pmatrix} \cdot lbs$$

Tension Design force; SRSS for loading from Each direction $T_{lag} := \max\left(\left|R_{lag.EQ}\right|, \left|R_{lag.W}\right|\right) = 541 \cdot lbs$

Shear load at each anchor location $V_{lag} := \frac{\max\left(V_{base.S} \cdot \sqrt{2}, V_{base.W}\right)}{N_t} = 239 \cdot lbs$

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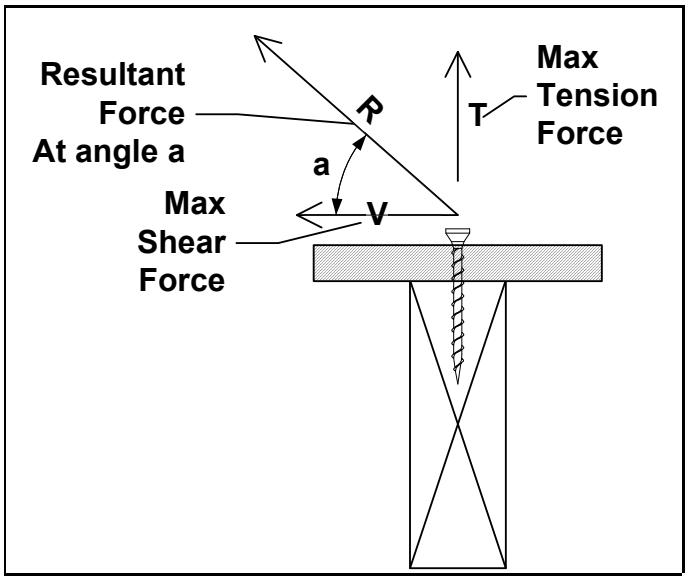
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For Lag Screws Subjected to Combined Lateral and Withdrawal Loading; Design Strength of the Lag Screw Shall Be Adjusted per Hankinson Formula as Prescribed by NDS 2018 Equation 12.4-1



Angle Between Wood Surface and Direction of Resultant Applied Load

$$(\alpha) := \operatorname{atan}\left(\frac{T_{lag}}{V_{lag}}\right) = 66\cdot\text{deg}$$

Combined Demand per Lag Screw @ Strength Level

$$R_{lag} := \sqrt{T_{lag}^{2} + V_{lag}^{2}} = 591\cdot\text{lbs}$$

Adjusted Capacity per NDS 2018 Equation 12.4-1 @ Strength Level

$$Z'_{\alpha} := \frac{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot Z'}{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot\cos(\alpha)^{2} + Z'\cdot\sin(\alpha)^{2}} = 692\cdot\text{lbs}$$

D/C Ratio for the Lag Screw connection to Wood Structure

$$\beta_{Lag} := \frac{R_{lag}}{Z'_{\alpha}} = 85\cdot\%$$

$$\text{Lag}_{Screw.Check} := \text{if}\left(\beta_{Lag} < 1.0, \text{"OK"}, \text{"NG"}\right)$$

$\text{Lag}_{Screw.Check} = \text{"OK"}$

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Bearing and Tilting in Curb Bolted Connection AISI S100-16

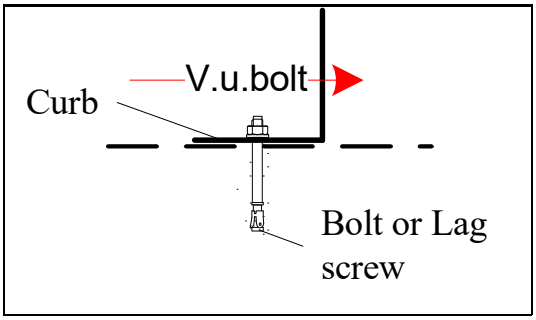
Nominal bolt diameter $d := 0.5in$

Uncoated sheet thickness $t_{curb} := thick("12GA") = 0.108 \cdot in$

Tensile strength of sheet $F_u := 65ksi$

Coefficient for conversion of units $\alpha := 1.0$

Modification Factor $m_f := 1.0$



Modification factor for type of bearing connection, per Table J3.3.1-2; For single shear connection with washers

Bearing Factor

$$C := \begin{cases} 3 \text{ if } \left(\frac{d}{t_{curb}} < 10\right) \wedge \left(0.024in < t_{curb} < 0.1875in\right) = 3 \\ "NG" \text{ if } \frac{d}{t_{curb}} > 10 \end{cases}$$

Bearing factor, which shall be determined according to Table J3.3.1-1 For d/t<10 where $d \div t_{curb} = 5$

Bearing Design Strength per AISI S100-16 Eq. J3.3.1-1

$$\phi P_{n_{(0)}} := (0.6) \cdot \left(m_f \cdot C \cdot d \cdot t_{curb} \cdot F_u\right) = 6341 \cdot lbs$$

Bolt Hole Deformation Design Strength per AISI S100-16 Eq. J3.3.2-1

$$\phi P_{n_{(1)}} := (0.65) \cdot \left[4.64 \cdot \left(\frac{\alpha}{in}\right) \cdot t_{curb} + 1.53\right] \cdot d \cdot t_{curb} \cdot F_u = 4655 \cdot lbs$$

Curb Connection Shear Capacity $\phi P_n := \min\left(\phi P_n\right) = 4655 \cdot lbs$

Loading demand at connection

$$V_{u.bolt} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{6} = 2476 \cdot lbs$$

$Curb\_Conn\_Shear := if\left(V_{u.bolt} < \phi P_n, "OK", "NG"\right)$

Curb_Conn_Shear = "OK"

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Thickness of Curb, ISO Rail and Clip

(Per AISC Table 17-10 Galvanized)

Hold Down Clip thickness

$t_{Clip} := "12GA"$ $t_{clip} := thick(t_{Clip}) = 0.1084 \cdot in$

Roof Curb thickness

$t_{Curb} := "12GA"$ $t_{curb} := thick(t_{Curb}) = 0.1084 \cdot in$

ISO RAIL thickness

$t_{Curb.iso} := "10GA"$ $t_{curb.iso} := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Note: Iso Rail thickness is only used if the curb is isolated. Not used for non-isolated curbs

Sheet Metal Screws (SMS) Equations and References

SMS properties (ESR-2196 Table 5)

$SMS_{Table} =$

"SMS"	"Diameter"	"HeadDiameter"	"Tension"	"Shear"
"Size"	"d"	"dw"	"Pts"	"Pss"
"#8"	0.164	0.335	1000	1170
"#10"	0.19	0.399	1370	1215
"#12"	0.216	0.415	2325	1880
"#14"	0.25	0.5	4580	2440

SMS Tension Eqns

$P_{not} = 0.85 \cdot t \cdot d \cdot F_u$ **(AISI S100-16 J4.4.1 & J4.4.2)**

$P_{nov} = 1.5 \cdot t \cdot d_w \cdot F_u$ **FOR THE MOST CASES, PULL-OUT CAPACITY IS THE LOWEST**

$P_{nts} = 0.8 \cdot P_{ts}$

SMS Shearn Eqns

$P_{vnot} = 4.2 \cdot \sqrt{(d \cdot t^3)} \cdot F_u$ **(AISI S100-16 J4.3.1)**

$P_{vnov} = 2.7 \cdot t \cdot d \cdot F_u$

$P_{vnss} = 0.8 \cdot P_{ss}$

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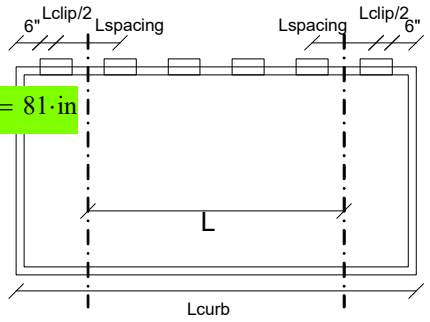
Hold Down Clip Design (Connection of the Mechanical unit to Curb)

Number of Clips on the long side $N_B := 6$

Moment Arm for overturning (Short side) $B := W_{curb} + 1.75in \cdot 2 = 81 \cdot in$

Number of Clips on the Short side. $N_L := 6$

Width of Clips $L_{clip} := 9in$



Curb Centerline Spacing (Long side)

$$L_{spacing} := \frac{L_{curb} - \left(6in + \frac{L_{clip}}{2}\right) \cdot 2}{N_B - 1} = 18.438 \cdot in$$

Moment Arm for overturning (Long side)

$$L := L_{curb} - 2 \cdot \left[6in + \frac{L_{clip}}{2} + L_{spacing} \cdot \frac{(N_L - 2)}{4}\right] = 55.313 \cdot in$$

Total Number of Clips

$$N_t := (N_B) \cdot 2sides = 12$$

Max net Tension Reaction due to Seismic, Fp

$$R_{clip.EQ} := MAX+\left[\begin{array}{l} \left[\frac{F_p \cdot Wt_{unit}}{B \cdot N_B} \cdot h_{CG.unit} + \frac{(0.9 - F_v) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B}\right] - \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} \\ \left[\frac{F_p \cdot Wt_{unit}}{L \cdot N_L} \cdot h_{CG.unit} + \frac{(0.9 - F_v) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L}\right] - \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} \end{array}\right] = \begin{pmatrix} 604 \\ 935 \end{pmatrix} \cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$R_{clip.W} := MAX+\left(\begin{array}{l} \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{unit}^2}{2}}{B \cdot N_B} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{unit}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{unit}^2}{2}}{L \cdot N_L} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{unit}}{N_t} \end{array}\right) = \begin{pmatrix} 1029 \\ 1021 \end{pmatrix} \cdot lbs$$

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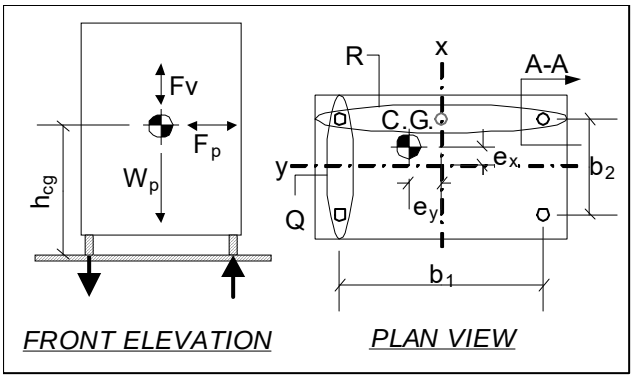
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Tensile and Shear Load calculation per ASHRAE RP-812



Eccentricity along X-X

$e_x := e_{width} = 6.094 \cdot in$

Eccentricity along Y-Y

$e_y := e_{length} = 3.157 \cdot in$

Distance between Seismic Restraints Along Y-Y

$b_1 := L_{curb} - 2 \cdot 6in = 101 \cdot in$

Distance between Seismic Restraints Along X-X

$b_2 := W_{curb} = 77 \cdot in$

Moment of Inertia about X-X

$$I_{xx} := \frac{N_t \cdot (N_t + 2) \cdot (b_1)^2}{12 \cdot (N_t - 2)} = 14335 \cdot in^2$$

Moment of Inertia about Y-Y

$$I_{yy} := \frac{N_t \cdot (b_2)^2}{4} = 17787 \cdot in^2$$

Angle about Tensile Load

$$\Theta_t := \operatorname{atan}\left[\frac{I_{yy} \cdot (b_1)}{I_{xx} \cdot (b_2)}\right] = 58 \cdot deg$$

Angle about Shear Load

$$\Theta_s := \begin{cases} \operatorname{atan}\left(\frac{e_x}{e_y}\right) & \text{if } e_y \neq 0 \\ 0deg & \text{if } e_y = 0 \end{cases} = 63 \cdot deg$$

Max Net Tensile Load Due to Seismic Load, Fp

$$T_{U.EQ.pt1} := \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} - \frac{(0.9 - F_v) \cdot Wt_{unit}}{b_1 \cdot b_2} \cdot \left(\frac{b_1}{2} \cdot e_x + \frac{b_2}{2} \cdot e_y - e_x \cdot e_y\right) = 59 \cdot lbs$$

$$T_{U.EQ.pt2} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \cos(\Theta_t) \cdot \frac{0.5 \cdot b_2}{I_{yy}} = -404 \cdot lbs$$

$$T_{U.EQ.pt3} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \sin(\Theta_t) \cdot \frac{0.5 \cdot b_1}{I_{xx}} = -1075 \cdot lbs$$

$T_{U.EQ} := T_{U.EQ.pt1} + T_{U.EQ.pt2} + T_{U.EQ.pt3} = -1420 \cdot lbs$

Max Net Shear Load Due to Seismic Load, Fp

$$V_{Ux.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\cos(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_2 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_1 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 524 \cdot lbs$$

$$V_{Uy.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\sin(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_1 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_2 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 893 \cdot lbs$$

$$V_{U.EQ} := \sqrt{V_{Ux.EQ}^2 + V_{Uy.EQ}^2} = 1035 \cdot lbs$$

Tension Design force for Hold Down Clips

$T_{clip} := \max(R_{clip.W_0}, R_{clip.W_1}, |R_{clip.EQ}|, |T_{U.EQ}|) = 1420 \cdot lbs$

$|R_{clip.EQ}| = 1113 \cdot lbs$ $|T_{U.EQ}| = 1420 \cdot lbs$

$T_{clip.EQ.max} := \max(|R_{clip.EQ}|, |T_{U.EQ}|) = 1420 \cdot lbs$

$T_{clip.W.max} := \max(R_{clip.W_0}, R_{clip.W_1}) = 1029 \cdot lbs$

Based on ASCE 7-16 Figure 29.4-1 magnitude of force coefficient,

Wind in diagonal direction to the face of equipment produces less force than that of the wind in perpendicular direction to the face of the equipment. Therefore, wind in diagonal direction does not need to be used

Shear Design force for Hold Down Clips

$$V_{clip} := \max\left(\frac{\max(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit})}{N_t}, |V_{U.EQ}|\right) = 1035 \cdot lbs$$

$F_p \cdot Wt_{unit} \cdot \frac{1}{N_t} = 899 \cdot lbs$ $|V_{U.EQ}| = 1035 \cdot lbs$

$P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t} = 675 \cdot lbs$

$V_{clip.EQ.max} := \max\left[\left(F_p \cdot Wt_{unit} \cdot \frac{1}{N_t}\right), |V_{U.EQ}|\right] = 1035 \cdot lbs$

$V_{clip.W.max} := \max\left(\left(P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t}\right)\right) = 675 \cdot lbs$

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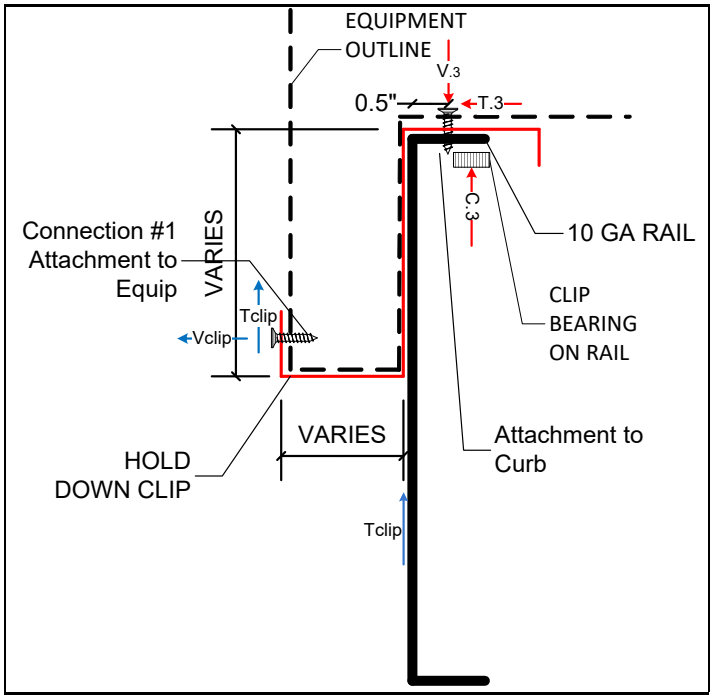
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Loading at Hold Down Clips @ Isolator Curb

$b_{return.iso} := Clip_b \cdot in = 2.125 \cdot in$

$b_{depth.iso} := Clip_c \cdot in = 6 \cdot in$



*For Reference Only

Mu Bending moment in the hold down

$M_u := T_{clip} \cdot b_{return.iso} = 3018 \cdot in \cdot lbs$

Resolve bending moment a T/C couple
Assume 0.5" bearing length
Moment Arm for T/C couple

$d_{T/C} := 1in - 0.5in = 0.5 \cdot in$

V3 is acting as shear on the screws. due to eccentricity of Tension force T

$$V_3 := \frac{T_{clip} \cdot \left[b_{return.iso} + (0) \right]}{d_{T/C}} = 6036 \cdot lbs$$

Additional load from Direct Shear acting out of plane (SRSS)

$V_3 := \sqrt{V_3^{\,2} + V_{clip}^{\,2}} = 6124 \cdot lbs$

Reaction C3 [compression force] is resisted by bearing of the hold down on the curb lip. Assume 0.5" bearing length

$C_3 := V_3 - T_{clip} = 4704 \cdot lbs$

T3 Load due to the shear acting out of plane tension on the screws.

$$T_3 := \left(\max\left(\frac{T_{clip} \cdot b_{return.iso}}{b_{depth.iso}}, V_{clip} \right) \right) = 1035 \cdot lbs$$

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Check Bending in Clip @ Isolator Curb

There are several restraints that prevents the hold down clip for iso-curb to have local bending at the bottom and transfer vertical load demand directly to the face of the curb.

- Hold down is bearing on the face of iso-rail / non-iso curb lip.
- Gasket will act as a "link" member to allow unit base rail and bottom flange to move totegther so flange can't bend unless the unit base rail bends first. However, unit base rail is not likely to bend so bottom flange won't bend

Hold Down Clip thickness

$t_{Clip} = \text{"12GA"}$ $t_{clip} := \text{thick}(t_{Clip}) = 0.1084 \cdot in$

Effective width of hold down clip

$b_c := L_{clip} = 9 \cdot in$

Yield strength of the Clip

$F_{y.c} := 50ksi$

Strength reduction for bending

$\phi_{clip} := 0.9$

Design Bending Capacity (LRFD)

$\phi M_n := \phi_{clip} \cdot F_{y.c} \left(\frac{b_c \cdot t_{clip}^2}{6} \right) = 793 \cdot in \cdot lbs$

Flexural bending demand

$M_{u.clip} := T_{clip} \cdot 0.5in = 710 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.clip}}{\phi M_n} = 0.895$

$Clip_{Bending} = \text{"OK"}$

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Check Flange Bending in Clip @ Isolator Curb

Note:
- **If the curb flange is welded to the 10GA channel and 10GA channel is welded back to the base of the curb, then both tension and compression due to equipment overturning will be taken care by the 10GA channel.**
- **Since the curb will be reinforced with 10GA channel under each isolator, it can be assumed that the loads will trasnferred down to the base structure through the channels. Therefore, flange downward bending at curb due to compressive load does not need to be checked.**

Roof Curb thickness

$t_{Curb} = \text{"12GA"}$ $t_{curb} := \text{thick}(t_{Curb}) = 0.1084 \cdot \text{in}$

Clip edge to edge distance

$$b_{edge2edge} := \frac{L_{curb} - \left(6\text{in} + \frac{L_{clip}}{2}\right)\cdot 2}{N_B - 1} - L_{clip} = 9.438 \cdot \text{in}$$

Effective width of Roof Curb

$b_{curb} := L_{clip} + b_{edge2edge} = 18.44 \cdot \text{in}$

Yield strength of the Curb

$F_{y.curb} := 50\text{ksi}$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb}\left[\frac{b_{curb}\cdot(t_{curb})^2}{6}\right] = 1625 \cdot \text{in}\cdot\text{lbs}$$

Width of Isolator

$w_{JQ.iso} := 2\text{in}$ **2 in. for CQAs**

Flexural bending demand

$$M_{u.Curb} := T_{clip}\cdot\left(\max\left(\frac{1.75\text{in}}{2} - 0.5\text{in}, \frac{w_{JQ.iso}}{2} - 1\text{in}\right)\right) = 533 \cdot \text{in}\cdot\text{lbs}$$

D/C Ratio for bending

$$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.328$$

$Curb_{Bending} = \text{"OK, Weld 10GA channel ends to curb flange"}$

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Design of Connection#1 Connection of Equipment to hold Down clip

Ultimate SMS screw connection Strength (LRFD)
Strength based on the smallest thickness of Curb and Equipment Housing (min 16 GA) [Fy = 50ksi & Fu=65ksi]

$n_{sms} := 4$ $Size_{ss} := "\#14"$

$t_{ss} := "16GA"$ $F_{u.ss} := 65ksi$

Nominal Tension Strength

$$P_{nt} := n_{sms} \cdot T_s(Size_{ss}, t_{ss}, F_{u.ss}) = 3508 \cdot lbs$$

$$P_{not} := n_{sms} \cdot T_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 3508 \cdot lbs$$

$$P_{nov} := n_{sms} \cdot T_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 12383 \cdot lbs$$

$$P_{nts} := n_{sms} \cdot T_{nts}(Size_{ss}, t_{ss}, F_{u.ss}) = 14656 \cdot lbs$$

Nominal Shear Strength

$$P_{ns} := n_{sms} \cdot V_s(Size_{ss}, t_{ss}, F_{u.ss}) = 7808 \cdot lbs$$

$$P_{vnot} := n_{sms} \cdot V_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 8737 \cdot lbs$$

$$P_{vnov} := n_{sms} \cdot V_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 11144 \cdot lbs$$

$$P_{vnss} := n_{sms} \cdot V_{nss}(Size_{ss}, t_{ss}, F_{u.ss}) = 7808 \cdot lbs$$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} V_{clip} \div (\phi_{sms} \cdot P_{nt}) \\ T_{clip} \div (\phi_{sms} \cdot P_{ns}) \end{bmatrix} = \begin{pmatrix} 59 \\ 36 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left[\begin{bmatrix} \left[\frac{T_{clip}}{P_{vnov}} + 0.71\left(\frac{V_{clip}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{T_{clip}}{P_{vnot}} + \left(\frac{V_{clip}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{T_{clip}}{P_{vnss}} + \left(\frac{V_{clip}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right] = 66 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

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Design of Connection#2 Connection of hold Down clip to Curb

Tension loads on SMS connection

$T_{s2} := V_3 = 6124 \cdot lbs$

Shear loads on SMS connection

$V_{s2} := T_3 = 1035 \cdot lbs$

Ultimate SMS screw connection Strength (LRFD)
Strength based on the smallest thickness of Curb and Equipment Housing (min 16 GA) [Fy = 50ksi & Fu=65ksi]

$n_{sms} := 8$ $Size_{ss} := "\#14"$

$t_{ss} := (t_{Curb.iso}) = "10GA"$ $F_{u.ss} := 65ksi$

Nominal Tension Strength

$P_{nt} := n_{sms} \cdot T_s(Size_{ss}, t_{ss}, F_{u.ss}) = 15271 \cdot lbs$

Note:
SMS is getting pulled up so the thicker curb iso rail is engaged for SMS capacity , rather than just the clip itself.

$P_{not} := n_{sms} \cdot T_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 15271 \cdot lbs$

$P_{nov} := n_{sms} \cdot T_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 53898 \cdot lbs$

$P_{nts} := n_{sms} \cdot T_{nts}(Size_{ss}, t_{ss}, F_{u.ss}) = 29312 \cdot lbs$

Nominal Shear Strength

$P_{ns} := n_{sms} \cdot V_s(Size_{ss}, t_{ss}, F_{u.ss}) = 15616 \cdot lbs$

$P_{vnot} := n_{sms} \cdot V_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 56103 \cdot lbs$

$P_{vnov} := n_{sms} \cdot V_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 48508 \cdot lbs$

$P_{vnss} := n_{sms} \cdot V_{nss}(Size_{ss}, t_{ss}, F_{u.ss}) = 15616 \cdot lbs$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} T_{s2} \div (\phi_{sms} \cdot P_{nt}) \\ V_{s2} \div (\phi_{sms} \cdot P_{ns}) \end{bmatrix} = \begin{pmatrix} 80 \\ 13 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left[\begin{bmatrix} \left[\frac{V_{s2}}{P_{vnov}} + 0.71\left(\frac{T_{s2}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{V_{s2}}{P_{vnot}} + \left(\frac{T_{s2}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{V_{s2}}{P_{vnss}} + \left(\frac{T_{s2}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right] = 61 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

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Hold Down clip Bending and Shear Interaction

Diameter of SMS:

$$d_{sms} := \text{vlookup}\left(Size_{ss}, SMS_{Table}, 1\right)_0 \cdot in = 0.25 \cdot in$$

Depth of flat web portion

$$h_{clip.shear} := L_{clip} - n_{sms} \cdot d_{sms} = 7 \cdot in$$

Depth-to-Thickness Ratio:

$$\frac{h_{clip.shear}}{t_{clip}} = 65 \qquad E := 29500ksi \qquad F_y := 50ksi \qquad \mu := 0.3$$

Nominal Shear Stress:
(For unreinforced web)
AISI S100-16 G2.1

$$k_v := 5.34 \qquad \sqrt{\frac{E \cdot k_v}{F_y}} = 56 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 85$$

Area of Web Element:

$$A_w := h_{clip.shear} \cdot t_{clip} = 0.759 \cdot in^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h_{clip.shear}}{t_{clip}}\right)^2} = 34.1 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} \qquad V_y := 0.6 \cdot A_w \cdot F_y = 23\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.937$$

Hole Shear Reduction Factor:
(for circular holes, AISI S100-16 Eq G3-1)

$$c := \frac{h_{clip.shear}}{2} - \frac{d_{sms}}{2.83} = 3.41 \cdot in$$

$$q_s := \begin{cases} 1.0 & \text{if } \frac{c}{t_{clip}} \geq 54 \\ \frac{c}{54 \cdot t_{clip}} & \text{if } 5 \leq \frac{c}{t_{clip}} < 54 \end{cases} = 0.583$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \leq 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \leq 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 19.792 \cdot kip$$

Design Shear Capacity with holes:

$$\phi V_{n.clip} := 0.95 \cdot V_n \cdot q_s = 11 \cdot kip$$

D/C Ratio of V and M per AISI S100-16 Eq H2-1

$$DCR_{V.M.int.clip} := \sqrt{\left(\frac{M_{u.clip}}{\phi M_n}\right)^2 + \left(\frac{\max\left(T_{clip}, V_{clip}\right)}{\phi V_{n.clip}}\right)^2} = 0.9046$$

Demand/Capacity Ratio:

$$VandM_{int.clip} = \text{"OK"}$$

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ISOLATOR DESIGN [PER OPM-0401-13]

OPM-0401-13 is based on allowable stress design

Number of isolators on the long side

$N_B := 8$ $N_{iso.long} := N_B = 8$

Moment Arm for overturning (Short side)

$B := W_{curb} + \frac{1.75in}{2} \cdot 2 = 79 \cdot in$

Number of isolators on the Short side.

$N_L := 6$

Isolator Centerline Spacing (Long side)

$L_{spacing.iso} := \frac{L_{curb} - (6in) \cdot 2}{N_B - 1} = 14.46 \cdot in$

Moment Arm for overturning (Long side)

$L := L_{curb} - 2 \cdot 6in - 2 \cdot L_{spacing.iso} \cdot \frac{(N_L - 2)}{4} = 72 \cdot in$

Total Number of isolators

$N_t := (N_B) \cdot 2sides = 16$

Max net Tension Reaction due to Seismic, Fp

$EQ_{ASD} := \left[0.6 - (0.7 \cdot F_v)\right] \cdot Wt_{unit} = 1.246\ kip$

$$R_{iso.EQ} := MAX+\left[\begin{bmatrix}\left[\frac{(0.7F_p) \cdot Wt_{unit}}{B \cdot N_B} \cdot (h_{CG.unit} + 0in) + \frac{EQ_{ASD} \cdot e_{width}}{B \cdot N_B}\right] - \frac{EQ_{ASD}}{N_t} \\ \left[\frac{(0.7F_p) \cdot Wt_{unit}}{L \cdot N_L} \cdot (h_{CG.unit} + 0in) + \frac{EQ_{ASD} \cdot e_{length}}{L \cdot N_L}\right] - \frac{EQ_{ASD}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}331 \\ 508\end{pmatrix} \cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$F_{wind.B} := \frac{P_{net} \cdot L_{unit} \cdot (H_{unit} + 0in)}{B \cdot N_B} \cdot \left(\frac{1}{2} \cdot H_{unit} + 0in\right) = 426 \cdot lbs$$

$$F_{wind.L} := \frac{P_{net} \cdot W_{unit} \cdot (H_{unit} + 0in)}{L \cdot N_L} \cdot \left(\frac{1}{2} \cdot H_{unit} + 0in\right) = 426 \cdot lbs$$

$$R_{iso.W} := (0.6) \cdot MAX+\left(\begin{pmatrix}F_{wind.B} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{Wt_{unit}}{N_t} \\ F_{wind.L} + \frac{P_v \cdot L_{unit.up} W_{unit}}{N_t} + \frac{Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{Wt_{unit}}{N_t}\end{pmatrix}\right) = \begin{pmatrix}459 \\ 454\end{pmatrix} \cdot lbs$$

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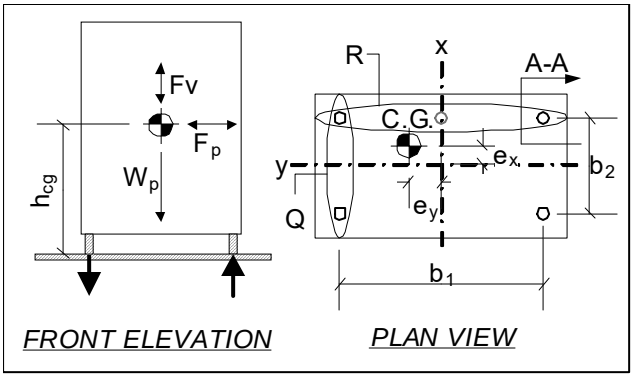
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Tensile and Shear Load calculation per ASHRAE RP-812



Eccentricity along X-X

$e_x := e_{width} = 6.09 \cdot in$

Eccentricity along Y-Y

$e_y := e_{length} = 3.16 \cdot in$

Distance between Seismic Restraints Along Y-Y

$b_1 := L_{curb} - 2 \cdot 6in = 101 \cdot in$

Distance between Seismic Restraints Along X-X

$b_2 := W_{curb} + 2 \cdot \frac{1.75in}{2} = 79 \cdot in$

Moment of Inertia about X-X

$I_{xx} := \frac{N_t \cdot (N_t + 2) \cdot (b_1)^2}{12 \cdot (N_t - 2)} = 17553 \cdot in^2$

Moment of Inertia about Y-Y

$I_{yy} := \frac{N_t \cdot (b_2)^2}{4} = 24806 \cdot in^2$

Angle about Tensile Load

$\Theta_t := \operatorname{atan}\left[\frac{I_{yy} \cdot (b_1)}{I_{xx} \cdot (b_2)}\right] = 61 \cdot deg$

Angle about Shear Load

$\Theta_s := \begin{cases} \operatorname{atan}\left(\frac{e_x}{e_y}\right) & \text{if } e_y \neq 0 \\ 0deg & \text{if } e_y = 0 \end{cases} = 63 \cdot deg$

Max Net Tensile Load Due to Seismic Load, Fp

$T_{U.EQ.pt1} := \frac{(0.6 - 0.7 \cdot F_v) \cdot Wt_{unit}}{N_t} - \frac{(0.6 - 0.7 \cdot F_v) \cdot Wt_{unit}}{b_1 \cdot b_2} \cdot \left(\frac{b_1}{2} \cdot e_x + \frac{b_2}{2} \cdot e_y - e_x \cdot e_y\right) = 13 \cdot lbs$

$T_{U.EQ.pt2} := -0.7 \cdot (F_p \cdot Wt_{unit}) \cdot (h_{CG.unit} + 0in) \cdot \cos(\Theta_t) \cdot \frac{0.5 \cdot b_2}{I_{yy}} = -191 \cdot lbs$

$T_{U.EQ.pt3} := -0.7 \cdot (F_p \cdot Wt_{unit}) \cdot (h_{CG.unit} + 0in) \cdot \sin(\Theta_t) \cdot \frac{0.5 \cdot b_1}{I_{xx}} = -631 \cdot lbs$

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$T_{U.EQ} := T_{U.EQ.pt1} + T_{U.EQ.pt2} + T_{U.EQ.pt3} = -810 \cdot lbs$

Max Net Shear Load Due to Seismic Load, Fp

$$V_{Ux.EQ} := 0.7 \cdot F_p \cdot Wt_{unit} \cdot \frac{\cos(\Theta_s)}{N_t} + \frac{0.7 \cdot F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_2 \cdot e_y + 0.7 \cdot F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_1 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 276 \cdot lbs$$

$$V_{Uy.EQ} := 0.7 \cdot F_p \cdot Wt_{unit} \cdot \frac{\sin(\Theta_s)}{N_t} + \frac{0.7 \cdot F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_1 \cdot e_y + 0.7 \cdot F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_2 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 470 \cdot lbs$$

$$V_{U.EQ} := \sqrt{V_{Ux.EQ}^2 + V_{Uy.EQ}^2} = 545 \cdot lbs$$

Tension Design force SRSS for loading from Each direction

$R_{iso.EQ.1.RP812} := \left| T_{U.EQ.pt1} + T_{U.EQ.pt3} \right| = 618 \cdot lbs$

$R_{iso.EQ.0.RP812} := \left| T_{U.EQ.pt1} + T_{U.EQ.pt2} \right| = 178 \cdot lbs$

$$R_{iso.EQ.max_1} := \max\left[\left(R_{iso.EQ.1.RP812} + 0 \cdot R_{iso.EQ.0.RP812}\right), \left(R_{iso.EQ_1} + 0 \cdot R_{iso.EQ_0}\right)\right] = 618 \cdot lbs$$

$$R_{iso.EQ.max_0} := \max\left[\left(R_{iso.EQ.0.RP812} + 0 \cdot R_{iso.EQ.1.RP812}\right), \left(R_{iso.EQ_0} + 0 \cdot R_{iso.EQ_1}\right)\right] = 331 \cdot lbs$$

For the plot:

$R_{iso.EQ.max_1} = 618 \cdot lbs$ $R_{iso.W_1} = 454 \cdot lbs$

$R_{iso.EQ.max_0} = 331 \cdot lbs$ $R_{iso.W_0} = 459 \cdot lbs$

Shear load at each anchor location

For the plot:

$$V_{iso.E} := \max\left[\left[\begin{array}{c} 1.0 \cdot V_{Ux.EQ} + 0 \cdot V_{Uy.EQ} \\ 0.3 \cdot V_{Ux.EQ} + 0 \cdot V_{Uy.EQ} \\ \left[\left(0.7F_p\right) \cdot Wt_{unit} \cdot \frac{1}{N_t}\right] \end{array}\right]\right] = 472 \cdot lbs \qquad V_{iso.W} := 0.6P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t} = 304 \cdot lbs$$

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Isolator Capacity:

$ID_{Iso} := "CQA"$

$T_{n.\Omega} := 2117lbs$ **(ASD)**

$V_{n.\Omega} := 775lbs$ **(ASD)**

Isolator Demand:

$R_{iso.max} := \max\left[\left(R_{iso.EQ.max_1}\right), \left(R_{iso.EQ.max_0}\right), \left(R_{iso.W_1}\right), \left(R_{iso.W_0}\right)\right] = 618 \cdot lbs$

$V_{iso.max} := \max\left(V_{iso.E}, V_{iso.W}\right) = 472 \cdot lbs$

D/C Ratio of Tension Only.:

$$DCR_{tension} := \frac{R_{iso.max}}{T_{n.\Omega}} = 0.292$$

$DCR_{tension} = "OK"$

D/C Ratio of Shear Only.:

$$DCR_{shear} := \frac{V_{iso.max}}{V_{n.\Omega}} = 0.609$$

$DCR_{shear} = "OK"$

D/C Ratio of Tension Only.:

$$DCR_{Int} := \frac{V_{iso.max}}{V_{n.\Omega}} + \frac{R_{iso.max}}{T_{n.\Omega}} = 0.901$$

$DCR_{Int} = "OK"$

ISOLATOR "SPRING" DESIGN [PER OPM-0401-13]

Factor of Safety of Spring

$FS_{spring} := 0.75$

Compressive Strength of Spring

$$C_{spring.\Omega} := \begin{cases} \left(FS_{spring} \cdot 300lbs\right) & \text{if } ID_{Iso} = "CQA" \\ \left(FS_{spring} \cdot 918lbs\right) & \text{if } ID_{Iso} = "CQB" \\ \left(FS_{spring} \cdot 918lbs\right) & \text{if } ID_{Iso} = "CQBX" \end{cases} = 225 \cdot lbs$$

Rated Load per unit self-weight

$$C_{unit.rated.load} := \frac{Wt_{unit}}{N_t} = 200 \cdot lbs$$

D/C Ratio of Spring Compression:

$$DCR := \frac{C_{unit.rated.load}}{C_{spring.\Omega}} = 0.888$$

$IsoSpring_{compression} = "OK"$

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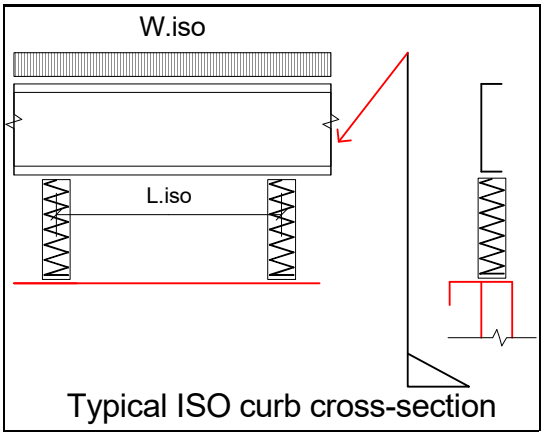
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Date DEC/12/2018

CURB & ANCHORAGE DESIGN Engineer LK

Check ISO Rail for Bending about Strong and Weak Axis (AISI S100-16 F2.1)



Typical ISO curb cross-section

Thickness of Curb:

$t_{Curb.iso}$ = "10GA" $t := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Inside Bend Radius:

$R := R_{iso} = 0.186 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web:

$h := 7.5in - 2 \cdot (t + R) = 6.85 \cdot in$

Width of Flange:

$h_w := 1in$

Check Curb Bending of Long Side (Strong axis)

Member per CFS: $CFS_{member} :=$ "10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"

Number of Isolators on each Long Side: $N_{iso.long} = 8$

Center-to-Center Spacing of Isolators $L_{iso} := \frac{L_{curb}}{N_{iso.long} - 1} = 16 \cdot in$

Distributed Load $\omega_{iso} := \omega_{x.L.vert} = 2.141\ klf$

Moment Demand on Iso Rail $M_{cx} := \frac{\omega_{iso} \cdot L_{iso}^2}{8} = 5.831 \cdot kip \cdot in$

Curb Elastic Modulus / Yield Stress: $E := 29500ksi$ $F_y := 50ksi$

Curb Shear Modulus: $G := 11300ksi$

Poisson's Ratio $\mu := 0.3$

Section Properties from CFS: $r_x = 2.4893 \cdot in$ $r_o = 2.519 \cdot in$ $C_w = 0.595 \cdot in^6$ $S_x = 1.855 \cdot in^3$

$r_y = 0.2288 \cdot in$ $J = 0.0058 \cdot in^4$ $S_y = 0.3669 \cdot in^3$

$r_{min} := min(r_x, r_y) = 0.2288 \cdot in$

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Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Flanges*

Flat Width:

$$w := h_w - R_{curb} = 0.847 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Unstiffened"}$$

Stress at the end of the Width:

$$f_2 := 11.407ksi \quad f_1 := 11.407ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \frac{f_2}{f_1} = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 0.43$$

Critical Compressive Stress:

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t}{w}\right)^2 = 304.86 \cdot ksi$$

Stress in Compression Element:

$$f := 18ksi$$

Note: Use f from "Elastive Flexural Buckling Stress" on "Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI E2)"

Slenderness Factor:

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 0.24$$

Local reduction factor:

$$\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 0.389$$

Effective Width of the Flanges:

$$b_{eff.flange} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 0.847 \cdot in$$

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Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Web*

Flat Width: $w := h = 6.851 \cdot in$

Stiffened Web Check: $Stiffened_{check} := "Stiffened"$

Stress at the end of the Width: $f_2 := 11.407ksi$ $f_1 := 11.407ksi$

Compressive Stress Ratio (Eq. 1.1.2-1): $\Psi := \frac{f_2}{f_1} = 1$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = "Stiffened" \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = "Unstiffened" \end{cases} = 4$$

Critical Compressive Stress: $F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t}{w}\right)^2 = 43.4 \cdot ksi$

Stress in Compression Element: $f := 18ksi$

Note: Use f from "Elastive Flexural Buckling Stress" on "Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI E2)"

Slenderness Factor: $\lambda := \sqrt{\frac{f}{F_{cr}}} = 0.64$

Local reduction factor: $\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 1.022$

Effective Width of the Web:

$$b_{eff.web} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 6.851 \cdot in$$

Effective Area of the Member: $A_e := 2 \cdot \left(b_{eff.flange} \cdot t\right) + b_{eff.web} \cdot t = 1.181 \cdot in^2$

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For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. F2.1.1-4,5)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(1.0 \cdot L_{iso}\right)^2}\right] = 97 \cdot ksi$$

$$\sigma_{ey} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{iso}}{r_y}\right)^2} = 58 \cdot ksi \qquad \frac{1.0 \cdot L_{iso}}{r_y} = 71$$

KL_r = "KL/r < 200, OK"

Cb per Eq. F2.1.1-2

$$M_A := \frac{\omega_{iso} \cdot \frac{L_{iso}}{4}}{2} \cdot \left(L_{iso} - \frac{L_{iso}}{4}\right) = 4.37 \cdot kip \cdot in$$

$$M_B := M_{cx} = 5.83 \cdot kip \cdot in$$

$$M_C := \frac{\omega_{iso} \cdot \frac{3 \cdot L_{iso}}{4}}{2} \cdot \left(L_{iso} - \frac{3 \cdot L_{iso}}{4}\right) = 4.37 \cdot kip \cdot in$$

$$C_b := \min\left(1.0, \frac{12.5 \cdot M_{cx}}{2.5 \cdot M_{cx} + 3 \cdot M_A + 4 \cdot M_B + 3.M_C}\right) = 1$$

Elastic Critical Lateral-Torsional Buckling Stress per Eq. F2.1.1-1 for Singly Symmetry:

$$F_e := \frac{C_b \cdot r_o \cdot A_e}{S_x} \cdot \sqrt{\sigma_{ey} \cdot \sigma_t} = 121 \cdot ksi$$

LTB Design Stress: Eq. F2.1-3,4,5:

$$F_c := \begin{cases} F_y & \text{if } F_e \geq 2.78 \cdot F_y \\ \frac{10}{9} \cdot F_y \cdot \left(1 - \frac{10 \cdot F_y}{36 \cdot F_e}\right) & \text{if } 2.78 \cdot F_y > F_e > 0.56 \cdot F_y \\ F_e & \text{if } 0.56 \cdot F_y \geq F_e \end{cases} = 49 \cdot ksi$$

Moment Capacity Eq. F2.1-1:

$$\phi M_{nx} := 0.9 \cdot S_x \cdot \min\left(F_c, F_y\right) = 82 \cdot kip \cdot in$$

D/C Ratio of Bending:

$$DCR := \frac{M_{cx}}{\phi M_{nx}} = 0.071$$

$Iso_{Bending}$ = "OK"

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Check Curb Bending of Long Side (Weak axis)

Center-to-Center Spacing of Braces

$$L_{brace} := \frac{L_{curb}}{N_{iso.long} - 1} = 16 \cdot in$$

Note for weak-axis bracing length:
Max weak-axis span length of Iso Rail is larger than L_{brace} per cut sheet. However, the Iso Rail is braced with clip at max 24" O.C. at top and isolator at max 36" O.C. at bottom such that the actual unbraced length is as follows.

Distributed Load

$$\omega_{iso} := \frac{\max\left(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit}\right)}{L_{curb}} = 1.143\ klf$$

Moment Demand on Iso Rail

$$M_{cy} := \frac{\omega_{iso} \cdot L_{brace}^{2}}{8} = 3.114 \cdot kip \cdot in$$

Member per CFS:

$$CFS_{member} = \text{"10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"}$$

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. F2.1.1-4,5)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(1.0 \cdot L_{brace}\right)^2}\right] = 97 \cdot ksi$$

$$\sigma_{ex} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{brace}}{r_x}\right)^2} = 6900 \cdot ksi \qquad \frac{1.0 \cdot L_{brace}}{r_x} = 6$$

$$KL_r = \text{"KL/r < 200, OK"}$$

Cb per Eq. F2.1.1-2

$$M_A := \frac{\omega_{iso} \cdot \frac{L_{brace}}{4}}{2} \cdot \left(L_{brace} - \frac{L_{brace}}{4}\right) = 2.34 \cdot kip \cdot in$$

$$M_B := M_{cy} = 3.11 \cdot kip \cdot in$$

$$M_C := \frac{\omega_{iso} \cdot \frac{3 \cdot L_{brace}}{4}}{2} \cdot \left(L_{brace} - \frac{3 \cdot L_{brace}}{4}\right) = 2.34 \cdot kip \cdot in$$

$$C_b := \min\left(1.0, \frac{12.5 \cdot M_{cx}}{2.5 \cdot M_{cx} + 3 \cdot M_A + 4 \cdot M_B + 3 \cdot M_C}\right) = 1$$

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Elastic Critical Lateral-Torsional Buckling Stress per Eq. F2.1.1-1 for Singly Symmetry:

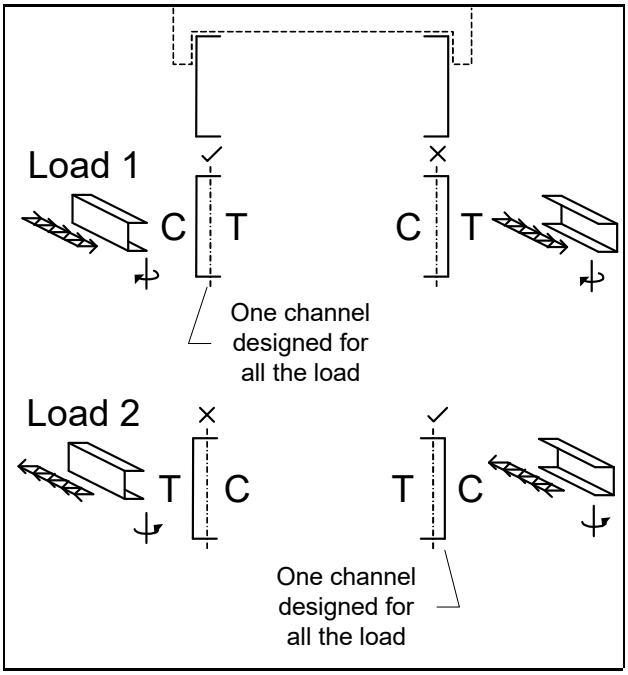
$$F_e := \frac{C_b \cdot r_o \cdot A_e}{S_y} \cdot \sqrt{\sigma_{ey} \cdot \sigma_t} = 610 \cdot ksi$$

LTB Design Stress: Eq. F2.1-3,4,5:

$$2.78 \cdot F_y = 139 \cdot ksi$$

$$0.56 \cdot F_y = 28 \cdot ksi$$

$$F_c := \begin{cases} F_y & \text{if } F_e \geq 2.78 \cdot F_y \\ \frac{10}{9} \cdot F_y \cdot \left(1 - \frac{10 \cdot F_y}{36 \cdot F_e}\right) & \text{if } 2.78 \cdot F_y > F_e > 0.56 \cdot F_y \\ F_e & \text{if } 0.56 \cdot F_y \geq F_e \end{cases} = 50 \cdot ksi$$



Note:

For ISO rail weak-axis bending capacity, rails are oriented and designed so that the stiffer side of ISO rail can take the entire bending load by itself without putting a lot of bending load to the iso rail on the other side

Moment Capacity Eq. F2.1-1:

$$\phi M_{ny} := 0.9 \cdot S_y \cdot \min\left(F_c, F_y\right) = 16.5105 \cdot kip \cdot in$$

D/C Ratio of Bending:

$$DCR := \frac{M_{cy}}{\phi M_{ny}} = 0.189$$

$$Iso_{Bending} := \text{if}\left(M_{cy} < \phi M_{ny}, \text{"OK"}, \text{"NG"}\right)$$

$Iso_{Bending} = \text{"OK"}$

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Web Crippling of ISO Rail (AISI S100-16 G.5)

Governing Compression:

$$P_{web.crip} := \frac{\omega_{x.L.vert} \cdot L_{iso}}{2} = 1442 \cdot lbs$$

Yield Strength:

$$F_y := 50ksi$$

Bearing Length:

$N := 2in$ **2 in. for CQAs**

Thickness of Curb:

$t_{Curb.iso} = \text{"10GA"}$ $t := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Inside Bend Radius:

$R := R_{iso} = 0.186 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web:

$h = 6.85 \cdot in$

Angle btween plane of web and bearing surface:

$\theta := 90deg$

Web Crippling Limit Check (AISI Table G5-2):

$$\frac{R}{t} = 1 \quad \frac{h}{t} = 50 \quad \frac{N}{t} = 14 \quad \frac{N}{h} = 0.29$$

$$LimitCheck_{webcrippling} := if\left[\left(\frac{h}{t} < 200\right) \wedge \left(\frac{N}{t} < 210\right) \wedge \left(\frac{N}{h} < 2\right) \wedge \left(\frac{R}{t} < 2\right), \text{"OK"}, \text{"NG, Need Reinf"}\right]$$

$LimitCheck_{webcrippling} = \text{"OK"}$

End Case Coefficient Single Web Channel (AISI Table G5-2):

$C := 2$ $C_R := 0.11$ $C_N := 0.37$ $C_h := 0.01$

Reduction Factor Web Crippling Strength:

$\phi_{web.end} := 0.75$ **(For Unfastened Flanges with Two-Flange Loading or Reaction. Worst Case)**

$\phi_{web.int} := 0.8$

Design Web Crippling Strength:

$$P_{n.end} := C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 3729 \cdot lbs$$

$$\phi P_{n.end} := \phi_{web.end} \cdot P_{n.end} = 2796 \cdot lbs$$

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Interior Case Coefficient Single Web Channel (AISI Table G5-2):

$C := 13$ $C_R := 0.47$ $C_N := 0.25$ $C_h := 0.04$

Design Web Crippling Strength:

$$P_{n.interior} := C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 7905 \cdot lbs$$

$$\phi P_{n.interior} := \left(\phi_{web.int}\right) \cdot P_{n.interior} = 6324 \cdot lbs$$

Design Strength:

$$P_{n.web.crip} := \min\left(P_{n.end}, P_{n.interior}\right) = 3729 \cdot lbs$$

$$\phi P_{n.web.crip} := \min\left(\phi P_{n.end}, \phi P_{n.interior}\right) = 2796 \cdot lbs$$

D/C Ratio of Shear:

$$DCR := \frac{P_{web.crip}}{\phi P_{n.web.crip}} = 0.516$$

Demand/Capacity Ratio:

$$Web_{crippling} := if\left[\left(P_{web.crip} < \phi P_{n.web.crip}\right) \wedge \left(\phi P_{n.end} > 0\right) \wedge \frac{h}{t} < 200, "OK", "NG, Need Reinf"\right]$$

$Web_{crippling} = "OK"$

D/C Ratio of Interaction:
AISI Eq. H3-1b

$$DCR_{int.web} := \frac{0.91 \cdot \left(\frac{P_{web.crip}}{P_{n.web.crip}}\right) + \frac{M_{cx}}{\left(\frac{\phi M_{nx}}{0.9}\right)}}{1.33 \cdot 0.9} = 0.348$$

$Iso_{Shear} = "OK"$

$Iso_{Interaction} = "OK"$

Per AISI S100-16 H3,
Only x-axis needs to check for interaction

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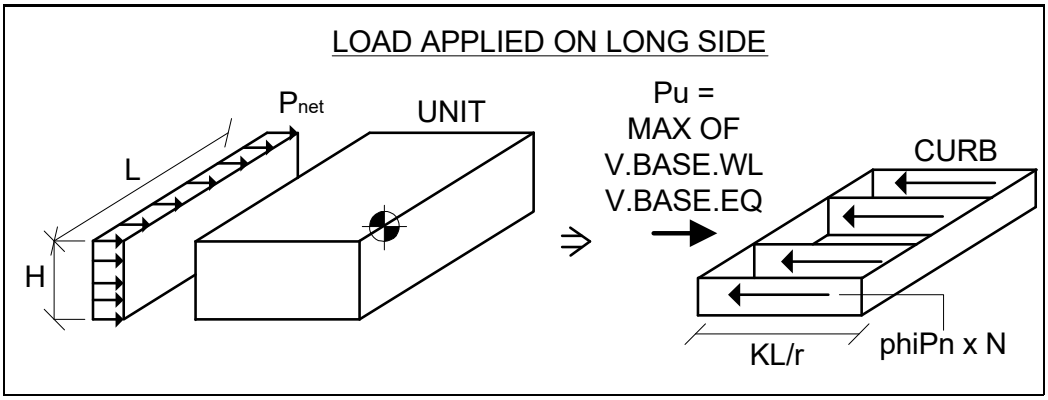
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Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI S100-16 E2)

Curb Axial Load Check due to Load on Long Side



Wind Base Shear of Unit on Long Side: $V_{base.W.L} := P_{net} \cdot L_{unit} \cdot H_{unit} = 8.1\,kip$

Seismic Base Shear of Unit on Long Side: $V_{base.S.L} := F_p \cdot Wt_{unit} = 10.8\,kip$

Max Axial: $P_u := \max\left(V_{base.S.L}, V_{base.W.L}\right) = 10783.46 \cdot lbs$

Member per CFS: $CFS_{member} =$ "10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"

Number of Curb in Length: $n_{iso} := 3$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{iso}} = 3.59\,kip$

Max Braced Length of Member: $L_{member} := W_{curb} = 77 \cdot in$

Effective Length factor: $K := 0.5$

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For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. E2.2-5, E2.2-6)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(K \cdot L_{member}\right)^2}\right] = 24 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2} = 10 \cdot ksi$$

$$\frac{K \cdot L_{member}}{r_{min}} = 168$$

KL_r = "KL/r < 200, OK"

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 7 \cdot ksi$$

Nominal Compressive Stress Capacity (Eq E2-4):

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 2.631$$

$$F_n := \begin{cases} 0.658^{\lambda_c^{\,2}} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^{\,2}}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 6.34 \cdot ksi$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot A_e \cdot F_n = 6.36\,kip$$

D/C Ratio of Compression:

$$DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.565$$

Note:
No need to check for interaction since equipment is not attached to the short side

$$Axial_{reinf} := \text{if}\left(P_{u.EAmember} < \phi P_{n.member}, \text{"OK"}, \text{"NG"}\right)$$

$Axial_{reinf}$ = "OK"

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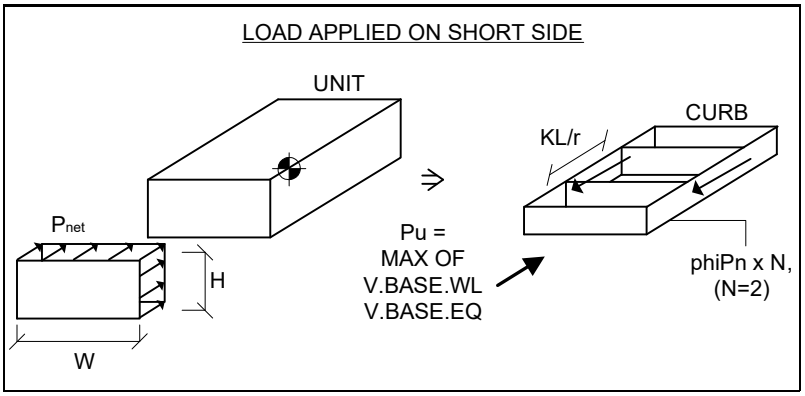
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Curb Axial Load Check due to Load on Short Side



Wind Base Shear on Short Side: $V_{base.W.H} := P_{net} \cdot W_{unit} \cdot H_{unit} = 5.6\,kip$

Seismic Base Shear of Unit on Short Side: $V_{base.S.W} := F_p \cdot Wt_{unit} = 10.8\,kip$

Max Axial: $P_u := \max\left(V_{base.S.W}, V_{base.W.H}\right) = 10783.46 \cdot lbs$

Member per CFS: $CFS_{member} = \text{"10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"}$

Number of Curb in Length: $n_{curb} := 2$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{curb}} = 5.39\,kip$

Max Braced Length of Member: $L_{member} := \frac{L_{curb}}{n_{iso} - 1} = 57 \cdot in$

Effective Length factor: $K := 0.5$

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. E2.2-5, E2.2-6)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(K \cdot L_{member}\right)^2}\right] = 38 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2} = 19 \cdot ksi \qquad \frac{K \cdot L_{member}}{r_{min}} = 124$$

$KL_r = \text{"KL/r < 200, OK"}$

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 13 \cdot ksi$$

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Nominal Compressive Stress Capacity (Eq E2-4):

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 1.989$$

$$F_n := \begin{cases} 0.658^{\lambda_c^2} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^2}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 11.08 \cdot \text{ksi}$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot A_e \cdot F_n = 11.12\,\text{kip}$$

D/C Ratio of Compression:

$$DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.485$$

$$Axial_{reinf} := \text{if}\left(P_{u.EAmember} < \phi P_{n.member}, \text{"OK"}, \text{"NG"}\right)$$

$Axial_{reinf} = \text{"OK"}$

Note:
If the load direction is in perpedicular plane to the short side of the equipment, the channels will only experience axial load and no bending will occur at the channel. Therefore, no need to check for interaction since the channels

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Shear of ISO Rail Webs without Holes (AISI S100-16 G2)

Note: The connection holes are not centered at mid-depth of isolated curb rail so AISI G2 shall be used

Deeper Section (h = depth)

Thickness of Curb: $t := \text{thick}(t_{Curb.iso}) = 0.138 \cdot in$

Depth-to-Thickness Ratio: $\frac{h}{t} = 50$

Curb Elastic Modulus: $E := 29500ksi$

Clear distance b/w transverse stiffeners of reinforced web: $a := L_{iso} = 16 \cdot in$

Clear Distance-to-Thickness Ratio: $\frac{a}{h} = 2.36$

Nominal Shear Stress:

$$k_v := \begin{cases} 5.34 \text{ if } a = L_{iso} \\ 4.00 + \frac{5.34}{\left(\frac{a}{h}\right)^2} \text{ if } \left(\frac{a}{h} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \frac{4.00}{\left(\frac{a}{h}\right)^2} \text{ if } \left(\frac{a}{h} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 6.06$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 60 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 90$$

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Curb Shear Check due to Load on Longer Side

Area of Web Element:

$$A_w := h \cdot t = 0.947 \cdot in^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 65.7 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} = 62\,kip \qquad V_y := 0.6 \cdot A_w \cdot F_y = 28\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.676$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 28.404 \cdot kip$$

Number of Members within Length: $n := 1$ **(Per Curb Design)**

Design Shear Capacity:

$$\phi V_{n.h} := 0.95 \cdot n \cdot V_n = 26.98 \cdot kip$$

Design Shear Demand:

$$V_{u.h} := \frac{\omega_{x.L.vert} \cdot L_{iso}}{2} = 1442.5 \cdot lbs$$

D/C Ratio of Shear:

$$DCR := \frac{V_{u.h}}{\phi V_{n.h}} = 0.053$$

Demand/Capacity Ratio:

$Shear_{in.plane} = \text{"OK"}$

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Shallower Section (h.w = Width)

Thickness of Curb: $t := thick(t_{Curb.iso}) = 0.138 \cdot in$

Depth-to-Thickness Ratio: $\frac{h_w}{t} = 7$

Curb Elastic Modulus: $E := 29500ksi$

Clear distance b/w transverse stiffeners of reinforced web: $a := L_{brace} = 16 \cdot in$

Clear Distance-to-Thickness Ratio: $\frac{a}{h_w} = 16.17$

Nominal Shear Stress:

$$k_v := \begin{cases} 5.34 & \text{if } a = L_{brace} \\ 4.00 + \frac{5.34}{\left(\frac{a}{h_w}\right)^2} & \text{if } \left(\frac{a}{h_w} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \frac{4.00}{\left(\frac{a}{h_w}\right)^2} & \text{if } \left(\frac{a}{h_w} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 5.36$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 56 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 85$$

Curb Shear Check due to Load on Longer Side

Area of Web Element: $A_w := h_w \cdot t = 0.1382 \cdot in^2$

Number of Members within Length: $n := 1$ **(Per Curb Design)**

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 58.1 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} = 8\,kip \qquad V_y := 0.6 \cdot A_w \cdot F_y = 4\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.719$$

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$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 4.146 \cdot \text{kip}$$

Design Shear Capacity:

$$\phi V_{n.hw} := 0.95 \cdot n \cdot V_n = 3.9 \cdot \text{kip}$$

Design Shear Demand:

$$V_{u.hw} := \frac{\left(\frac{\max\left(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit}\right)}{L_{curb}} \right) \cdot L_{brace}}{2} = 770.2 \cdot \text{lbs}$$

D/C Ratio of Shear:

$$DCR := \frac{V_{u.hw}}{\phi V_{n.hw}} = 0.196$$

Demand/Capacity Ratio:

$Shear_{in.plane}$ = "OK"

D/C Ratio of Vx and Mx:

$$DCR_{V.M.int} := \begin{cases} \left(0.6 \cdot \frac{M_{cx}}{\phi M_{nx}} + \frac{V_{u.h}}{\phi V_{n.h}}\right) \cdot \frac{1}{1.3} & \text{if } \frac{M_{cx}}{\phi M_{nx}} > 0.5 \wedge \frac{V_{u.h}}{\phi V_{n.h}} > 0.7 \\ \sqrt{\left(\frac{M_{cx}}{\phi M_{nx}}\right)^2 + \left(\frac{V_{u.h}}{\phi V_{n.h}}\right)^2} & \text{otherwise} \end{cases} = 0.089$$

Demand/Capacity Ratio:

$VandMx_{int}$ = "OK"

D/C Ratio of Vy and My:

$$DCR_{V.M.int} := \begin{cases} \left(0.6 \cdot \frac{M_{cy}}{\phi M_{ny}} + \frac{V_{u.hw}}{\phi V_{n.hw}}\right) \cdot \frac{1}{1.3} & \text{if } \frac{M_{cy}}{\phi M_{ny}} > 0.5 \wedge \frac{V_{u.hw}}{\phi V_{n.hw}} > 0.7 \\ \sqrt{\left(\frac{M_{cy}}{\phi M_{ny}}\right)^2 + \left(\frac{V_{u.hw}}{\phi V_{n.hw}}\right)^2} & \text{otherwise} \end{cases} = 0.272$$

Demand/Capacity Ratio:

$VandMy_{int}$ = "OK"

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Web Crippling/Compression of Non-iso CanFab Curb (AISI S100-16 G5)

Governing Compression for Non-Isolated Curb:

$$P_{web.crip.int} := \max\left[\frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}}, \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}}\right] \cdot L_{spacing.non.iso} = 5483 \cdot lbs$$

$$P_{web.crip.end} := 0.5 \cdot P_{web.crip.int} = 2741 \cdot lbs$$

Yield Strength: $F_y := 50ksi$

Bearing Length: $N_{bearing} := L_{spacing.non.iso} = 31 \cdot in$

Thickness of Curb: $t_{Curb} = \text{"12GA"}$ $t := thick(t_{Curb}) = 0.1084 \cdot in$

Inside Bend Radius: $R := R_{curb} = 0.153 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web: $h := 30in - 2 \cdot (t + R) = 29.48 \cdot in$

Angle btween plane of web and bearing surface: $\theta := 90deg$

Web Crippling Limit Check (AISI Table G5-2): $\frac{R}{t} = 1$ $\frac{h}{t} = 272$ $\frac{N_{bearing}}{t} = 283$ $\frac{N_{bearing}}{h} = 1.04$

End Case Coefficient Single Web Channel (AISI Table G5-2): $C := 13$ $C_R := 0.32$ $C_N := 0.05$ $C_h := 0.04$

Reduction Factor Web Crippling Strength: $\phi_{web.end} := 0.9$ $\phi_{web.int} := 0.8$ **(For Unfastened partially Stiffened Flanges with Two-Flange Loading or Reaction.)**

Design Web Crippling Strength:

$$\phi P_{n.end} := \left(\phi_{web.end}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 2674 \cdot lbs$$

Interior Case Coefficient Single Web Channel (AISI Table G5-2): $C := 24$ $C_R := 0.52$ $C_N := 0.15$ $C_h := 0.001$

Design Web Crippling Strength:

$$\phi P_{n.interior} := \left(\phi_{web.int}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 14990 \cdot lbs$$

D/C Ratio of Shear: $DCR_{end} := \frac{P_{web.crip.end}}{2 \cdot \phi P_{n.end}} = 0.513$ $DCR_{int} := \frac{P_{web.crip.int}}{\phi P_{n.interior}} = 0.366$

Demand/Capacity Ratio: **Note: Factor of 2 for two ends connected together at the end**

$Web_{crippling} = \text{"OK"}$

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Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Length

Roof Curb thickness

$t_{Curb} = \text{"12GA"}$ $t_{curb} := thick(t_{Curb}) = 0.1084 \cdot in$

Min width of Roof Curb

$b_{curb} := L_{curb} + W_{curb} \cdot 2 = 267.19 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := L_{curb} + \min\left(\frac{W_{curb}}{2} \cdot 2, \frac{L_{curb}}{2}\right) = 170 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{matrix} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{matrix} \right] \right] = 23547 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.L.vert.up} \cdot L_{curb}) \cdot (0.75in) = 8772 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.373$

$Curb_{BotFlangeBending} = \text{"OK"}$

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Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Width

Roof Curb thickness

$t_{Curb} = \text{"12GA"}$ $t_{curb} := thick(t_{Curb}) = 0.1084 \cdot in$

Min width of Roof Curb

$b_{curb} := W_{curb} + \frac{L_{curb}}{4} \cdot 2 + 3in \cdot 2 = 139.59 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := W_{curb} + \min\left(\frac{L_{curb}}{6} \cdot 2, W_{curb}\right) = 115 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{matrix} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{matrix} \right] \right] = 12302 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.W.vert.up} \cdot W_{curb}) \cdot (0.75in) = 5027 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.409$

$Curb_{BotFlangeBending} = \text{"OK"}$

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Web Crippling/Compression of Iso CanFab Curb (AISI S100-16 G5)

Note: Curb stiffeners directly transfer the compressive load from isolator to the base. Therefore, curb web crippling is prevented.

Curb Web with Reinforcement

Max Compression: $Comp_{maxtot} := \max(|C_S|, |C_W|) = 25326.47 \cdot lbs$

Reinforcement per CFS: $CFS_{reinf} :=$ "Single Stiffener 10GA 1"x7"x1" Fy=50ksi 18" Tall on min. 16GA "

Note: min. of 10 GA channel and min. 16 GA curb web

Number of Reinforcement in Length: $n_{reinf} := N_{iso.long} = 8$

Max Compression per Reinf: $Comp_{per.reinf} := \frac{Comp_{maxtot}}{n_{reinf}} = 3.166\,kip$

Spacing: $Spacing := \frac{L_{curb}}{n_{reinf}} = 14 \cdot in$ $KL_r := \frac{1.0 \cdot (H_{curb} - 12.5in)}{0.2339in} = 128$

Factored Nominal Comp. Capacity per reinforcement: $\phi P_{n.reinf} = 21.066 \cdot kip$ **(See attached CFS)**

Total Factored nominal Comp Capacity: $\phi P_{n.tot} := n_{reinf} \cdot \phi P_{n.reinf} = 169 \cdot kip$

D/C Ratio of Compression: $DCR := \frac{Comp_{maxtot}}{\phi P_{n.tot}} = 0.15$

$Comp_{reinf} := if(Comp_{maxtot} < \phi P_{n.tot}, "OK", "NG")$ $Comp_{reinf} = "OK"$

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Check CanFab Curb for Compressive Force due to T/C Coupling of Overturning

Note:
-Since the equipment is only attached to the longer sides of the CanFab Curb, most likely there will be compressive force onto the curb due to T/C coupling.
- Rectangular CanFab Curb will be considered as "Channel" to resist the compressive force.

Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Flanges*

Flat Width:

$$w := \frac{W_{curb}}{2} - R_{curb} = 38.348 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Unstiffened"}$$

Stress at the end of the Width:

$$f_2 := 50ksi \qquad f_1 := 50ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \left| \frac{f_2}{f_1} \right| = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 0.43$$

Critical Compressive Stress (Eq 1.1-4):

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w}\right)^2 = 0.09 \cdot ksi$$

Stress in Compression Element:

$$f := F_y = 50 \cdot ksi \qquad \textbf{(Assume f = Fy)}$$

Slenderness Factor (Eq 1.1-3):

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 23.36$$

Local reduction factor (Eq 1.1-2):

$$\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 0.042$$

Effective Width of the Flanges:

$$b_{eff.flange} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 1.626 \cdot in$$

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Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Web*

Flat Width:

$$w := L_{curb} - R_{curb} \cdot 2 = 112.883 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Stiffened"}$$

Stress at the end of the Width:

$$f_2 := 50ksi \qquad f_1 := 50ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \left| \frac{f_2}{f_1} \right| = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 4$$

Critical Compressive Stress (Eq 1.1-4):

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w} \right)^2 = 0.1 \cdot ksi$$

Stress in Compression Element:

$$f := F_y = 50 \cdot ksi \qquad \textbf{(Assume f = Fy)}$$

Slenderness Factor (Eq 1.1-3):

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 22.55$$

Local reduction factor (Eq 1.1-2):

$$\rho := \left(1 - \frac{0.22}{\lambda}\right) \frac{1}{\lambda} = 0.044$$

Effective Width of the Web:

$$b_{eff.web} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 4.958 \cdot in$$

Effective Area of the Member:

$$A_e := 2 \cdot \left(b_{eff.flange} \cdot t_{curb} \right) + b_{eff.web} \cdot t_{curb} = 0.89 \cdot in^2$$

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Length of the Compressive Member: $L_{curb.web} := h = 29.478 \cdot in$

Young's Modulus for Cold Form Steel: $E := 29500 ksi$

Curb Shear Modulus: $G := 11300 ksi$

Poisson's Ratio $\mu := 0.3$

Section Properties of the Member (From Section Properties Calculator):

$A_{half.curb} := 13.599 in^2$ $r_o := 50.187 in$ $I_x := 26250.724 in^4$ $I_y := 1949.977 in^4$

$J := 0.023 in^4$ $r_x := \sqrt{\frac{I_x}{A_{half.curb}}} = 43.936 \cdot in$ $r_y := \sqrt{\frac{I_y}{A_{half.curb}}} = 11.975 \cdot in$

$C_w := 4.431 \cdot 10^6 \cdot in^6$ $r_{min} := \min(r_x, r_y) = 11.975 \cdot in$

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^2}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{(1.0 \cdot L_{curb.web})^2}\right] = 662356.96 \cdot ksi$$

$$\sigma_{e.y} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_y}\right)^2} = 48044.354 \cdot ksi \qquad \sigma_{e.x} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_x}\right)^2} = 646776.38 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2} = 48044.354 \cdot ksi$$

$$\frac{1.0 \cdot L_{curb.web}}{r_{min}} = 2.46$$

$KL_r = "KL/r < 200, OK"$

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 44795.12 \cdot ksi$$

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Nominal Compressive Stress Capacity: (Eq E2-4)

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 0.033$$

$$F_n := \begin{cases} 0.658^{\lambda_c^2} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^2}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 49.98 \cdot \text{ksi}$$

Compressive Capacity:

$$P_{n.member} := A_e \cdot F_n = 44.47 \cdot \text{kip}$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot P_{n.member} = 37.8 \cdot \text{kip}$$

Factored Max Compressive Force:

$$P_{comp.max} := \max\left(\left|C_S\right|, \left|C_W\right|\right) = 25.326\,\text{kip}$$

D/C Ratio of Compression:

$$DCR := \frac{P_{comp.max}}{\phi P_{n.member}} = 0.67$$

$$Axial_{curb.comp} := \text{if}\left(P_{comp.max} < \phi P_{n.member}, \text{"OK"}, \text{"Provide Channel from above as Web Stiffener"}\right)$$

$Axial_{curb.comp} = \text{"OK"}$

Note: No need to check for interaction since the curb is only subjected to the compressive force.

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Shear of CanFab Curb Webs without Holes (AISI S100-16 G2)

Note: Since the unit is stiffer than the curb and the curb is firmly attached to the unit and to the base structure, curbs will mainly take the lateral forces as shear and axial load rather than bending.

Thickness of Curb:

$$t := \text{thick}(t_{Curb}) = 0.108 \cdot \text{in}$$

Depth-to-Thickness Ratio:

$$\frac{h}{t} = 272$$

Curb Elastic Modulus:

$$E := 29500\text{ksi}$$

Clear distance b/w transverse stiffeners of reinforced web:

$$a := \max\left(\frac{L_{curb}}{2}, W_{curb}\right) = 77 \cdot \text{in} \qquad \frac{a}{h} = 2.61$$

$$k_v := \begin{cases} 5.34 & \text{if } a = L_{curb} \\ 4.00 + \dfrac{5.34}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \dfrac{4.00}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 5.93$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 59 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 89$$

Curb Shear Check due to Load on Longer Side

Area of Web Element:

$$A_w := W_{curb} \cdot t = 8 \cdot \text{in}^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 2.1 \cdot \text{ksi}$$

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$V_{cr} := A_w \cdot F_{cr} = 18\,kip \quad V_y := 0.6 \cdot A_w \cdot F_y = 250\,kip \quad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 3.747$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 17.834 \cdot kip$$

Number of Members within Length: $n := 2$ **(Per Curb Design)**

Design Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 33885.1 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.H} := P_{net} \cdot L_{unit} \cdot H_{total} = 13293.1 \cdot lbs$

Design Shear Demand: $V_u := \max(V_{base.S}, V_{base.W.H}) = 14857.1 \cdot lbs$

D/C Ratio of Shear: $DCR := \frac{V_u}{\phi V_n} = 0.438$

Demand/Capacity Ratio:

$Shear_{in.plane} := \text{if}(V_u < \phi V_n, \text{"OK"}, \text{"NG"})$

$Shear_{in.plane} = \text{"OK"}$

Curb Shear Check due to Load on Shorter Side

Area of Web Element: $A_w := L_{curb} \cdot t = 12 \cdot in^2$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 2.1 \cdot ksi$$

$V_{cr} := A_w \cdot F_{cr} = 26\,kip \quad V_y := 0.6 \cdot A_w \cdot F_y = 368\,kip \quad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 3.747$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 26.216 \cdot kip$$

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Number of Members within Length: $n := 2$ **(Per Curb Design)**

Factored Nominal Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 49810.3 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot W_{unit} \cdot H_{total} = 9149.6 \cdot lbs$

Factored Shear Demand: $V_u := \max(V_{base.S}, V_{base.W.L}) = 14857.1 \cdot lbs$

D/C Ratio of Shear: $DCR := \frac{V_u}{\phi V_n} = 0.298$

Demand/Capacity Ratio:

$Shear_{in.plane} := \text{if}(V_u < \phi V_n, \text{"OK"}, \text{"NG"})$

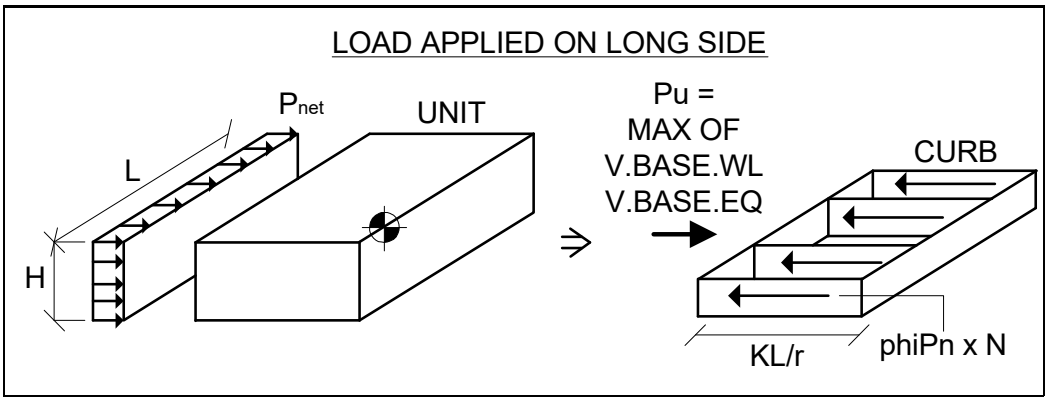
$Shear_{in.plane} = \text{"OK"}$

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Check CanFab Curb for In-Plane Axial due to EQ and Wind (AISI S100-16 E2)

Curb Axial Load Check due to Load on Long Side



Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot L_{unit} \cdot H_{total} = 13.3\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.L}) = 14857.09 \cdot lbs$

Member per CFS: $CFS_{member} :=$ "12GA Custom Curb 30" Tall L.b = 63in"

Max Braced Length of Member: $L_{member} := 48in$ **Conservative since the max anchor spacing is 24"**

Number of Curb in Length: $n_{curb.long} := 3$

Radius of gyration in y-axis: $r_{y.curb} := 0.558in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{2} = 7.43\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 86$ $KL_r =$ "KL/r < 200, OK"

Spacing: $Spacing := \frac{L_{curb}}{n_{curb.long}} = 38 \cdot in$

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 12.036 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.617$

$Axial_{short.curb} =$ "OK"

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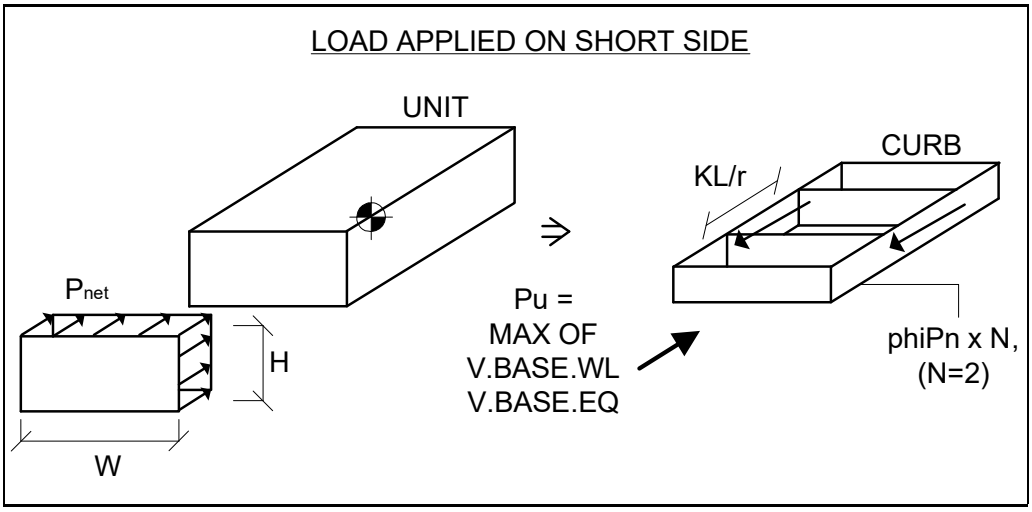
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Curb Axial Load Check due to Load on Short Side



Wind Base Shear on Short Side: $V_{base.W.H} := P_{net} \cdot W_{unit} \cdot H_{total} = 9.1\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.H}) = 14857.09 \cdot lbs$

Member per CFS: CFS_{member} = "12GA Custom Curb 30" Tall L.b = 63in"

Max Braced Length of Member: $L_{member} := \frac{L_{curb}}{n_{curb.long} - 1} = 57 \cdot in$

Number of Curb in Length: $n_{curb} := 2$

Radius of gyration in y-axis: $r_{y.curb} := 0.558\,in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{curb}} = 7.43\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 101$ KL_r = "KL/r < 200, OK"

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 12.036 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.617$

$Axial_{long.curb}$ = "OK"

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DESIGN
for
MAX CURB HEIGHT OF 36"

950 S. GRAND AVENUE, 4TH FLOOR, LOS ANGELES, CALIFORNIA 90015 (213) 483-6490

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Design Wind Loads for Rooftop Equipment (ASCE 7-16 § Table 29.1-1)

$z := 60ft$ **Height above ground level**

$B := 60ft$ **Horizontal dimension of building measured normal to wind direction**

$Exp_{category} := "C"$ **Exposure Category per ASCE 7-16 § 26.7**

$Risk_{category} := "IV"$ **Risk Category per ASCE 7-16 Table 1.5-1**

$$V := \begin{cases} 0mph & \text{if } Risk_{category} = "I" \\ 0mph & \text{if } Risk_{category} = "II" \\ 175mph & \text{otherwise} \end{cases} = 175 \cdot mph$$

Basic Wind Speed per ASCE 7-16 Figure 26.5-1 A,B or C

$K_z = 1.14$ **Velocity Pressure Exposure Coefficient per ASCE 7-16 Table 29.10-1 [Exposure Category "C"]**

$K_{zt} := 1.0$ **Topographic Factor per ASCE 7-16 § 26.8, Figure 26.8-1**

$K_e := 1.0$ **Ground Elevation Factor per ASCE 7-16 § 26.9, Table 26.9-1**

$K_d := 0.85$ **Wind Directionality Factor per ASCE 7-16 § 26.6, Table 26.6-1 (Equipment)**

$q_z := 0.00256 K_z \cdot K_{zt} \cdot K_d \cdot K_e \cdot V^2 = 75.74 \cdot psf$ **Velocity pressure evaluated at height z above ground per ASCE 7-10 § 26.10.2; Eq. 26.10-1**

$GC_{r.lateral.max} := 1.9$ **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.9 for rooftop structures and equipment with Af less than (0.1Bh). (GCr) shall be permitted to be reduced linearly from 1.9 to 1.0 as the value of Af is increased from (0.1Bh) to (Bh)

$GC_{r.vertical.max} := 1.5$ **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.5 for rooftop structures and equipment with A_r less than (0.1*BL*). (GC_r) shall be permitted to be reduced linearly from 1.5 to 1.0 as the value of A_r is increased from (0.1*BL*) to (*BL*)

$P_{net} := q_z \cdot GC_{r.lateral.max} = 143.91 \cdot psf$ **Design Lateral Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-2**

$P_v := q_z \cdot GC_{r.vertical.max} = 113.61 \cdot psf$ **Design Vertical Uplift Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-3**

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Seismic Demands on Nonstructural Components (ASCE 7-16 § 13.3 & 13.6):

$S_{DS} := 1.5$ **Design spectral response acceleration parameter at short periods per USGS map**

$I_p := 1.5$ **Component importance factor ASCE 7-16 § 13.1.3**

$\Omega_0 := 2.0$ **Overstrength factor ASCE 7-16 Table 13.6.1**

Vibr_Isolation = "Yes" **Placement of Unit Vibration Isolated:**

Note: Only "F_p" at seismic concrete anchor has been increased with overstrength factor "Ω_0"

$a_p := 2.5$ $R_p = 2.0$ **Seismic coefficients a_p & R_p**
Per ASCE 7-16 Table 13.6-1 for
Mechanical & Electrical Components

$z = 60\,ft$ **Height in structure of point of attachment of component with respect to the base**

$h := 60ft$ **Average roof height of structure with respect to the base**
Where for roof top equipment:

$z \div h = 1$

F_p: Horizontal Seismic Design Force per *ASCE7-16 § 13.3.1*

F_p shall be takes as $\left(\frac{0.4 \cdot a_p \cdot S_{DS} \cdot I_p}{R_p}\right) \cdot \left(1 + 2 \cdot \frac{z}{h}\right) \cdot W_p = 337.5 \cdot \% \cdot W_p$

F_p is not required to be taken as greater than $\left(1.6 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 360 \cdot \% \cdot W_p$

F_p shall not be taken as less than $\left(0.3 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 67.5 \cdot \% \cdot W_p$

Governing F_p : Horizontal Seismic Design Force $F_p = 337.5 \cdot \% \cdot W_p$

F_v: Vertical Load per ASCE7-16 § 13.3.1.2

Concurrent Vertical Seismic Force: $F_v := 0.2 \cdot S_{DS} \cdot W_p = 30 \cdot \% \cdot W_p$

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Flat Roof Snow Loads (ASCE 7-16 § 7.3):

$Terrain_{CAT} := "C"$ **Terrain Category ASCE 7-16 § 26.7 & Table 7.3-1**

$Exp_{Roof} := "Partially Exposed"$ **Exposure of Roof ASCE 7-16 Table 7.3-1**

$C_e = 1$ **Exposure Factor ASCE 7-16 Table 7.3-1**

$Thermal_{condition} := "All structures except below"$ **Thermal Condition ASCE 7-16 Table 7.3-2**

$C_t = 1$ **Thermal Factor ASCE 7-16 Table 7.3-2**

$Risk_{category} = "IV"$ **Risk Category per ASCE 7-16 Table 1.5-1**

$I_s = 1.2$ **Snow Importance Factor ASCE 7-16 Table 1.5-2**

$p_g := 40psf$ **Ground Snow Loads ASCE 7-16 Figure 7.2-1**

$$p_f := \max\left(0.7 \cdot C_e \cdot C_t \cdot I_s \cdot p_g, \text{if}\left(p_g > 20psf, 20psf \cdot I_s, I_s \cdot p_g\right)\right) = 34 \cdot psf$$

Flat Roof Snow Loads ASCE 7-16 Equation 7.3-1 and § 7.3.4

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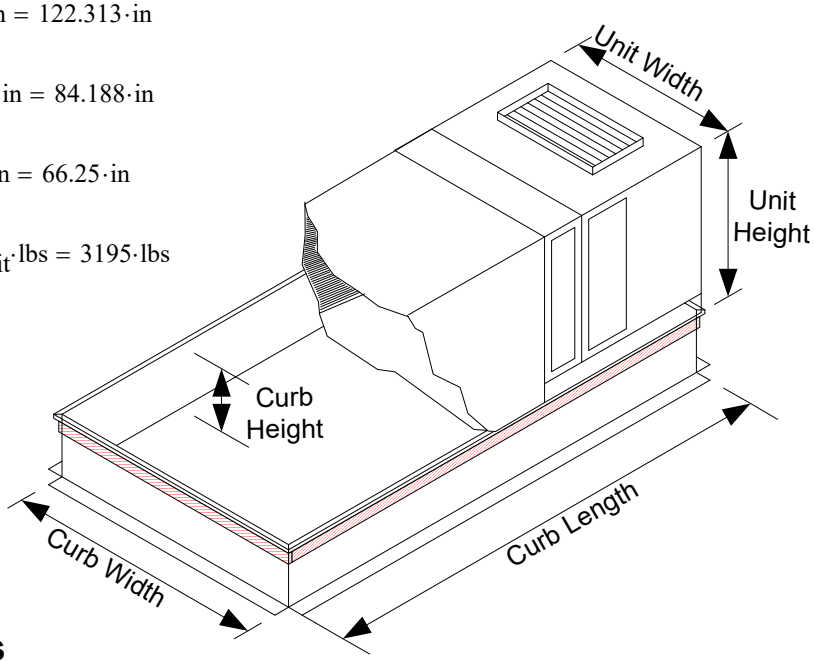
Mechanical Unit Dimensions Curb = "C-6010"

Length of Unit $L_{unit} := L_{unit} \cdot in = 122.313 \cdot in$

Width of Unit $W_{unit} := W_{unit} \cdot in = 84.188 \cdot in$

Height of Unit $H_{unit} := H_{unit} \cdot in = 66.25 \cdot in$

Weight of Unit $Wt_{unit} := Wt_{unit} \cdot lbs = 3195 \cdot lbs$



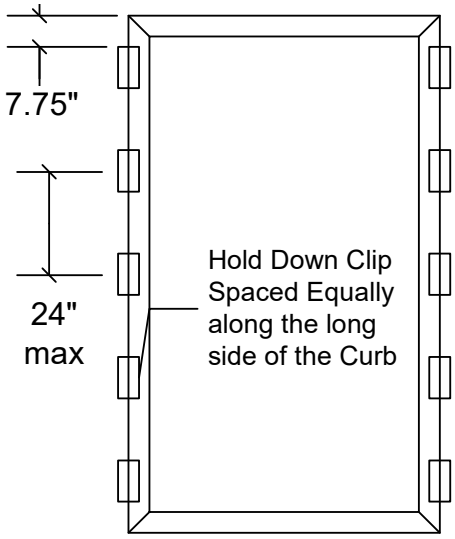
Roof Curb Dimensions

Length of Curb $L_{curb} := L_{curb} \cdot in = 113.188 \cdot in$

Width of Curb $W_{curb} := W_{curb} \cdot in = 77 \cdot in$

Height of Curb $H_{curb} := H_{curb} \cdot in = 48.5 \cdot in$

Weight of Curb $Wt_{curb} := Wt_{curb} \cdot lbs = 1239 \cdot lbs$



Curb Plan

Overall System Dimensions

Total Weight

$Wt_{tot} := Wt_{unit} + Wt_{curb} = 4402 \cdot lbs$

Total height

$H_{total} := H_{unit} + H_{curb} = 114.75 \cdot in$

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Seismic Loading + Snow Loading

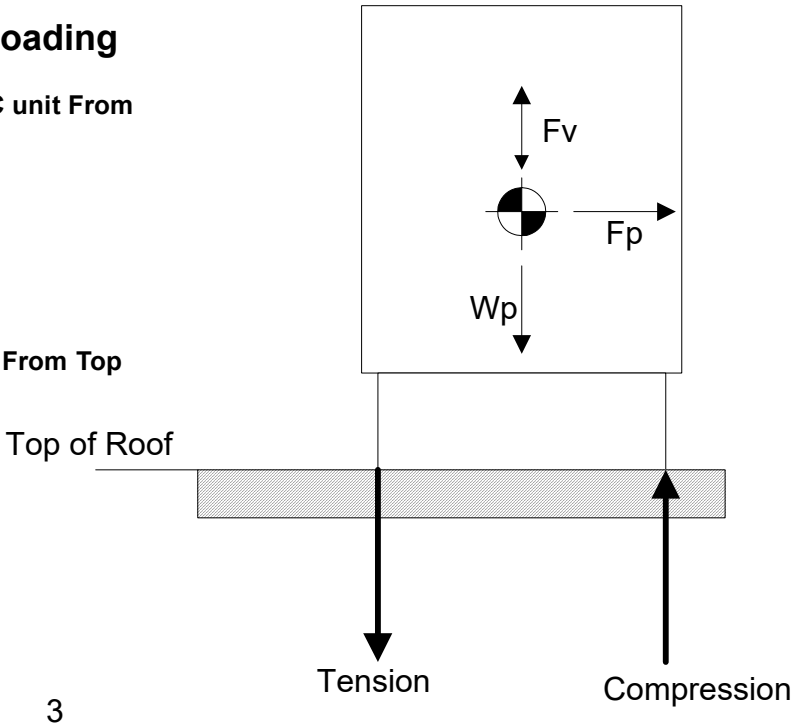
Height for Center of Gravity for HVAC unit From Top of Roof

$h_{CG.unit} := \frac{1}{2} H_{unit} = 33 \cdot in$

$h_{CG} := H_{curb} + h_{CG.unit} = 81.63 \cdot in$

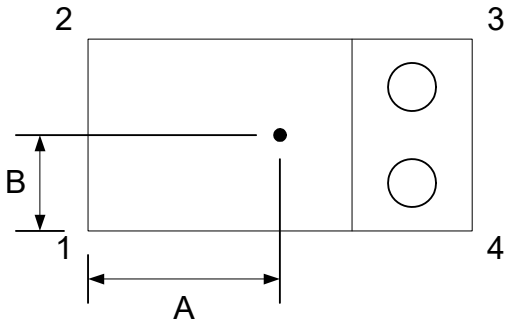
Height for Center of Gravity for Curb From Top of Roof

$h_{CG.curb} := \frac{H_{curb}}{2} = 24.25 \cdot in$



Max Seismic Base Shear

$V_{base.S} := F_p \cdot Wt_{tot} = 14857 \cdot lbs$



Unit C.G. distance in axis parallel to Curb Width $B_{ecc.width} := CG_{short} \cdot in = 36 \cdot in$

Eccentricity in axis parallel to Curb Width

$$e_{width} := \begin{cases} 0in & \text{if } B_{ecc.width} = \text{"N/A"} \\ \left| B_{ecc.width} - \frac{W_{unit}}{2} \right| & \text{otherwise} \end{cases} = 6.09 \cdot in$$

Unit C.G. distance in axis parallel to Curb Length $A_{ecc.length} := CG_{long} \cdot in = 58 \cdot in$

Eccentricity in axis parallel to Curb Length

$$e_{length} := \begin{cases} 0in & \text{if } A_{ecc.length} = \text{"N/A"} \\ \left| A_{ecc.length} - \frac{L_{unit}}{2} \right| & \text{otherwise} \end{cases} = 3.16 \cdot in$$

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Max Net Tension Reaction On Each Side Due To Seismic Loads

$$T_S := \begin{bmatrix} \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{W_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{W_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} \right] \\ \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{L_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{L_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} \right] \end{bmatrix} = \begin{pmatrix} -11545 \\ -7382 \end{pmatrix}\cdot lbs$$

Max Net Compression Reaction On Each Side Due To Seismic Loads

$$C_S := \begin{bmatrix} \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{W_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \\ \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{L_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \end{bmatrix} = \begin{pmatrix} 21353 \\ 16072 \end{pmatrix}\cdot lbs$$

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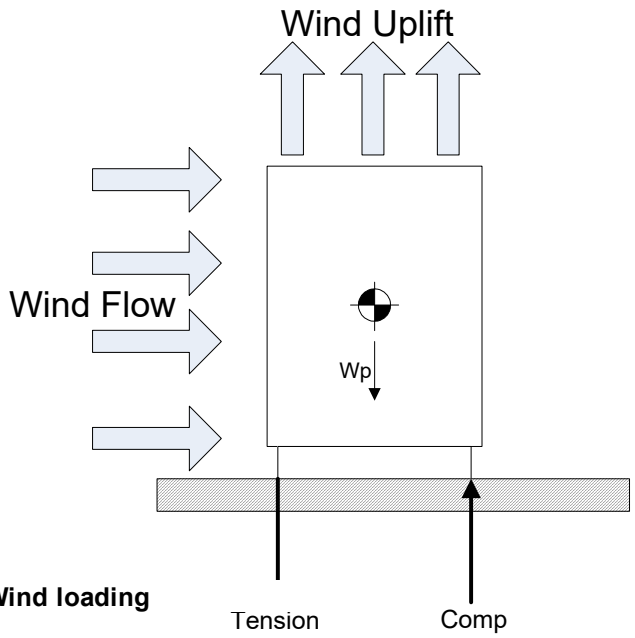
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Wind Loading + Snow Loading



Max Base Shear due to wind loading

$V_{base.W} := P_{net} \cdot L_{unit} \cdot H_{total} = 14026 \cdot lbs$

Max Uplift due to wind loading

$L_{unit.up} := L_{unit} - 0in = 122.313 \cdot in$

$P_{uplift.W} := P_v \cdot L_{unit.up} \cdot W_{unit} = 8124 \cdot lbs$

Max Net Tension Reaction On Each Side Due To Wind loading

$$T_W := \begin{pmatrix} \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} - \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \\ \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} - \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} -12760 \\ -7055 \end{pmatrix} \cdot lbs$$

Max Net Compression Reaction On Each Side Due To Wind loading

$$C_W := \begin{pmatrix} \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} + \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \\ \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} + \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} 15318 \\ 9564 \end{pmatrix} \cdot lbs$$

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Governing Loading @ Curb

Max uplift vertical load along the length of the curb

$$\omega_{x.L.vert.up} := \frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}} = 1353 \cdot plf$$

Max compressive vertical load along the length of the curb

$$\omega_{x.L.vert.comp} := \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}} = 2264 \cdot plf$$

Max vertical load along the length of the curb

$$\omega_{x.L.vert} := \max\left(\omega_{x.L.vert.up}, \omega_{x.L.vert.comp}\right) = 2264 \cdot plf$$

Max uplift vertical load along the width of the curb

$$\omega_{x.W.vert.up} := \frac{\max\left[\left|T_{S_{(1)}}\right|, \left|T_{W_{(1)}}\right|\right]}{W_{curb}} = 1150 \cdot plf$$

Max compressive vertical load along the width of the curb

$$\omega_{x.W.vert.comp} := \frac{\max\left[\left|C_{S_{(1)}}\right|, \left|C_{W_{(1)}}\right|\right]}{W_{curb}} = 2505 \cdot plf$$

Max vertical loading along the width of the curb

$$\omega_{x.W.vert} := \max\left(\omega_{x.W.vert.up}, \omega_{x.W.vert.comp}\right) = 2505 \cdot plf$$

$$\begin{pmatrix} V_{base.S} \\ V_{base.W} \end{pmatrix} = \begin{pmatrix} 14857 \\ 14026 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} |T_S| \\ |C_S| \end{pmatrix} = \begin{pmatrix} 13703 \\ 26725 \end{pmatrix} \cdot lbs$$

$$\begin{pmatrix} F_v \cdot Wt_{tot} \\ P_v \cdot L_{unit} \cdot W_{unit} \end{pmatrix} = \begin{pmatrix} 1321 \\ 8124 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} |T_W| \\ |C_W| \end{pmatrix} = \begin{pmatrix} 14581 \\ 18059 \end{pmatrix} \cdot lbs$$

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Anchorage To Concrete [Expansion Anchor per ACI 318-14]

Number of connection on the long side

$N_B := 7 + 2$

Moment Arm for overturning (Short side)

$B := W_{curb} + 3in \cdot 2 = 83 \cdot in$

Number of Connection on the Short side.

$N_L := 5 + 2$

Moment Arm for over turning (Long side)

$L := L_{curb} + 3in \cdot 2 = 119 \cdot in$

Total Number of Connections

$N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 24$

Max Net Tension Reaction Due to Seismic Load, Fp

$$R_{c.EQ.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 16 \cdot lbs \qquad R_{c.EQ.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 7 \cdot lbs$$

$$R_{c.EQ} := MAX+\left[\begin{bmatrix}\left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{c.EQ.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{c.EQ.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}2527 \\ 2244\end{pmatrix} \cdot lbs$$

Max net Tension Reaction Due to Wind Load, Pnet

$$R_{c.W} := MAX+\left[\begin{bmatrix}\frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}1274 \\ 848\end{pmatrix} \cdot lbs$$

Governing Load Case:

$Govern := if\left(\left|R_{c.EQ}\right| > \left|R_{c.W}\right|, "Seismic", "Wind"\right) = "Seismic"$

Governing Tension Reaction at Each anchor Point:

$R_c := if\left(Govern = "Seismic", R_{c.EQ}, R_{c.W}\right) = \begin{pmatrix}2527 \\ 2244\end{pmatrix} \cdot lbs$

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Max Tension on anchor: $N_{ua} := \max(R_c) = 2527 \cdot lbs$

Max Shear on anchor: $V_{ua} := \frac{\max(\Omega_0 \cdot V_{base.S}, V_{base.W})}{N_t} = 1238 \cdot lbs$

Hilti Kwik Bolt TZ – Carbon Steel
5/8" Anchor with min 4" embedment
Base material: 6" thick Cracked concrete w/
Compressive strength fc' = 3000 psi
Min 6" away from the concrete edge
Evaluation Report: ICC-ESR 1917

Loading Condition:	**Seismic**

Design Tension Capacity [ϕN_n]:	3,631	[lbs]
Design Shear Capacity [ϕV_n]:	4,940	[lbs]

$\phi N_n := \phi N_n \cdot lbs = 3631 \cdot lbs$

$\phi V_n := \phi V_n \cdot lbs = 4940 \cdot lbs$

Utilization:

Tension Utilization:

$\beta_N := \frac{N_{ua}}{\phi N_n} = 70 \cdot \%$

Shear Utilization:

$\beta_V := \frac{V_{ua}}{\phi V_n} = 25 \cdot \%$

Interaction of Tensile and Shear Forces:
Per ACI 318-14 Sec. 17.6

$\beta_{NV} := \frac{(\beta_N) + (\beta_V)}{1.2} = 79 \cdot \%$

$$check\_interaction := \begin{pmatrix} if(\beta_N < 1.0, "OK", "NG") \\ if(\beta_V < 1.0, "OK", "NG") \\ if(\beta_{NV} < 1.0, "OK", "NG") \end{pmatrix} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

$$check\_interaction = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

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Anchorage To Structural Steel [Fillet Weld Conn. per AISI S100-16]

Fillet Weld 2" Long Along the Long and Short Side. Min 2 Connections per Side
Spacing: 48" O.C. for Non-Isolated Curbs; 24" for Isolated Curbs

Number of Welds on the Long Side $N_B := 6$

Moment Arm for Overturning (Short Side) $B := W_{curb} = 77 \cdot in$

Number of Welds on the Short Side. $N_L := 4$

Moment Arm for Overturning (Long Side) $L := L_{curb} = 113 \cdot in$

Total Number of Connections $N_t := \left[\left(N_B\right) + \left(N_L\right)\right] \cdot 2sides = 20$

Max Net Tension Reaction due to Seismic Load FP

$$R_{weld.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 25 \cdot lbs$$

$$R_{weld.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 13 \cdot lbs$$

$$R_{weld.EQ} := MAX+\left[\begin{bmatrix}\left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{weld.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{weld.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}2012 \\ 2044\end{pmatrix} \cdot lbs$$

Max Net Tension Reaction due to Wind Load Pnet

$$R_{weld.W} := MAX+\left[\begin{bmatrix}\frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}1988 \\ 1452\end{pmatrix} \cdot lbs$$

Tension Design Force; SRSS for Loading from Each Direction $T_{u.weld} := \max\left(\left|R_{weld.EQ}\right|, \left|R_{weld.W}\right|\right) = 2868 \cdot lbs$

Shear Load at Each Weld Connection $V_{u.weld} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{N_t} = 743 \cdot lbs$

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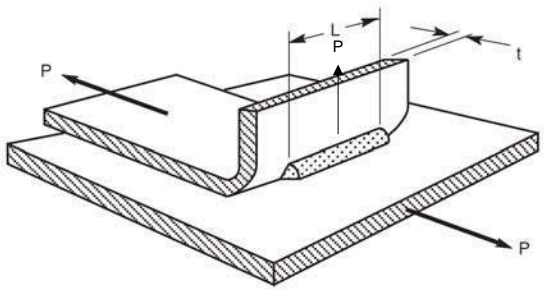
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Total Demand: SRSS of V and T

$$R_{u.weld} := \sqrt{T_{u.weld}^2 + V_{u.weld}^2} = 2963 \cdot lbs$$

Fillet Weld Design per AISI S100-16 Section J2.5

Weld Length at Each Connection Point $L_w := 2in$



Effective Throat Fillet Weld Size

$$t_w := \left(\frac{1}{8}in\right) \cdot 0.707 = 0.088 \cdot in$$

Thickness for the Thinnest Martial Being Welded
Min Curb Thickness = 16GA with Fu=65 ksi

$t_1 := thick("12GA") = 0.1084 \cdot in$

$F_u := 65ksi$

Min weld material strength

$F_{exx} := 70ksi$

For Longitudinal Loading [Parallel capacity is considered to be loading in the direction of the length of the weld] per (Eq. J2.5-1) &(Eq. J2.5-2)

$$\phi P_{long} := \begin{cases} (0.6)\left(1 - \frac{0.01 \cdot L_w}{t_1}\right) \cdot L_w \cdot t_1 \cdot F_u & \text{if } \frac{L_w}{t_1} < 25 \\ (0.5) \cdot 0.75 \cdot t_1 \cdot L_w \cdot F_u & \text{otherwise} \end{cases} = 6895 \cdot lbs$$

where $L_w \div t_1 = 18$

For Transverse Loading per (Eq. J2.5-5)

$$\phi P_{trans} := (0.65) \cdot t_1 \cdot L_w \cdot F_u = 9160 \cdot lbs$$

Strength of Weld Material per (Eq. J2.5-7)

$$\phi P_{weld} := (0.6) \cdot 0.75 \cdot t_w \cdot L_w \cdot F_{exx} = 5568 \cdot lbs$$

Design Strength of Fillet Weld

$$\phi P_n := \min\left(\phi P_{long}, \phi P_{trans}, \phi P_{weld}\right) = 5568 \cdot lbs$$

D/C Ratio for the Welded Connection

$$\beta_{NW} := \frac{R_{u.weld}}{\phi P_n} = 53 \cdot \%$$

$weld_{check} := if\left(\beta_{NW} < 1.0, "OK", "NG"\right)$

$weld_{check} = "OK"$

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Anchorage To Wood Member WITH Lag Screws [NDS-2018 LRFD Strength Design]

*** Use 3/8" Lag Screws along Each Side of the Curb**
*** Assume G=0.5 Douglas Fir-Larch**

Wood Lag Screw Capacity per NDS 2018 Section 11.3

Wet Service Factor: $Cond := "DRY"$ **(e.g. CA = "DRY", AK = "WET")**

$$C_M := \begin{cases} 1.0 & \text{if } Cond = "DRY" \\ 0.7 & \text{if } Cond = "WET" \end{cases} = 1$$ **NDS 2018 Table 11.3.3**

Temperature Factor:
$$C_t := \begin{cases} 0.8 & \text{if } Cond = "DRY" \\ 0.7 & \text{if } Cond = "WET" \end{cases} = 0.8$$ **NDS 2018 Table 11.3.4**

Group Action Factor: $C_g := 0.97$ **NDS 2018 Table 11.3.6C**

Geometry Factor: $C_\Delta := 1.0$ **NDS 2018 Table 12.5.1A,B**

End Grain Factor: $C_{eg} := 1.0$ **NDS 2018 Sec. 12.5.2**

Diaphragm Factor: $C_{di} := 1.0$ **NDS 2018 Sec. 12.5.3**

Toe-Nail Factor: $C_{tn} := 1.0$ **NDS 2018 Sec. 12.5.4**

Format Conversion Factor: $K_F := 3.32$ **NDS 2018 Table 11.3.1**

Resistance Factor: $\phi := 0.65$ **NDS 2018 Table 11.3.1**

Time Effect Factor: $\lambda := 1.0$ **NDS 2018 App N.3.3**

Lateral Design Value: $Z := 130lbs$ **NDS 2018 Table 12K**

Withdrawal Design Value: $W := 305lbs$ **NDS 2018 Table 12.2A**

Lag Screw Diameter: $D_{lag} := \frac{3}{8}in$

Lag Screw Length: $L_{lag} := 4in$

Length of Tapered Tip: $E_{lag} := \frac{7}{32}in$

Lag Screw Penetration: $P_{lag} := 3.78125in$

Eff. Lag Screw Penetration for withdrawal: $P_{\omega.lag} := 2in + \frac{9}{32}in = 2.28 \cdot in$ **NDS 2018 Appx. Table L2**

NDS 2018 Sec. 12.1.4.6

Minimum Penetration DCR <1.0: $DCR_{min.penetration} := \frac{4 \cdot D_{lag}}{P_{\omega.lag}} = 0.66$ $DCR_{min.penetration} = "OK"$

Adj. Lateral Design Value: $Z' := Z \cdot C_M \cdot C_t \cdot C_g \cdot C_\Delta \cdot C_{eg} \cdot C_{di} \cdot C_{tn} \cdot K_F \cdot \phi \cdot \lambda = 218 \cdot lbs$

Adj. Withdrawal Design Value: $W' := W \cdot C_M^{\,2} \cdot C_t \cdot C_{eg} \cdot C_{tn} \cdot K_F \cdot \phi \cdot \lambda = 527 \cdot lbs$ **NDS 2018 Table 11.3.1**

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Number of Lag Screws on the Long Side $N_B := 28 + 2$

Moment Arm for Overturning (Short Side) $B := W_{curb} = 77 \cdot in$

Number of Lag Screws on the Short Side $N_L := 19 + 2$

Moment Arm for Overturning (Long Side) $L := L_{curb} = 113 \cdot in$

Total Number of Lag Screws $N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 94$

Max net Tension Reaction due to Seismic, Fp

$$R_{lag.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 5 \cdot lbs$$

$$R_{lag.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 3 \cdot lbs$$

$$R_{lag.EQ} := MAX+\left[\begin{bmatrix} \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{lag.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{lag.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 401 \\ 386 \end{pmatrix} \cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$R_{lag.W} := MAX+\left[\begin{bmatrix} \frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{L \cdot N_L \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 400 \\ 281 \end{pmatrix} \cdot lbs$$

Tension Design force; SRSS for loading from Each direction $T_{lag} := \max\left(\left|R_{lag.EQ}\right|, \left|R_{lag.W}\right|\right) = 557 \cdot lbs$

Shear load at each anchor location $V_{lag} := \frac{\max\left(V_{base.S} \cdot \sqrt{2}, V_{base.W}\right)}{N_t} = 224 \cdot lbs$

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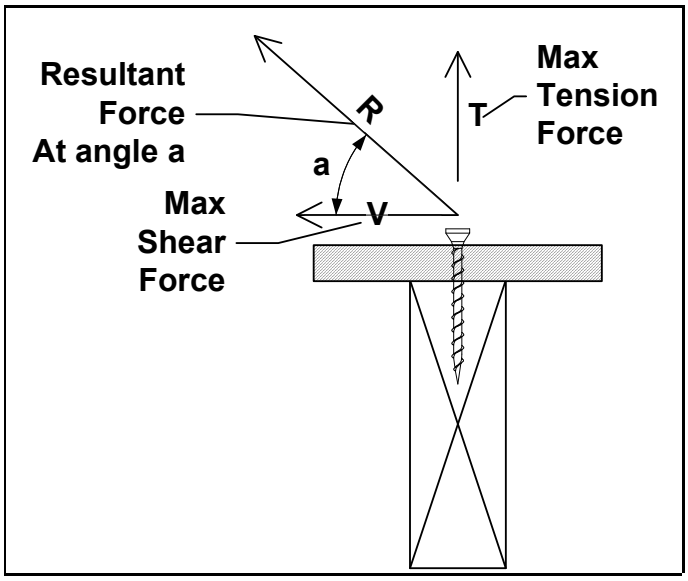
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For Lag Screws Subjected to Combined Lateral and Withdrawal Loading; Design Strength of the Lag Screw Shall Be Adjusted per Hankinson Formula as Prescribed by NDS 2018 Equation 12.4-1



Angle Between Wood Surface and Direction of Resultant Applied Load

$$(\alpha) := \operatorname{atan}\left(\frac{T_{lag}}{V_{lag}}\right) = 68\cdot\text{deg}$$

Combined Demand per Lag Screw @ Strength Level

$$R_{lag} := \sqrt{T_{lag}^{2} + V_{lag}^{2}} = 600\cdot\text{lbs}$$

Adjusted Capacity per NDS 2018 Equation 12.4-1 @ Strength Level

$$Z'_{\alpha} := \frac{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot Z'}{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot\cos(\alpha)^{2} + Z'\cdot\sin(\alpha)^{2}} = 738\cdot\text{lbs}$$

D/C Ratio for the Lag Screw connection to Wood Structure

$$\beta_{Lag} := \frac{R_{lag}}{Z'_{\alpha}} = 81\cdot\%$$

$$\text{Lag}_{Screw.Check} := \text{if}\left(\beta_{Lag} < 1.0, \text{"OK"}, \text{"NG"}\right)$$

$\text{Lag}_{Screw.Check} = \text{"OK"}$

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Bearing and Tilting in Curb Bolted Connection AISI S100-16

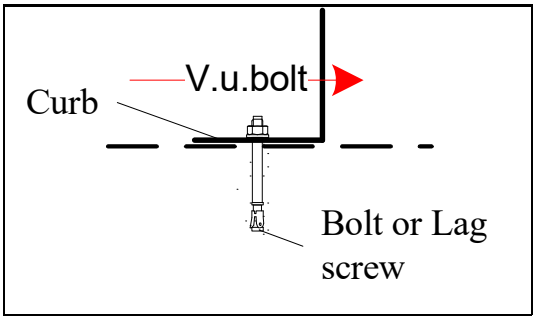
Nominal bolt diameter $d := 0.5in$

Uncoated sheet thickness $t_{curb} := thick("12GA") = 0.108 \cdot in$

Tensile strength of sheet $F_u := 65ksi$

Coefficient for conversion of units $\alpha := 1.0$

Modification Factor $m_f := 1.0$



Modification factor for type of bearing connection, per Table J3.3.1-2; For single shear connection with washers

Bearing Factor $C := \begin{cases} 3 \text{ if } \left(\frac{d}{t_{curb}} < 10\right) \wedge \left(0.024in < t_{curb} < 0.1875in\right) = 3 \\ "NG" \text{ if } \frac{d}{t_{curb}} > 10 \end{cases}$

Bearing factor, which shall be determined according to Table J3.3.1-1 For d/t<10 where $d \div t_{curb} = 5$

Bearing Design Strength per AISI S100-16 Eq. J3.3.1-1

$$\phi P_{n_{(0)}} := (0.6) \cdot \left(m_f \cdot C \cdot d \cdot t_{curb} \cdot F_u\right) = 6341 \cdot lbs$$

Bolt Hole Deformation Design Strength per AISI S100-16 Eq. J3.3.2-1

$$\phi P_{n_{(1)}} := (0.65) \cdot \left[4.64 \cdot \left(\frac{\alpha}{in}\right) \cdot t_{curb} + 1.53\right] \cdot d \cdot t_{curb} \cdot F_u = 4655 \cdot lbs$$

Curb Connection Shear Capacity $\phi P_n := \min\left(\phi P_n\right) = 4655 \cdot lbs$

Loading demand at connection $V_{u.bolt} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{6} = 2476 \cdot lbs$

$Curb\_Conn\_Shear := \text{if}\left(V_{u.bolt} < \phi P_n, "OK", "NG"\right)$ Curb_Conn_Shear = "OK"

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Thickness of Curb, ISO Rail and Clip

(Per AISC Table 17-10 Galvanized)

Hold Down Clip thickness

$t_{Clip} := "12GA"$ $t_{clip} := thick(t_{Clip}) = 0.1084 \cdot in$

Roof Curb thickness

$t_{Curb} := "12GA"$ $t_{curb} := thick(t_{Curb}) = 0.1084 \cdot in$

ISO RAIL thickness

$t_{Curb.iso} := "10GA"$ $t_{curb.iso} := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Note: Iso Rail thickness is only used if the curb is isolated. Not used for non-isolated curbs

Sheet Metal Screws (SMS) Equations and References

SMS properties (ESR-2196 Table 5)

$SMS_{Table} =$

"SMS"	"Diameter"	"HeadDiameter"	"Tension"	"Shear"
"Size"	"d"	"dw"	"Pts"	"Pss"
"#8"	0.164	0.335	1000	1170
"#10"	0.19	0.399	1370	1215
"#12"	0.216	0.415	2325	1880
"#14"	0.25	0.5	4580	2440

SMS Tension Eqns

$P_{not} = 0.85 \cdot t \cdot d \cdot F_u$ **(AISI S100-16 J4.4.1 & J4.4.2)**

$P_{nov} = 1.5 \cdot t \cdot d_w \cdot F_u$ **FOR THE MOST CASES, PULL-OUT CAPACITY IS THE LOWEST**

$P_{nts} = 0.8 \cdot P_{ts}$

SMS Shearn Eqns

$P_{vnot} = 4.2 \cdot \sqrt{(d \cdot t^3)} \cdot F_u$ **(AISI S100-16 J4.3.1)**

$P_{vnov} = 2.7 \cdot t \cdot d \cdot F_u$

$P_{vnss} = 0.8 \cdot P_{ss}$

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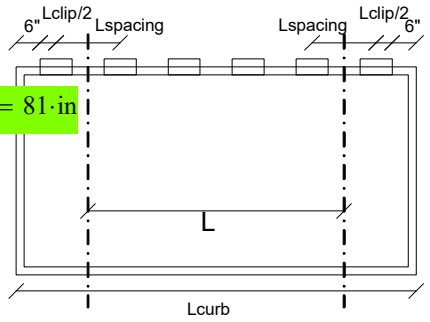
Hold Down Clip Design (Connection of the Mechanical unit to Curb)

Number of Clips on the long side $N_B := 6$

Moment Arm for overturning (Short side) $B := W_{curb} + 1.75in \cdot 2 = 81 \cdot in$

Number of Clips on the Short side. $N_L := 6$

Width of Clips $L_{clip} := 9in$



Curb Centerline Spacing (Long side)

$$L_{spacing} := \frac{L_{curb} - \left(6in + \frac{L_{clip}}{2}\right) \cdot 2}{N_B - 1} = 18.438 \cdot in$$

Moment Arm for overturning (Long side)

$$L := L_{curb} - 2 \cdot \left[6in + \frac{L_{clip}}{2} + L_{spacing} \cdot \frac{(N_L - 2)}{4}\right] = 55.313 \cdot in$$

Total Number of Clips

$$N_t := (N_B) \cdot 2sides = 12$$

Max net Tension Reaction due to Seismic, Fp

$$R_{clip.EQ} := MAX+\left[\begin{array}{l} \left[\frac{F_p \cdot Wt_{unit}}{B \cdot N_B} \cdot h_{CG.unit} + \frac{(0.9 - F_v) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B}\right] - \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} \\ \left[\frac{F_p \cdot Wt_{unit}}{L \cdot N_L} \cdot h_{CG.unit} + \frac{(0.9 - F_v) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L}\right] - \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} \end{array}\right] = \begin{pmatrix} 604 \\ 935 \end{pmatrix} \cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$R_{clip.W} := MAX+\left(\begin{array}{l} \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{unit}^2}{2}}{B \cdot N_B} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{unit}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{unit}^2}{2}}{L \cdot N_L} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{unit}}{N_t} \end{array}\right) = \begin{pmatrix} 1029 \\ 1021 \end{pmatrix} \cdot lbs$$

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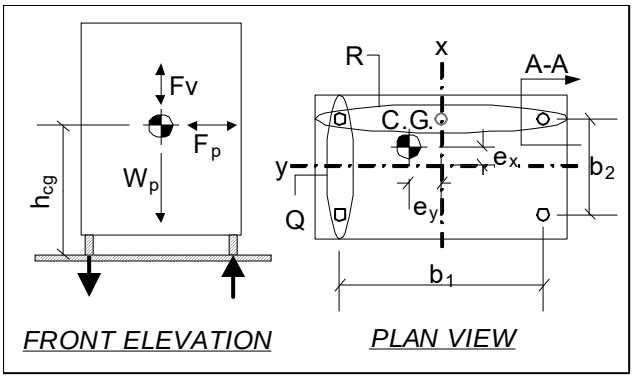
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Tensile and Shear Load calculation per ASHRAE RP-812



Eccentricity along X-X

$e_x := e_{width} = 6.094 \cdot in$

Eccentricity along Y-Y

$e_y := e_{length} = 3.157 \cdot in$

Distance between Seismic Restraints Along Y-Y

$b_1 := L_{curb} - 2 \cdot 6in = 101 \cdot in$

Distance between Seismic Restraints Along X-X

$b_2 := W_{curb} = 77 \cdot in$

Moment of Inertia about X-X

$$I_{xx} := \frac{N_t \cdot (N_t + 2) \cdot (b_1)^2}{12 \cdot (N_t - 2)} = 14335 \cdot in^2$$

Moment of Inertia about Y-Y

$$I_{yy} := \frac{N_t \cdot (b_2)^2}{4} = 17787 \cdot in^2$$

Angle about Tensile Load

$$\Theta_t := \operatorname{atan}\left[\frac{I_{yy} \cdot (b_1)}{I_{xx} \cdot (b_2)}\right] = 58 \cdot deg$$

Angle about Shear Load

$$\Theta_s := \begin{cases} \operatorname{atan}\left(\frac{e_x}{e_y}\right) & \text{if } e_y \neq 0 \\ 0deg & \text{if } e_y = 0 \end{cases} = 63 \cdot deg$$

Max Net Tensile Load Due to Seismic Load, Fp

$$T_{U.EQ.pt1} := \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} - \frac{(0.9 - F_v) \cdot Wt_{unit}}{b_1 \cdot b_2} \cdot \left(\frac{b_1}{2} \cdot e_x + \frac{b_2}{2} \cdot e_y - e_x \cdot e_y\right) = 59 \cdot lbs$$

$$T_{U.EQ.pt2} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \cos(\Theta_t) \cdot \frac{0.5 \cdot b_2}{I_{yy}} = -404 \cdot lbs$$

$$T_{U.EQ.pt3} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \sin(\Theta_t) \cdot \frac{0.5 \cdot b_1}{I_{xx}} = -1075 \cdot lbs$$

$T_{U.EQ} := T_{U.EQ.pt1} + T_{U.EQ.pt2} + T_{U.EQ.pt3} = -1420 \cdot lbs$

Max Net Shear Load Due to Seismic Load, Fp

$$V_{Ux.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\cos(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_2 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_1 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 524 \cdot lbs$$

$$V_{Uy.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\sin(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_1 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_2 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 893 \cdot lbs$$

$$V_{U.EQ} := \sqrt{V_{Ux.EQ}^2 + V_{Uy.EQ}^2} = 1035 \cdot lbs$$

Tension Design force for Hold Down Clips

$T_{clip} := \max(R_{clip.W_0}, R_{clip.W_1}, |R_{clip.EQ}|, |T_{U.EQ}|) = 1420 \cdot lbs$

$|R_{clip.EQ}| = 1113 \cdot lbs$ $|T_{U.EQ}| = 1420 \cdot lbs$

$T_{clip.EQ.max} := \max(|R_{clip.EQ}|, |T_{U.EQ}|) = 1420 \cdot lbs$

$T_{clip.W.max} := \max(R_{clip.W_0}, R_{clip.W_1}) = 1029 \cdot lbs$

Based on ASCE 7-16 Figure 29.4-1 magnitude of force coefficient,

Wind in diagonal direction to the face of equipment produces less force than that of the wind in perpendicular direction to the face of the equipment. Therefore, wind in diagonal direction does not need to be used

Shear Design force for Hold Down Clips

$$V_{clip} := \max\left(\frac{\max(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit})}{N_t}, |V_{U.EQ}|\right) = 1035 \cdot lbs$$

$F_p \cdot Wt_{unit} \cdot \frac{1}{N_t} = 899 \cdot lbs$ $|V_{U.EQ}| = 1035 \cdot lbs$

$P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t} = 675 \cdot lbs$

$V_{clip.EQ.max} := \max\left[\left(F_p \cdot Wt_{unit} \cdot \frac{1}{N_t}\right), |V_{U.EQ}|\right] = 1035 \cdot lbs$

$V_{clip.W.max} := \max\left(\left(P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t}\right)\right) = 675 \cdot lbs$

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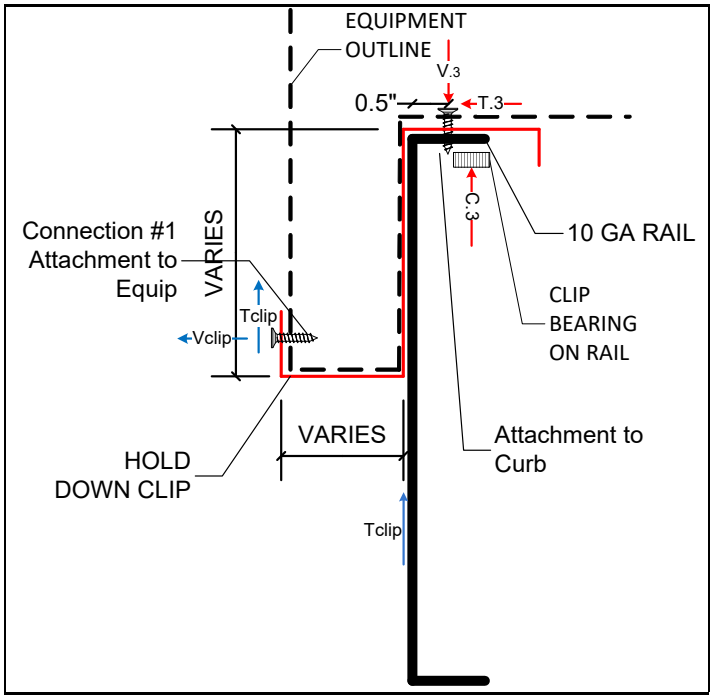
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Loading at Hold Down Clips @ Isolator Curb

$b_{return.iso} := Clip_b \cdot in = 2.125 \cdot in$

$b_{depth.iso} := Clip_c \cdot in = 6 \cdot in$



*For Reference Only

Mu Bending moment in the hold down

$M_u := T_{clip} \cdot b_{return.iso} = 3018 \cdot in \cdot lbs$

Resolve bending moment a T/C couple
Assume 0.5" bearing length
Moment Arm for T/C couple

$d_{T/C} := 1in - 0.5in = 0.5 \cdot in$

V3 is acting as shear on the screws. due to eccentricity of Tension force T

$$V_3 := \frac{T_{clip} \cdot \left[b_{return.iso} + (0) \right]}{d_{T/C}} = 6036 \cdot lbs$$

Additional load from Direct Shear acting out of plane (SRSS)

$V_3 := \sqrt{V_3^{\,2} + V_{clip}^{\,2}} = 6124 \cdot lbs$

Reaction C3 [compression force] is resisted by bearing of the hold down on the curb lip. Assume 0.5" bearing length

$C_3 := V_3 - T_{clip} = 4704 \cdot lbs$

T3 Load due to the shear acting out of plane tension on the screws.

$$T_3 := \left(\max\left(\frac{T_{clip} \cdot b_{return.iso}}{b_{depth.iso}}, V_{clip} \right) \right) = 1035 \cdot lbs$$

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Check Bending in Clip @ Isolator Curb

There are several restraints that prevents the hold down clip for iso-curb to have local bending at the bottom and transfer vertical load demand directly to the face of the curb.

- Hold down is bearing on the face of iso-rail / non-iso curb lip.
- Gasket will act as a "link" member to allow unit base rail and bottom flange to move totegther so flange can't bend unless the unit base rail bends first. However, unit base rail is not likely to bend so bottom flange won't bend

Hold Down Clip thickness

$t_{Clip} = \text{"12GA"}$ $t_{clip} := \text{thick}(t_{Clip}) = 0.1084 \cdot in$

Effective width of hold down clip

$b_c := L_{clip} = 9 \cdot in$

Yield strength of the Clip

$F_{y.c} := 50ksi$

Strength reduction for bending

$\phi_{clip} := 0.9$

Design Bending Capacity (LRFD)

$\phi M_n := \phi_{clip} \cdot F_{y.c} \left(\frac{b_c \cdot t_{clip}^2}{6} \right) = 793 \cdot in \cdot lbs$

Flexural bending demand

$M_{u.clip} := T_{clip} \cdot 0.5in = 710 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.clip}}{\phi M_n} = 0.895$

$Clip_{Bending} = \text{"OK"}$

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Check Flange Bending in Clip @ Isolator Curb

Note:
- **If the curb flange is welded to the 10GA channel and 10GA channel is welded back to the base of the curb, then both tension and compression due to equipment overturning will be taken care by the 10GA channel.**
- **Since the curb will be reinforced with 10GA channel under each isolator, it can be assumed that the loads will trasnferred down to the base structure through the channels. Therefore, flange downward bending at curb due to compressive load does not need to be checked.**

Roof Curb thickness

$t_{Curb} = \text{"12GA"}$ $t_{curb} := thick(t_{Curb}) = 0.1084 \cdot in$

Clip edge to edge distance

$$b_{edge2edge} := \frac{L_{curb} - \left(6in + \frac{L_{clip}}{2}\right) \cdot 2}{N_B - 1} - L_{clip} = 9.438 \cdot in$$

Effective width of Roof Curb

$b_{curb} := L_{clip} + b_{edge2edge} = 18.44 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\frac{b_{curb} \cdot (t_{curb})^2}{6}\right] = 1625 \cdot in \cdot lbs$$

Width of Isolator

$w_{JQ.iso} := 2in$ **2 in. for CQAs**

Flexural bending demand

$$M_{u.Curb} := T_{clip} \cdot \left(\max\left(\frac{1.75in}{2} - 0.5in, \frac{w_{JQ.iso}}{2} - 1in\right)\right) = 533 \cdot in \cdot lbs$$

D/C Ratio for bending

$$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.328$$

$Curb_{Bending} = \text{"OK, Weld 10GA channel ends to curb flange"}$

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Design of Connection#1 Connection of Equipment to hold Down clip

Ultimate SMS screw connection Strength (LRFD)
Strength based on the smallest thickness of Curb and Equipment Housing (min 16 GA) [Fy = 50ksi & Fu=65ksi]

$n_{sms} := 4$ $Size_{ss} := "\#14"$

$t_{ss} := "16GA"$ $F_{u.ss} := 65ksi$

Nominal Tension Strength

$P_{nt} := n_{sms} \cdot T_s(Size_{ss}, t_{ss}, F_{u.ss}) = 3508 \cdot lbs$

$P_{not} := n_{sms} \cdot T_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 3508 \cdot lbs$

$P_{nov} := n_{sms} \cdot T_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 12383 \cdot lbs$

$P_{nts} := n_{sms} \cdot T_{nts}(Size_{ss}, t_{ss}, F_{u.ss}) = 14656 \cdot lbs$

Nominal Shear Strength

$P_{ns} := n_{sms} \cdot V_s(Size_{ss}, t_{ss}, F_{u.ss}) = 7808 \cdot lbs$

$P_{vnot} := n_{sms} \cdot V_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 8737 \cdot lbs$

$P_{vnov} := n_{sms} \cdot V_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 11144 \cdot lbs$

$P_{vnss} := n_{sms} \cdot V_{nss}(Size_{ss}, t_{ss}, F_{u.ss}) = 7808 \cdot lbs$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} V_{clip} \div (\phi_{sms} \cdot P_{nt}) \\ T_{clip} \div (\phi_{sms} \cdot P_{ns}) \end{bmatrix} = \begin{pmatrix} 59 \\ 36 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left[\begin{bmatrix} \left[\frac{T_{clip}}{P_{vnov}} + 0.71\left(\frac{V_{clip}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{T_{clip}}{P_{vnot}} + \left(\frac{V_{clip}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{T_{clip}}{P_{vnss}} + \left(\frac{V_{clip}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right] = 66 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

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Design of Connection#2 Connection of hold Down clip to Curb

Tension loads on SMS connection

$T_{s2} := V_3 = 6124 \cdot lbs$

Shear loads on SMS connection

$V_{s2} := T_3 = 1035 \cdot lbs$

Ultimate SMS screw connection Strength (LRFD)
Strength based on the smallest thickness of Curb and Equipment Housing (min 16 GA) [Fy = 50ksi & Fu=65ksi]

$n_{sms} := 8$ $Size_{ss} := "\#14"$

$t_{ss} := (t_{Curb.iso}) = "10GA"$ $F_{u.ss} := 65ksi$

Nominal Tension Strength

$P_{nt} := n_{sms} \cdot T_s(Size_{ss}, t_{ss}, F_{u.ss}) = 15271 \cdot lbs$

Note:
SMS is getting pulled up so the thicker curb iso rail is engaged for SMS capacity , rather than just the clip itself.

$P_{not} := n_{sms} \cdot T_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 15271 \cdot lbs$

$P_{nov} := n_{sms} \cdot T_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 53898 \cdot lbs$

$P_{nts} := n_{sms} \cdot T_{nts}(Size_{ss}, t_{ss}, F_{u.ss}) = 29312 \cdot lbs$

Nominal Shear Strength

$P_{ns} := n_{sms} \cdot V_s(Size_{ss}, t_{ss}, F_{u.ss}) = 15616 \cdot lbs$

$P_{vnot} := n_{sms} \cdot V_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 56103 \cdot lbs$

$P_{vnov} := n_{sms} \cdot V_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 48508 \cdot lbs$

$P_{vnss} := n_{sms} \cdot V_{nss}(Size_{ss}, t_{ss}, F_{u.ss}) = 15616 \cdot lbs$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} T_{s2} \div (\phi_{sms} \cdot P_{nt}) \\ V_{s2} \div (\phi_{sms} \cdot P_{ns}) \end{bmatrix} = \begin{pmatrix} 80 \\ 13 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left[\begin{bmatrix} \left[\frac{V_{s2}}{P_{vnov}} + 0.71\left(\frac{T_{s2}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{V_{s2}}{P_{vnot}} + \left(\frac{T_{s2}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{V_{s2}}{P_{vnss}} + \left(\frac{T_{s2}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right] = 61 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

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Hold Down clip Bending and Shear Interaction

Diameter of SMS:

$$d_{sms} := \text{vlookup}\left(Size_{ss}, SMS_{Table}, 1\right)_0 \cdot in = 0.25 \cdot in$$

Depth of flat web portion

$$h_{clip.shear} := L_{clip} - n_{sms} \cdot d_{sms} = 7 \cdot in$$

Depth-to-Thickness Ratio:

$$\frac{h_{clip.shear}}{t_{clip}} = 65 \qquad E := 29500ksi \qquad F_y := 50ksi \qquad \mu := 0.3$$

Nominal Shear Stress:
(For unreinforced web)
AISI S100-16 G2.1

$$k_v := 5.34 \qquad \sqrt{\frac{E \cdot k_v}{F_y}} = 56 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 85$$

Area of Web Element:

$$A_w := h_{clip.shear} \cdot t_{clip} = 0.759 \cdot in^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h_{clip.shear}}{t_{clip}}\right)^2} = 34.1 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} \qquad V_y := 0.6 \cdot A_w \cdot F_y = 23\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.937$$

Hole Shear Reduction Factor:
(for circular holes, AISI S100-16 Eq G3-1)

$$c := \frac{h_{clip.shear}}{2} - \frac{d_{sms}}{2.83} = 3.41 \cdot in$$

$$q_s := \begin{cases} 1.0 & \text{if } \frac{c}{t_{clip}} \geq 54 \\ \frac{c}{54 \cdot t_{clip}} & \text{if } 5 \leq \frac{c}{t_{clip}} < 54 \end{cases} = 0.583$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \leq 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \leq 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 19.792 \cdot kip$$

Design Shear Capacity with holes:

$$\phi V_{n.clip} := 0.95 \cdot V_n \cdot q_s = 11 \cdot kip$$

D/C Ratio of V and M per AISI S100-16 Eq H2-1

$$DCR_{V.M.int.clip} := \sqrt{\left(\frac{M_{u.clip}}{\phi M_n}\right)^2 + \left(\frac{\max\left(T_{clip}, V_{clip}\right)}{\phi V_{n.clip}}\right)^2} = 0.9046$$

Demand/Capacity Ratio:

$VandM_{int.clip} = \text{"OK"}$

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ISOLATOR DESIGN [PER OPM-0401-13]

OPM-0401-13 is based on allowable stress design

Number of isolators on the long side

$N_B := 8$ $N_{iso.long} := N_B = 8$

Moment Arm for overturning (Short side)

$B := W_{curb} + \frac{1.75in}{2} \cdot 2 = 79 \cdot in$

Number of isolators on the Short side.

$N_L := 6$

Isolator Centerline Spacing (Long side)

$L_{spacing.iso} := \frac{L_{curb} - (6in) \cdot 2}{N_B - 1} = 14.46 \cdot in$

Moment Arm for overturning (Long side)

$L := L_{curb} - 2 \cdot 6in - 2 \cdot L_{spacing.iso} \cdot \frac{(N_L - 2)}{4} = 72 \cdot in$

Total Number of isolators

$N_t := (N_B) \cdot 2sides = 16$

Max net Tension Reaction due to Seismic, Fp

$EQ_{ASD} := \left[0.6 - (0.7 \cdot F_v)\right] \cdot Wt_{unit} = 1.246\ kip$

$$R_{iso.EQ} := MAX+\left[\begin{bmatrix}\left[\frac{(0.7F_p) \cdot Wt_{unit}}{B \cdot N_B} \cdot (h_{CG.unit} + 0in) + \frac{EQ_{ASD} \cdot e_{width}}{B \cdot N_B}\right] - \frac{EQ_{ASD}}{N_t} \\ \left[\frac{(0.7F_p) \cdot Wt_{unit}}{L \cdot N_L} \cdot (h_{CG.unit} + 0in) + \frac{EQ_{ASD} \cdot e_{length}}{L \cdot N_L}\right] - \frac{EQ_{ASD}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}331 \\ 508\end{pmatrix} \cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$F_{wind.B} := \frac{P_{net} \cdot L_{unit} \cdot (H_{unit} + 0in)}{B \cdot N_B} \cdot \left(\frac{1}{2} \cdot H_{unit} + 0in\right) = 426 \cdot lbs$$

$$F_{wind.L} := \frac{P_{net} \cdot W_{unit} \cdot (H_{unit} + 0in)}{L \cdot N_L} \cdot \left(\frac{1}{2} \cdot H_{unit} + 0in\right) = 426 \cdot lbs$$

$$R_{iso.W} := (0.6) \cdot MAX+\left(\begin{pmatrix}F_{wind.B} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{Wt_{unit}}{N_t} \\ F_{wind.L} + \frac{P_v \cdot L_{unit.up} W_{unit}}{N_t} + \frac{Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{Wt_{unit}}{N_t}\end{pmatrix}\right) = \begin{pmatrix}459 \\ 454\end{pmatrix} \cdot lbs$$

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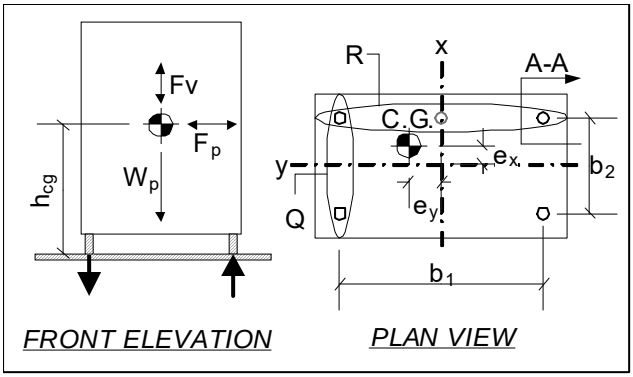
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Tensile and Shear Load calculation per ASHRAE RP-812



Eccentricity along X-X

$e_x := e_{width} = 6.09 \cdot in$

Eccentricity along Y-Y

$e_y := e_{length} = 3.16 \cdot in$

Distance between Seismic Restraints Along Y-Y

$b_1 := L_{curb} - 2 \cdot 6in = 101 \cdot in$

Distance between Seismic Restraints Along X-X

$b_2 := W_{curb} + 2 \cdot \frac{1.75in}{2} = 79 \cdot in$

Moment of Inertia about X-X

$I_{xx} := \frac{N_t \cdot (N_t + 2) \cdot (b_1)^2}{12 \cdot (N_t - 2)} = 17553 \cdot in^2$

Moment of Inertia about Y-Y

$I_{yy} := \frac{N_t \cdot (b_2)^2}{4} = 24806 \cdot in^2$

Angle about Tensile Load

$\Theta_t := \operatorname{atan}\left[\frac{I_{yy} \cdot (b_1)}{I_{xx} \cdot (b_2)}\right] = 61 \cdot deg$

Angle about Shear Load

$$\Theta_s := \begin{cases} \operatorname{atan}\left(\frac{e_x}{e_y}\right) & \text{if } e_y \neq 0 \\ 0deg & \text{if } e_y = 0 \end{cases} = 63 \cdot deg$$

Max Net Tensile Load Due to Seismic Load, Fp

$$T_{U.EQ.pt1} := \frac{(0.6 - 0.7 \cdot F_v) \cdot Wt_{unit}}{N_t} - \frac{(0.6 - 0.7 \cdot F_v) \cdot Wt_{unit}}{b_1 \cdot b_2} \cdot \left(\frac{b_1}{2} \cdot e_x + \frac{b_2}{2} \cdot e_y - e_x \cdot e_y\right) = 13 \cdot lbs$$

$$T_{U.EQ.pt2} := -0.7 \cdot (F_p \cdot Wt_{unit}) \cdot (h_{CG.unit} + 0in) \cdot \cos(\Theta_t) \cdot \frac{0.5 \cdot b_2}{I_{yy}} = -191 \cdot lbs$$

$$T_{U.EQ.pt3} := -0.7 \cdot (F_p \cdot Wt_{unit}) \cdot (h_{CG.unit} + 0in) \cdot \sin(\Theta_t) \cdot \frac{0.5 \cdot b_1}{I_{xx}} = -631 \cdot lbs$$

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$T_{U.EQ} := T_{U.EQ.pt1} + T_{U.EQ.pt2} + T_{U.EQ.pt3} = -810 \cdot lbs$

Max Net Shear Load Due to Seismic Load, Fp

$$V_{Ux.EQ} := 0.7 \cdot F_p \cdot Wt_{unit} \cdot \frac{\cos(\Theta_s)}{N_t} + \frac{0.7 \cdot F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_2 \cdot e_y + 0.7 \cdot F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_1 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 276 \cdot lbs$$

$$V_{Uy.EQ} := 0.7 \cdot F_p \cdot Wt_{unit} \cdot \frac{\sin(\Theta_s)}{N_t} + \frac{0.7 \cdot F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_1 \cdot e_y + 0.7 \cdot F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_2 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 470 \cdot lbs$$

$$V_{U.EQ} := \sqrt{V_{Ux.EQ}^2 + V_{Uy.EQ}^2} = 545 \cdot lbs$$

Tension Design force SRSS for loading from Each direction

$R_{iso.EQ.1.RP812} := \left| T_{U.EQ.pt1} + T_{U.EQ.pt3} \right| = 618 \cdot lbs$

$R_{iso.EQ.0.RP812} := \left| T_{U.EQ.pt1} + T_{U.EQ.pt2} \right| = 178 \cdot lbs$

$$R_{iso.EQ.max_1} := \max\left[\left(R_{iso.EQ.1.RP812} + 0 \cdot R_{iso.EQ.0.RP812}\right), \left(R_{iso.EQ_1} + 0 \cdot R_{iso.EQ_0}\right)\right] = 618 \cdot lbs$$

$$R_{iso.EQ.max_0} := \max\left[\left(R_{iso.EQ.0.RP812} + 0 \cdot R_{iso.EQ.1.RP812}\right), \left(R_{iso.EQ_0} + 0 \cdot R_{iso.EQ_1}\right)\right] = 331 \cdot lbs$$

For the plot:

$R_{iso.EQ.max_1} = 618 \cdot lbs$ $R_{iso.W_1} = 454 \cdot lbs$

$R_{iso.EQ.max_0} = 331 \cdot lbs$ $R_{iso.W_0} = 459 \cdot lbs$

Shear load at each anchor location

For the plot:

$$V_{iso.E} := \max\left[\left[\begin{array}{c} 1.0 \cdot V_{Ux.EQ} + 0 \cdot V_{Uy.EQ} \\ 0.3 \cdot V_{Ux.EQ} + 0 \cdot V_{Uy.EQ} \\ \left[\left(0.7F_p\right) \cdot Wt_{unit} \cdot \frac{1}{N_t}\right] \end{array}\right]\right] = 472 \cdot lbs \qquad V_{iso.W} := 0.6P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t} = 304 \cdot lbs$$

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Isolator Capacity:

$ID_{Iso} := "CQA"$

$T_{n.\Omega} := 2117lbs$ **(ASD)**

$V_{n.\Omega} := 775lbs$ **(ASD)**

Isolator Demand:

$R_{iso.max} := \max\left[\left(R_{iso.EQ.max_1}\right),\left(R_{iso.EQ.max_0}\right),\left(R_{iso.W_1}\right),\left(R_{iso.W_0}\right)\right] = 618\cdot lbs$

$V_{iso.max} := \max\left(V_{iso.E}, V_{iso.W}\right) = 472\cdot lbs$

D/C Ratio of Tension Only.:

$$DCR_{tension} := \frac{R_{iso.max}}{T_{n.\Omega}} = 0.292$$

$DCR_{tension} = "OK"$

D/C Ratio of Shear Only.:

$$DCR_{shear} := \frac{V_{iso.max}}{V_{n.\Omega}} = 0.609$$

$DCR_{shear} = "OK"$

D/C Ratio of Tension Only.:

$$DCR_{Int} := \frac{V_{iso.max}}{V_{n.\Omega}} + \frac{R_{iso.max}}{T_{n.\Omega}} = 0.901$$

$DCR_{Int} = "OK"$

ISOLATOR "SPRING" DESIGN [PER OPM-0401-13]

Factor of Safety of Spring

$FS_{spring} := 0.75$

Compressive Strength of Spring

$$C_{spring.\Omega} := \begin{cases} \left(FS_{spring}\cdot 300lbs\right) & \text{if } ID_{Iso} = "CQA" \\ \left(FS_{spring}\cdot 918lbs\right) & \text{if } ID_{Iso} = "CQB" \\ \left(FS_{spring}\cdot 918lbs\right) & \text{if } ID_{Iso} = "CQBX" \end{cases} = 225\cdot lbs$$

Rated Load per unit self-weight

$$C_{unit.rated.load} := \frac{Wt_{unit}}{N_t} = 200\cdot lbs$$

D/C Ratio of Spring Compression:

$$DCR := \frac{C_{unit.rated.load}}{C_{spring.\Omega}} = 0.888$$

$IsoSpring_{compression} = "OK"$

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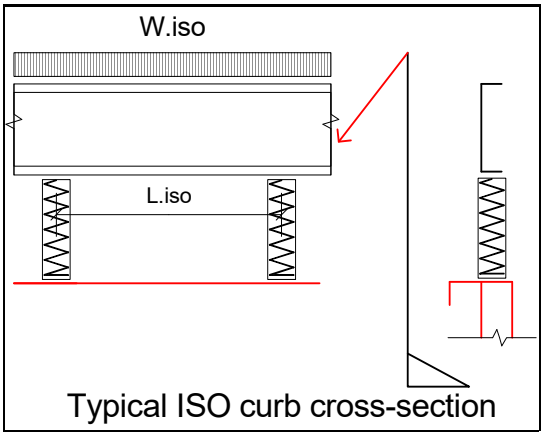
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Check ISO Rail for Bending about Strong and Weak Axis (AISI S100-16 F2.1)



Typical ISO curb cross-section

Thickness of Curb:

$t_{Curb.iso}$ = "10GA" $t := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Inside Bend Radius:

$R := R_{iso} = 0.186 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web:

$h := 7.5in - 2 \cdot (t + R) = 6.85 \cdot in$

Width of Flange:

$h_w := 1in$

Check Curb Bending of Long Side (Strong axis)

Member per CFS: $CFS_{member} :=$ "10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"

Number of Isolators on each Long Side: $N_{iso.long} = 8$

Center-to-Center Spacing of Isolators $L_{iso} := \frac{L_{curb}}{N_{iso.long} - 1} = 16 \cdot in$

Distributed Load $\omega_{iso} := \omega_{x.L.vert} = 2.264\,klf$

Moment Demand on Iso Rail $M_{cx} := \frac{\omega_{iso} \cdot L_{iso}^2}{8} = 6.165 \cdot kip \cdot in$

Curb Elastic Modulus / Yield Stress: $E := 29500ksi$ $F_y := 50ksi$

Curb Shear Modulus: $G := 11300ksi$

Poisson's Ratio $\mu := 0.3$

Section Properties from CFS: $r_x = 2.4893 \cdot in$ $r_o = 2.519 \cdot in$ $C_w = 0.595 \cdot in^6$ $S_x = 1.855 \cdot in^3$

$r_y = 0.2288 \cdot in$ $J = 0.0058 \cdot in^4$ $S_y = 0.3669 \cdot in^3$

$r_{min} := \min(r_x, r_y) = 0.2288 \cdot in$

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Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Flanges*

Flat Width:

$$w := h_w - R_{curb} = 0.847 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Unstiffened"}$$

Stress at the end of the Width:

$$f_2 := 11.407ksi \quad f_1 := 11.407ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \frac{f_2}{f_1} = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 0.43$$

Critical Compressive Stress:

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t}{w}\right)^2 = 304.86 \cdot ksi$$

Stress in Compression Element:

$$f := 18ksi$$

Note: Use f from "Elastive Flexural Buckling Stress" on "Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI E2)"

Slenderness Factor:

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 0.24$$

Local reduction factor:

$$\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 0.389$$

Effective Width of the Flanges:

$$b_{eff.flange} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 0.847 \cdot in$$

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Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Web*

Flat Width:

$w := h = 6.851 \cdot in$

Stiffened Web Check:

$Stiffened_{check} := "Stiffened"$

Stress at the end of the Width:

$f_2 := 11.407ksi$ $f_1 := 11.407ksi$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \frac{f_2}{f_1} = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = "Stiffened" \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = "Unstiffened" \end{cases} = 4$$

Critical Compressive Stress:

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t}{w}\right)^2 = 43.4 \cdot ksi$$

Stress in Compression Element:

$f := 18ksi$

Note: Use f from "Elastive Flexural Buckling Stress" on "Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI E2)"

Slenderness Factor:

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 0.64$$

Local reduction factor:

$$\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 1.022$$

Effective Width of the Web:

$$b_{eff.web} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 6.851 \cdot in$$

Effective Area of the Member:

$$A_e := 2 \cdot \left(b_{eff.flange} \cdot t\right) + b_{eff.web} \cdot t = 1.181 \cdot in^2$$

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For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. F2.1.1-4,5)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(1.0 \cdot L_{iso}\right)^2}\right] = 97 \cdot ksi$$

$$\sigma_{ey} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{iso}}{r_y}\right)^2} = 58 \cdot ksi \qquad \frac{1.0 \cdot L_{iso}}{r_y} = 71$$

KL_r = "KL/r < 200, OK"

Cb per Eq. F2.1.1-2

$$M_A := \frac{\omega_{iso} \cdot \frac{L_{iso}}{4}}{2} \cdot \left(L_{iso} - \frac{L_{iso}}{4}\right) = 4.62 \cdot kip \cdot in$$

$$M_B := M_{cx} = 6.17 \cdot kip \cdot in$$

$$M_C := \frac{\omega_{iso} \cdot \frac{3 \cdot L_{iso}}{4}}{2} \cdot \left(L_{iso} - \frac{3 \cdot L_{iso}}{4}\right) = 4.62 \cdot kip \cdot in$$

$$C_b := \min\left(1.0, \frac{12.5 \cdot M_{cx}}{2.5 \cdot M_{cx} + 3 \cdot M_A + 4 \cdot M_B + 3.M_C}\right) = 1$$

Elastic Critical Lateral-Torsional Buckling Stress per Eq. F2.1.1-1 for Singly Symmetry:

$$F_e := \frac{C_b \cdot r_o \cdot A_e}{S_x} \cdot \sqrt{\sigma_{ey} \cdot \sigma_t} = 121 \cdot ksi$$

LTB Design Stress: Eq. F2.1-3,4,5:

$$F_c := \begin{cases} F_y & \text{if } F_e \geq 2.78 \cdot F_y \\ \frac{10}{9} \cdot F_y \cdot \left(1 - \frac{10 \cdot F_y}{36 \cdot F_e}\right) & \text{if } 2.78 \cdot F_y > F_e > 0.56 \cdot F_y \\ F_e & \text{if } 0.56 \cdot F_y \geq F_e \end{cases} = 49 \cdot ksi$$

Moment Capacity Eq. F2.1-1:

$$\phi M_{nx} := 0.9 \cdot S_x \cdot \min\left(F_c, F_y\right) = 82 \cdot kip \cdot in$$

D/C Ratio of Bending:

$$DCR := \frac{M_{cx}}{\phi M_{nx}} = 0.075$$

$Iso_{Bending}$ = "OK"

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Check Curb Bending of Long Side (Weak axis)

Center-to-Center Spacing of Braces

$$L_{brace} := \frac{L_{curb}}{N_{iso.long} - 1} = 16 \cdot in$$

Note for weak-axis bracing length:
Max weak-axis span length of Iso Rail is larger than L_{brace} per cut sheet. However, the Iso Rail is braced with clip at max 24" O.C. at top and isolator at max 36" O.C. at bottom such that the actual unbraced length is as follows.

Distributed Load

$$\omega_{iso} := \frac{\max\left(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit}\right)}{L_{curb}} = 1.143\ klf$$

Moment Demand on Iso Rail

$$M_{cy} := \frac{\omega_{iso} \cdot L_{brace}^{2}}{8} = 3.114 \cdot kip \cdot in$$

Member per CFS:

$$CFS_{member} = \text{"10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"}$$

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. F2.1.1-4,5)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(1.0 \cdot L_{brace}\right)^2}\right] = 97 \cdot ksi$$

$$\sigma_{ex} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{brace}}{r_x}\right)^2} = 6900 \cdot ksi \qquad \frac{1.0 \cdot L_{brace}}{r_x} = 6$$

$$KL_r = \text{"KL/r < 200, OK"}$$

Cb per Eq. F2.1.1-2

$$M_A := \frac{\omega_{iso} \cdot \frac{L_{brace}}{4}}{2} \cdot \left(L_{brace} - \frac{L_{brace}}{4}\right) = 2.34 \cdot kip \cdot in$$

$$M_B := M_{cy} = 3.11 \cdot kip \cdot in$$

$$M_C := \frac{\omega_{iso} \cdot \frac{3 \cdot L_{brace}}{4}}{2} \cdot \left(L_{brace} - \frac{3 \cdot L_{brace}}{4}\right) = 2.34 \cdot kip \cdot in$$

$$C_b := \min\left(1.0, \frac{12.5 \cdot M_{cx}}{2.5 \cdot M_{cx} + 3 \cdot M_A + 4 \cdot M_B + 3 \cdot M_C}\right) = 1$$

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Elastic Critical Lateral-Torsional Buckling Stress per Eq. F2.1.1-1 for Singly Symmetry:

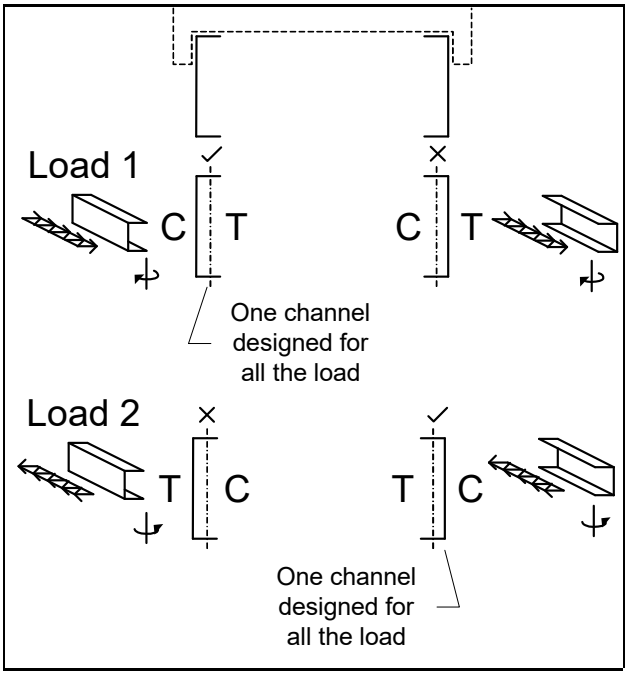
$$F_e := \frac{C_b \cdot r_o \cdot A_e}{S_y} \cdot \sqrt{\sigma_{ey} \cdot \sigma_t} = 610 \cdot ksi$$

LTB Design Stress: Eq. F2.1-3,4,5:

$$2.78 \cdot F_y = 139 \cdot ksi$$

$$0.56 \cdot F_y = 28 \cdot ksi$$

$$F_c := \begin{cases} F_y & \text{if } F_e \geq 2.78 \cdot F_y \\ \frac{10}{9} \cdot F_y \cdot \left(1 - \frac{10 \cdot F_y}{36 \cdot F_e}\right) & \text{if } 2.78 \cdot F_y > F_e > 0.56 \cdot F_y \\ F_e & \text{if } 0.56 \cdot F_y \geq F_e \end{cases} = 50 \cdot ksi$$



Note:

For ISO rail weak-axis bending capacity, rails are oriented and designed so that the stiffer side of ISO rail can take the entire bending load by itself without putting a lot of bending load to the iso rail on the other side

Moment Capacity Eq. F2.1-1:

$$\phi M_{ny} := 0.9 \cdot S_y \cdot \min(F_c, F_y) = 16.5105 \cdot kip \cdot in$$

D/C Ratio of Bending:

$$DCR := \frac{M_{cy}}{\phi M_{ny}} = 0.189$$

$$Iso_{Bending} := \text{if}(M_{cy} < \phi M_{ny}, \text{"OK"}, \text{"NG"})$$

$Iso_{Bending} = \text{"OK"}$

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Web Crippling of ISO Rail (AISI S100-16 G.5)

Governing Compression:

$$P_{web.crip} := \frac{\omega_{x.L.vert} \cdot L_{iso}}{2} = 1525 \cdot lbs$$

Yield Strength:

$$F_y := 50ksi$$

Bearing Length:

$N := 2in$ **2 in. for CQAs**

Thickness of Curb:

$t_{Curb.iso} = \text{"10GA"}$ $t := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Inside Bend Radius:

$R := R_{iso} = 0.186 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web:

$h = 6.85 \cdot in$

Angle btween plane of web and bearing surface:

$\theta := 90deg$

Web Crippling Limit Check (AISI Table G5-2):

$\frac{R}{t} = 1$ $\frac{h}{t} = 50$ $\frac{N}{t} = 14$ $\frac{N}{h} = 0.29$

$$LimitCheck_{webcrippling} := if\left[\left(\frac{h}{t} < 200\right) \wedge \left(\frac{N}{t} < 210\right) \wedge \left(\frac{N}{h} < 2\right) \wedge \left(\frac{R}{t} < 2\right), \text{"OK"}, \text{"NG, Need Reinf"}\right]$$

$LimitCheck_{webcrippling} = \text{"OK"}$

End Case Coefficient Single Web Channel (AISI Table G5-2):

$C := 2$ $C_R := 0.11$ $C_N := 0.37$ $C_h := 0.01$

Reduction Factor Web Crippling Strength:

$\phi_{web.end} := 0.75$ **(For Unfastened Flanges with Two-Flange Loading or Reaction. Worst Case)**

$\phi_{web.int} := 0.8$

Design Web Crippling Strength:

$$P_{n.end} := C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 3729 \cdot lbs$$

$$\phi P_{n.end} := \phi_{web.end} \cdot P_{n.end} = 2796 \cdot lbs$$

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Interior Case Coefficient Single Web Channel (AISI Table G5-2):

$C := 13$ $C_R := 0.47$ $C_N := 0.25$ $C_h := 0.04$

Design Web Crippling Strength:

$$P_{n.interior} := C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 7905 \cdot lbs$$

$$\phi P_{n.interior} := \left(\phi_{web.int}\right) \cdot P_{n.interior} = 6324 \cdot lbs$$

Design Strength:

$$P_{n.web.crip} := \min\left(P_{n.end}, P_{n.interior}\right) = 3729 \cdot lbs$$

$$\phi P_{n.web.crip} := \min\left(\phi P_{n.end}, \phi P_{n.interior}\right) = 2796 \cdot lbs$$

D/C Ratio of Shear:

$$DCR := \frac{P_{web.crip}}{\phi P_{n.web.crip}} = 0.545$$

Demand/Capacity Ratio:

$$Web_{crippling} := if\left[\left(P_{web.crip} < \phi P_{n.web.crip}\right) \wedge \left(\phi P_{n.end} > 0\right) \wedge \frac{h}{t} < 200, "OK", "NG, Need Reinf"\right]$$

$Web_{crippling} = "OK"$

D/C Ratio of Interaction:
AISI Eq. H3-1b

$$DCR_{int.web} := \frac{0.91 \cdot \left(\frac{P_{web.crip}}{P_{n.web.crip}}\right) + \frac{M_{cx}}{\left(\frac{\phi M_{nx}}{0.9}\right)}}{1.33 \cdot 0.9} = 0.367$$

$Iso_{Shear} = "OK"$

$Iso_{Interaction} = "OK"$

Per AISI S100-16 H3,
Only x-axis needs to check for interaction

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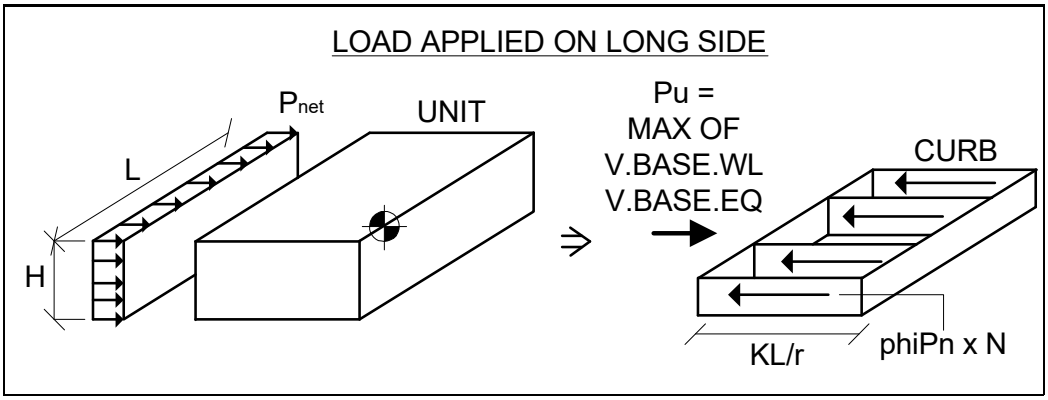
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Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI S100-16 E2)

Curb Axial Load Check due to Load on Long Side



Wind Base Shear of Unit on Long Side: $V_{base.W.L} := P_{net} \cdot L_{unit} \cdot H_{unit} = 8.1\,kip$

Seismic Base Shear of Unit on Long Side: $V_{base.S.L} := F_p \cdot Wt_{unit} = 10.8\,kip$

Max Axial: $P_u := \max\left(V_{base.S.L}, V_{base.W.L}\right) = 10783.46 \cdot lbs$

Member per CFS: $CFS_{member} =$ "10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"

Number of Curb in Length: $n_{iso} := 3$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{iso}} = 3.59\,kip$

Max Braced Length of Member: $L_{member} := W_{curb} = 77 \cdot in$

Effective Length factor: $K := 0.5$

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For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. E2.2-5, E2.2-6)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(K \cdot L_{member}\right)^2}\right] = 24 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2} = 10 \cdot ksi$$

$$\frac{K \cdot L_{member}}{r_{min}} = 168$$

KL_r = "KL/r < 200, OK"

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 7 \cdot ksi$$

Nominal Compressive Stress Capacity (Eq E2-4):

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 2.631$$

$$F_n := \begin{cases} 0.658^{\lambda_c^{\,2}} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^{\,2}}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 6.34 \cdot ksi$$

Strength reduction for Compression: $\phi_c := 0.85$

Factored Compressive Capacity: $\phi P_{n.member} := \phi_c \cdot A_e \cdot F_n = 6.36\,kip$

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.565$

$Axial_{reinf} := \text{if}\left(P_{u.EAmember} < \phi P_{n.member}, \text{"OK"}, \text{"NG"}\right)$

$Axial_{reinf}$ = "OK"

Note:
No need to check for interaction since equipment is not attached to the short side

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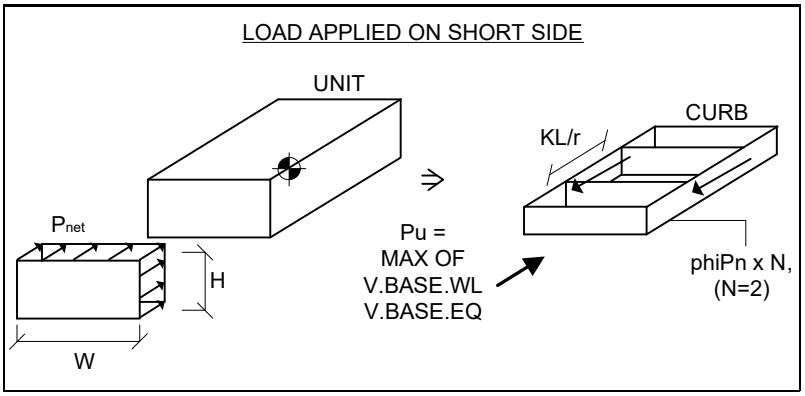
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Curb Axial Load Check due to Load on Short Side



Wind Base Shear on Short Side: $V_{base.W.H} := P_{net} \cdot W_{unit} \cdot H_{unit} = 5.6\,kip$

Seismic Base Shear of Unit on Short Side: $V_{base.S.W} := F_p \cdot Wt_{unit} = 10.8\,kip$

Max Axial: $P_u := \max\left(V_{base.S.W}, V_{base.W.H}\right) = 10783.46 \cdot lbs$

Member per CFS: $CFS_{member} = \text{"10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"}$

Number of Curb in Length: $n_{curb} := 2$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{curb}} = 5.39\,kip$

Max Braced Length of Member: $L_{member} := \frac{L_{curb}}{n_{iso} - 1} = 57 \cdot in$

Effective Length factor: $K := 0.5$

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. E2.2-5, E2.2-6)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(K \cdot L_{member}\right)^2}\right] = 38 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2} = 19 \cdot ksi \qquad \frac{K \cdot L_{member}}{r_{min}} = 124$$

$KL_r = \text{"KL/r < 200, OK"}$

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 13 \cdot ksi$$

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Nominal Compressive Stress Capacity (Eq E2-4):

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 1.989$$

$$F_n := \begin{cases} 0.658^{\lambda_c^2} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^2}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 11.08 \cdot \text{ksi}$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot A_e \cdot F_n = 11.12\,\text{kip}$$

D/C Ratio of Compression:

$$DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.485$$

$$Axial_{reinf} := \text{if}\left(P_{u.EAmember} < \phi P_{n.member}, \text{"OK"}, \text{"NG"}\right)$$

$Axial_{reinf} = \text{"OK"}$

Note:
If the load direction is in perpedicular plane to the short side of the equipment, the channels will only experience axial load and no bending will occur at the channel. Therefore, no need to check for interaction since the channels

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Shear of ISO Rail Webs without Holes (AISI S100-16 G2)

Note: The connection holes are not centered at mid-depth of isolated curb rail so AISI G2 shall be used

Deeper Section (h = depth)

Thickness of Curb: $t := \text{thick}(t_{Curb.iso}) = 0.138 \cdot in$

Depth-to-Thickness Ratio: $\frac{h}{t} = 50$

Curb Elastic Modulus: $E := 29500ksi$

Clear distance b/w transverse stiffeners of reinforced web: $a := L_{iso} = 16 \cdot in$

Clear Distance-to-Thickness Ratio: $\frac{a}{h} = 2.36$

Nominal Shear Stress:

$$k_v := \begin{cases} 5.34 \text{ if } a = L_{iso} \\ 4.00 + \frac{5.34}{\left(\frac{a}{h}\right)^2} \text{ if } \left(\frac{a}{h} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \frac{4.00}{\left(\frac{a}{h}\right)^2} \text{ if } \left(\frac{a}{h} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 6.06$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 60 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 90$$

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Curb Shear Check due to Load on Longer Side

Area of Web Element:

$$A_w := h \cdot t = 0.947 \cdot in^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 65.7 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} = 62\,kip \qquad V_y := 0.6 \cdot A_w \cdot F_y = 28\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.676$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 28.404 \cdot kip$$

Number of Members within Length: $n := 1$ **(Per Curb Design)**

Design Shear Capacity:

$$\phi V_{n.h} := 0.95 \cdot n \cdot V_n = 26.98 \cdot kip$$

Design Shear Demand:

$$V_{u.h} := \frac{\omega_{x.L.vert} \cdot L_{iso}}{2} = 1525.2 \cdot lbs$$

D/C Ratio of Shear:

$$DCR := \frac{V_{u.h}}{\phi V_{n.h}} = 0.057$$

Demand/Capacity Ratio:

$Shear_{in.plane} = \text{"OK"}$

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Shallower Section (h.w = Width)

Thickness of Curb: $t := thick(t_{Curb.iso}) = 0.138 \cdot in$

Depth-to-Thickness Ratio: $\frac{h_w}{t} = 7$

Curb Elastic Modulus: $E := 29500ksi$

Clear distance b/w transverse stiffeners of reinforced web: $a := L_{brace} = 16 \cdot in$

Clear Distance-to-Thickness Ratio: $\frac{a}{h_w} = 16.17$

Nominal Shear Stress:

$$k_v := \begin{cases} 5.34 & \text{if } a = L_{brace} \\ 4.00 + \frac{5.34}{\left(\frac{a}{h_w}\right)^2} & \text{if } \left(\frac{a}{h_w} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \frac{4.00}{\left(\frac{a}{h_w}\right)^2} & \text{if } \left(\frac{a}{h_w} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 5.36$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 56 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 85$$

Curb Shear Check due to Load on Longer Side

Area of Web Element: $A_w := h_w \cdot t = 0.1382 \cdot in^2$

Number of Members within Length: $n := 1$ **(Per Curb Design)**

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 58.1 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} = 8\,kip \qquad V_y := 0.6 \cdot A_w \cdot F_y = 4\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.719$$

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$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 4.146 \cdot \text{kip}$$

Design Shear Capacity:

$$\phi V_{n.hw} := 0.95 \cdot n \cdot V_n = 3.9 \cdot \text{kip}$$

Design Shear Demand:

$$V_{u.hw} := \frac{\left(\frac{\max\left(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit}\right)}{L_{curb}} \right) \cdot L_{brace}}{2} = 770.2 \cdot \text{lbs}$$

D/C Ratio of Shear:

$$DCR := \frac{V_{u.hw}}{\phi V_{n.hw}} = 0.196$$

Demand/Capacity Ratio:

$Shear_{in.plane}$ = "OK"

D/C Ratio of Vx and Mx:

$$DCR_{V.M.int} := \begin{cases} \left(0.6 \cdot \frac{M_{cx}}{\phi M_{nx}} + \frac{V_{u.h}}{\phi V_{n.h}}\right) \cdot \frac{1}{1.3} & \text{if } \frac{M_{cx}}{\phi M_{nx}} > 0.5 \wedge \frac{V_{u.h}}{\phi V_{n.h}} > 0.7 \\ \sqrt{\left(\frac{M_{cx}}{\phi M_{nx}}\right)^2 + \left(\frac{V_{u.h}}{\phi V_{n.h}}\right)^2} & \text{otherwise} \end{cases} = 0.094$$

Demand/Capacity Ratio:

$VandMx_{int}$ = "OK"

D/C Ratio of Vy and My:

$$DCR_{V.M.int} := \begin{cases} \left(0.6 \cdot \frac{M_{cy}}{\phi M_{ny}} + \frac{V_{u.hw}}{\phi V_{n.hw}}\right) \cdot \frac{1}{1.3} & \text{if } \frac{M_{cy}}{\phi M_{ny}} > 0.5 \wedge \frac{V_{u.hw}}{\phi V_{n.hw}} > 0.7 \\ \sqrt{\left(\frac{M_{cy}}{\phi M_{ny}}\right)^2 + \left(\frac{V_{u.hw}}{\phi V_{n.hw}}\right)^2} & \text{otherwise} \end{cases} = 0.272$$

Demand/Capacity Ratio:

$VandMy_{int}$ = "OK"

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Web Crippling/Compression of Non-iso CanFab Curb (AISI S100-16 G5)

Governing Compression for Non-Isolated Curb:

$$P_{web.crip.int} := \max\left[\frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}}, \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}}\right] \cdot L_{spacing.non.iso} = 5797 \cdot lbs$$

$$P_{web.crip.end} := 0.5 \cdot P_{web.crip.int} = 2898 \cdot lbs$$

Yield Strength: $F_y := 50ksi$

Bearing Length: $N_{bearing} := L_{spacing.non.iso} = 31 \cdot in$

Thickness of Curb: $t_{Curb} = \text{"12GA"}$ $t := thick(t_{Curb}) = 0.1084 \cdot in$

Inside Bend Radius: $R := R_{curb} = 0.153 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web: $h := 36in - 2 \cdot (t + R) = 35.48 \cdot in$

Angle btween plane of web and bearing surface: $\theta := 90deg$

Web Crippling Limit Check (AISI Table G5-2): $\frac{R}{t} = 1$ $\frac{h}{t} = 327$ $\frac{N_{bearing}}{t} = 283$ $\frac{N_{bearing}}{h} = 0.87$

End Case Coefficient Single Web Channel (AISI Table G5-2): $C := 13$ $C_R := 0.32$ $C_N := 0.05$ $C_h := 0.04$

Reduction Factor Web Crippling Strength: $\phi_{web.end} := 0.9$ $\phi_{web.int} := 0.8$ **(For Unfastened partially Stiffened Flanges with Two-Flange Loading or Reaction.)**

Design Web Crippling Strength:

$$\phi P_{n.end} := \left(\phi_{web.end}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 2171 \cdot lbs$$

Interior Case Coefficient Single Web Channel (AISI Table G5-2): $C := 24$ $C_R := 0.52$ $C_N := 0.15$ $C_h := 0.001$

Design Web Crippling Strength:

$$\phi P_{n.interior} := \left(\phi_{web.int}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 14965 \cdot lbs$$

D/C Ratio of Shear: $DCR_{end} := \frac{P_{web.crip.end}}{2 \cdot \phi P_{n.end}} = 0.668$ $DCR_{int} := \frac{P_{web.crip.int}}{\phi P_{n.interior}} = 0.387$

Demand/Capacity Ratio: **Note: Factor of 2 for two ends connected together at the end**

$Web_{crippling} = \text{"OK"}$

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Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Length

Roof Curb thickness

$t_{Curb} = \text{"12GA"}$ $t_{curb} := thick(t_{Curb}) = 0.1084 \cdot in$

Min width of Roof Curb

$b_{curb} := L_{curb} + \frac{W_{curb}}{2} \cdot 2 + 3in \cdot 2 \cdot 2 = 202.19 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := L_{curb} + \min\left(\frac{W_{curb}}{2} \cdot 2, \frac{L_{curb}}{2}\right) = 170 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{matrix} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{matrix} \right] \right] = 17819 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.L.vert.up} \cdot L_{curb}) \cdot (0.75in) = 9570 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.537$

$Curb_{BotFlangeBending} = \text{"OK"}$

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Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Width

Roof Curb thickness

$t_{Curb} = \text{"12GA"}$ $t_{curb} := thick(t_{Curb}) = 0.1084 \cdot in$

Min width of Roof Curb

$b_{curb} := W_{curb} + \frac{L_{curb}}{4} \cdot 2 + 3in \cdot 2 = 139.59 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := W_{curb} + \min\left(\frac{L_{curb}}{6} \cdot 2, W_{curb}\right) = 115 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{matrix} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{matrix} \right] \right] = 12302 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.W.vert.up} \cdot W_{curb}) \cdot (0.75in) = 5537 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.45$

$Curb_{BotFlangeBending} = \text{"OK"}$

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Web Crippling/Compression of Iso CanFab Curb (AISI S100-16 G5)

Note: Curb stiffeners directly transfer the compressive load from isolator to the base. Therefore, curb web crippling is prevented.

Curb Web with Reinforcement

Max Compression: $Comp_{maxtot} := \max(|C_S|, |C_W|) = 26724.96 \cdot lbs$

Reinforcement per CFS: $CFS_{reinf} :=$ "Single Stiffener 10GA 1"x7"x1" Fy=50ksi 36" Tall on min. 16GA "

Note: min. of 10 GA channel and min. 16 GA curb web

Number of Reinforcement in Length: $n_{reinf} := N_{iso.long} = 8$

Max Compression per Reinf: $Comp_{per.reinf} := \frac{Comp_{maxtot}}{n_{reinf}} = 3.341\ kip$

Spacing: $Spacing := \frac{L_{curb}}{n_{reinf}} = 14 \cdot in$ $KL_r := \frac{1.0 \cdot (H_{curb} - 12.5in)}{0.2339in} = 154$

Factored Nominal Comp. Capacity per reinforcement: $\phi P_{n.reinf} = 9.719 \cdot kip$ **(See attached CFS)**

Total Factored nominal Comp Capacity: $\phi P_{n.tot} := n_{reinf} \cdot \phi P_{n.reinf} = 78 \cdot kip$

D/C Ratio of Compression: $DCR := \frac{Comp_{maxtot}}{\phi P_{n.tot}} = 0.34$

$Comp_{reinf} := if(Comp_{maxtot} < \phi P_{n.tot}, "OK", "NG")$ $Comp_{reinf} = "OK"$

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Check CanFab Curb for Compressive Force due to T/C Coupling of Overturning

Note:
-Since the equipment is only attached to the longer sides of the CanFab Curb, most likely there will be compressive force onto the curb due to T/C coupling.
- Rectangular CanFab Curb will be considered as "Channel" to resist the compressive force.

Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Flanges*

Flat Width:

$$w := \frac{W_{curb}}{2} - R_{curb} = 38.348 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Unstiffened"}$$

Stress at the end of the Width:

$$f_2 := 50ksi \qquad f_1 := 50ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \left| \frac{f_2}{f_1} \right| = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 0.43$$

Critical Compressive Stress (Eq 1.1-4):

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w}\right)^2 = 0.09 \cdot ksi$$

Stress in Compression Element:

$$f := F_y = 50 \cdot ksi \qquad \textbf{(Assume f = Fy)}$$

Slenderness Factor (Eq 1.1-3):

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 23.36$$

Local reduction factor (Eq 1.1-2):

$$\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 0.042$$

Effective Width of the Flanges:

$$b_{eff.flange} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 1.626 \cdot in$$

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Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Web*

Flat Width:

$$w := L_{curb} - R_{curb} \cdot 2 = 112.883 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Stiffened"}$$

Stress at the end of the Width:

$$f_2 := 50ksi \qquad f_1 := 50ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \left| \frac{f_2}{f_1} \right| = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 4$$

Critical Compressive Stress (Eq 1.1-4):

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w} \right)^2 = 0.1 \cdot ksi$$

Stress in Compression Element:

$$f := F_y = 50 \cdot ksi \qquad \textbf{(Assume f = Fy)}$$

Slenderness Factor (Eq 1.1-3):

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 22.55$$

Local reduction factor (Eq 1.1-2):

$$\rho := \left(1 - \frac{0.22}{\lambda}\right) \frac{1}{\lambda} = 0.044$$

Effective Width of the Web:

$$b_{eff.web} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 4.958 \cdot in$$

Effective Area of the Member:

$$A_e := 2 \cdot \left(b_{eff.flange} \cdot t_{curb} \right) + b_{eff.web} \cdot t_{curb} = 0.89 \cdot in^2$$

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Length of the Compressive Member: $L_{curb.web} := h = 35.478 \cdot in$

Young's Modulus for Cold Form Steel: $E := 29500ksi$

Curb Shear Modulus: $G := 11300ksi$

Poisson's Ratio $\mu := 0.3$

Section Properties of the Member (From Section Properties Calculator):

$A_{half.curb} := 13.599in^2$ $r_o := 50.187in$ $I_x := 26250.724in^4$ $I_y := 1949.977in^4$

$J := 0.023in^4$ $r_x := \sqrt{\frac{I_x}{A_{half.curb}}} = 43.936 \cdot in$ $r_y := \sqrt{\frac{I_y}{A_{half.curb}}} = 11.975 \cdot in$

$C_w := 4.431 \cdot 10^6 \cdot in^6$ $r_{min} := \min(r_x, r_y) = 11.975 \cdot in$

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^2}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{(1.0 \cdot L_{curb.web})^2}\right] = 457268.1 \cdot ksi$$

$$\sigma_{e.y} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_y}\right)^2} = 33168.14 \cdot ksi \qquad \sigma_{e.x} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_x}\right)^2} = 446511.777 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2} = 33168.14 \cdot ksi$$

$$\frac{1.0 \cdot L_{curb.web}}{r_{min}} = 2.96$$

$KL_r = \text{"KL/r < 200, OK"}$

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 30924.983 \cdot ksi$$

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Nominal Compressive Stress Capacity: (Eq E2-4)

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 0.04$$

$$F_n := \begin{cases} 0.658^{\lambda_c^2} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^2}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 49.97 \cdot \text{ksi}$$

Compressive Capacity:

$$P_{n.member} := A_e \cdot F_n = 44.47 \cdot \text{kip}$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot P_{n.member} = 37.8 \cdot \text{kip}$$

Factored Max Compressive Force:

$$P_{comp.max} := \max\left(\left|C_S\right|, \left|C_W\right|\right) = 26.725\ \text{kip}$$

D/C Ratio of Compression:

$$DCR := \frac{P_{comp.max}}{\phi P_{n.member}} = 0.707$$

$$Axial_{curb.comp} := \text{if}\left(P_{comp.max} < \phi P_{n.member}, \text{"OK"}, \text{"Provide Channel from above as Web Stiffener"}\right)$$

$Axial_{curb.comp} = \text{"OK"}$

Note: No need to check for interaction since the curb is only subjected to the compressive force.

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Shear of CanFab Curb Webs without Holes (AISI S100-16 G2)

Note: Since the unit is stiffer than the curb and the curb is firmly attached to the unit and to the base structure, curbs will mainly take the lateral forces as shear and axial load rather than bending.

Thickness of Curb:

$$t := \text{thick}(t_{Curb}) = 0.108 \cdot \text{in}$$

Depth-to-Thickness Ratio:

$$\frac{h}{t} = 327$$

Curb Elastic Modulus:

$$E := 29500\text{ksi}$$

Clear distance b/w transverse stiffeners of reinforced web:

$$a := \max\left(\frac{L_{curb}}{2}, W_{curb}\right) = 77 \cdot \text{in} \qquad \frac{a}{h} = 2.17$$

$$k_v := \begin{cases} 5.34 & \text{if } a = L_{curb} \\ 4.00 + \dfrac{5.34}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \dfrac{4.00}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 6.19$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 60 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 91$$

Curb Shear Check due to Load on Longer Side

Area of Web Element:

$$A_w := W_{curb} \cdot t = 8 \cdot \text{in}^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 1.5 \cdot \text{ksi}$$

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$V_{cr} := A_w \cdot F_{cr} = 13\,kip$ $V_y := 0.6 \cdot A_w \cdot F_y = 250\,kip$ $\lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 4.413$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 12.858 \cdot kip$$

Number of Members within Length: $n := 2$ **(Per Curb Design)**

Design Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 24431 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.H} := P_{net} \cdot L_{unit} \cdot H_{total} = 14026.5 \cdot lbs$

Design Shear Demand: $V_u := \max(V_{base.S}, V_{base.W.H}) = 14857.1 \cdot lbs$

D/C Ratio of Shear: $DCR := \frac{V_u}{\phi V_n} = 0.608$

Demand/Capacity Ratio:

$Shear_{in.plane} := \text{if}(V_u < \phi V_n, \text{"OK"}, \text{"NG"})$

$Shear_{in.plane} = \text{"OK"}$

Curb Shear Check due to Load on Shorter Side

Area of Web Element: $A_w := L_{curb} \cdot t = 12 \cdot in^2$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 1.5 \cdot ksi$$

$V_{cr} := A_w \cdot F_{cr} = 19\,kip$ $V_y := 0.6 \cdot A_w \cdot F_y = 368\,kip$ $\lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 4.413$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 18.902 \cdot kip$$

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Number of Members within Length: $n := 2$ **(Per Curb Design)**

Factored Nominal Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 35913 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot W_{unit} \cdot H_{total} = 9654.4 \cdot lbs$

Factored Shear Demand: $V_u := \max(V_{base.S}, V_{base.W.L}) = 14857.1 \cdot lbs$

D/C Ratio of Shear: $DCR := \frac{V_u}{\phi V_n} = 0.414$

Demand/Capacity Ratio:

$Shear_{in.plane} := \text{if}(V_u < \phi V_n, \text{"OK"}, \text{"NG"})$

$Shear_{in.plane} = \text{"OK"}$

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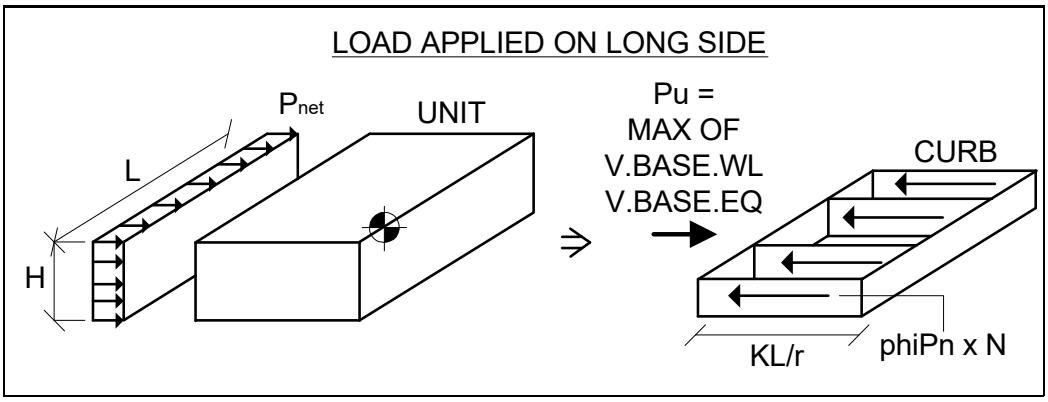
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Date DEC/12/2018

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Check CanFab Curb for In-Plane Axial due to EQ and Wind (AISI S100-16 E2)

Curb Axial Load Check due to Load on Long Side



Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot L_{unit} \cdot H_{total} = 14\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.L}) = 14857.09 \cdot lbs$

Member per CFS: $CFS_{member} :=$ "12GA Custom Curb 36" Tall L.b = 80in"

Max Braced Length of Member: $L_{member} := 48in$ **Conservative since the max anchor spacing is 24"**

Number of Curb in Length: $n_{curb.long} := 3$

Radius of gyration in y-axis: $r_{y.curb} := 0.521\,in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{2} = 7.43\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 92$ $KL_r =$ "KL/r < 200, OK"

Spacing: $Spacing := \frac{L_{curb}}{n_{curb.long}} = 38 \cdot in$

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 9.846 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.754$

$Axial_{short.curb} =$ "OK"

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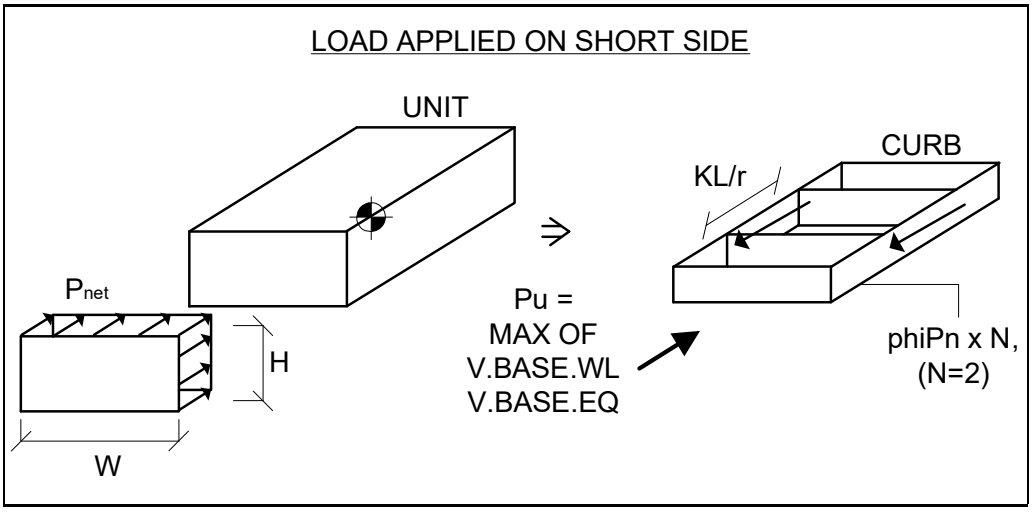
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Project: IBC 2018 Group C Job No. J13001 . 382

Date DEC/12/2018

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Curb Axial Load Check due to Load on Short Side



Wind Base Shear on Short Side: $V_{base.W.H} := P_{net} \cdot W_{unit} \cdot H_{total} = 9.7\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.H}) = 14857.09 \cdot lbs$

Member per CFS: CFS_{member} = "12GA Custom Curb 36" Tall L.b = 80in"

Max Braced Length of Member: $L_{member} := \frac{L_{curb}}{n_{curb.long} - 1} = 57 \cdot in$

Number of Curb in Length: $n_{curb} := 2$

Radius of gyration in y-axis: $r_{y.curb} := 0.521\,in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{curb}} = 7.43\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 109$ KL_r = "KL/r < 200, OK"

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 9.846 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.754$

$Axial_{long.curb}$ = "OK"

A241

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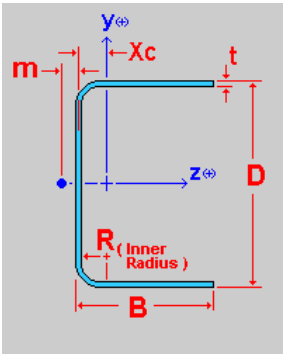
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REFERENCE

Shape Name : **Canfab 6009 14GA**
Database : **AISI Custom**
Shape Type : **CU**
Material : **Cold Formed**

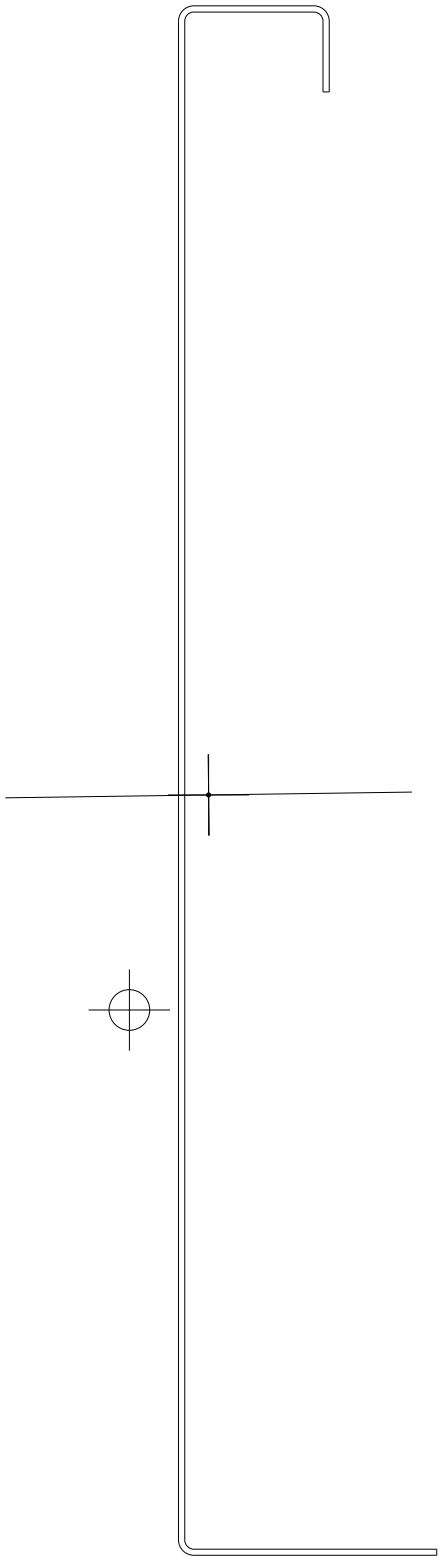


D	: 113	in	J	: .023	in^4
B	: 39	in	Cw	: 4.431e+6	in^6
t	: .071	in	ro	: 50.187	in
R	: .107	in	Xc	: 7.96	in
Area	: 13.599	in^2	m	: 13.137	in
Iyy	: 1949.977	in^4	j	: 63.338	in
Izz	: 26250.724	in^4			

CFS Version 10.0.0
Section: Section 1.cfss
Channel 18x3x1-14 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 12/11/2018 11:53:09 PM
By: Leonard Kim
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CFS Version 10.0.0
Section: Section 1.cfss
Channel 18x3x1-14 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 12/11/2018 11:53:09 PM
By: Leonard Kim
Printed: 12/12/2018 12:00:18 AM

Section Inputs

```
Material: A653 SS Grade 50/1
No strength increase from cold work of forming.
Modulus of Elasticity, E           29500 ksi
Yield Strength, Fy                    50 ksi
Tensile Strength, Fu                  65 ksi
Warping Constant Override, Cw          0 in^6
Torsion Constant Override, J           0 in^4

Stiffened Channel, Thickness 0.0713 in (14 Gage)
Placement of Part from Origin:
X to center of gravity           0 in
Y to center of gravity           0 in
Outside dimensions, Open shape
        Length      Angle     Radius  Web      k    Hole Size   Distance
          (in)      (deg)       (in)         Coef.       (in)       (in)
  1      3.000    180.000    0.10690 Single  0.000      0.000      1.500
  2     18.000     90.000    0.10690 Cee     0.000      0.000      9.000
  3      1.750      0.000    0.10690 Single  0.000      0.000      0.875
  4      1.000    -90.000    0.10690 None    0.000      0.000      0.500
```

Full Section Properties

```
Area      1.6650 in^2   Wt.    0.0056611 k/ft   Width     23.353 in

Ix        64.695 in^4   rx         6.233 in     Ixy       -0.908 in^4
Sx(t)     7.0576 in^3   y(t)       9.167 in     α          0.813 deg
Sx(b)     7.3241 in^3   y(b)       8.833 in
                       Height    18.000 in
Iy         0.750 in^4   ry         0.671 in     xo        -0.921 in
Sy(l)     2.1476 in^3   x(l)       0.349 in     yo        -2.498 in
Sy(r)     0.2828 in^3   x(r)       2.651 in     jx        15.499 in
                       Width      3.000 in     jy         2.726 in
I1        64.708 in^4   r1         6.234 in
I2         0.737 in^4   r2         0.665 in
Ic        65.445 in^4   rc         6.269 in     Cw        42.375 in^6
Io        77.246 in^4   ro         6.811 in     J      0.0028215 in^4
```

Member Check - 2016 North American Specification - US (LRFD)

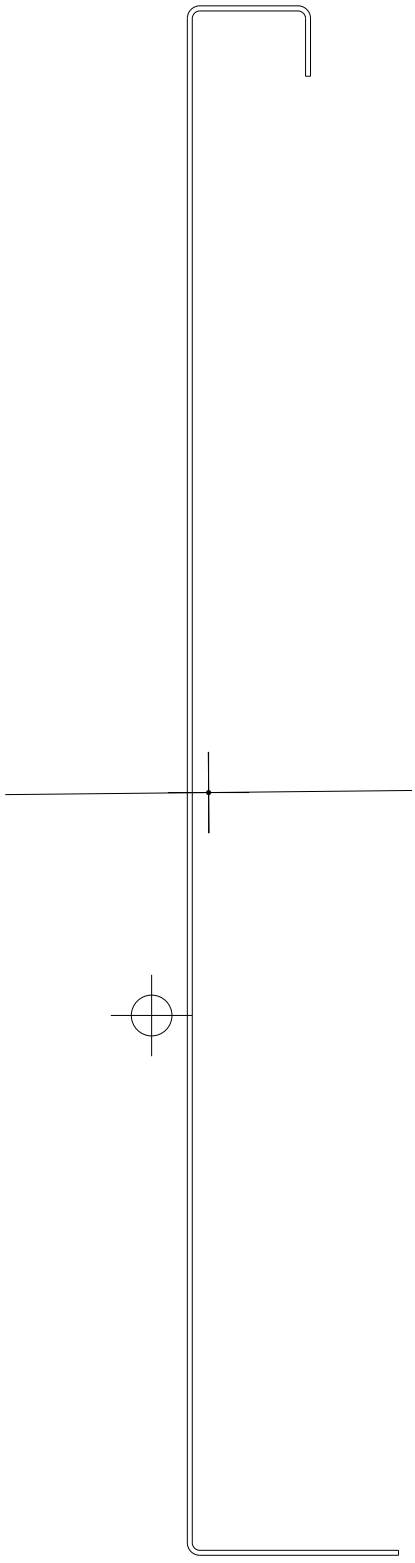
```
Material Type: A653 SS Grade 50/1, Fy=50 ksi
Design Parameters:
Lx        5.2500 ft     Ly        5.2500 ft     Lt        5.2500 ft
Kx        1.0000        Ky        1.0000        Kt        1.0000
Cbx       1.0000        Cby       1.0000        ex        0.0000 in
Cmx       1.0000        Cmy       1.0000        ey        0.0000 in
Braced Flange: None     kϕ             0 k
Red. Factor, R: 0       Lm        5.2500 ft

Loads:           P         Mx         Vy         My         Vx
                (k)     (k-in)        (k)     (k-in)        (k)
Entered       0.000       0.00      0.000       0.00      0.000
Applied       0.000       0.00      0.000       0.00      0.000
Strength     11.417     150.13      2.340       8.82      8.566
```

CFS Version 10.0.0
Section: Section 1.cfss
Channel 22x3x1-14 Gage

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CFS Version 10.0.0
Section: Section 1.cfss
Channel 22x3x1-14 Gage

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By: Leonard Kim
Printed: 12/12/2018 12:15:26 AM

Section Inputs

```
Material: A653 SS Grade 50/1
No strength increase from cold work of forming.
Modulus of Elasticity, E           29500 ksi
Yield Strength, Fy                    50 ksi
Tensile Strength, Fu                  65 ksi
Warping Constant Override, Cw          0 in^6
Torsion Constant Override, J           0 in^4

Stiffened Channel, Thickness 0.0713 in (14 Gage)
Placement of Part from Origin:
X to center of gravity           0 in
Y to center of gravity           0 in
Outside dimensions, Open shape
        Length      Angle     Radius  Web      k    Hole Size   Distance
          (in)      (deg)       (in)         Coef.       (in)       (in)
  1      3.000    180.000    0.10690 Single  0.000      0.000      1.500
  2     22.000     90.000    0.10690 Cee     0.000      0.000     11.000
  3      1.750      0.000    0.10690 Single  0.000      0.000      0.875
  4      1.000    -90.000    0.10690 None    0.000      0.000      0.500
```

Full Section Properties

```
Area      1.9502 in^2   Wt.    0.0066308 k/ft   Width     27.353 in

Ix        108.38 in^4   rx         7.455 in     Ixy        -1.12 in^4
Sx(t)      9.702 in^3   y(t)      11.170 in     α          0.594 deg
Sx(b)     10.007 in^3   y(b)      10.830 in
                       Height    22.000 in
Iy          0.77 in^4   ry         0.630 in     xo        -0.810 in
Sy(l)      2.552 in^3   x(l)       0.303 in     yo        -3.165 in
Sy(r)      0.287 in^3   x(r)       2.697 in     jx        22.700 in
                       Width      3.000 in     jy         3.415 in
I1        108.39 in^4   r1         7.455 in
I2          0.76 in^4   r2         0.625 in
Ic        109.15 in^4   rc         7.481 in     Cw        66.606 in^6
Io        129.97 in^4   ro         8.163 in     J      0.0033048 in^4
```

Member Check - 2016 North American Specification - US (LRFD)

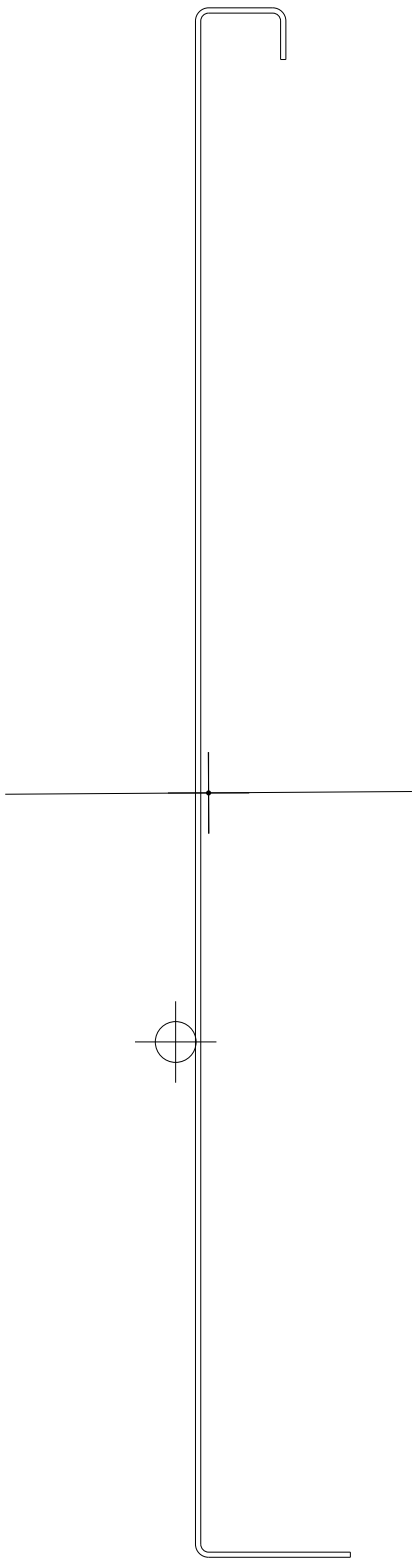
```
Material Type: A653 SS Grade 50/1, Fy=50 ksi
Design Parameters:
Lx        5.2500 ft     Ly        5.2500 ft     Lt        5.2500 ft
Kx        1.0000        Ky        1.0000        Kt        1.0000
Cbx       1.0000        Cby       1.0000        ex        0.0000 in
Cmx       1.0000        Cmy       1.0000        ey        0.0000 in
Braced Flange: None     kϕ             0 k
Red. Factor, R: 0       Lm        5.2500 ft

Loads:           P         Mx         Vy         My         Vx
                (k)     (k-in)        (k)     (k-in)        (k)
Entered      0.0000       0.00     0.0000       0.00     0.0000
Applied      0.0000       0.00     0.0000       0.00     0.0000
Strength     9.5558     175.80     1.9075       8.85     8.5659
```

CFS Version 10.0.0
Section: Section 1.cfss
Channel 30x3x1-12 Gage

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CFS Version 10.0.0
Section: Section 1.cfss
Channel 30x3x1-12 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 12/12/2018 12:28:48 AM
By: Leonard Kim
Printed: 12/12/2018 12:29:59 AM

Section Inputs

```
Material: A653 SS Grade 50/1
No strength increase from cold work of forming.
Modulus of Elasticity, E           29500 ksi
Yield Strength, Fy                    50 ksi
Tensile Strength, Fu                  65 ksi
Warping Constant Override, Cw          0 in^6
Torsion Constant Override, J           0 in^4

Stiffened Channel, Thickness 0.1017 in (12 Gage)
Placement of Part from Origin:
X to center of gravity           0 in
Y to center of gravity           0 in
Outside dimensions, Open shape
        Length      Angle     Radius  Web      k    Hole Size   Distance
          (in)      (deg)       (in)         Coef.       (in)       (in)
  1      3.000    180.000    0.15250 Single  0.000      0.000      1.500
  2     30.000     90.000    0.15250 Cee     0.000      0.000     15.000
  3      1.750      0.000    0.15250 Single  0.000      0.000      0.875
  4      1.000    -90.000    0.15250 None    0.000      0.000      0.500
```

Full Section Properties

```
Area      3.5781 in^2   Wt.     0.012166 k/ft   Width     35.183 in

Ix        345.11 in^4   rx         9.821 in     Ixy        -2.32 in^4
Sx(t)     22.706 in^3   y(t)      15.199 in     α          0.387 deg
Sx(b)     23.318 in^3   y(b)      14.801 in
                       Height    30.000 in
Iy          1.11 in^4   ry         0.558 in     xo        -0.637 in
Sy(l)      4.397 in^3   x(l)       0.254 in     yo        -4.823 in
Sy(r)      0.406 in^3   x(r)       2.747 in     jx        41.980 in
                       Width      3.000 in     jy         5.132 in
I1        345.13 in^4   r1         9.821 in
I2          1.10 in^4   r2         0.554 in
Ic        346.23 in^4   rc         9.837 in     Cw        180.01 in^6
Io        430.90 in^4   ro        10.974 in     J       0.012336 in^4
```

Member Check - 2016 North American Specification - US (LRFD)

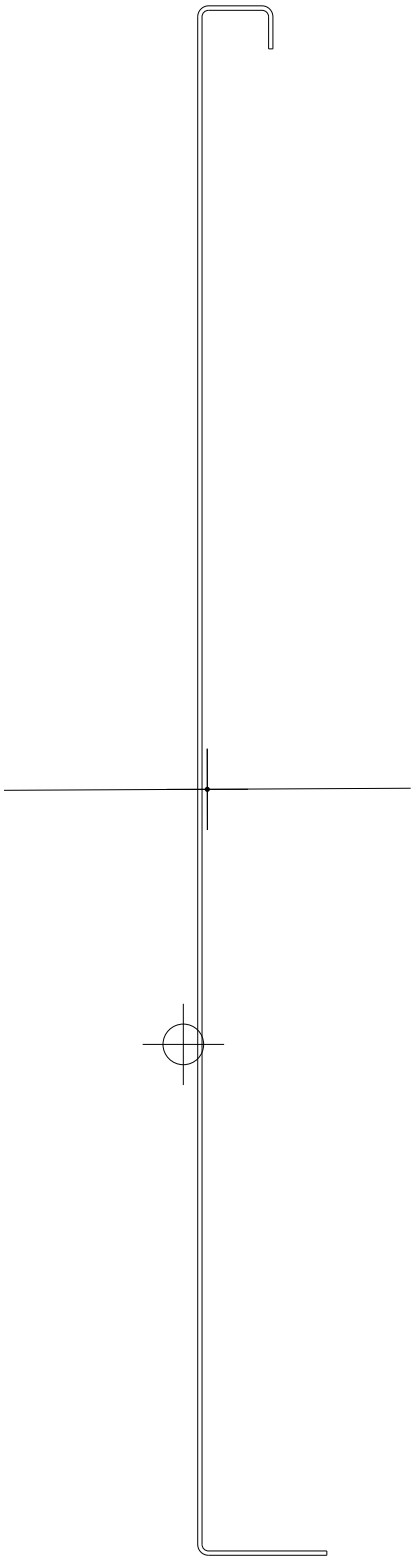
```
Material Type: A653 SS Grade 50/1, Fy=50 ksi
Design Parameters:
Lx        5.2500 ft     Ly        5.2500 ft     Lt        5.2500 ft
Kx        1.0000        Ky        1.0000        Kt        1.0000
Cbx       1.0000        Cby       1.0000        ex        0.0000 in
Cmx       1.0000        Cmy       1.0000        ey        0.0000 in
Braced Flange: None     kϕ             0 k
Red. Factor, R: 0       Lm        5.2500 ft

Loads:           P         Mx         Vy         My         Vx
                (k)     (k-in)        (k)     (k-in)        (k)
Entered       0.000       0.00      0.000       0.00      0.000
Applied       0.000       0.00      0.000       0.00      0.000
Strength     12.036     360.35      4.063      12.80     11.557
```

CFS Version 10.0.0
Section: Section 1.cfss
Channel 36x3x1-12 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 12/12/2018 12:47:10 AM
By: Leonard Kim
Printed: 12/12/2018 12:53:22 AM



CFS Version 10.0.0
Section: Section 1.cfss
Channel 36x3x1-12 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 12/12/2018 12:47:10 AM
By: Leonard Kim
Printed: 12/12/2018 12:53:22 AM

Section Inputs

```
Material: A653 SS Grade 50/1
No strength increase from cold work of forming.
Modulus of Elasticity, E           29500 ksi
Yield Strength, Fy                    50 ksi
Tensile Strength, Fu                  65 ksi
Warping Constant Override, Cw          0 in^6
Torsion Constant Override, J           0 in^4

Stiffened Channel, Thickness 0.1017 in (12 Gage)
Placement of Part from Origin:
X to center of gravity           0 in
Y to center of gravity           0 in
Outside dimensions, Open shape
        Length      Angle     Radius  Web      k    Hole Size   Distance
          (in)      (deg)       (in)         Coef.       (in)       (in)
  1      3.000    180.000    0.15250 Single  0.000      0.000      1.500
  2     36.000     90.000    0.15250 Cee     0.000      0.000     18.000
  3      1.750      0.000    0.15250 Single  0.000      0.000      0.875
  4      1.000    -90.000    0.15250 None    0.000      0.000      0.500
```

Full Section Properties

```
Area      4.1883 in^2   Wt.     0.014240 k/ft   Width     41.183 in

Ix        563.41 in^4   rx        11.598 in     Ixy        -2.80 in^4
Sx(t)     30.953 in^3   y(t)      18.202 in     α          0.285 deg
Sx(b)     31.657 in^3   y(b)      17.798 in
                       Height    36.000 in
Iy          1.14 in^4   ry         0.521 in     xo        -0.556 in
Sy(l)      5.074 in^3   x(l)       0.224 in     yo        -5.928 in
Sy(r)      0.409 in^3   x(r)       2.776 in     jx        60.364 in
                       Width      3.000 in     jy         6.254 in
I1        563.43 in^4   r1        11.598 in
I2          1.12 in^4   r2         0.518 in
Ic        564.55 in^4   rc        11.610 in     Cw        269.37 in^6
Io        713.01 in^4   ro        13.048 in     J       0.014440 in^4
```

Member Check - 2016 North American Specification - US (LRFD)

```
Material Type: A653 SS Grade 50/1, Fy=50 ksi
Design Parameters:
Lx        6.6700 ft     Ly        6.6700 ft     Lt        6.6700 ft
Kx        1.0000        Ky        1.0000        Kt        1.0000
Cbx       1.0000        Cby       1.0000        ex        0.0000 in
Cmx       1.0000        Cmy       1.0000        ey        0.0000 in
Braced Flange: None     kϕ             0 k
Red. Factor, R: 0       Lm        6.6700 ft

Loads:           P         Mx         Vy         My         Vx
                (k)     (k-in)        (k)     (k-in)        (k)
Entered       0.000       0.00      0.000       0.00      0.000
Applied       0.000       0.00      0.000       0.00      0.000
Strength      9.846     283.04      3.376      12.87     11.557
```

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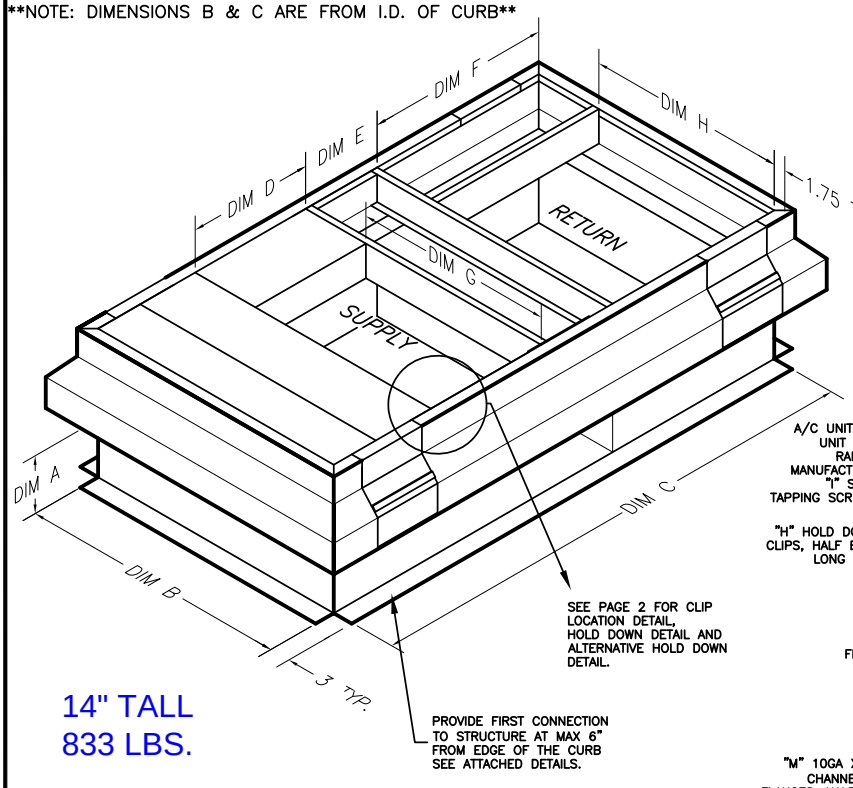
12.5 Ton

FOR: GROUP C ISO
CARRIER 15 - 17-1/2 TONS
48/50HC 17, 48/50TC 17, 18, 20, 50TCQ 17 48/50 LC 14

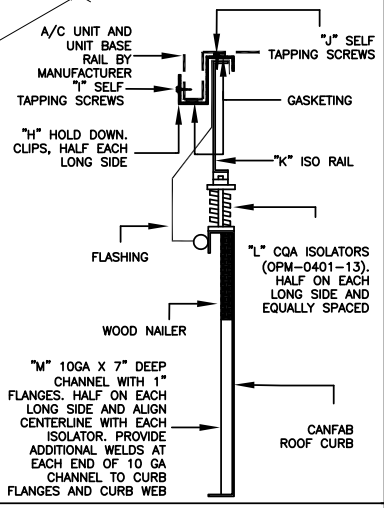
PART NO: 1080-IC

DIM A	DIM B	DIM C	DIM D	DIM E	DIM F	DIM G	DIM H
VARIES MAX 36" SEE TABLE 3	76.875"	117.875"	27.875"	25.9375"	22.1875"	63.875"	69.5625"

NOTE: DIMENSIONS B & C ARE FROM I.D. OF CURB



14" TALL
833 LBS.



NOTE: FINISH CURB HEIGHT IS 13.5" TALLER THAN DIMENSION A.

ALL WORK SHALL CONFORM TO THE STANDARD OF 2018 INTERNATIONAL BUILDING CODE & 2019 CALIFORNIA BUILDING CODE.

SEISMIC DESIGN CRITERIA
-SDS = 1.5 ap = 2.5
-I = 1.5 Rp = 2.0

WIND DESIGN CRITERIA
-MAX 60 FT TALL BUILDING
-EXPOSURE C
-175 MPH, 3 SECOND GUST WIND

NOTE:
INSTALLER TO VERIFY WITH A LICENSED STRUCTURAL ENGINEER IN THE CORRESPONDING STATE THE ADEQUACY OF THE STRUCTURE FOR LOADS IMPOSED BY THE UNIT AND THE CURB IN ADDITION TO ALL OTHER LOADS.
-INSTALLER TO VERIFY WITH A LICENSED STRUCTURAL ENGINEER IN THE CORRESPONDING STATE THAT THE SEISMIC AND WIND DESIGN CRITERIA NOTED ON THIS DRAWING ARE ADEQUATE FOR THE SITE SPECIFIC VALUES. OTHERWISE, CONTACT CANNON FABRICATION FOR A SITE SPECIFIC ANALYSIS AND DRAWINGS.

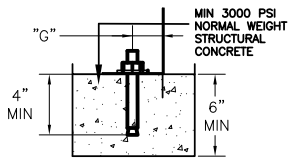
CURB CONSTRUCTION
1) ☐ WELDED
2) ☐ BOLTED
3) ☐ FINGERLOCK
-ALL WELDING CONSTRUCTION CERTIFIED TO ANSI/AWS D1.3 STRUCTURAL WELDING CODE-SHEET METAL
-SELF-DRILLING SCREW SHALL MEET ASTM C1513 SPECIFICATION AND INSTALLED PER AISI-S100
-NO GAP IS ALLOWED BETWEEN TWO METAL SHEET SURFACES WHERE SHEET METAL SCREW IS CONNECTED

CURB AND UNIT INFORMATION
"A" GAUGE GALVANIZED STEEL CURB

-SEE TABLE 3 FOR ALLOWABLE CURB AND UNIT DIMENSIONAL AND WEIGHT

-SEE TABLE 4 FOR TABULATED CURB AND ANCHORAGE INFORMATION PER VARYING CURB HEIGHT

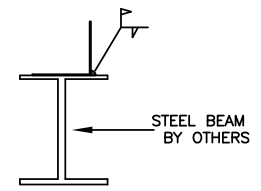
- ALPHA DESIGNATIONS "A" THRU "M", CAN BE FOUND ON TABLE 4, PAGE 3



ATTACHMENT TO STRUCTURAL CONCRETE

"B" 5/8" HILTI KWIK BOLT TZ SS 304, HALF EACH LONG SIDE.
"C" 5/8" HILTI KWIK BOLT TZ SS 304, HALF EACH SHORT SIDE.

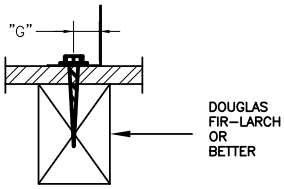
NOTE:
-MIN 6" AWAY FROM THE NEAREST CONCRETE EDGE (INSTALL PER ICC-ES ESR-1917).
-STRUCTURALLY ACCEPTABLE TO SUBSTITUTE HILTI KBTZ STAINLESS STEEL BOLTS WITH HILTI KBTZ CARBON STEEL BOLTS ONLY IF ALL THE BOLTS ARE COMPLETELY WATERPROOFED AND PROTECTED AGAINST THE WEATHER.
-BOLTS SHALL BE EQUALLY SPACED



ATTACHMENT TO STRUCTURAL STEEL

1/8" FILLET WELD, 2" LONG, "D" ON CENTER.

NOTE:
-PROVIDE MIN 2 CONNECTIONS WHERE THE CURB SIDE IS SHORTER THAN THE WELD SPACING.
-PROVIDE WELDS ON ALL SIDES



ATTACHMENT TO WOOD

"E" 3/8"x4" LAG SCREWS, HALF EACH LONG SIDE.
"F" 3/8"x4" LAG SCREWS, HALF EACH SHORT SIDE.

NOTE:
-SCREWS SHALL BE EQUALLY SPACED.

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Job No.: 19022

REGISTERED PROFESSIONAL ENGINEER
GREGORY LOUIS OROZCO
No. 4957
STRUCTURAL
STATE OF CALIFORNIA

3/13/2019

PROJECT: IBC 2018 UPDATE/ CBC 2019 UPDATE DATE: 3.12.19

ENGINEER: LD DISTRIBUTOR:

DRAWING NUMBER: GROUP_C_ISO.DWG

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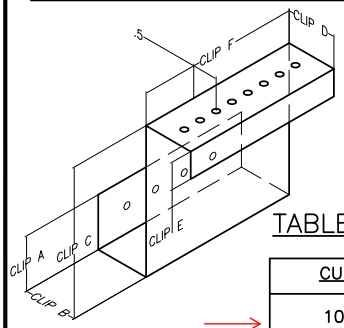
FOR: GROUP C ISO

PART NO: SEE BELOW

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HOLD DOWN DETAIL

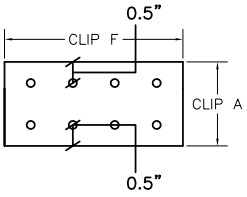


NOTE:
SEE TABLE 1 FOR DESIGNATED HOLD DOWN CLIP PER CURB

TABLE 1 HOLD DOWN CLIP PER CURB

CURB	CLIP	GAUGE	CLIP A [IN]	CLIP B [IN]	CLIP C [IN]	CLIP D [IN]	CLIP E [IN]	CLIP F [IN]
1080/ 1084/1094	1909-SHD12-12	12 GA	1.5	2.625	4.5625	1.875	1.0	9.0
3010	3902-SHD14-12	12 GA	1.5	5.295	3.825	2.0	1.0	9.0
6008/6010	6911-SHD12-12	12 GA	2.0	2.125	6.0	1.875	1.0	9.0
6010-HIC	8004-SHD-D-12-10	10 GA	2.0	N/A	N/A	N/A	N/A	9.0

**NOTE: 6010-HIC HAS FLAT STYLE CLIP (SEE LEFT)



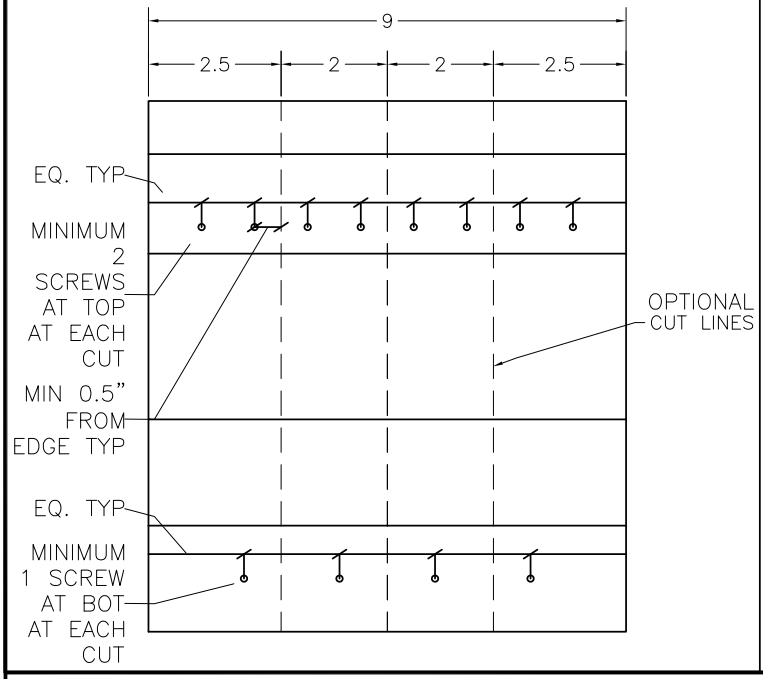


3/13/2019

ALTERNATIVE HOLD DOWN DETAIL

NOTE:
APPLICABLE ONLY FOR 9" LONG HOLD DOWN WITH (8) SCREWS AT TOP AND (4) SCREWS AT BOT EQUALLY SPACED

1. INFORMATION SHOWN ON THE STAMPED CANFAB CURB DRAWING IS THE MINIMUM REQUIREMENTS FOR THE CURB CONSTRUCTION AND INSTALLATION. NO STRUCTURAL OBJECTION TO THE USE OF LARGER SIZE SCREWS AND THICKER GAUGE SHEET METAL THAN THE INFORMATION SHOWN ON THE STAMPED CANFAB CURB DRAWING.
2. NO STRUCTURAL OBJECTION TO SHIFTING THE ATTACHMENT CLIPS ALONG THE CURB. FIRST AND LAST CLIP IN THE SERIES OF CLIPS SHALL BE LOCATED PER CLIP LOCATION DETAIL PER STAMPED CANFAB CURB DRAWING. DISTANCE SHIFTED SHALL NOT BE LARGER THAN THE LENGTH OF THE CLIP.
3. NO STRUCTURAL OBJECTION TO CUTTING THE ATTACHMENT CLIPS PER REQUIREMENTS AS SHOWN ON BELOW SKETCH.



CLIP LOCATION DETAIL

NOTE:
SEE TABLE 2 FOR CLIP LOCATION

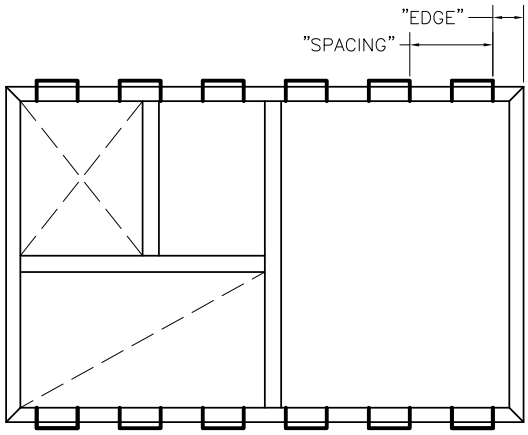


TABLE 2 CLIP LOCATION

CURB	EDGE [IN]	SPACING [IN]
1080	7.75	21.175
1084/1094	7.75	16.85
3010	7.75	16.875
6008	7.75	15.45
6010	7.75	18.4375
6010-HIC	7.75	18.4375

**NOTE: 3010-IC HAS TOTAL OF 14 CLIPS **

PROJECT: IBC 2018 UPDATE/ CBC 2019 UPDATE DATE: 3.12.19

ENGINEER: LD DISTRIBUTOR:

DRAWING NUMBER: GROUP_C_ISO.DWG

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FOR: GROUP C ISO

PART NO: SEE BELOW

TABLE 3 ALLOWABLE CURB AND UNIT DIMENSION AND WEIGHT

RELATED CURBS	LCURB [IN]	WCURB [IN]	HCURB [IN]	WTCURB [LBS]	LUNIT [IN]	WUNIT [IN]	HUNIT [IN]	WTUNIT [LBS]	CG.LONG [IN]	CG.SHORT [IN]	CG.HEIGHT [IN]
1080	SEE PAGE 1	SEE PAGE 1	MIN 8	MIN 732	127.875	86.375	49.375	MAX 3261	68.7	40.9	HUNIT/2
			11	783							
			14	833							
			18	963							
			24	1232							
			MAX 36	MAX 1521							
1084	SEE PAGE 1	SEE PAGE 1	MIN 8	MIN 526	115.875	63.375	57.375	MAX 2900	57	31.5	HUNIT/2
			11	573							
			14	618							
			18	679							
			24	947							
			MAX 36	MAX 1201							
1084-XIC	SEE PAGE 1	SEE PAGE 1	MIN 8	MIN 529	115.875	63.375	57.375	MAX 2900	57	31.5	HUNIT/2
			11	576							
			14	621							
			18	682							
			24	950							
			MAX 36	MAX 1204							
1094	SEE PAGE 1	SEE PAGE 1	MIN 8	MIN 520	115.875	63.375	57.375	MAX 2729	58	32	HUNIT/2
			11	567							
			14	612							
			18	673							
			24	941							
			MAX 36	MAX 1195							
1094-XIC	SEE PAGE 1	SEE PAGE 1	MIN 8	MIN 523	115.875	63.375	57.375	MAX 2729	58	32	HUNIT/2
			11	570							
			14	615							
			18	676							
			24	944							
			MAX 36	MAX 1198							
3010	SEE PAGE 1	SEE PAGE 1	MIN 8	MIN 602	180.594	92	63	MAX 3918	85.25	45	HUNIT/2
			11	652							
			14	702							
			18	771							
			24	989							
			MAX 36	MAX 1240							

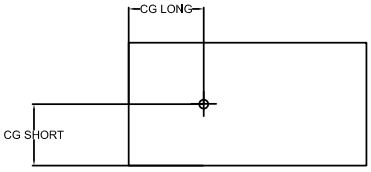
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3/13/2019



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ENGINEER: LD DISTRIBUTOR:

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3/13/2019

TABLE 3 ALLOWABLE CURB AND UNIT DIMENSION AND WEIGHT (CONTINUE)

RELATED CURBS	LCURB [IN]	WCURB [IN]	HCURB [IN]	WTCURB [LBS]	LUNIT [IN]	WUNIT [IN]	HUNIT [IN]	WTUNIT [LBS]	CG.LONG [IN]	CG.SHORT [IN]	CG.HEIGHT [IN]
6008	SEE PAGE 1	SEE PAGE 1	MIN 8	MIN 499	122.313	84.188	66.25	MAX 3195	58	36	HUNIT/2
			11	543							
			14	587							
			18	646							
			24	828							
			MAX 36	MAX 1043							
6010	SEE PAGE 1	SEE PAGE 1	MIN 8	MIN 631	122.313	84.188	66.25	MAX 3195	58	36	HUNIT/2
			11	679							
			14	727							
			18	792							
			24	999							
			MAX 36	MAX 1239							
6010-HIC	SEE PAGE 1	SEE PAGE 1	MIN 8	MIN 862	122.313	84.188	66.25	MAX 3195	58	36	HUNIT/2
			11	907							
			14	951							
			18	1010							
			24	1213							
			MAX 36	MAX 1426							

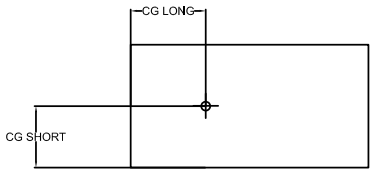


TABLE 4 TABULATED CURB AND ANCHORAGE INFORMATION PER VARYING HEIGHT

		0 < H ≤ 18"	18" < H ≤ 22"	22" < H ≤ 30"	30" < H ≤ 36"
A	CURB THICKNESS	14 GA, 12 GA FOR 6010-HIC	14 GA, 12 GA FOR 6010-HIC	12 GA	12 GA
B	EXP. ANCHOR	12	12	14	14
C	EXP. ANCHOR	8	8	8	10
D	WELD	24"	18"	18"	18"
E	SCREWS	48	50	52	56
F	SCREWS	32	34	36	38
G	DISTANCE	MAX 0.75"	MAX 0.75"	MAX 0.75"	MAX 0.75"
H	NO. OF CLIPS	12 TYPICAL, 14 FOR 3010	12 TYPICAL, 14 FOR 3010	12 TYPICAL, 14 FOR 3010	12 TYPICAL, 14 FOR 3010
I	CLIP SMS	(4) #14	(4) #14	(4) #14	(4) #14
J	CLIP SMS	(8) #14	(8) #14	(8) #14	(8) #14
K	ISO RAIL	10 GA 7.5" DEEP X 1" FLANGES			
L	NO. OF ISOLATORS	16 TYP. 17 FOR 1084-XIC AND 1094-XIC			
M	NO. OF STIFFENERS	16 TYP. 17 FOR 1084-XIC AND 1094-XIC			

PROJECT: IBC 2018 UPDATE/ CBC 2019 UPDATE DATE: 3.12.19

ENGINEER: LD DISTRIBUTOR:

DRAWING NUMBER: GROUP_C_ISO.DWG

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FOR:

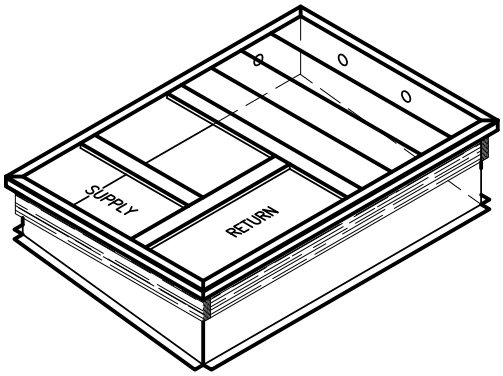
PART NO:

Pitched Roof Curb

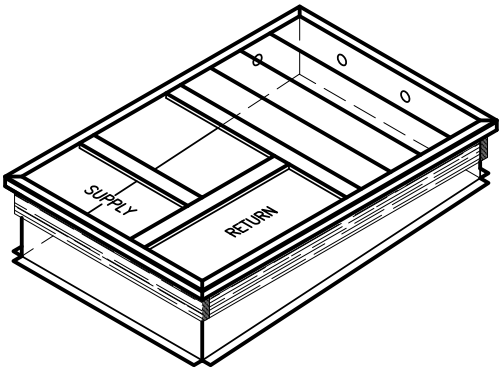
Drawing Must Accompany All Pitched Curb Orders

APPLIES TO STANDARD AND ISOLATION CURBS

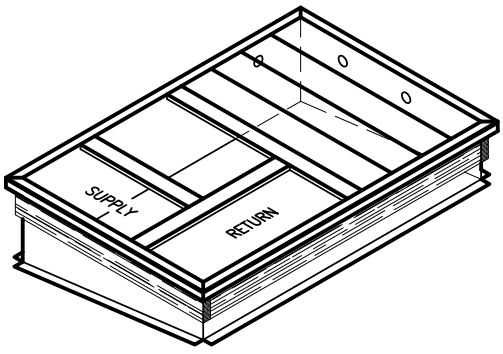
(A)



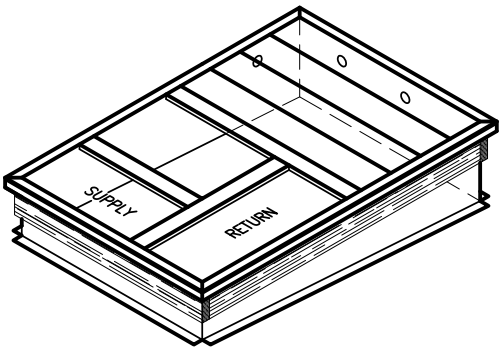
(B)



(C)



(D)



_____ On 12"

(Circle A, B, C or D To Specify Duct Placement)

PROJECT:

DATE: 01.08.19

ENGINEER:

DISTRIBUTOR:

DRAWING NUMBER:

STRUCTURAL CALCULATIONS

for

IBC 2018
Group C
6010, 6010-HIC, 1080, 1084, 1084-XIC, 1094, 1094XIC
(6010 GOVERNS)

ISOLATED CANFAB CURB

(Max Curb Height up to 36")

CURB AND ANCHORAGE WIND & SEISMIC DESIGN

Prepared for:

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JAMA Project No. J19022.005
PO#13121
MAR/12/2019

THE CURB HAS BEEN DESIGNED FOR SDS = 1.5G, I = 1.5 AND WIND REGION V = 175MPH. FOR HIGH SEISMIC REGIONS WITH SDS > 1.5G, I > 1.5 OR WIND REGIONS V > 175MPH, FURTHER ANALYSIS AND MODIFICATIONS TO THE CURB ARE REQUIRED PRIOR TO CONSTRUCTION

THE SUPPORTING STRUCTURE SHALL BE REVIEWED AND APPROVED BY OTHERS. BUILDING ENGINEER OF RECORD SHALL PROVIDE SUPPORT STRUCTURE AND VERIFY THE ADEQUACY OF THE STRUCTURE FOR LOADS IMPOSED ON THEM BY UNIT AS WELL AS ALL OTHER LOADS.

NO INSTALLATION SHALL TAKE PLACE UNTIL THE CURB, ANCHORAGE AND SUPPORTING STRUCTURE ARE APPROVED BY THE APPROPRIATE JURISDICTION.



3/13/2019

MARTIN & associates
JOHN A. MARTIN & ASSOCIATES, INC.
Structural Engineers
PREPARED BY: L. KIM

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Architect: CANNON FABRICATION, INC. Sheet

Project: IBC 2018 Group C Job No. J13001 . 382

Date DEC/12/2018

CURB & ANCHORAGE DESIGN Engineer LK

DESIGN
for
MAX CURB HEIGHT OF 18"

950 S. GRAND AVENUE, 4TH FLOOR, LOS ANGELES, CALIFORNIA 90015 (213) 483-6490

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Design Wind Loads for Rooftop Equipment (ASCE 7-16 § Table 29.1-1)

$z := 60ft$ **Height above ground level**

$B := 60ft$ **Horizontal dimension of building measured normal to wind direction**

$Exp_{category} := "C"$ **Exposure Category per ASCE 7-16 § 26.7**

$Risk_{category} := "IV"$ **Risk Category per ASCE 7-16 Table 1.5-1**

$$V := \begin{cases} 0mph & \text{if } Risk_{category} = "I" \\ 0mph & \text{if } Risk_{category} = "II" \\ 175mph & \text{otherwise} \end{cases} = 175 \cdot mph$$

Basic Wind Speed per ASCE 7-16 Figure 26.5-1 A,B or C

$K_z = 1.14$ **Velocity Pressure Exposure Coefficient per ASCE 7-16 Table 29.10-1 [Exposure Category "C"]**

$K_{zt} := 1.0$ **Topographic Factor per ASCE 7-16 § 26.8, Figure 26.8-1**

$K_e := 1.0$ **Ground Elevation Factor per ASCE 7-16 § 26.9, Table 26.9-1**

$K_d := 0.85$ **Wind Directionality Factor per ASCE 7-16 § 26.6, Table 26.6-1 (Equipment)**

$q_z := 0.00256 K_z \cdot K_{zt} \cdot K_d \cdot K_e \cdot V^2 = 75.74 \cdot psf$ **Velocity pressure evaluated at height z above ground per ASCE 7-10 § 26.10.2; Eq. 26.10-1**

$GC_{r.lateral.max} := 1.9$ **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.9 for rooftop structures and equipment with Af less than (0.1Bh). (GCr) shall be permitted to be reduced linearly from 1.9 to 1.0 as the value of Af is increased from (0.1Bh) to (Bh)

$GC_{r.vertical.max} := 1.5$ **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.5 for rooftop structures and equipment with A_r less than (0.1*BL*). (GC_r) shall be permitted to be reduced linearly from 1.5 to 1.0 as the value of A_r is increased from (0.1*BL*) to (*BL*)

$P_{net} := q_z \cdot GC_{r.lateral.max} = 143.91 \cdot psf$ **Design Lateral Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-2**

$P_v := q_z \cdot GC_{r.vertical.max} = 113.61 \cdot psf$ **Design Vertical Uplift Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-3**

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Seismic Demands on Nonstructural Components (ASCE 7-16 § 13.3 & 13.6):

$S_{DS} := 1.5$ **Design spectral response acceleration parameter at short periods per USGS map**

$I_p := 1.5$ **Component importance factor ASCE 7-16 § 13.1.3**

$\Omega_0 := 2.0$ **Overstrength factor ASCE 7-16 Table 13.6.1**

Vibr_Isolation = "Yes" **Placement of Unit Vibration Isolated:**

Note: Only "F_p" at seismic concrete anchor has been increased with overstrength factor "Ω_0"

$a_p := 2.5$ $R_p = 2.0$ **Seismic coefficients a_p & R_p**
Per ASCE 7-16 Table 13.6-1 for
Mechanical & Electrical Components

$z = 60\,ft$ **Height in structure of point of attachment of component with respect to the base**

$h := 60ft$ **Average roof height of structure with respect to the base**
Where for roof top equipment:

$z \div h = 1$

F_p: Horizontal Seismic Design Force per *ASCE7-16 § 13.3.1*

F_p shall be takes as $\left(\frac{0.4 \cdot a_p \cdot S_{DS} \cdot I_p}{R_p}\right) \cdot \left(1 + 2 \cdot \frac{z}{h}\right) \cdot W_p = 337.5 \cdot \% \cdot W_p$

F_p is not required to be taken as greater than $\left(1.6 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 360 \cdot \% \cdot W_p$

F_p shall not be taken as less than $\left(0.3 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 67.5 \cdot \% \cdot W_p$

Governing F_p : Horizontal Seismic Design Force $F_p = 337.5 \cdot \% \cdot W_p$

F_v: Vertical Load per ASCE7-16 § 13.3.1.2

Concurrent Vertical Seismic Force: $F_v := 0.2 \cdot S_{DS} \cdot W_p = 30 \cdot \% \cdot W_p$

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Flat Roof Snow Loads (ASCE 7-16 § 7.3):

$Terrain_{CAT} := "C"$ **Terrain Category ASCE 7-16 § 26.7 & Table 7.3-1**

$Exp_{Roof} := "Partially\ Exposed"$ **Exposure of Roof ASCE 7-16 Table 7.3-1**

$C_e = 1$ **Exposure Factor ASCE 7-16 Table 7.3-1**

$Thermal_{condition} := "All\ structures\ except\ below"$ **Thermal Condition ASCE 7-16 Table 7.3-2**

$C_t = 1$ **Thermal Factor ASCE 7-16 Table 7.3-2**

$Risk_{category} = "IV"$ **Risk Category per ASCE 7-16 Table 1.5-1**

$I_s = 1.2$ **Snow Importance Factor ASCE 7-16 Table 1.5-2**

$p_g := 40psf$ **Ground Snow Loads ASCE 7-16 Figure 7.2-1**

$$p_f := \max\left(0.7 \cdot C_e \cdot C_t \cdot I_s \cdot p_g, \text{if}\left(p_g > 20psf, 20psf \cdot I_s, I_s \cdot p_g\right)\right) = 34 \cdot psf$$

Flat Roof Snow Loads ASCE 7-16 Equation 7.3-1 and § 7.3.4

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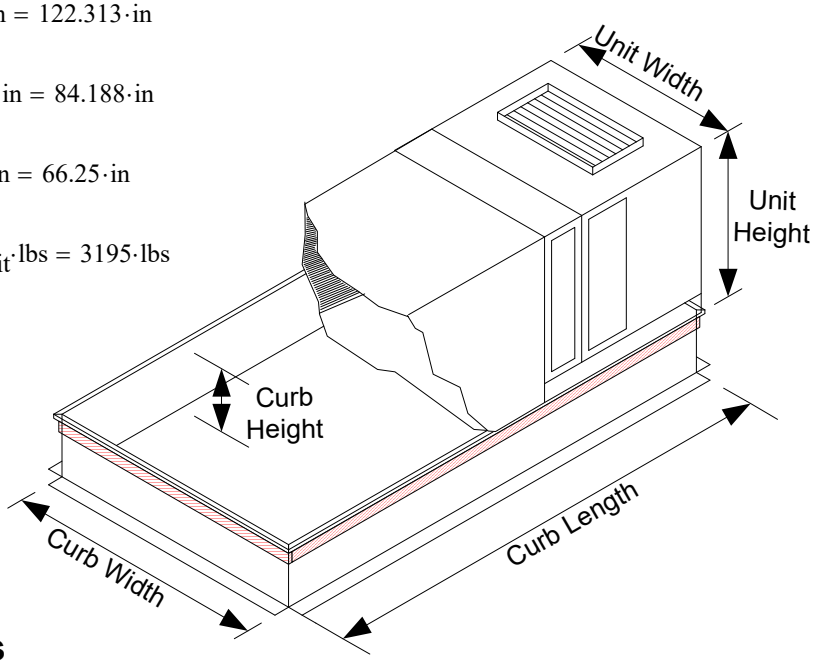
Mechanical Unit Dimensions Curb = "C-6010"

Length of Unit $L_{unit} := L_{unit} \cdot in = 122.313 \cdot in$

Width of Unit $W_{unit} := W_{unit} \cdot in = 84.188 \cdot in$

Height of Unit $H_{unit} := H_{unit} \cdot in = 66.25 \cdot in$

Weight of Unit $Wt_{unit} := Wt_{unit} \cdot lbs = 3195 \cdot lbs$



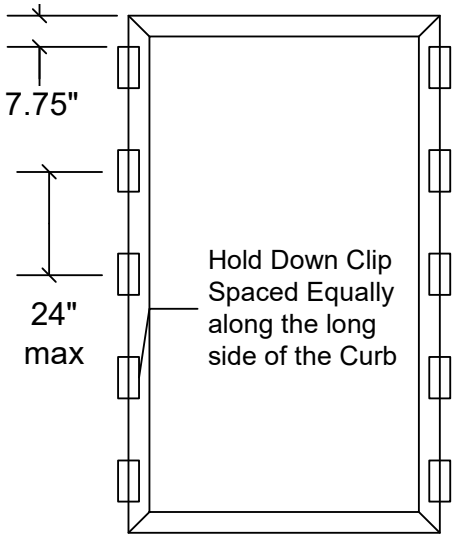
Roof Curb Dimensions

Length of Curb $L_{curb} := L_{curb} \cdot in = 113.188 \cdot in$

Width of Curb $W_{curb} := W_{curb} \cdot in = 77 \cdot in$

Height of Curb $H_{curb} := H_{curb} \cdot in = 30.5 \cdot in$

Weight of Curb $Wt_{curb} := Wt_{curb} \cdot lbs = 1239 \cdot lbs$



Curb Plan

Overall System Dimensions

Total Weight

$Wt_{tot} := Wt_{unit} + Wt_{curb} = 4402 \cdot lbs$

Total height

$H_{total} := H_{unit} + H_{curb} = 96.75 \cdot in$

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Seismic Loading + Snow Loading

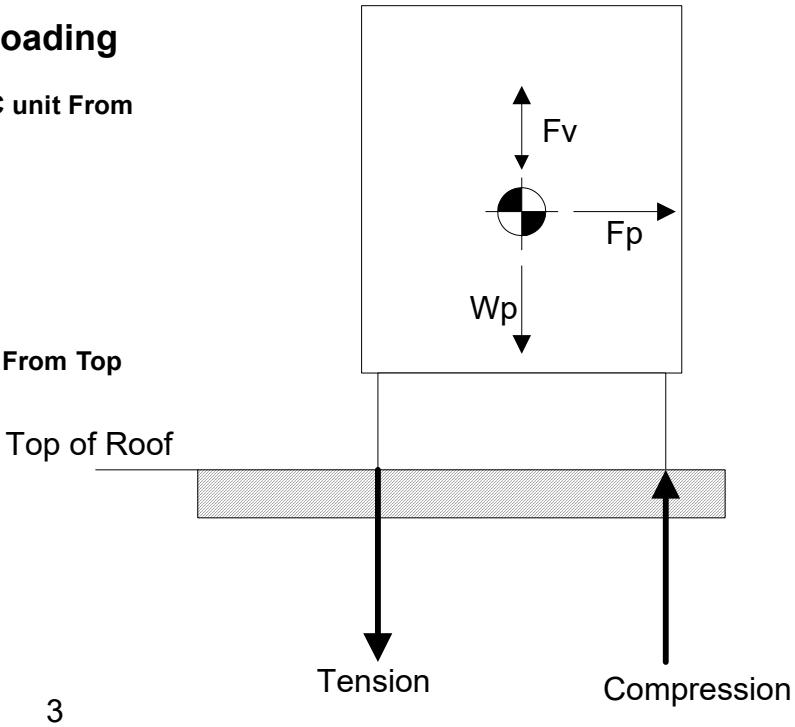
Height for Center of Gravity for HVAC unit From Top of Roof

$h_{CG.unit} := \frac{1}{2} H_{unit} = 33 \cdot in$

$h_{CG} := H_{curb} + h_{CG.unit} = 63.63 \cdot in$

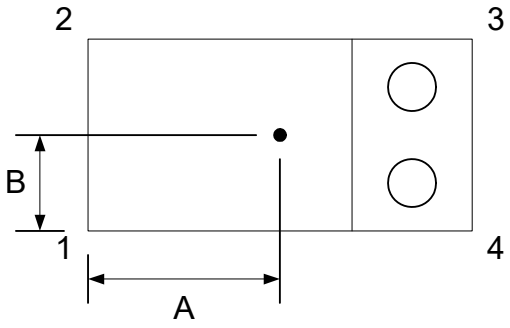
Height for Center of Gravity for Curb From Top of Roof

$h_{CG.curb} := \frac{H_{curb}}{2} = 15.25 \cdot in$



Max Seismic Base Shear

$V_{base.S} := F_p \cdot Wt_{tot} = 14857 \cdot lbs$



Unit C.G. distance in axis parallel to Curb Width $B_{ecc.width} := CG_{short} \cdot in = 36 \cdot in$

Eccentricity in axis parallel to Curb Width

$$e_{width} := \begin{cases} 0in & \text{if } B_{ecc.width} = \text{"N/A"} \\ \left| B_{ecc.width} - \frac{W_{unit}}{2} \right| & \text{otherwise} \end{cases} = 6.09 \cdot in$$

Unit C.G. distance in axis parallel to Curb Length $A_{ecc.length} := CG_{long} \cdot in = 58 \cdot in$

Eccentricity in axis parallel to Curb Length

$$e_{length} := \begin{cases} 0in & \text{if } A_{ecc.length} = \text{"N/A"} \\ \left| A_{ecc.length} - \frac{L_{unit}}{2} \right| & \text{otherwise} \end{cases} = 3.16 \cdot in$$

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Max Net Tension Reaction On Each Side Due To Seismic Loads

$$T_S := \begin{bmatrix} \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{W_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{W_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} \right] \\ \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{L_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{L_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} \right] \end{bmatrix} = \begin{pmatrix} -8548 \\ -5343 \end{pmatrix}\cdot lbs$$

Max Net Compression Reaction On Each Side Due To Seismic Loads

$$C_S := \begin{bmatrix} \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{W_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \\ \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{L_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \end{bmatrix} = \begin{pmatrix} 17879 \\ 13709 \end{pmatrix}\cdot lbs$$

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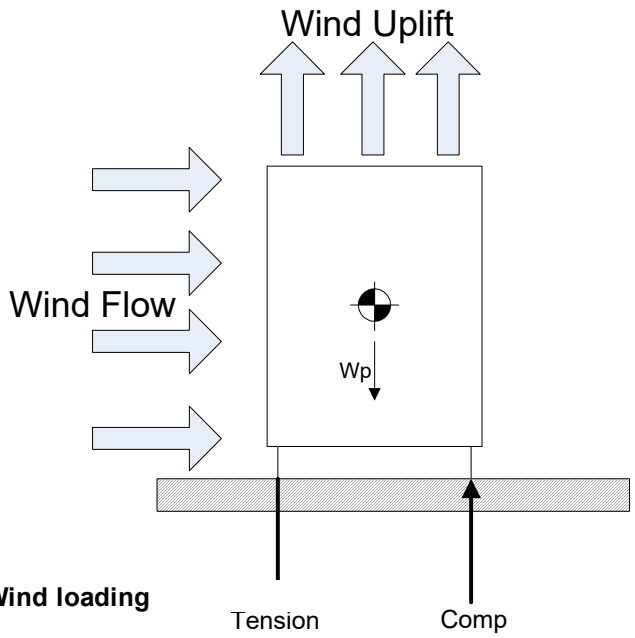
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Wind Loading + Snow Loading



Max Base Shear due to wind loading

$V_{base.W} := P_{net} \cdot L_{unit} \cdot H_{total} = 11826 \cdot lbs$

Max Uplift due to wind loading

$L_{unit.up} := L_{unit} - 0in = 122.313 \cdot in$

$P_{uplift.W} := P_v \cdot L_{unit.up} \cdot W_{unit} = 8124 \cdot lbs$

Max Net Tension Reaction On Each Side Due To Wind loading

$$T_W := \begin{pmatrix} \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} - \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \\ \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} - \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} -9739 \\ -5640 \end{pmatrix} \cdot lbs$$

Max Net Compression Reaction On Each Side Due To Wind loading

$$C_W := \begin{pmatrix} \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} + \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \\ \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} + \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} 12297 \\ 8149 \end{pmatrix} \cdot lbs$$

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Governing Loading @ Curb

Max uplift vertical load along the length of the curb

$$\omega_{x.L.vert.up} := \frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}} = 1032 \cdot plf$$

Max compressive vertical load along the length of the curb

$$\omega_{x.L.vert.comp} := \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}} = 1896 \cdot plf$$

Max vertical load along the length of the curb

$$\omega_{x.L.vert} := \max\left(\omega_{x.L.vert.up}, \omega_{x.L.vert.comp}\right) = 1896 \cdot plf$$

Max uplift vertical load along the width of the curb

$$\omega_{x.W.vert.up} := \frac{\max\left[\left|T_{S_{(1)}}\right|, \left|T_{W_{(1)}}\right|\right]}{W_{curb}} = 879 \cdot plf$$

Max compressive vertical load along the width of the curb

$$\omega_{x.W.vert.comp} := \frac{\max\left[\left|C_{S_{(1)}}\right|, \left|C_{W_{(1)}}\right|\right]}{W_{curb}} = 2136 \cdot plf$$

Max vertical loading along the width of the curb

$$\omega_{x.W.vert} := \max\left(\omega_{x.W.vert.up}, \omega_{x.W.vert.comp}\right) = 2136 \cdot plf$$

$$\begin{pmatrix} V_{base.S} \\ V_{base.W} \end{pmatrix} = \begin{pmatrix} 14857 \\ 11826 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} \left|T_S\right| \\ \left|C_S\right| \end{pmatrix} = \begin{pmatrix} 10081 \\ 22530 \end{pmatrix} \cdot lbs$$

$$\begin{pmatrix} F_v \cdot Wt_{tot} \\ P_v \cdot L_{unit} \cdot W_{unit} \end{pmatrix} = \begin{pmatrix} 1321 \\ 8124 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} \left|T_W\right| \\ \left|C_W\right| \end{pmatrix} = \begin{pmatrix} 11254 \\ 14752 \end{pmatrix} \cdot lbs$$

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Anchorage To Concrete [Expansion Anchor per ACI 318-14]

Number of connection on the long side

$N_B := 6 + 2$

Moment Arm for overturning (Short side)

$B := W_{curb} + 3in \cdot 2 = 83 \cdot in$

Number of Connection on the Short side.

$N_L := 4 + 2$

Moment Arm for over turning (Long side)

$L := L_{curb} + 3in \cdot 2 = 119 \cdot in$

Total Number of Connections

$N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 20$

Max Net Tension Reaction Due to Seismic Load, Fp

$$R_{c.EQ.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 18 \cdot lbs \qquad R_{c.EQ.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 8 \cdot lbs$$

$$R_{c.EQ} := MAX+\left[\begin{bmatrix}\left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{c.EQ.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{c.EQ.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}2139 \\ 1969\end{pmatrix} \cdot lbs$$

Max net Tension Reaction Due to Wind Load, Pnet

$$R_{c.W} := MAX+\left[\begin{bmatrix}\frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}1096 \\ 771\end{pmatrix} \cdot lbs$$

Governing Load Case:

$Govern := if\left(\left|R_{c.EQ}\right| > \left|R_{c.W}\right|, "Seismic", "Wind"\right) = "Seismic"$

Governing Tension Reaction at Each anchor Point:

$R_c := if\left(Govern = "Seismic", R_{c.EQ}, R_{c.W}\right) = \begin{pmatrix}2139 \\ 1969\end{pmatrix} \cdot lbs$

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Max Tension on anchor: $N_{ua} := \max(R_c) = 2139 \cdot lbs$

Max Shear on anchor: $V_{ua} := \frac{\max(\Omega_0 \cdot V_{base.S}, V_{base.W})}{N_t} = 1486 \cdot lbs$

Hilti Kwik Bolt TZ – Carbon Steel
5/8" Anchor with min 4" embedment
Base material: 6" thick Cracked concrete w/
Compressive strength fc' = 3000 psi
Min 6" away from the concrete edge
Evaluation Report: ICC-ESR 1917

Loading Condition:	**Seismic**

Design Tension Capacity [ϕN_n]:	3,631	[lbs]
Design Shear Capacity [ϕV_n]:	4,940	[lbs]

$\phi N_n := \phi N_n \cdot lbs = 3631 \cdot lbs$

$\phi V_n := \phi V_n \cdot lbs = 4940 \cdot lbs$

Utilization:

Tension Utilization:

$\beta_N := \frac{N_{ua}}{\phi N_n} = 59 \cdot \%$

Shear Utilization:

$\beta_V := \frac{V_{ua}}{\phi V_n} = 30 \cdot \%$

Interaction of Tensile and Shear Forces:
Per ACI 318-14 Sec. 17.6

$\beta_{NV} := \frac{(\beta_N) + (\beta_V)}{1.2} = 74 \cdot \%$

$$check\_interaction := \begin{pmatrix} if(\beta_N < 1.0, "OK", "NG") \\ if(\beta_V < 1.0, "OK", "NG") \\ if(\beta_{NV} < 1.0, "OK", "NG") \end{pmatrix} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

$$check\_interaction = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

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Anchorage To Structural Steel [Fillet Weld Conn. per AISI S100-16]

Fillet Weld 2" Long Along the Long and Short Side. Min 2 Connections per Side
Spacing: 48" O.C. for Non-Isolated Curbs; 24" for Isolated Curbs

Number of Welds on the Long Side $N_B := 5$

Moment Arm for Overturning (Short Side) $B := W_{curb} = 77 \cdot in$

Number of Welds on the Short Side. $N_L := 3$

Moment Arm for Overturning (Long Side) $L := L_{curb} = 113 \cdot in$

Total Number of Connections $N_t := \left[\left(N_B\right) + \left(N_L\right)\right] \cdot 2sides = 16$

Max Net Tension Reaction due to Seismic Load FP

$$R_{weld.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 30 \cdot lbs$$

$$R_{weld.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 18 \cdot lbs$$

$$R_{weld.EQ} := MAX+\left[\begin{bmatrix}\left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{weld.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{weld.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}1809 \\ 2056\end{pmatrix} \cdot lbs$$

Max Net Tension Reaction due to Wind Load Pnet

$$R_{weld.W} := MAX+\left[\begin{bmatrix}\frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}1792 \\ 1447\end{pmatrix} \cdot lbs$$

Tension Design Force; SRSS for Loading from Each Direction $T_{u.weld} := \max\left(\left|R_{weld.EQ}\right|, \left|R_{weld.W}\right|\right) = 2739 \cdot lbs$

Shear Load at Each Weld Connection $V_{u.weld} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{N_t} = 929 \cdot lbs$

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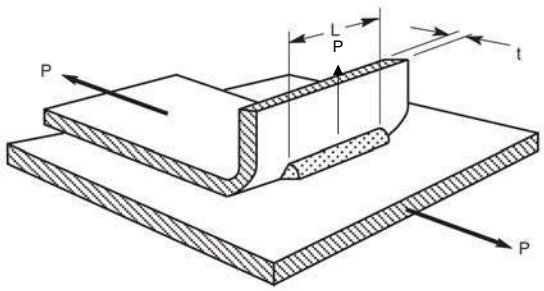
Total Demand: SRSS of V and T

$$R_{u.weld} := \sqrt{T_{u.weld}^2 + V_{u.weld}^2} = 2892 \cdot lbs$$

Fillet Weld Design per AISI S100-16 Section J2.5

Weld Length at Each Connection Point

$$L_w := 2in$$



Effective Throat Fillet Weld Size

$$t_w := \left(\frac{1}{8}in\right) \cdot 0.707 = 0.088 \cdot in$$

Thickness for the Thinnest Martial Being Welded
Min Curb Thickness = 16GA with Fu=65 ksi

$$t_1 := thick("14GA") = 0.0785 \cdot in$$

$$F_u := 65ksi$$

Min weld material strength

$$F_{exx} := 70ksi$$

For Longitudinal Loading [Parallel capacity is considered to be loading in the direction of the length of the weld] per (Eq. J2.5-1) &(Eq. J2.5-2)

$$\phi P_{long} := \begin{cases} (0.6)\left(1 - \frac{0.01 \cdot L_w}{t_1}\right) \cdot L_w \cdot t_1 \cdot F_u & \text{if } \frac{L_w}{t_1} < 25 \\ (0.5) \cdot 0.75 \cdot t_1 \cdot L_w \cdot F_u & \text{otherwise} \end{cases} = 3827 \cdot lbs$$

where $L_w \div t_1 = 25$

For Transverse Loading per (Eq. J2.5-5)

$$\phi P_{trans} := (0.65) \cdot t_1 \cdot L_w \cdot F_u = 6633 \cdot lbs$$

Strength of Weld Material per (Eq. J2.5-7)

$$\phi P_{weld} := (0.6) \cdot 0.75 \cdot t_w \cdot L_w \cdot F_{exx} = 5568 \cdot lbs$$

Design Strength of Fillet Weld

$$\phi P_n := \min\left(\phi P_{long}, \phi P_{trans}, \phi P_{weld}\right) = 3827 \cdot lbs$$

D/C Ratio for the Welded Connection

$$\beta_{NW} := \frac{R_{u.weld}}{\phi P_n} = 76 \cdot \%$$

$$weld_{check} := if\left(\beta_{NW} < 1.0, "OK", "NG"\right)$$

$weld_{check} = "OK"$

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Anchorage To Wood Member WITH Lag Screws [NDS-2018 LRFD Strength Design]

*** Use 3/8" Lag Screws along Each Side of the Curb**
*** Assume G=0.5 Douglas Fir-Larch**

Wood Lag Screw Capacity per NDS 2018 Section 11.3

Wet Service Factor: Cond := "DRY" **(e.g. CA = "DRY", AK = "WET")**

$$C_M := \begin{cases} 1.0 & \text{if Cond = "DRY"} \\ 0.7 & \text{if Cond = "WET"} \end{cases} = 1$$ **NDS 2018 Table 11.3.3**

Temperature Factor:
$$C_t := \begin{cases} 0.8 & \text{if Cond = "DRY"} \\ 0.7 & \text{if Cond = "WET"} \end{cases} = 0.8$$ **NDS 2018 Table 11.3.4**

Group Action Factor: $C_g := 0.97$ **NDS 2018 Table 11.3.6C**

Geometry Factor: $C_\Delta := 1.0$ **NDS 2018 Table 12.5.1A,B**

End Grain Factor: $C_{eg} := 1.0$ **NDS 2018 Sec. 12.5.2**

Diaphragm Factor: $C_{di} := 1.0$ **NDS 2018 Sec. 12.5.3**

Toe-Nail Factor: $C_{tn} := 1.0$ **NDS 2018 Sec. 12.5.4**

Format Conversion Factor: $K_F := 3.32$ **NDS 2018 Table 11.3.1**

Resistance Factor: $\phi := 0.65$ **NDS 2018 Table 11.3.1**

Time Effect Factor: $\lambda := 1.0$ **NDS 2018 App N.3.3**

Lateral Design Value: $Z := 130\text{lbs}$ **NDS 2018 Table 12K**

Withdrawal Design Value: $W := 305\text{lbs}$ **NDS 2018 Table 12.2A**

Lag Screw Diameter: $D_{lag} := \frac{3}{8}\text{in}$

Lag Screw Length: $L_{lag} := 4\text{in}$

Length of Tapered Tip: $E_{lag} := \frac{7}{32}\text{in}$

Lag Screw Penetration: $P_{lag} := 3.78125\text{in}$

Eff. Lag Screw Penetration for withdrawal: $P_{\omega.lag} := 2\text{in} + \frac{9}{32}\text{in} = 2.28\cdot\text{in}$ **NDS 2018 Appx. Table L2**

NDS 2018 Sec. 12.1.4.6

Minimum Penetration DCR <1.0: $DCR_{min.penetration} := \frac{4\cdot D_{lag}}{P_{\omega.lag}} = 0.66$ $DCR_{min.penetration} = \text{"OK"}$

Adj. Lateral Design Value: $Z' := Z\cdot C_M\cdot C_t\cdot C_g\cdot C_\Delta\cdot C_{eg}\cdot C_{di}\cdot C_{tn}\cdot K_F\cdot\phi\cdot\lambda = 218\cdot\text{lbs}$

Adj. Withdrawal Design Value: $W' := W\cdot C_M^{\,2}\cdot C_t\cdot C_{eg}\cdot C_{tn}\cdot K_F\cdot\phi\cdot\lambda = 527\cdot\text{lbs}$ **NDS 2018 Table 11.3.1**

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Number of Lag Screws on the Long Side $N_B := 24 + 2$

Moment Arm for Overturning (Short Side) $B := W_{curb} = 77 \cdot in$

Number of Lag Screws on the Short Side $N_L := 16 + 2$

Moment Arm for Overturning (Long Side) $L := L_{curb} = 113 \cdot in$

Total Number of Lag Screws $N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 80$

Max net Tension Reaction due to Seismic, Fp

$$R_{lag.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 6 \cdot lbs$$

$$R_{lag.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 3 \cdot lbs$$

$$R_{lag.EQ} := MAX+\left[\begin{bmatrix} \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{lag.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{lag.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 347 \\ 337 \end{pmatrix} \cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$R_{lag.W} := MAX+\left[\begin{bmatrix} \frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{L \cdot N_L \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 347 \\ 250 \end{pmatrix} \cdot lbs$$

Tension Design force; SRSS for loading from Each direction $T_{lag} := \max\left(\left|R_{lag.EQ}\right|, \left|R_{lag.W}\right|\right) = 484 \cdot lbs$

Shear load at each anchor location $V_{lag} := \frac{\max\left(V_{base.S} \cdot \sqrt{2}, V_{base.W}\right)}{N_t} = 263 \cdot lbs$

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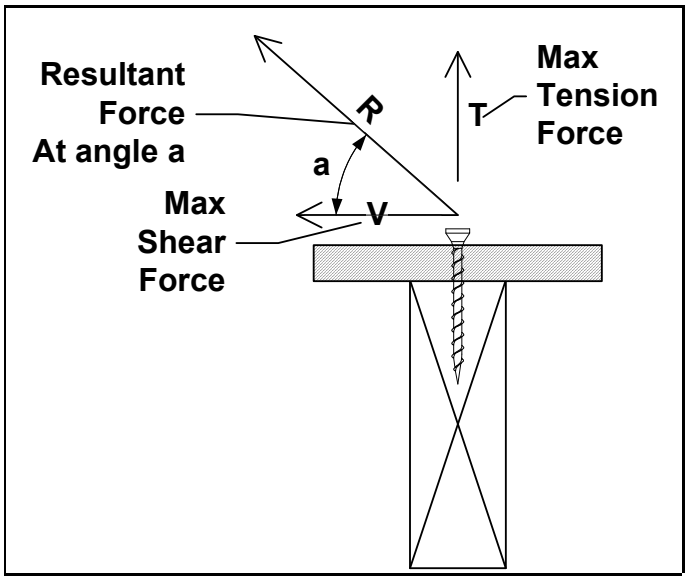
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For Lag Screws Subjected to Combined Lateral and Withdrawal Loading; Design Strength of the Lag Screw Shall Be Adjusted per Hankinson Formula as Prescribed by NDS 2018 Equation 12.4-1



Angle Between Wood Surface and Direction of Resultant Applied Load

$$(\alpha) := \operatorname{atan}\left(\frac{T_{lag}}{V_{lag}}\right) = 61\cdot\text{deg}$$

Combined Demand per Lag Screw @ Strength Level

$$R_{lag} := \sqrt{T_{lag}^{2} + V_{lag}^{2}} = 550\cdot\text{lbs}$$

Adjusted Capacity per NDS 2018 Equation 12.4-1 @ Strength Level

$$Z'_{\alpha} := \frac{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot Z'}{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot\cos(\alpha)^{2} + Z'\cdot\sin(\alpha)^{2}} = 592\cdot\text{lbs}$$

D/C Ratio for the Lag Screw connection to Wood Structure

$$\beta_{Lag} := \frac{R_{lag}}{Z'_{\alpha}} = 93\cdot\%$$

$$Lag_{Screw.Check} := \text{if}\left(\beta_{Lag} < 1.0, \text{"OK"}, \text{"NG"}\right)$$

$Lag_{Screw.Check}$ = "OK"

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Bearing and Tilting in Curb Bolted Connection AISI S100-16

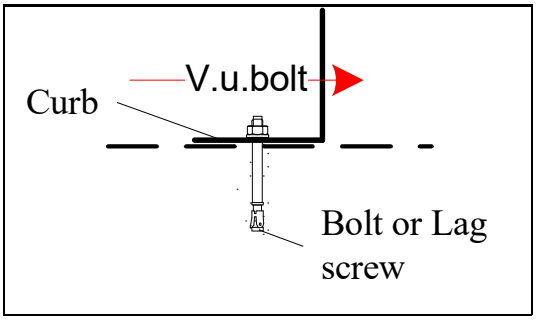
Nominal bolt diameter $d := 0.5in$

Uncoated sheet thickness $t_{curb} := thick("14GA") = 0.079 \cdot in$

Tensile strength of sheet $F_u := 65ksi$

Coefficient for conversion of units $\alpha := 1.0$

Modification Factor $m_f := 1.0$



Modification factor for type of bearing connection, per Table J3.3.1-2; For single shear connection with washers

Bearing Factor $C := \begin{cases} 3 & \text{if } \left(\frac{d}{t_{curb}} < 10\right) \wedge \left(0.024in < t_{curb} < 0.1875in\right) \\ "NG" & \text{if } \frac{d}{t_{curb}} > 10 \end{cases} = 3$

Bearing factor, which shall be determined according to Table J3.3.1-1 For d/t<10 where $d \div t_{curb} = 6$

Bearing Design Strength per AISI S100-16 Eq. J3.3.1-1

$$\phi P_{n_{(0)}} := (0.6) \cdot \left(m_f \cdot C \cdot d \cdot t_{curb} \cdot F_u\right) = 4592 \cdot lbs$$

Bolt Hole Deformation Design Strength per AISI S100-16 Eq. J3.3.2-1

$$\phi P_{n_{(1)}} := (0.65) \cdot \left[4.64 \cdot \left(\frac{\alpha}{in}\right) \cdot t_{curb} + 1.53\right] \cdot d \cdot t_{curb} \cdot F_u = 3141 \cdot lbs$$

Curb Connection Shear Capacity $\phi P_n := \min\left(\phi P_n\right) = 3141 \cdot lbs$

Loading demand at connection $V_{u.bolt} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{6} = 2476 \cdot lbs$

$Curb\_Conn\_Shear := if\left(V_{u.bolt} < \phi P_n, "OK", "NG"\right)$ Curb_Conn_Shear = "OK"

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Thickness of Curb, ISO Rail and Clip

(Per AISC Table 17-10 Galvanized)

Hold Down Clip thickness

$t_{Clip} := "12GA"$ $t_{clip} := thick(t_{Clip}) = 0.1084 \cdot in$

Roof Curb thickness

$t_{Curb} := "14GA"$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

ISO RAIL thickness

$t_{Curb.iso} := "10GA"$ $t_{curb.iso} := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Note: Iso Rail thickness is only used if the curb is isolated. Not used for non-isolated curbs

Sheet Metal Screws (SMS) Equations and References

SMS properties (ESR-2196 Table 5)

$SMS_{Table} =$

"SMS"	"Diameter"	"HeadDiameter"	"Tension"	"Shear"
"Size"	"d"	"dw"	"Pts"	"Pss"
"#8"	0.164	0.335	1000	1170
"#10"	0.19	0.399	1370	1215
"#12"	0.216	0.415	2325	1880
"#14"	0.25	0.5	4580	2440

SMS Tension Eqns

$P_{not} = 0.85 \cdot t \cdot d \cdot F_u$

$P_{nov} = 1.5 \cdot t \cdot d_w \cdot F_u$

$P_{nts} = 0.8 \cdot P_{ts}$

(AISI S100-16 J4.4.1 & J4.4.2)

FOR THE MOST CASES, PULL-OUT CAPACITY IS THE LOWEST

SMS Shearn Eqns

$P_{vnot} = 4.2 \cdot \sqrt{(d \cdot t^3)} \cdot F_u$

$P_{vnov} = 2.7 \cdot t \cdot d \cdot F_u$

$P_{vnss} = 0.8 \cdot P_{ss}$

(AISI S100-16 J4.3.1)

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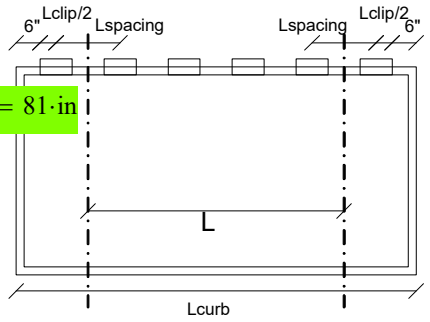
Hold Down Clip Design (Connection of the Mechanical unit to Curb)

Number of Clips on the long side $N_B := 6$

Moment Arm for overturning (Short side) $B := W_{curb} + 1.75in \cdot 2 = 81 \cdot in$

Number of Clips on the Short side. $N_L := 6$

Width of Clips $L_{clip} := 9in$



Curb Centerline Spacing (Long side)

$$L_{spacing} := \frac{L_{curb} - \left(6in + \frac{L_{clip}}{2}\right) \cdot 2}{N_B - 1} = 18.438 \cdot in$$

Moment Arm for overturning (Long side)

$$L := L_{curb} - 2 \cdot \left[6in + \frac{L_{clip}}{2} + L_{spacing} \cdot \frac{(N_L - 2)}{4}\right] = 55.313 \cdot in$$

Total Number of Clips

$$N_t := (N_B) \cdot 2sides = 12$$

Max net Tension Reaction due to Seismic, Fp

$$R_{clip.EQ} := MAX+\left[\begin{array}{l} \left[\frac{F_p \cdot Wt_{unit}}{B \cdot N_B} \cdot h_{CG.unit} + \frac{(0.9 - F_v) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B}\right] - \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} \\ \left[\frac{F_p \cdot Wt_{unit}}{L \cdot N_L} \cdot h_{CG.unit} + \frac{(0.9 - F_v) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L}\right] - \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} \end{array}\right] = \begin{pmatrix} 604 \\ 935 \end{pmatrix} \cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$R_{clip.W} := MAX+\left(\begin{array}{l} \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{unit}^2}{2}}{B \cdot N_B} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{unit}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{unit}^2}{2}}{L \cdot N_L} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{unit}}{N_t} \end{array}\right) = \begin{pmatrix} 1029 \\ 1021 \end{pmatrix} \cdot lbs$$

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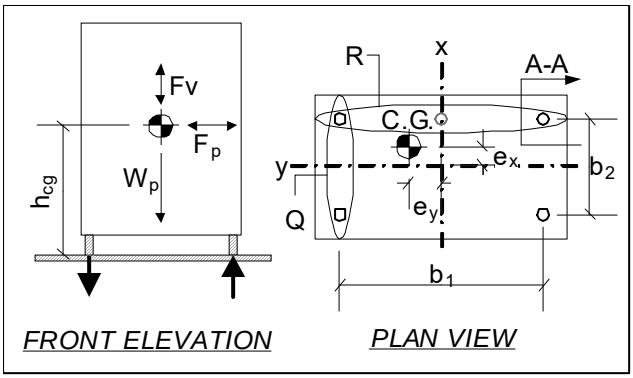
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Tensile and Shear Load calculation per ASHRAE RP-812



Eccentricity along X-X

$e_x := e_{width} = 6.094 \cdot in$

Eccentricity along Y-Y

$e_y := e_{length} = 3.157 \cdot in$

Distance between Seismic Restraints Along Y-Y

$b_1 := L_{curb} - 2 \cdot 6in = 101 \cdot in$

Distance between Seismic Restraints Along X-X

$b_2 := W_{curb} = 77 \cdot in$

Moment of Inertia about X-X

$$I_{xx} := \frac{N_t \cdot (N_t + 2) \cdot (b_1)^2}{12 \cdot (N_t - 2)} = 14335 \cdot in^2$$

Moment of Inertia about Y-Y

$$I_{yy} := \frac{N_t \cdot (b_2)^2}{4} = 17787 \cdot in^2$$

Angle about Tensile Load

$$\Theta_t := \operatorname{atan}\left[\frac{I_{yy} \cdot (b_1)}{I_{xx} \cdot (b_2)}\right] = 58 \cdot deg$$

Angle about Shear Load

$$\Theta_s := \begin{cases} \operatorname{atan}\left(\frac{e_x}{e_y}\right) & \text{if } e_y \neq 0 \\ 0deg & \text{if } e_y = 0 \end{cases} = 63 \cdot deg$$

Max Net Tensile Load Due to Seismic Load, Fp

$$T_{U.EQ.pt1} := \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} - \frac{(0.9 - F_v) \cdot Wt_{unit}}{b_1 \cdot b_2} \cdot \left(\frac{b_1}{2} \cdot e_x + \frac{b_2}{2} \cdot e_y - e_x \cdot e_y\right) = 59 \cdot lbs$$

$$T_{U.EQ.pt2} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \cos(\Theta_t) \cdot \frac{0.5 \cdot b_2}{I_{yy}} = -404 \cdot lbs$$

$$T_{U.EQ.pt3} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \sin(\Theta_t) \cdot \frac{0.5 \cdot b_1}{I_{xx}} = -1075 \cdot lbs$$

$T_{U.EQ} := T_{U.EQ.pt1} + T_{U.EQ.pt2} + T_{U.EQ.pt3} = -1420 \cdot lbs$

Max Net Shear Load Due to Seismic Load, Fp

$$V_{Ux.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\cos(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_2 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_1 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 524 \cdot lbs$$

$$V_{Uy.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\sin(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_1 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_2 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 893 \cdot lbs$$

$$V_{U.EQ} := \sqrt{V_{Ux.EQ}^2 + V_{Uy.EQ}^2} = 1035 \cdot lbs$$

Tension Design force for Hold Down Clips

$T_{clip} := \max(R_{clip.W_0}, R_{clip.W_1}, |R_{clip.EQ}|, |T_{U.EQ}|) = 1420 \cdot lbs$

$|R_{clip.EQ}| = 1113 \cdot lbs$ $|T_{U.EQ}| = 1420 \cdot lbs$

$T_{clip.EQ.max} := \max(|R_{clip.EQ}|, |T_{U.EQ}|) = 1420 \cdot lbs$

$T_{clip.W.max} := \max(R_{clip.W_0}, R_{clip.W_1}) = 1029 \cdot lbs$

Based on ASCE 7-16 Figure 29.4-1 magnitude of force coefficient,

Wind in diagonal direction to the face of equipment produces less force than that of the wind in perpendicular direction to the face of the equipment. Therefore, wind in diagonal direction does not need to be used

Shear Design force for Hold Down Clips

$$V_{clip} := \max\left(\frac{\max(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit})}{N_t}, |V_{U.EQ}|\right) = 1035 \cdot lbs$$

$F_p \cdot Wt_{unit} \cdot \frac{1}{N_t} = 899 \cdot lbs$ $|V_{U.EQ}| = 1035 \cdot lbs$

$P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t} = 675 \cdot lbs$

$V_{clip.EQ.max} := \max\left[\left(F_p \cdot Wt_{unit} \cdot \frac{1}{N_t}\right), |V_{U.EQ}|\right] = 1035 \cdot lbs$

$V_{clip.W.max} := \max\left(\left(P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t}\right)\right) = 675 \cdot lbs$

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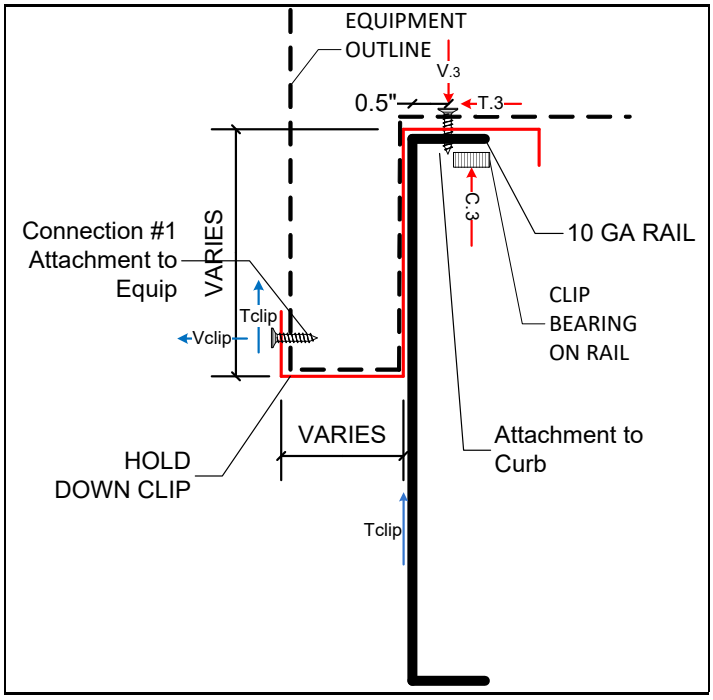
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Loading at Hold Down Clips @ Isolator Curb

$b_{return.iso} := Clip_b \cdot in = 2.125 \cdot in$

$b_{depth.iso} := Clip_c \cdot in = 6 \cdot in$



*For Reference Only

Mu Bending moment in the hold down

$M_u := T_{clip} \cdot b_{return.iso} = 3018 \cdot in \cdot lbs$

Resolve bending moment a T/C couple
Assume 0.5" bearing length
Moment Arm for T/C couple

$d_{T/C} := 1in - 0.5in = 0.5 \cdot in$

V3 is acting as shear on the screws. due to eccentricity of Tension force T

$$V_3 := \frac{T_{clip} \cdot \left[b_{return.iso} + (0) \right]}{d_{T/C}} = 6036 \cdot lbs$$

Additional load from Direct Shear acting out of plane (SRSS)

$V_3 := \sqrt{V_3^{\,2} + V_{clip}^{\,2}} = 6124 \cdot lbs$

Reaction C3 [compression force] is resisted by bearing of the hold down on the curb lip. Assume 0.5" bearing length

$C_3 := V_3 - T_{clip} = 4704 \cdot lbs$

T3 Load due to the shear acting out of plane tension on the screws.

$$T_3 := \left(\max\left(\frac{T_{clip} \cdot b_{return.iso}}{b_{depth.iso}}, V_{clip} \right) \right) = 1035 \cdot lbs$$

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Check Bending in Clip @ Isolator Curb

There are several restraints that prevents the hold down clip for iso-curb to have local bending at the bottom and transfer vertical load demand directly to the face of the curb.

- Hold down is bearing on the face of iso-rail / non-iso curb lip.
- Gasket will act as a "link" member to allow unit base rail and bottom flange to move totegther so flange can't bend unless the unit base rail bends first. However, unit base rail is not likely to bend so bottom flange won't bend

Hold Down Clip thickness

$t_{Clip} = \text{"12GA"}$ $t_{clip} := \text{thick}(t_{Clip}) = 0.1084 \cdot in$

Effective width of hold down clip

$b_c := L_{clip} = 9 \cdot in$

Yield strength of the Clip

$F_{y.c} := 50ksi$

Strength reduction for bending

$\phi_{clip} := 0.9$

Design Bending Capacity (LRFD)

$\phi M_n := \phi_{clip} \cdot F_{y.c} \left(\frac{b_c \cdot t_{clip}^2}{6} \right) = 793 \cdot in \cdot lbs$

Flexural bending demand

$M_{u.clip} := T_{clip} \cdot 0.5in = 710 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.clip}}{\phi M_n} = 0.895$

$Clip_{Bending} = \text{"OK"}$

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Check Flange Bending in Clip @ Isolator Curb

Note:
- **If the curb flange is welded to the 10GA channel and 10GA channel is welded back to the base of the curb, then both tension and compression due to equipment overturning will be taken care by the 10GA channel.**
- **Since the curb will be reinforced with 10GA channel under each isolator, it can be assumed that the loads will trasnferred down to the base structure through the channels. Therefore, flange downward bending at curb due to compressive load does not need to be checked.**

Roof Curb thickness

$t_{Curb} = \text{"14GA"}$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

Clip edge to edge distance

$$b_{edge2edge} := \frac{L_{curb} - \left(6in + \frac{L_{clip}}{2}\right) \cdot 2}{N_B - 1} - L_{clip} = 9.438 \cdot in$$

Effective width of Roof Curb

$b_{curb} := L_{clip} + b_{edge2edge} = 18.44 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\frac{b_{curb} \cdot (t_{curb})^2}{6}\right] = 852 \cdot in \cdot lbs$$

Width of Isolator

$w_{JQ.iso} := 2in$ **2 in. for CQAs**

Flexural bending demand

$$M_{u.Curb} := T_{clip} \cdot \left(\max\left(\frac{1.75in}{2} - 0.5in, \frac{w_{JQ.iso}}{2} - 1in\right)\right) = 533 \cdot in \cdot lbs$$

D/C Ratio for bending

$$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.625$$

$Curb_{Bending} = \text{"OK, Weld 10GA channel ends to curb flange"}$

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Design of Connection#1 Connection of Equipment to hold Down clip

Ultimate SMS screw connection Strength (LRFD)
Strength based on the smallest thickness of Curb and Equipment Housing (min 16 GA) [Fy = 50ksi & Fu=65ksi]

$n_{sms} := 4$ $Size_{ss} := "\#14"$

$t_{ss} := "16GA"$ $F_{u.ss} := 65ksi$

Nominal Tension Strength

$$P_{nt} := n_{sms} \cdot T_s(Size_{ss}, t_{ss}, F_{u.ss}) = 3508 \cdot lbs$$

$$P_{not} := n_{sms} \cdot T_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 3508 \cdot lbs$$

$$P_{nov} := n_{sms} \cdot T_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 12383 \cdot lbs$$

$$P_{nts} := n_{sms} \cdot T_{nts}(Size_{ss}, t_{ss}, F_{u.ss}) = 14656 \cdot lbs$$

Nominal Shear Strength

$$P_{ns} := n_{sms} \cdot V_s(Size_{ss}, t_{ss}, F_{u.ss}) = 7808 \cdot lbs$$

$$P_{vnot} := n_{sms} \cdot V_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 8737 \cdot lbs$$

$$P_{vnov} := n_{sms} \cdot V_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 11144 \cdot lbs$$

$$P_{vnss} := n_{sms} \cdot V_{nss}(Size_{ss}, t_{ss}, F_{u.ss}) = 7808 \cdot lbs$$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} V_{clip} \div (\phi_{sms} \cdot P_{nt}) \\ T_{clip} \div (\phi_{sms} \cdot P_{ns}) \end{bmatrix} = \begin{pmatrix} 59 \\ 36 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left[\begin{bmatrix} \left[\frac{T_{clip}}{P_{vnov}} + 0.71\left(\frac{V_{clip}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{T_{clip}}{P_{vnot}} + \left(\frac{V_{clip}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{T_{clip}}{P_{vnss}} + \left(\frac{V_{clip}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right] = 66 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

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Design of Connection#2 Connection of hold Down clip to Curb

Tension loads on SMS connection

$T_{s2} := V_3 = 6124 \cdot lbs$

Shear loads on SMS connection

$V_{s2} := T_3 = 1035 \cdot lbs$

Ultimate SMS screw connection Strength (LRFD)
Strength based on the smallest thickness of Curb and Equipment Housing (min 16 GA) [Fy = 50ksi & Fu=65ksi]

$n_{sms} := 8$ $Size_{ss} := "\#14"$

$t_{ss} := (t_{Curb.iso}) = "10GA"$ $F_{u.ss} := 65ksi$

Nominal Tension Strength

$P_{nt} := n_{sms} \cdot T_s(Size_{ss}, t_{ss}, F_{u.ss}) = 15271 \cdot lbs$

Note:
SMS is getting pulled up so the thicker curb iso rail is engaged for SMS capacity , rather than just the clip itself.

$P_{not} := n_{sms} \cdot T_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 15271 \cdot lbs$

$P_{nov} := n_{sms} \cdot T_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 53898 \cdot lbs$

$P_{nts} := n_{sms} \cdot T_{nts}(Size_{ss}, t_{ss}, F_{u.ss}) = 29312 \cdot lbs$

Nominal Shear Strength

$P_{ns} := n_{sms} \cdot V_s(Size_{ss}, t_{ss}, F_{u.ss}) = 15616 \cdot lbs$

$P_{vnot} := n_{sms} \cdot V_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 56103 \cdot lbs$

$P_{vnov} := n_{sms} \cdot V_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 48508 \cdot lbs$

$P_{vnss} := n_{sms} \cdot V_{nss}(Size_{ss}, t_{ss}, F_{u.ss}) = 15616 \cdot lbs$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} T_{s2} \div (\phi_{sms} \cdot P_{nt}) \\ V_{s2} \div (\phi_{sms} \cdot P_{ns}) \end{bmatrix} = \begin{pmatrix} 80 \\ 13 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left[\begin{bmatrix} \left[\frac{V_{s2}}{P_{vnov}} + 0.71\left(\frac{T_{s2}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{V_{s2}}{P_{vnot}} + \left(\frac{T_{s2}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{V_{s2}}{P_{vnss}} + \left(\frac{T_{s2}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right] = 61 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

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Hold Down clip Bending and Shear Interaction

Diameter of SMS:

$$d_{sms} := \text{vlookup}\left(Size_{ss}, SMS_{Table}, 1\right)_0 \cdot in = 0.25 \cdot in$$

Depth of flat web portion

$$h_{clip.shear} := L_{clip} - n_{sms} \cdot d_{sms} = 7 \cdot in$$

Depth-to-Thickness Ratio:

$$\frac{h_{clip.shear}}{t_{clip}} = 65 \qquad E := 29500ksi \qquad F_y := 50ksi \qquad \mu := 0.3$$

Nominal Shear Stress:
(For unreinforced web)
AISI S100-16 G2.1

$$k_v := 5.34 \qquad \sqrt{\frac{E \cdot k_v}{F_y}} = 56 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 85$$

Area of Web Element:

$$A_w := h_{clip.shear} \cdot t_{clip} = 0.759 \cdot in^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h_{clip.shear}}{t_{clip}}\right)^2} = 34.1 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} \qquad V_y := 0.6 \cdot A_w \cdot F_y = 23\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.937$$

Hole Shear Reduction Factor:
(for circular holes, AISI S100-16 Eq G3-1)

$$c := \frac{h_{clip.shear}}{2} - \frac{d_{sms}}{2.83} = 3.41 \cdot in$$

$$q_s := \begin{cases} 1.0 & \text{if } \frac{c}{t_{clip}} \geq 54 \\ \frac{c}{54 \cdot t_{clip}} & \text{if } 5 \leq \frac{c}{t_{clip}} < 54 \end{cases} = 0.583$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \leq 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \leq 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 19.792 \cdot kip$$

Design Shear Capacity with holes:

$$\phi V_{n.clip} := 0.95 \cdot V_n \cdot q_s = 11 \cdot kip$$

D/C Ratio of V and M per AISI S100-16 Eq H2-1

$$DCR_{V.M.int.clip} := \sqrt{\left(\frac{M_{u.clip}}{\phi M_n}\right)^2 + \left(\frac{\max\left(T_{clip}, V_{clip}\right)}{\phi V_{n.clip}}\right)^2} = 0.9046$$

Demand/Capacity Ratio:

$VandM_{int.clip} = \text{"OK"}$

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ISOLATOR DESIGN [PER OPM-0401-13]

OPM-0401-13 is based on allowable stress design

Number of isolators on the long side

$N_B := 8$ $N_{iso.long} := N_B = 8$

Moment Arm for overturning (Short side)

$B := W_{curb} + \frac{1.75in}{2} \cdot 2 = 79 \cdot in$

Number of isolators on the Short side.

$N_L := 6$

Isolator Centerline Spacing (Long side)

$L_{spacing.iso} := \frac{L_{curb} - (6in) \cdot 2}{N_B - 1} = 14.46 \cdot in$

Moment Arm for overturning (Long side)

$L := L_{curb} - 2 \cdot 6in - 2 \cdot L_{spacing.iso} \cdot \frac{(N_L - 2)}{4} = 72 \cdot in$

Total Number of isolators

$N_t := (N_B) \cdot 2sides = 16$

Max net Tension Reaction due to Seismic, Fp

$EQ_{ASD} := \left[0.6 - (0.7 \cdot F_v)\right] \cdot Wt_{unit} = 1.246\ kip$

$$R_{iso.EQ} := MAX+\left[\left[\left[\frac{(0.7F_p) \cdot Wt_{unit}}{B \cdot N_B} \cdot (h_{CG.unit} + 0in) + \frac{EQ_{ASD} \cdot e_{width}}{B \cdot N_B}\right] - \frac{EQ_{ASD}}{N_t}\right]\right] = \begin{pmatrix} 331 \\ 508 \end{pmatrix} \cdot lbs$$

$$\left[\left[\frac{(0.7F_p) \cdot Wt_{unit}}{L \cdot N_L} \cdot (h_{CG.unit} + 0in) + \frac{EQ_{ASD} \cdot e_{length}}{L \cdot N_L}\right] - \frac{EQ_{ASD}}{N_t}\right]$$

Max net Tension Reaction due to Wind load, Pnet

$$F_{wind.B} := \frac{P_{net} \cdot L_{unit} \cdot (H_{unit} + 0in)}{B \cdot N_B} \cdot \left(\frac{1}{2} \cdot H_{unit} + 0in\right) = 426 \cdot lbs$$

$$F_{wind.L} := \frac{P_{net} \cdot W_{unit} \cdot (H_{unit} + 0in)}{L \cdot N_L} \cdot \left(\frac{1}{2} \cdot H_{unit} + 0in\right) = 426 \cdot lbs$$

$$R_{iso.W} := (0.6) \cdot MAX+\left(\begin{pmatrix} F_{wind.B} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{Wt_{unit}}{N_t} \\ F_{wind.L} + \frac{P_v \cdot L_{unit.up} W_{unit}}{N_t} + \frac{Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{Wt_{unit}}{N_t} \end{pmatrix}\right) = \begin{pmatrix} 459 \\ 454 \end{pmatrix} \cdot lbs$$

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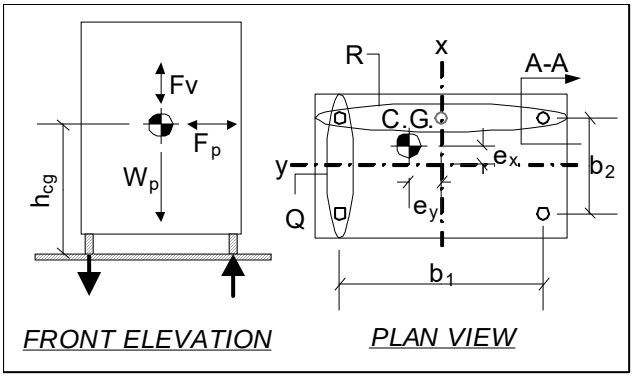
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Tensile and Shear Load calculation per ASHRAE RP-812



Eccentricity along X-X

$e_x := e_{width} = 6.09 \cdot in$

Eccentricity along Y-Y

$e_y := e_{length} = 3.16 \cdot in$

Distance between Seismic Restraints Along Y-Y

$b_1 := L_{curb} - 2 \cdot 6in = 101 \cdot in$

Distance between Seismic Restraints Along X-X

$b_2 := W_{curb} + 2 \cdot \frac{1.75in}{2} = 79 \cdot in$

Moment of Inertia about X-X

$I_{xx} := \frac{N_t \cdot (N_t + 2) \cdot (b_1)^2}{12 \cdot (N_t - 2)} = 17553 \cdot in^2$

Moment of Inertia about Y-Y

$I_{yy} := \frac{N_t \cdot (b_2)^2}{4} = 24806 \cdot in^2$

Angle about Tensile Load

$\Theta_t := \operatorname{atan}\left[\frac{I_{yy} \cdot (b_1)}{I_{xx} \cdot (b_2)}\right] = 61 \cdot deg$

Angle about Shear Load

$\Theta_s := \begin{cases} \operatorname{atan}\left(\frac{e_x}{e_y}\right) & \text{if } e_y \neq 0 \\ 0deg & \text{if } e_y = 0 \end{cases} = 63 \cdot deg$

Max Net Tensile Load Due to Seismic Load, Fp

$T_{U.EQ.pt1} := \frac{(0.6 - 0.7 \cdot F_v) \cdot Wt_{unit}}{N_t} - \frac{(0.6 - 0.7 \cdot F_v) \cdot Wt_{unit}}{b_1 \cdot b_2} \cdot \left(\frac{b_1}{2} \cdot e_x + \frac{b_2}{2} \cdot e_y - e_x \cdot e_y\right) = 13 \cdot lbs$

$T_{U.EQ.pt2} := -0.7 \cdot (F_p \cdot Wt_{unit}) \cdot (h_{CG.unit} + 0in) \cdot \cos(\Theta_t) \cdot \frac{0.5 \cdot b_2}{I_{yy}} = -191 \cdot lbs$

$T_{U.EQ.pt3} := -0.7 \cdot (F_p \cdot Wt_{unit}) \cdot (h_{CG.unit} + 0in) \cdot \sin(\Theta_t) \cdot \frac{0.5 \cdot b_1}{I_{xx}} = -631 \cdot lbs$

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$T_{U.EQ} := T_{U.EQ.pt1} + T_{U.EQ.pt2} + T_{U.EQ.pt3} = -810 \cdot lbs$

Max Net Shear Load Due to Seismic Load, Fp

$$V_{Ux.EQ} := 0.7 \cdot F_p \cdot Wt_{unit} \cdot \frac{\cos(\Theta_s)}{N_t} + \frac{0.7 \cdot F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_2 \cdot e_y + 0.7 \cdot F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_1 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 276 \cdot lbs$$

$$V_{Uy.EQ} := 0.7 \cdot F_p \cdot Wt_{unit} \cdot \frac{\sin(\Theta_s)}{N_t} + \frac{0.7 \cdot F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_1 \cdot e_y + 0.7 \cdot F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_2 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 470 \cdot lbs$$

$$V_{U.EQ} := \sqrt{V_{Ux.EQ}^2 + V_{Uy.EQ}^2} = 545 \cdot lbs$$

Tension Design force SRSS for loading from Each direction

$R_{iso.EQ.1.RP812} := \left| T_{U.EQ.pt1} + T_{U.EQ.pt3} \right| = 618 \cdot lbs$

$R_{iso.EQ.0.RP812} := \left| T_{U.EQ.pt1} + T_{U.EQ.pt2} \right| = 178 \cdot lbs$

$$R_{iso.EQ.max_1} := \max\left[\left(R_{iso.EQ.1.RP812} + 0 \cdot R_{iso.EQ.0.RP812}\right), \left(R_{iso.EQ_1} + 0 \cdot R_{iso.EQ_0}\right)\right] = 618 \cdot lbs$$

$$R_{iso.EQ.max_0} := \max\left[\left(R_{iso.EQ.0.RP812} + 0 \cdot R_{iso.EQ.1.RP812}\right), \left(R_{iso.EQ_0} + 0 \cdot R_{iso.EQ_1}\right)\right] = 331 \cdot lbs$$

For the plot:

$R_{iso.EQ.max_1} = 618 \cdot lbs$ $R_{iso.W_1} = 454 \cdot lbs$

$R_{iso.EQ.max_0} = 331 \cdot lbs$ $R_{iso.W_0} = 459 \cdot lbs$

Shear load at each anchor location

For the plot:

$$V_{iso.E} := \max\left[\left[\begin{array}{c} 1.0 \cdot V_{Ux.EQ} + 0 \cdot V_{Uy.EQ} \\ 0.3 \cdot V_{Ux.EQ} + 0 \cdot V_{Uy.EQ} \\ \left[\left(0.7F_p\right) \cdot Wt_{unit} \cdot \frac{1}{N_t}\right] \end{array}\right]\right] = 472 \cdot lbs \qquad V_{iso.W} := 0.6P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t} = 304 \cdot lbs$$

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Isolator Capacity:

$ID_{Iso} := "CQA"$

$T_{n.\Omega} := 2117lbs$ **(ASD)**

$V_{n.\Omega} := 775lbs$ **(ASD)**

Isolator Demand:

$R_{iso.max} := \max\left[\left(R_{iso.EQ.max_1}\right),\left(R_{iso.EQ.max_0}\right),\left(R_{iso.W_1}\right),\left(R_{iso.W_0}\right)\right] = 618\cdot lbs$

$V_{iso.max} := \max\left(V_{iso.E}, V_{iso.W}\right) = 472\cdot lbs$

D/C Ratio of Tension Only.:

$$DCR_{tension} := \frac{R_{iso.max}}{T_{n.\Omega}} = 0.292$$

$DCR_{tension} = "OK"$

D/C Ratio of Shear Only.:

$$DCR_{shear} := \frac{V_{iso.max}}{V_{n.\Omega}} = 0.609$$

$DCR_{shear} = "OK"$

D/C Ratio of Tension Only.:

$$DCR_{Int} := \frac{V_{iso.max}}{V_{n.\Omega}} + \frac{R_{iso.max}}{T_{n.\Omega}} = 0.901$$

$DCR_{Int} = "OK"$

ISOLATOR "SPRING" DESIGN [PER OPM-0401-13]

Factor of Safety of Spring

$FS_{spring} := 0.75$

Compressive Strength of Spring

$$C_{spring.\Omega} := \begin{cases} \left(FS_{spring}\cdot 300lbs\right) & \text{if } ID_{Iso} = "CQA" \\ \left(FS_{spring}\cdot 918lbs\right) & \text{if } ID_{Iso} = "CQB" \\ \left(FS_{spring}\cdot 918lbs\right) & \text{if } ID_{Iso} = "CQBX" \end{cases} = 225\cdot lbs$$

Rated Load per unit self-weight

$$C_{unit.rated.load} := \frac{Wt_{unit}}{N_t} = 200\cdot lbs$$

D/C Ratio of Spring Compression:

$$DCR := \frac{C_{unit.rated.load}}{C_{spring.\Omega}} = 0.888$$

$IsoSpring_{compression} = "OK"$

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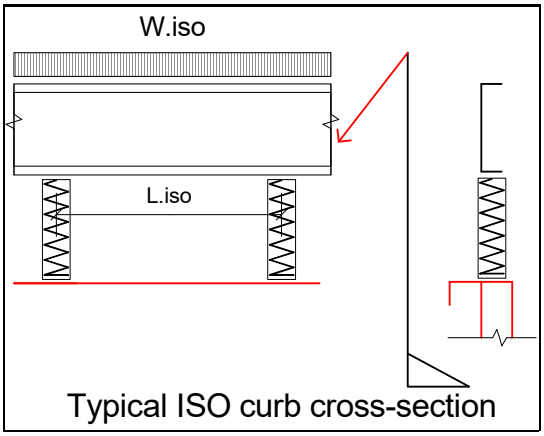
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Check ISO Rail for Bending about Strong and Weak Axis (AISI S100-16 F2.1)



Typical ISO curb cross-section

Thickness of Curb:

$t_{Curb.iso}$ = "10GA" $t := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Inside Bend Radius:

$R := R_{iso} = 0.186 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web:

$h := 7.5in - 2 \cdot (t + R) = 6.85 \cdot in$

Width of Flange:

$h_w := 1in$

Check Curb Bending of Long Side (Strong axis)

Member per CFS: $CFS_{member} :=$ "10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"

Number of Isolators on each Long Side: $N_{iso.long} = 8$

Center-to-Center Spacing of Isolators $L_{iso} := \frac{L_{curb}}{N_{iso.long} - 1} = 16 \cdot in$

Distributed Load $\omega_{iso} := \omega_{x.L.vert} = 1.896\,klf$

Moment Demand on Iso Rail $M_{cx} := \frac{\omega_{iso} \cdot L_{iso}^2}{8} = 5.163 \cdot kip \cdot in$

Curb Elastic Modulus / Yield Stress: $E := 29500ksi$ $F_y := 50ksi$

Curb Shear Modulus: $G := 11300ksi$

Poisson's Ratio $\mu := 0.3$

Section Properties from CFS: $r_x = 2.4893 \cdot in$ $r_o = 2.519 \cdot in$ $C_w = 0.595 \cdot in^6$ $S_x = 1.855 \cdot in^3$

$r_y = 0.2288 \cdot in$ $J = 0.0058 \cdot in^4$ $S_y = 0.3669 \cdot in^3$

$r_{min} := min(r_x, r_y) = 0.2288 \cdot in$

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Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Flanges*

Flat Width:

$$w := h_w - R_{curb} = 0.893 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Unstiffened"}$$

Stress at the end of the Width:

$$f_2 := 11.407ksi \quad f_1 := 11.407ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \frac{f_2}{f_1} = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 0.43$$

Critical Compressive Stress:

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t}{w}\right)^2 = 274.53 \cdot ksi$$

Stress in Compression Element:

$$f := 18ksi$$

Note: Use f from "Elastive Flexural Buckling Stress" on "Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI E2)"

Slenderness Factor:

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 0.26$$

Local reduction factor:

$$\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 0.55$$

Effective Width of the Flanges:

$$b_{eff.flange} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 0.893 \cdot in$$

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Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Web*

Flat Width: $w := h = 6.851 \cdot in$

Stiffened Web Check: $Stiffened_{check} := "Stiffened"$

Stress at the end of the Width: $f_2 := 11.407ksi$ $f_1 := 11.407ksi$

Compressive Stress Ratio (Eq. 1.1.2-1): $\Psi := \frac{f_2}{f_1} = 1$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = "Stiffened" \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = "Unstiffened" \end{cases} = 4$$

Critical Compressive Stress: $F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t}{w}\right)^2 = 43.4 \cdot ksi$

Stress in Compression Element: $f := 18ksi$

Note: Use f from "Elastive Flexural Buckling Stress" on "Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI E2)"

Slenderness Factor: $\lambda := \sqrt{\frac{f}{F_{cr}}} = 0.64$

Local reduction factor: $\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 1.022$

Effective Width of the Web:

$$b_{eff.web} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 6.851 \cdot in$$

Effective Area of the Member: $A_e := 2 \cdot \left(b_{eff.flange} \cdot t\right) + b_{eff.web} \cdot t = 1.194 \cdot in^2$

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For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. F2.1.1-4,5)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(1.0 \cdot L_{iso}\right)^2}\right] = 96 \cdot ksi$$

$$\sigma_{ey} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{iso}}{r_y}\right)^2} = 58 \cdot ksi \qquad \frac{1.0 \cdot L_{iso}}{r_y} = 71$$

KL_r = "KL/r < 200, OK"

Cb per Eq. F2.1.1-2

$$M_A := \frac{\omega_{iso} \cdot \frac{L_{iso}}{4}}{2} \cdot \left(L_{iso} - \frac{L_{iso}}{4}\right) = 3.87 \cdot kip \cdot in$$

$$M_B := M_{cx} = 5.16 \cdot kip \cdot in$$

$$M_C := \frac{\omega_{iso} \cdot \frac{3 \cdot L_{iso}}{4}}{2} \cdot \left(L_{iso} - \frac{3 \cdot L_{iso}}{4}\right) = 3.87 \cdot kip \cdot in$$

$$C_b := \min\left(1.0, \frac{12.5 \cdot M_{cx}}{2.5 \cdot M_{cx} + 3 \cdot M_A + 4 \cdot M_B + 3.M_C}\right) = 1$$

Elastic Critical Lateral-Torsional Buckling Stress per Eq. F2.1.1-1 for Singly Symmetry:

$$F_e := \frac{C_b \cdot r_o \cdot A_e}{S_x} \cdot \sqrt{\sigma_{ey} \cdot \sigma_t} = 121 \cdot ksi$$

LTB Design Stress: Eq. F2.1-3,4,5:

$$F_c := \begin{cases} F_y & \text{if } F_e \geq 2.78 \cdot F_y \\ \frac{10}{9} \cdot F_y \cdot \left(1 - \frac{10 \cdot F_y}{36 \cdot F_e}\right) & \text{if } 2.78 \cdot F_y > F_e > 0.56 \cdot F_y \\ F_e & \text{if } 0.56 \cdot F_y \geq F_e \end{cases} = 49 \cdot ksi$$

Moment Capacity Eq. F2.1-1:

$$\phi M_{nx} := 0.9 \cdot S_x \cdot \min\left(F_c, F_y\right) = 82 \cdot kip \cdot in$$

D/C Ratio of Bending:

$$DCR := \frac{M_{cx}}{\phi M_{nx}} = 0.063$$

$Iso_{Bending}$ = "OK"

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Check Curb Bending of Long Side (Weak axis)

Center-to-Center Spacing of Braces

$$L_{brace} := \frac{L_{curb}}{N_{iso.long} - 1} = 16 \cdot in$$

Note for weak-axis bracing length:
Max weak-axis span length of Iso Rail is larger than L_{brace} per cut sheet. However, the Iso Rail is braced with clip at max 24" O.C. at top and isolator at max 36" O.C. at bottom such that the actual unbraced length is as follows.

Distributed Load

$$\omega_{iso} := \frac{\max\left(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit}\right)}{L_{curb}} = 1.143\ klf$$

Moment Demand on Iso Rail

$$M_{cy} := \frac{\omega_{iso} \cdot L_{brace}^{2}}{8} = 3.114 \cdot kip \cdot in$$

Member per CFS:

$$CFS_{member} = \text{"10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"}$$

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. F2.1.1-4,5)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(1.0 \cdot L_{brace}\right)^2}\right] = 96 \cdot ksi$$

$$\sigma_{ex} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{brace}}{r_x}\right)^2} = 6900 \cdot ksi \qquad \frac{1.0 \cdot L_{brace}}{r_x} = 6$$

$$KL_r = \text{"KL/r < 200, OK"}$$

Cb per Eq. F2.1.1-2

$$M_A := \frac{\omega_{iso} \cdot \frac{L_{brace}}{4}}{2} \cdot \left(L_{brace} - \frac{L_{brace}}{4}\right) = 2.34 \cdot kip \cdot in$$

$$M_B := M_{cy} = 3.11 \cdot kip \cdot in$$

$$M_C := \frac{\omega_{iso} \cdot \frac{3 \cdot L_{brace}}{4}}{2} \cdot \left(L_{brace} - \frac{3 \cdot L_{brace}}{4}\right) = 2.34 \cdot kip \cdot in$$

$$C_b := \min\left(1.0, \frac{12.5 \cdot M_{cx}}{2.5 \cdot M_{cx} + 3 \cdot M_A + 4 \cdot M_B + 3 \cdot M_C}\right) = 1$$

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Elastic Critical Lateral-Torsional Buckling Stress per Eq. F2.1.1-1 for Singly Symmetry:

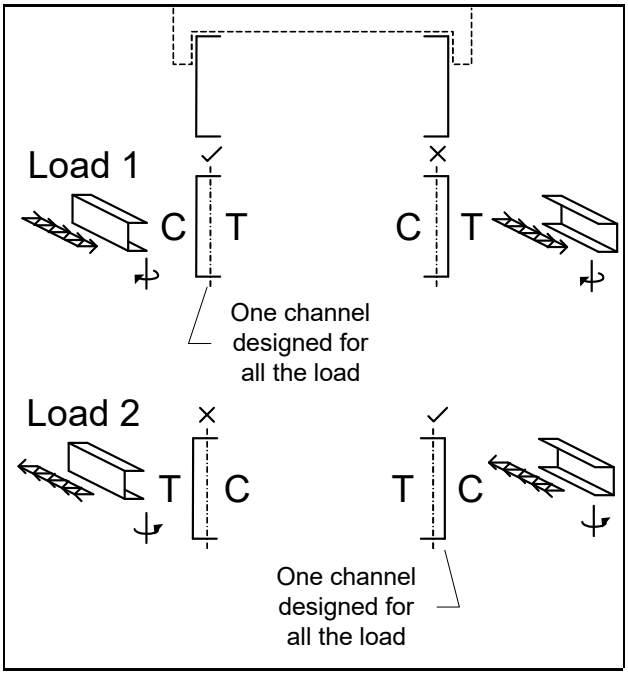
$$F_e := \frac{C_b \cdot r_o \cdot A_e}{S_y} \cdot \sqrt{\sigma_{ey} \cdot \sigma_t} = 613 \cdot ksi$$

LTB Design Stress: Eq. F2.1-3,4,5:

$$2.78 \cdot F_y = 139 \cdot ksi$$

$$0.56 \cdot F_y = 28 \cdot ksi$$

$$F_c := \begin{cases} F_y & \text{if } F_e \geq 2.78 \cdot F_y \\ \frac{10}{9} \cdot F_y \cdot \left(1 - \frac{10 \cdot F_y}{36 \cdot F_e}\right) & \text{if } 2.78 \cdot F_y > F_e > 0.56 \cdot F_y \\ F_e & \text{if } 0.56 \cdot F_y \geq F_e \end{cases} = 50 \cdot ksi$$



Note:

For ISO rail weak-axis bending capacity, rails are oriented and designed so that the stiffer side of ISO rail can take the entire bending load by itself without putting a lot of bending load to the iso rail on the other side

Moment Capacity Eq. F2.1-1:

$$\phi M_{ny} := 0.9 \cdot S_y \cdot \min(F_c, F_y) = 16.5105 \cdot kip \cdot in$$

D/C Ratio of Bending:

$$DCR := \frac{M_{cy}}{\phi M_{ny}} = 0.189$$

$$Iso_{Bending} := \text{if}(M_{cy} < \phi M_{ny}, \text{"OK"}, \text{"NG"})$$

$Iso_{Bending} = \text{"OK"}$

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Web Crippling of ISO Rail (AISI S100-16 G.5)

Governing Compression:

$$P_{web.crip} := \frac{\omega_{x.L.vert} \cdot L_{iso}}{2} = 1277 \cdot lbs$$

Yield Strength:

$$F_y := 50ksi$$

Bearing Length:

$N := 2in$ **2 in. for CQAs**

Thickness of Curb:

$t_{Curb.iso} = \text{"10GA"}$ $t := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Inside Bend Radius:

$R := R_{iso} = 0.186 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web:

$h = 6.85 \cdot in$

Angle btween plane of web and bearing surface:

$\theta := 90deg$

Web Crippling Limit Check (AISI Table G5-2):

$\frac{R}{t} = 1$ $\frac{h}{t} = 50$ $\frac{N}{t} = 14$ $\frac{N}{h} = 0.29$

$$LimitCheck_{webcrippling} := if\left[\left(\frac{h}{t} < 200\right) \wedge \left(\frac{N}{t} < 210\right) \wedge \left(\frac{N}{h} < 2\right) \wedge \left(\frac{R}{t} < 2\right), \text{"OK"}, \text{"NG, Need Reinf"}\right]$$

$LimitCheck_{webcrippling} = \text{"OK"}$

End Case Coefficient Single Web Channel (AISI Table G5-2):

$C := 2$ $C_R := 0.11$ $C_N := 0.37$ $C_h := 0.01$

Reduction Factor Web Crippling Strength:

$\phi_{web.end} := 0.75$

$\phi_{web.int} := 0.8$

(For Unfastened Flanges with Two-Flange Loading or Reaction. Worst Case)

Design Web Crippling Strength:

$$P_{n.end} := C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 3729 \cdot lbs$$

$$\phi P_{n.end} := \phi_{web.end} \cdot P_{n.end} = 2796 \cdot lbs$$

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Interior Case Coefficient Single Web Channel (AISI Table G5-2):

$C := 13$ $C_R := 0.47$ $C_N := 0.25$ $C_h := 0.04$

Design Web Crippling Strength:

$$P_{n.interior} := C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 7905 \cdot lbs$$

$$\phi P_{n.interior} := \left(\phi_{web.int}\right) \cdot P_{n.interior} = 6324 \cdot lbs$$

Design Strength:

$$P_{n.web.crip} := \min\left(P_{n.end}, P_{n.interior}\right) = 3729 \cdot lbs$$

$$\phi P_{n.web.crip} := \min\left(\phi P_{n.end}, \phi P_{n.interior}\right) = 2796 \cdot lbs$$

D/C Ratio of Shear:

$$DCR := \frac{P_{web.crip}}{\phi P_{n.web.crip}} = 0.457$$

Demand/Capacity Ratio:

$$Web_{crippling} := \text{if}\left[\left(P_{web.crip} < \phi P_{n.web.crip}\right) \wedge \left(\phi P_{n.end} > 0\right) \wedge \frac{h}{t} < 200, \text{"OK"}, \text{"NG, Need Reinf"}\right]$$

$Web_{crippling} = \text{"OK"}$

D/C Ratio of Interaction:
AISI Eq. H3-1b

$$DCR_{int.web} := \frac{0.91 \cdot \left(\frac{P_{web.crip}}{P_{n.web.crip}}\right) + \frac{M_{cx}}{\left(\frac{\phi M_{nx}}{0.9}\right)}}{1.33 \cdot 0.9} = 0.308$$

$Iso_{Shear} = \text{"OK"}$

$Iso_{Interaction} = \text{"OK"}$

Per AISI S100-16 H3,
Only x-axis needs to check for interaction

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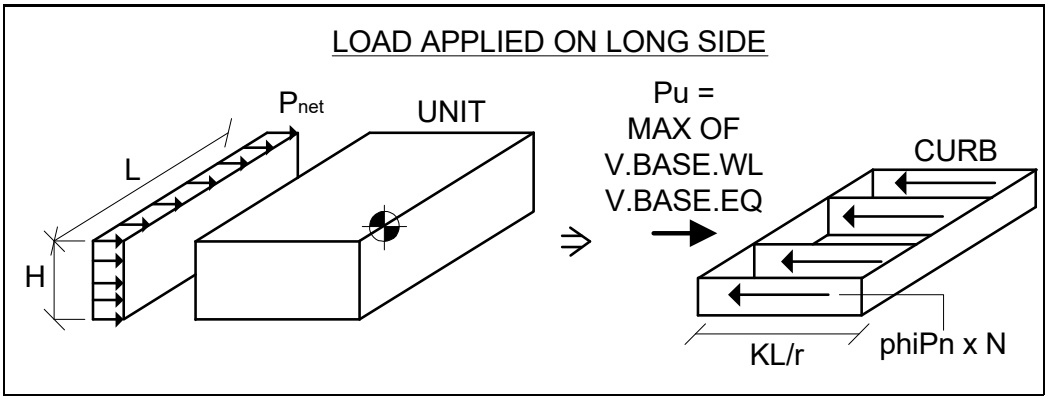
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Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI S100-16 E2)

Curb Axial Load Check due to Load on Long Side



Wind Base Shear of Unit on Long Side: $V_{base.W.L} := P_{net} \cdot L_{unit} \cdot H_{unit} = 8.1\,kip$

Seismic Base Shear of Unit on Long Side: $V_{base.S.L} := F_p \cdot Wt_{unit} = 10.8\,kip$

Max Axial: $P_u := \max(V_{base.S.L}, V_{base.W.L}) = 10783.46 \cdot lbs$

Member per CFS: $CFS_{member} =$ "10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"

Number of Curb in Length: $n_{iso} := 3$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{iso}} = 3.59\,kip$

Max Braced Length of Member: $L_{member} := W_{curb} = 77 \cdot in$

Effective Length factor: $K := 0.5$

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For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. E2.2-5, E2.2-6)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(K \cdot L_{member}\right)^2}\right] = 24 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2} = 10 \cdot ksi$$

$$\frac{K \cdot L_{member}}{r_{min}} = 168$$

KL_r = "KL/r < 200, OK"

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 7 \cdot ksi$$

Nominal Compressive Stress Capacity (Eq E2-4):

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 2.635$$

$$F_n := \begin{cases} 0.658^{\lambda_c^{\,2}} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^{\,2}}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 6.32 \cdot ksi$$

Strength reduction for Compression: $\phi_c := 0.85$

Factored Compressive Capacity: $\phi P_{n.member} := \phi_c \cdot A_e \cdot F_n = 6.41\,kip$

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.561$

$Axial_{reinf} := \text{if}\left(P_{u.EAmember} < \phi P_{n.member}, \text{"OK"}, \text{"NG"}\right)$

$Axial_{reinf}$ = "OK"

Note:
No need to check for interaction since equipment is not attached to the short side

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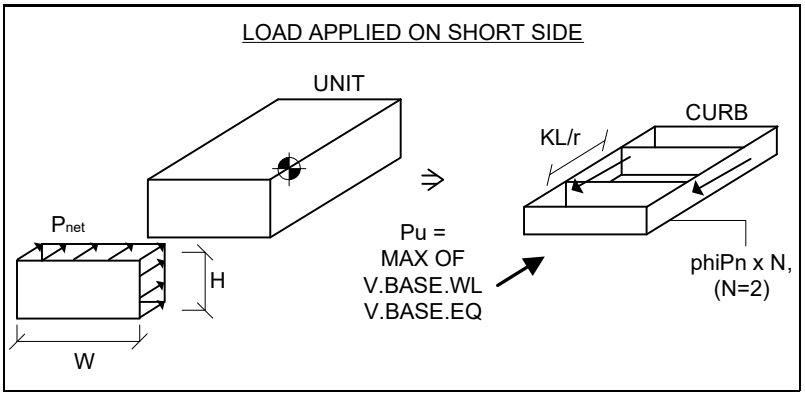
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Curb Axial Load Check due to Load on Short Side



Wind Base Shear on Short Side: $V_{base.W.H} := P_{net} \cdot W_{unit} \cdot H_{unit} = 5.6\,kip$

Seismic Base Shear of Unit on Short Side: $V_{base.S.W} := F_p \cdot Wt_{unit} = 10.8\,kip$

Max Axial: $P_u := \max\left(V_{base.S.W}, V_{base.W.H}\right) = 10783.46 \cdot lbs$

Member per CFS: $CFS_{member} = \text{"10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"}$

Number of Curb in Length: $n_{curb} := 2$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{curb}} = 5.39\,kip$

Max Braced Length of Member: $L_{member} := \frac{L_{curb}}{n_{iso} - 1} = 57 \cdot in$

Effective Length factor: $K := 0.5$

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. E2.2-5, E2.2-6)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(K \cdot L_{member}\right)^2}\right] = 37 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2} = 19 \cdot ksi \qquad \frac{K \cdot L_{member}}{r_{min}} = 124$$

$KL_r = \text{"KL/r < 200, OK"}$

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 13 \cdot ksi$$

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Nominal Compressive Stress Capacity (Eq E2-4):

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 1.993$$

$$F_n := \begin{cases} 0.658^{\lambda_c^2} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^2}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 11.04 \cdot \text{ksi}$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot A_e \cdot F_n = 11.2\,\text{kip}$$

D/C Ratio of Compression:

$$DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.481$$

$$Axial_{reinf} := \text{if}\left(P_{u.EAmember} < \phi P_{n.member}, \text{"OK"}, \text{"NG"}\right)$$

$Axial_{reinf} = \text{"OK"}$

Note:
If the load direction is in perpedicular plane to the short side of the equipment, the channels will only experience axial load and no bending will occur at the channel. Therefore, no need to check for interaction since the channels

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Shear of ISO Rail Webs without Holes (AISI S100-16 G2)

Note: The connection holes are not centered at mid-depth of isolated curb rail so AISI G2 shall be used

Deeper Section (h = depth)

Thickness of Curb: $t := \text{thick}(t_{Curb.iso}) = 0.138 \cdot in$

Depth-to-Thickness Ratio: $\frac{h}{t} = 50$

Curb Elastic Modulus: $E := 29500ksi$

Clear distance b/w transverse stiffeners of reinforced web: $a := L_{iso} = 16 \cdot in$

Clear Distance-to-Thickness Ratio: $\frac{a}{h} = 2.36$

Nominal Shear Stress:

$$k_v := \begin{cases} 5.34 \text{ if } a = L_{iso} \\ 4.00 + \frac{5.34}{\left(\frac{a}{h}\right)^2} \text{ if } \left(\frac{a}{h} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \frac{4.00}{\left(\frac{a}{h}\right)^2} \text{ if } \left(\frac{a}{h} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 6.06$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 60 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 90$$

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Curb Shear Check due to Load on Longer Side

Area of Web Element:

$$A_w := h \cdot t = 0.947 \cdot in^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 65.7 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} = 62\,kip \qquad V_y := 0.6 \cdot A_w \cdot F_y = 28\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.676$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 28.404 \cdot kip$$

Number of Members within Length: $n := 1$ **(Per Curb Design)**

Design Shear Capacity:

$$\phi V_{n.h} := 0.95 \cdot n \cdot V_n = 26.98 \cdot kip$$

Design Shear Demand:

$$V_{u.h} := \frac{\omega_{x.L.vert} \cdot L_{iso}}{2} = 1277.1 \cdot lbs$$

D/C Ratio of Shear:

$$DCR := \frac{V_{u.h}}{\phi V_{n.h}} = 0.047$$

Demand/Capacity Ratio:

$Shear_{in.plane} = \text{"OK"}$

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Shallower Section (h.w = Width)

Thickness of Curb: $t := thick(t_{Curb.iso}) = 0.138 \cdot in$

Depth-to-Thickness Ratio: $\frac{h_w}{t} = 7$

Curb Elastic Modulus: $E := 29500ksi$

Clear distance b/w transverse stiffeners of reinforced web: $a := L_{brace} = 16 \cdot in$

Clear Distance-to-Thickness Ratio: $\frac{a}{h_w} = 16.17$

Nominal Shear Stress:

$$k_v := \begin{cases} 5.34 & \text{if } a = L_{brace} \\ 4.00 + \frac{5.34}{\left(\frac{a}{h_w}\right)^2} & \text{if } \left(\frac{a}{h_w} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \frac{4.00}{\left(\frac{a}{h_w}\right)^2} & \text{if } \left(\frac{a}{h_w} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 5.36$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 56 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 85$$

Curb Shear Check due to Load on Longer Side

Area of Web Element: $A_w := h_w \cdot t = 0.1382 \cdot in^2$

Number of Members within Length: $n := 1$ **(Per Curb Design)**

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 58.1 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} = 8\,kip \qquad V_y := 0.6 \cdot A_w \cdot F_y = 4\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.719$$

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$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 4.146 \cdot \text{kip}$$

Design Shear Capacity:

$$\phi V_{n.hw} := 0.95 \cdot n \cdot V_n = 3.9 \cdot \text{kip}$$

Design Shear Demand:

$$V_{u.hw} := \frac{\left(\frac{\max\left(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit}\right)}{L_{curb}} \right) \cdot L_{brace}}{2} = 770.2 \cdot \text{lbs}$$

D/C Ratio of Shear:

$$DCR := \frac{V_{u.hw}}{\phi V_{n.hw}} = 0.196$$

Demand/Capacity Ratio:

$Shear_{in.plane}$ = "OK"

D/C Ratio of Vx and Mx:

$$DCR_{V.M.int} := \begin{cases} \left(0.6 \cdot \frac{M_{cx}}{\phi M_{nx}} + \frac{V_{u.h}}{\phi V_{n.h}}\right) \cdot \frac{1}{1.3} & \text{if } \frac{M_{cx}}{\phi M_{nx}} > 0.5 \wedge \frac{V_{u.h}}{\phi V_{n.h}} > 0.7 \\ \sqrt{\left(\frac{M_{cx}}{\phi M_{nx}}\right)^2 + \left(\frac{V_{u.h}}{\phi V_{n.h}}\right)^2} & \text{otherwise} \end{cases} = 0.079$$

Demand/Capacity Ratio:

$VandMx_{int}$ = "OK"

D/C Ratio of Vy and My:

$$DCR_{V.M.int} := \begin{cases} \left(0.6 \cdot \frac{M_{cy}}{\phi M_{ny}} + \frac{V_{u.hw}}{\phi V_{n.hw}}\right) \cdot \frac{1}{1.3} & \text{if } \frac{M_{cy}}{\phi M_{ny}} > 0.5 \wedge \frac{V_{u.hw}}{\phi V_{n.hw}} > 0.7 \\ \sqrt{\left(\frac{M_{cy}}{\phi M_{ny}}\right)^2 + \left(\frac{V_{u.hw}}{\phi V_{n.hw}}\right)^2} & \text{otherwise} \end{cases} = 0.272$$

Demand/Capacity Ratio:

$VandMy_{int}$ = "OK"

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Web Crippling/Compression of Non-iso CanFab Curb (AISI S100-16 G5)

Governing Compression for Non-Isolated Curb:

$$P_{web.crip.int} := \max\left[\frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}}, \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}}\right] \cdot L_{spacing.non.iso} = 4854 \cdot lbs$$

$$P_{web.crip.end} := 0.5 \cdot P_{web.crip.int} = 2427 \cdot lbs$$

Yield Strength: $F_y := 50ksi$

Bearing Length: $N_{bearing} := L_{spacing.non.iso} = 31 \cdot in$

Thickness of Curb: $t_{Curb} = \text{"14GA"}$ $t := thick(t_{Curb}) = 0.0785 \cdot in$

Inside Bend Radius: $R := R_{curb} = 0.107 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web: $h := 18in - 2 \cdot (t + R) = 17.63 \cdot in$

Angle btween plane of web and bearing surface: $\theta := 90deg$

Web Crippling Limit Check (AISI Table G5-2): $\frac{R}{t} = 1$ $\frac{h}{t} = 225$ $\frac{N_{bearing}}{t} = 391$ $\frac{N_{bearing}}{h} = 1.74$

End Case Coefficient Single Web Channel (AISI Table G5-2): $C := 13$ $C_R := 0.32$ $C_N := 0.05$ $C_h := 0.04$

Reduction Factor Web Crippling Strength: $\phi_{web.end} := 0.9$ $\phi_{web.int} := 0.8$ **(For Unfastened partially Stiffened Flanges with Two-Flange Loading or Reaction.)**

Design Web Crippling Strength:

$$\phi P_{n.end} := \left(\phi_{web.end}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 1800 \cdot lbs$$

Interior Case Coefficient Single Web Channel (AISI Table G5-2): $C := 24$ $C_R := 0.52$ $C_N := 0.15$ $C_h := 0.001$

Design Web Crippling Strength:

$$\phi P_{n.interior} := \left(\phi_{web.int}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 9091 \cdot lbs$$

D/C Ratio of Shear: $DCR_{end} := \frac{P_{web.crip.end}}{2 \cdot \phi P_{n.end}} = 0.674$ $DCR_{int} := \frac{P_{web.crip.int}}{\phi P_{n.interior}} = 0.534$

Demand/Capacity Ratio: **Note: Factor of 2 for two ends connected together at the end**

$Web_{crippling} = \text{"OK"}$

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Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Length

Roof Curb thickness

$t_{Curb} = \text{"14GA"}$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

Min width of Roof Curb

$b_{curb} := L_{curb} + \frac{W_{curb}}{2} \cdot 2 + 3in \cdot 2 \cdot 2 = 202.19 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := L_{curb} + \min\left(\frac{W_{curb}}{2} \cdot 2, \frac{L_{curb}}{2}\right) = 170 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{array}{c} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{array} \right] \right] = 9344 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.L.vert.up} \cdot L_{curb}) \cdot (0.75in) = 7304 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.782$

$Curb_{BotFlangeBending} = \text{"OK"}$

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Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Width

Roof Curb thickness

$t_{Curb} = \text{"14GA"}$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

Min width of Roof Curb

$b_{curb} := W_{curb} + \frac{L_{curb}}{4} \cdot 2 + 3in \cdot 2 = 139.59 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := W_{curb} + \min\left(\frac{L_{curb}}{6} \cdot 2, W_{curb}\right) = 115 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{array}{c} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{array} \right] \right] = 6452 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.W.vert.up} \cdot W_{curb}) \cdot (0.75in) = 4230 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.656$

$Curb_{BotFlangeBending} = \text{"OK"}$

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Web Crippling/Compression of Iso CanFab Curb (AISI S100-16 G5)

Note: Curb stiffeners directly transfer the compressive load from isolator to the base. Therefore, curb web crippling is prevented.

Curb Web with Reinforcement

Max Compression: $Comp_{maxtot} := \max(|C_S|, |C_W|) = 22530.11 \cdot lbs$

Reinforcement per CFS: $CFS_{reinf} :=$ "Single Stiffener 10GA 1"x7"x1" Fy=50ksi 18" Tall on min. 16GA "

Note: min. of 10 GA channel and min. 16 GA curb web

Number of Reinforcement in Length: $n_{reinf} := N_{iso.long} = 8$

Max Compression per Reinf: $Comp_{per.reinf} := \frac{Comp_{maxtot}}{n_{reinf}} = 2.816\,kip$

Spacing: $Spacing := \frac{L_{curb}}{n_{reinf}} = 14 \cdot in$ $KL_r := \frac{1.0 \cdot (H_{curb} - 12.5in)}{0.2339in} = 77$

Factored Nominal Comp. Capacity per reinforcement: $\phi P_{n.reinf} = 21.066 \cdot kip$ **(See attached CFS)**

Total Factored nominal Comp Capacity: $\phi P_{n.tot} := n_{reinf} \cdot \phi P_{n.reinf} = 169 \cdot kip$

D/C Ratio of Compression: $DCR := \frac{Comp_{maxtot}}{\phi P_{n.tot}} = 0.13$

$Comp_{reinf} := if(Comp_{maxtot} < \phi P_{n.tot}, "OK", "NG")$ $Comp_{reinf} = "OK"$

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Check CanFab Curb for Compressive Force due to T/C Coupling of Overturning

Note:
-Since the equipment is only attached to the longer sides of the CanFab Curb, most likely there will be compressive force onto the curb due to T/C coupling.
- Rectangular CanFab Curb will be considered as "Channel" to resist the compressive force.

Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Flanges*

Flat Width:

$$w := \frac{W_{curb}}{2} - R_{curb} = 38.393 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Unstiffened"}$$

Stress at the end of the Width:

$$f_2 := 50ksi \qquad f_1 := 50ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \left| \frac{f_2}{f_1} \right| = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 0.43$$

Critical Compressive Stress (Eq 1.1-4):

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w}\right)^2 = 0.05 \cdot ksi$$

Stress in Compression Element:

$$f := F_y = 50 \cdot ksi \qquad \textbf{(Assume f = Fy)}$$

Slenderness Factor (Eq 1.1-3):

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 32.3$$

Local reduction factor (Eq 1.1-2):

$$\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 0.031$$

Effective Width of the Flanges:

$$b_{eff.flange} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 1.181 \cdot in$$

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Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Web*

Flat Width:

$$w := L_{curb} - R_{curb} \cdot 2 = 112.974 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Stiffened"}$$

Stress at the end of the Width:

$$f_2 := 50ksi \qquad f_1 := 50ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \left| \frac{f_2}{f_1} \right| = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 4$$

Critical Compressive Stress (Eq 1.1-4):

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w} \right)^2 = 0.05 \cdot ksi$$

Stress in Compression Element:

$$f := F_y = 50 \cdot ksi \qquad \textbf{(Assume f = Fy)}$$

Slenderness Factor (Eq 1.1-3):

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 31.16$$

Local reduction factor (Eq 1.1-2):

$$\rho := \left(1 - \frac{0.22}{\lambda}\right) \frac{1}{\lambda} = 0.032$$

Effective Width of the Web:

$$b_{eff.web} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 3.6 \cdot in$$

Effective Area of the Member:

$$A_e := 2 \cdot \left(b_{eff.flange} \cdot t_{curb} \right) + b_{eff.web} \cdot t_{curb} = 0.468 \cdot in^2$$

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Length of the Compressive Member: $L_{curb.web} := h = 17.629 \cdot in$

Young's Modulus for Cold Form Steel: $E := 29500ksi$

Curb Shear Modulus: $G := 11300ksi$

Poisson's Ratio $\mu := 0.3$

Section Properties of the Member (From Section Properties Calculator):

$A_{half.curb} := 13.599in^2$ $r_o := 50.187in$ $I_x := 26250.724in^4$ $I_y := 1949.977in^4$

$J := 0.023in^4$ $r_x := \sqrt{\frac{I_x}{A_{half.curb}}} = 43.936 \cdot in$ $r_y := \sqrt{\frac{I_y}{A_{half.curb}}} = 11.975 \cdot in$

$C_w := 4.431 \cdot 10^6 \cdot in^6$ $r_{min} := \min(r_x, r_y) = 11.975 \cdot in$

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^2}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{(1.0 \cdot L_{curb.web})^2}\right] = 3521946.764 \cdot ksi$$

$$\sigma_{e.y} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_y}\right)^2} = 134331.872 \cdot ksi \qquad \sigma_{e.x} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_x}\right)^2} = 1808384.866 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2} = 134331.872 \cdot ksi$$

$$\frac{1.0 \cdot L_{curb.web}}{r_{min}} = 1.47$$

$KL_r = \text{"KL/r < 200, OK"}$

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 129396.512 \cdot ksi$$

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Nominal Compressive Stress Capacity: (Eq E2-4)

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 0.02$$

$$F_n := \begin{cases} 0.658^{\lambda_c^2} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^2}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 49.99 \cdot \text{ksi}$$

Compressive Capacity:

$$P_{n.member} := A_e \cdot F_n = 23.39 \cdot \text{kip}$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot P_{n.member} = 19.88 \cdot \text{kip}$$

Factored Max Compressive Force:

$$P_{comp.max} := \max\left(\left|C_S\right|, \left|C_W\right|\right) = 22.53 \text{ kip}$$

D/C Ratio of Compression:

$$DCR := \frac{P_{comp.max}}{\phi P_{n.member}} = 1.133$$

$$Axial_{curb.comp} := \text{if}\left(P_{comp.max} < \phi P_{n.member}, \text{"OK"}, \text{"Provide Channel from above as Web Stiffener"}\right)$$

$Axial_{curb.comp}$ = "Provide Channel from above as Web Stiffener"

Note: No need to check for interaction since the curb is only subjected to the compressive force.

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Shear of CanFab Curb Webs without Holes (AISI S100-16 G2)

Note: Since the unit is stiffer than the curb and the curb is firmly attached to the unit and to the base structure, curbs will mainly take the lateral forces as shear and axial load rather than bending.

Thickness of Curb:

$$t := thick(t_{Curb}) = 0.079 \cdot in$$

Depth-to-Thickness Ratio:

$$\frac{h}{t} = 225$$

Curb Elastic Modulus:

$$E := 29500ksi$$

Clear distance b/w transverse stiffeners of reinforced web:

$$a := \max\left(\frac{L_{curb}}{2}, W_{curb}\right) = 77 \cdot in \qquad \frac{a}{h} = 4.37$$

$$k_v := \begin{cases} 5.34 & \text{if } a = L_{curb} \\ 4.00 + \dfrac{5.34}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \dfrac{4.00}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 5.55$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 57 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 86$$

Curb Shear Check due to Load on Longer Side

Area of Web Element:

$$A_w := W_{curb} \cdot t = 6 \cdot in^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 2.9 \cdot ksi$$

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$V_{cr} := A_w \cdot F_{cr} = 18\,kip \quad V_y := 0.6 \cdot A_w \cdot F_y = 181\,kip \quad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 3.198$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 17.734 \cdot kip$$

Number of Members within Length: $n := 2$ **(Per Curb Design)**

Design Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 33694.2 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.H} := P_{net} \cdot L_{unit} \cdot H_{total} = 11826.3 \cdot lbs$

Design Shear Demand: $V_u := \max(V_{base.S}, V_{base.W.H}) = 14857.1 \cdot lbs$

D/C Ratio of Shear: $DCR := \frac{V_u}{\phi V_n} = 0.441$

Demand/Capacity Ratio:

$Shear_{in.plane} := \text{if}(V_u < \phi V_n, \text{"OK"}, \text{"NG"})$

$Shear_{in.plane} = \text{"OK"}$

Curb Shear Check due to Load on Shorter Side

Area of Web Element: $A_w := L_{curb} \cdot t = 9 \cdot in^2$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot (1 - \mu^2) \cdot \left(\frac{h}{t}\right)^2} = 2.9 \cdot ksi$$

$V_{cr} := A_w \cdot F_{cr} = 26\,kip \quad V_y := 0.6 \cdot A_w \cdot F_y = 267\,kip \quad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 3.198$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 26.068 \cdot kip$$

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Number of Members within Length: $n := 2$ **(Per Curb Design)**

Factored Nominal Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 49529.5 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot W_{unit} \cdot H_{total} = 8140 \cdot lbs$

Factored Shear Demand: $V_u := \max(V_{base.S}, V_{base.W.L}) = 14857.1 \cdot lbs$

D/C Ratio of Shear: $DCR := \frac{V_u}{\phi V_n} = 0.3$

Demand/Capacity Ratio:

$Shear_{in.plane} := if(V_u < \phi V_n, "OK", "NG")$

$Shear_{in.plane} = "OK"$

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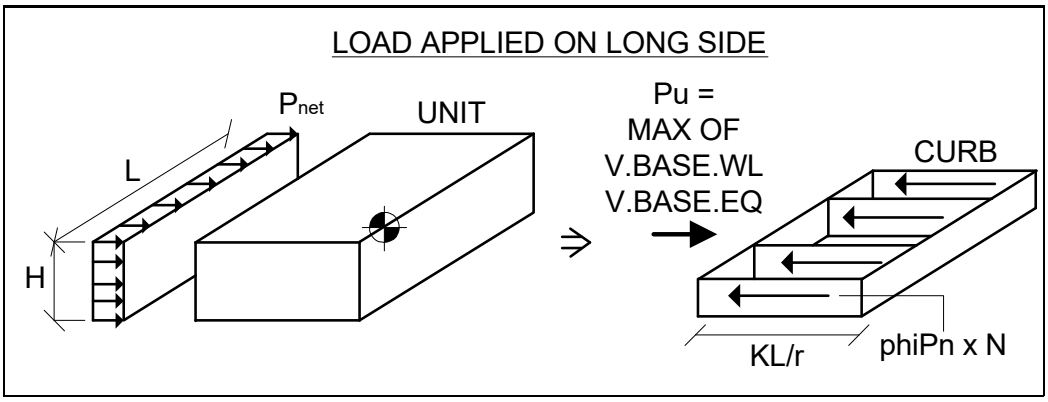
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Check CanFab Curb for In-Plane Axial due to EQ and Wind (AISI S100-16 E2)

Curb Axial Load Check due to Load on Long Side



Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot L_{unit} \cdot H_{total} = 11.8\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.L}) = 14857.09 \cdot lbs$

Member per CFS: $CFS_{member} :=$ "14GA Custom Curb 18" Tall L.b = 63in"

Max Braced Length of Member: $L_{member} := 48in$ **Conservative since the max anchor spacing is 24"**

Number of Curb in Length: $n_{curb.long} := 3$

Radius of gyration in y-axis: $r_{y.curb} := 0.671\,in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{2} = 7.43\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 72$ $KL_r =$ "KL/r < 200, OK"

Spacing: $Spacing := \frac{L_{curb}}{n_{curb.long}} = 38 \cdot in$

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 11.417 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.651$

$Axial_{short.curb} =$ "OK"

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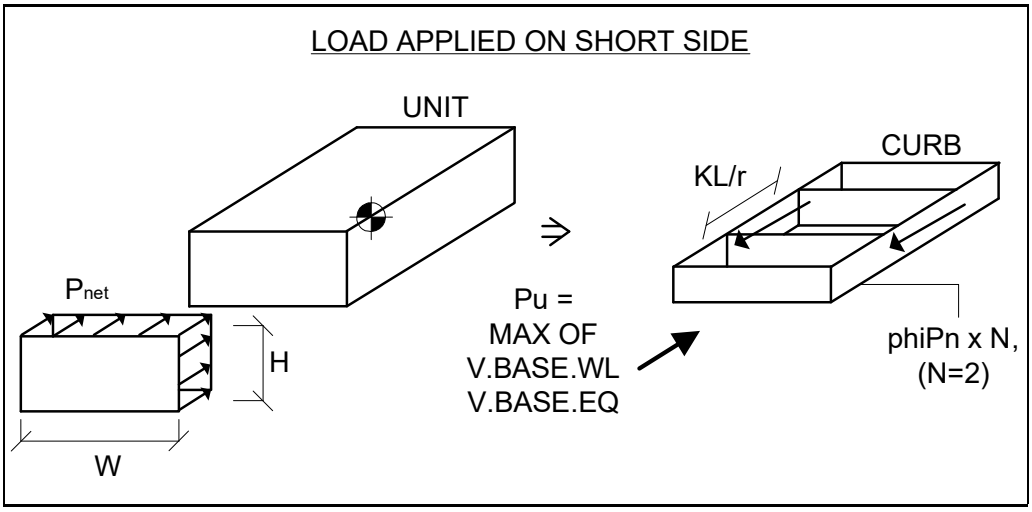
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Curb Axial Load Check due to Load on Short Side



Wind Base Shear on Short Side: $V_{base.W.H} := P_{net} \cdot W_{unit} \cdot H_{total} = 8.1\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.H}) = 14857.09 \cdot lbs$

Member per CFS: CFS_{member} = "14GA Custom Curb 18" Tall L.b = 63in"

Max Braced Length of Member: $L_{member} := \frac{L_{curb}}{n_{curb.long} - 1} = 57 \cdot in$

Number of Curb in Length: $n_{curb} := 2$

Radius of gyration in y-axis: $r_{y.curb} := 0.671\,in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{curb}} = 7.43\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 84$ KL_r = "KL/r < 200, OK"

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 11.417 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.651$

$Axial_{long.curb}$ = "OK"

A61

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DESIGN
for
MAX CURB HEIGHT OF 22"

950 S. GRAND AVENUE, 4TH FLOOR, LOS ANGELES, CALIFORNIA 90015 (213) 483-6490

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Design Wind Loads for Rooftop Equipment (ASCE 7-16 § Table 29.1-1)

$z := 60ft$ **Height above ground level**

$B := 60ft$ **Horizontal dimension of building measured normal to wind direction**

$Exp_{category} := "C"$ **Exposure Category per ASCE 7-16 § 26.7**

$Risk_{category} := "IV"$ **Risk Category per ASCE 7-16 Table 1.5-1**

$$V := \begin{cases} 0mph & \text{if } Risk_{category} = "I" \\ 0mph & \text{if } Risk_{category} = "II" \\ 175mph & \text{otherwise} \end{cases} = 175 \cdot mph$$

Basic Wind Speed per ASCE 7-16 Figure 26.5-1 A,B or C

$K_z = 1.14$ **Velocity Pressure Exposure Coefficient per ASCE 7-16 Table 29.10-1 [Exposure Category "C"]**

$K_{zt} := 1.0$ **Topographic Factor per ASCE 7-16 § 26.8, Figure 26.8-1**

$K_e := 1.0$ **Ground Elevation Factor per ASCE 7-16 § 26.9, Table 26.9-1**

$K_d := 0.85$ **Wind Directionality Factor per ASCE 7-16 § 26.6, Table 26.6-1 (Equipment)**

$q_z := 0.00256 K_z \cdot K_{zt} \cdot K_d \cdot K_e \cdot V^2 = 75.74 \cdot psf$ **Velocity pressure evaluated at height z above ground per ASCE 7-10 § 26.10.2; Eq. 26.10-1**

$GC_{r.lateral.max} := 1.9$ **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.9 for rooftop structures and equipment with Af less than (0.1Bh). (GCr) shall be permitted to be reduced linearly from 1.9 to 1.0 as the value of Af is increased from (0.1Bh) to (Bh)

$GC_{r.vertical.max} := 1.5$ **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.5 for rooftop structures and equipment with A_r less than (0.1*BL*). (GC_r) shall be permitted to be reduced linearly from 1.5 to 1.0 as the value of A_r is increased from (0.1*BL*) to (*BL*)

$P_{net} := q_z \cdot GC_{r.lateral.max} = 143.91 \cdot psf$ **Design Lateral Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-2**

$P_v := q_z \cdot GC_{r.vertical.max} = 113.61 \cdot psf$ **Design Vertical Uplift Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-3**

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Seismic Demands on Nonstructural Components (ASCE 7-16 § 13.3 & 13.6):

$S_{DS} := 1.5$ **Design spectral response acceleration parameter at short periods per USGS map**

$I_p := 1.5$ **Component importance factor ASCE 7-16 § 13.1.3**

$\Omega_0 := 2.0$ **Overstrength factor ASCE 7-16 Table 13.6.1**

Vibr_Isolation = "Yes" **Placement of Unit Vibration Isolated:**

Note: Only "F_p" at seismic concrete anchor has been increased with overstrength factor "Ω_0"

$a_p := 2.5$ $R_p = 2.0$ **Seismic coefficients a_p & R_p**
Per ASCE 7-16 Table 13.6-1 for
Mechanical & Electrical Components

$z = 60\,ft$ **Height in structure of point of attachment of component with respect to the base**

$h := 60ft$ **Average roof height of structure with respect to the base**
Where for roof top equipment:

$z \div h = 1$

F_p: Horizontal Seismic Design Force per *ASCE7-16 § 13.3.1*

F_p shall be takes as $\left(\frac{0.4 \cdot a_p \cdot S_{DS} \cdot I_p}{R_p}\right) \cdot \left(1 + 2 \cdot \frac{z}{h}\right) \cdot W_p = 337.5 \cdot \%_{\cdot} W_p$

F_p is not required to be taken as greater than $\left(1.6 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 360 \cdot \%_{\cdot} W_p$

F_p shall not be taken as less than $\left(0.3 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 67.5 \cdot \%_{\cdot} W_p$

Governing F_p : Horizontal Seismic Design Force $F_p = 337.5 \cdot \%_{\cdot} W_p$

F_v: Vertical Load per ASCE7-16 § 13.3.1.2

Concurrent Vertical Seismic Force: $F_v := 0.2 \cdot S_{DS} \cdot W_p = 30 \cdot \%_{\cdot} W_p$

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Flat Roof Snow Loads (ASCE 7-16 § 7.3):

$Terrain_{CAT} := "C"$ **Terrain Category ASCE 7-16 § 26.7 & Table 7.3-1**

$Exp_{Roof} := "Partially Exposed"$ **Exposure of Roof ASCE 7-16 Table 7.3-1**

$C_e = 1$ **Exposure Factor ASCE 7-16 Table 7.3-1**

$Thermal_{condition} := "All structures except below"$ **Thermal Condition ASCE 7-16 Table 7.3-2**

$C_t = 1$ **Thermal Factor ASCE 7-16 Table 7.3-2**

$Risk_{category} = "IV"$ **Risk Category per ASCE 7-16 Table 1.5-1**

$I_s = 1.2$ **Snow Importance Factor ASCE 7-16 Table 1.5-2**

$p_g := 40psf$ **Ground Snow Loads ASCE 7-16 Figure 7.2-1**

$$p_f := \max\left(0.7 \cdot C_e \cdot C_t \cdot I_s \cdot p_g, \text{if}\left(p_g > 20psf, 20psf \cdot I_s, I_s \cdot p_g\right)\right) = 34 \cdot psf$$

Flat Roof Snow Loads ASCE 7-16 Equation 7.3-1 and § 7.3.4

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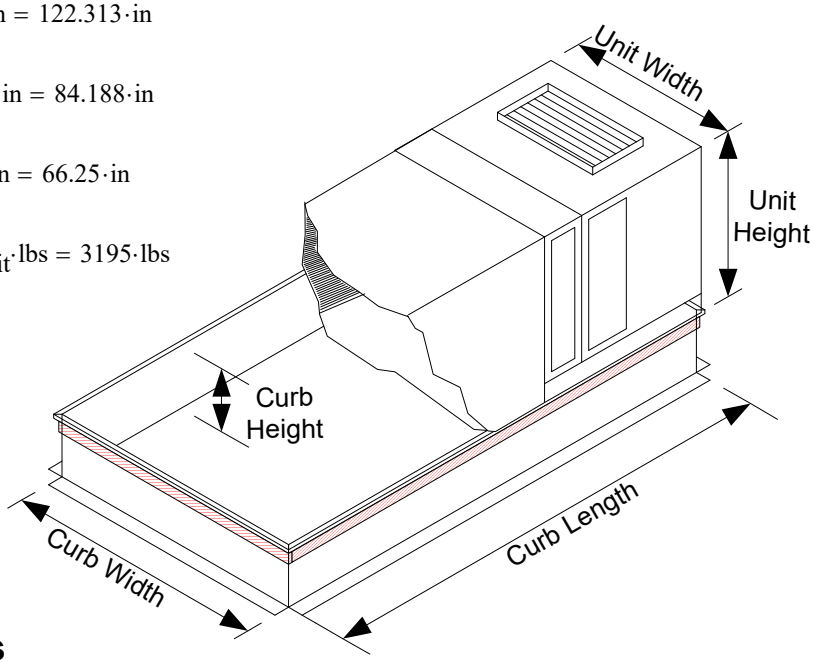
Mechanical Unit Dimensions Curb = "C-6010"

Length of Unit $L_{unit} := L_{unit} \cdot in = 122.313 \cdot in$

Width of Unit $W_{unit} := W_{unit} \cdot in = 84.188 \cdot in$

Height of Unit $H_{unit} := H_{unit} \cdot in = 66.25 \cdot in$

Weight of Unit $Wt_{unit} := Wt_{unit} \cdot lbs = 3195 \cdot lbs$



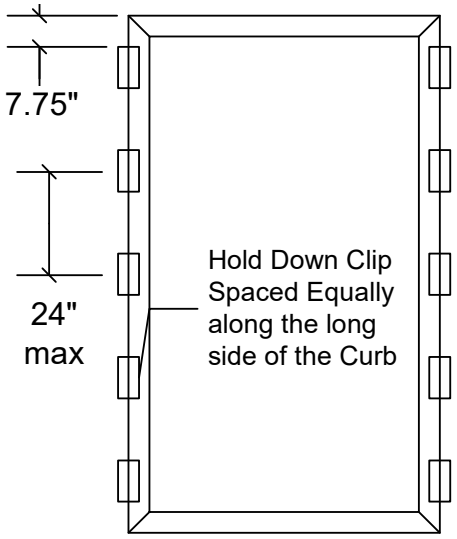
Roof Curb Dimensions

Length of Curb $L_{curb} := L_{curb} \cdot in = 113.188 \cdot in$

Width of Curb $W_{curb} := W_{curb} \cdot in = 77 \cdot in$

Height of Curb $H_{curb} := H_{curb} \cdot in = 34.5 \cdot in$

Weight of Curb $Wt_{curb} := Wt_{curb} \cdot lbs = 1239 \cdot lbs$



Curb Plan

Overall System Dimensions

Total Weight

$Wt_{tot} := Wt_{unit} + Wt_{curb} = 4402 \cdot lbs$

Total height

$H_{total} := H_{unit} + H_{curb} = 100.75 \cdot in$

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Seismic Loading + Snow Loading

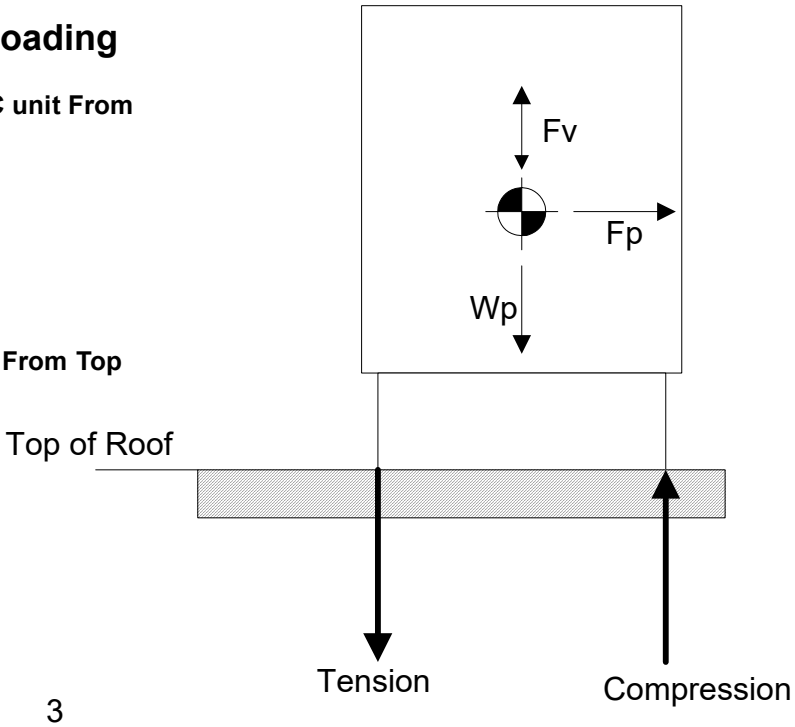
Height for Center of Gravity for HVAC unit From Top of Roof

$h_{CG.unit} := \frac{1}{2} H_{unit} = 33 \cdot in$

$h_{CG} := H_{curb} + h_{CG.unit} = 67.63 \cdot in$

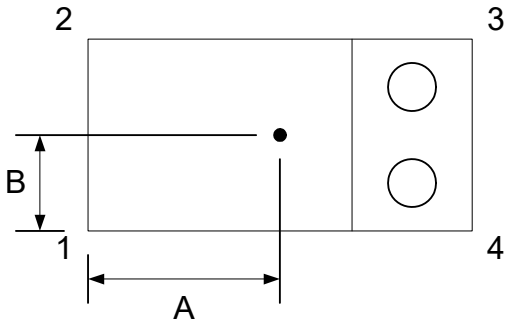
Height for Center of Gravity for Curb From Top of Roof

$h_{CG.curb} := \frac{H_{curb}}{2} = 17.25 \cdot in$



Max Seismic Base Shear

$V_{base.S} := F_p \cdot Wt_{tot} = 14857 \cdot lbs$



Unit C.G. distance in axis parallel to Curb Width $B_{ecc.width} := CG_{short} \cdot in = 36 \cdot in$

Eccentricity in axis parallel to Curb Width

$$e_{width} := \begin{cases} 0in & \text{if } B_{ecc.width} = \text{"N/A"} \\ \left| B_{ecc.width} - \frac{W_{unit}}{2} \right| & \text{otherwise} \end{cases} = 6.09 \cdot in$$

Unit C.G. distance in axis parallel to Curb Length $A_{ecc.length} := CG_{long} \cdot in = 58 \cdot in$

Eccentricity in axis parallel to Curb Length

$$e_{length} := \begin{cases} 0in & \text{if } A_{ecc.length} = \text{"N/A"} \\ \left| A_{ecc.length} - \frac{L_{unit}}{2} \right| & \text{otherwise} \end{cases} = 3.16 \cdot in$$

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Max Net Tension Reaction On Each Side Due To Seismic Loads

$$T_S := \begin{bmatrix} \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{W_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{W_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} \right] \\ \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{L_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{L_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} \right] \end{bmatrix} = \begin{pmatrix} -9214 \\ -5796 \end{pmatrix}\cdot lbs$$

Max Net Compression Reaction On Each Side Due To Seismic Loads

$$C_S := \begin{bmatrix} \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{W_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \\ \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{L_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \end{bmatrix} = \begin{pmatrix} 18651 \\ 14234 \end{pmatrix}\cdot lbs$$

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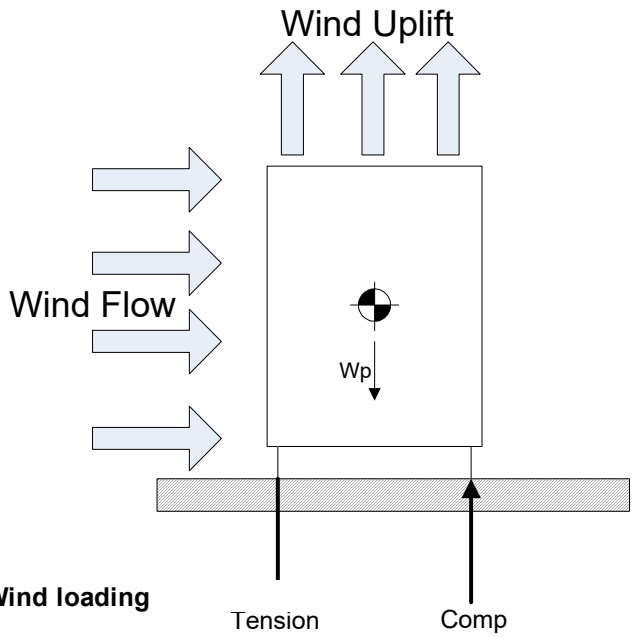
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Wind Loading + Snow Loading



Max Base Shear due to wind loading

$V_{base.W} := P_{net} \cdot L_{unit} \cdot H_{total} = 12315 \cdot lbs$

Max Uplift due to wind loading

$L_{unit.up} := L_{unit} - 0in = 122.313 \cdot in$

$P_{uplift.W} := P_v \cdot L_{unit.up} \cdot W_{unit} = 8124 \cdot lbs$

Max Net Tension Reaction On Each Side Due To Wind loading

$$T_W := \begin{pmatrix} \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} - \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \\ \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} - \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} -10366 \\ -5934 \end{pmatrix} \cdot lbs$$

Max Net Compression Reaction On Each Side Due To Wind loading

$$C_W := \begin{pmatrix} \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} + \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \\ \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} + \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} 12924 \\ 8443 \end{pmatrix} \cdot lbs$$

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Governing Loading @ Curb

Max uplift vertical load along the length of the curb

$$\omega_{x.L.vert.up} := \frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}} = 1099 \cdot plf$$

Max compressive vertical load along the length of the curb

$$\omega_{x.L.vert.comp} := \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}} = 1977 \cdot plf$$

Max vertical load along the length of the curb

$$\omega_{x.L.vert} := \max\left(\omega_{x.L.vert.up}, \omega_{x.L.vert.comp}\right) = 1977 \cdot plf$$

Max uplift vertical load along the width of the curb

$$\omega_{x.W.vert.up} := \frac{\max\left[\left|T_{S_{(1)}}\right|, \left|T_{W_{(1)}}\right|\right]}{W_{curb}} = 925 \cdot plf$$

Max compressive vertical load along the width of the curb

$$\omega_{x.W.vert.comp} := \frac{\max\left[\left|C_{S_{(1)}}\right|, \left|C_{W_{(1)}}\right|\right]}{W_{curb}} = 2218 \cdot plf$$

Max vertical loading along the width of the curb

$$\omega_{x.W.vert} := \max\left(\omega_{x.W.vert.up}, \omega_{x.W.vert.comp}\right) = 2218 \cdot plf$$

$$\begin{pmatrix} V_{base.S} \\ V_{base.W} \end{pmatrix} = \begin{pmatrix} 14857 \\ 12315 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} \left|T_S\right| \\ \left|C_S\right| \end{pmatrix} = \begin{pmatrix} 10886 \\ 23462 \end{pmatrix} \cdot lbs$$

$$\begin{pmatrix} F_v \cdot Wt_{tot} \\ P_v \cdot L_{unit} \cdot W_{unit} \end{pmatrix} = \begin{pmatrix} 1321 \\ 8124 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} \left|T_W\right| \\ \left|C_W\right| \end{pmatrix} = \begin{pmatrix} 11944 \\ 15437 \end{pmatrix} \cdot lbs$$

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Anchorage To Concrete [Expansion Anchor per ACI 318-14]

Number of connection on the long side

$N_B := 6 + 2$

Moment Arm for overturning (Short side)

$B := W_{curb} + 3in \cdot 2 = 83 \cdot in$

Number of Connection on the Short side.

$N_L := 4 + 2$

Moment Arm for over turning (Long side)

$L := L_{curb} + 3in \cdot 2 = 119 \cdot in$

Total Number of Connections

$N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 20$

Max Net Tension Reaction Due to Seismic Load, Fp

$$R_{c.EQ.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 18 \cdot lbs \qquad R_{c.EQ.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 8 \cdot lbs$$

$$R_{c.EQ} := MAX+\left[\begin{bmatrix}\left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{c.EQ.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{c.EQ.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}2294 \\ 2112\end{pmatrix} \cdot lbs$$

Max net Tension Reaction Due to Wind Load, Pnet

$$R_{c.W} := MAX+\left[\begin{bmatrix}\frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}1169 \\ 818\end{pmatrix} \cdot lbs$$

Governing Load Case:

$Govern := if\left(\left|R_{c.EQ}\right| > \left|R_{c.W}\right|, "Seismic", "Wind"\right) = "Seismic"$

Governing Tension Reaction at Each anchor Point:

$R_c := if\left(Govern = "Seismic", R_{c.EQ}, R_{c.W}\right) = \begin{pmatrix}2294 \\ 2112\end{pmatrix} \cdot lbs$

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Max Tension on anchor: $N_{ua} := \max(R_c) = 2294 \cdot lbs$

Max Shear on anchor: $V_{ua} := \frac{\max(\Omega_0 \cdot V_{base.S}, V_{base.W})}{N_t} = 1486 \cdot lbs$

Hilti Kwik Bolt TZ – Carbon Steel
5/8" Anchor with min 4" embedment
Base material: 6" thick Cracked concrete w/
Compressive strength fc' = 3000 psi
Min 6" away from the concrete edge
Evaluation Report: ICC-ESR 1917

Loading Condition:	**Seismic**

Design Tension Capacity [ϕN_n]:	3,631	[lbs]
Design Shear Capacity [ϕV_n]:	4,940	[lbs]

$\phi N_n := \phi N_n \cdot lbs = 3631 \cdot lbs$

$\phi V_n := \phi V_n \cdot lbs = 4940 \cdot lbs$

Utilization:

Tension Utilization:

$\beta_N := \frac{N_{ua}}{\phi N_n} = 63 \cdot \%$

Shear Utilization:

$\beta_V := \frac{V_{ua}}{\phi V_n} = 30 \cdot \%$

Interaction of Tensile and Shear Forces:
Per ACI 318-14 Sec. 17.6

$\beta_{NV} := \frac{(\beta_N) + (\beta_V)}{1.2} = 78 \cdot \%$

$$check\_interaction := \begin{pmatrix} if(\beta_N < 1.0, "OK", "NG") \\ if(\beta_V < 1.0, "OK", "NG") \\ if(\beta_{NV} < 1.0, "OK", "NG") \end{pmatrix} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

$$check\_interaction = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

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Anchorage To Structural Steel [Fillet Weld Conn. per AISI S100-16]

Fillet Weld 2" Long Along the Long and Short Side. Min 2 Connections per Side
Spacing: 48" O.C. for Non-Isolated Curbs; 24" for Isolated Curbs

Number of Welds on the Long Side $N_B := 6$

Moment Arm for Overturning (Short Side) $B := W_{curb} = 77 \cdot in$

Number of Welds on the Short Side. $N_L := 4$

Moment Arm for Overturning (Long Side) $L := L_{curb} = 113 \cdot in$

Total Number of Connections $N_t := \left[\left(N_B\right) + \left(N_L\right)\right] \cdot 2sides = 20$

Max Net Tension Reaction due to Seismic Load FP

$$R_{weld.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 25 \cdot lbs$$

$$R_{weld.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 13 \cdot lbs$$

$$R_{weld.EQ} := MAX+\left[\begin{bmatrix}\left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{weld.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{weld.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}1624 \\ 1647\end{pmatrix} \cdot lbs$$

Max Net Tension Reaction due to Wind Load Pnet

$$R_{weld.W} := MAX+\left[\begin{bmatrix}\frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}1589 \\ 1171\end{pmatrix} \cdot lbs$$

Tension Design Force; SRSS for Loading from Each Direction $T_{u.weld} := \max\left(\left|R_{weld.EQ}\right|, \left|R_{weld.W}\right|\right) = 2313 \cdot lbs$

Shear Load at Each Weld Connection $V_{u.weld} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{N_t} = 743 \cdot lbs$

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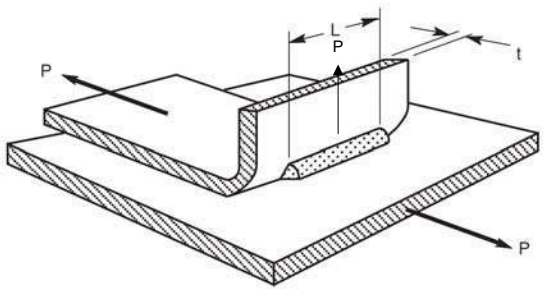
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Total Demand: SRSS of V and T

$$R_{u.weld} := \sqrt{T_{u.weld}^2 + V_{u.weld}^2} = 2429 \cdot lbs$$

Fillet Weld Design per AISI S100-16 Section J2.5

Weld Length at Each Connection Point $L_w := 2in$



Effective Throat Fillet Weld Size

$$t_w := \left(\frac{1}{8}in\right) \cdot 0.707 = 0.088 \cdot in$$

Thickness for the Thinnest Martial Being Welded
Min Curb Thickness = 16GA with Fu=65 ksi

$t_1 := thick("14GA") = 0.0785 \cdot in$

$F_u := 65ksi$

Min weld material strength

$F_{exx} := 70ksi$

For Longitudinal Loading [Parallel capacity is considered to be loading in the direction of the length of the weld] per (Eq. J2.5-1) &(Eq. J2.5-2)

$$\phi P_{long} := \begin{cases} (0.6)\left(1 - \frac{0.01 \cdot L_w}{t_1}\right) \cdot L_w \cdot t_1 \cdot F_u & \text{if } \frac{L_w}{t_1} < 25 \\ (0.5) \cdot 0.75 \cdot t_1 \cdot L_w \cdot F_u & \text{otherwise} \end{cases} = 3827 \cdot lbs$$

where $L_w \div t_1 = 25$

For Transverse Loading per (Eq. J2.5-5)

$$\phi P_{trans} := (0.65) \cdot t_1 \cdot L_w \cdot F_u = 6633 \cdot lbs$$

Strength of Weld Material per (Eq. J2.5-7)

$$\phi P_{weld} := (0.6) \cdot 0.75 \cdot t_w \cdot L_w \cdot F_{exx} = 5568 \cdot lbs$$

Design Strength of Fillet Weld

$$\phi P_n := \min\left(\phi P_{long}, \phi P_{trans}, \phi P_{weld}\right) = 3827 \cdot lbs$$

D/C Ratio for the Welded Connection

$$\beta_{NW} := \frac{R_{u.weld}}{\phi P_n} = 63 \cdot \%$$

$weld_{check} := if\left(\beta_{NW} < 1.0, "OK", "NG"\right)$

$weld_{check} = "OK"$

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Anchorage To Wood Member WITH Lag Screws [NDS-2018 LRFD Strength Design]

*** Use 3/8" Lag Screws along Each Side of the Curb**
*** Assume G=0.5 Douglas Fir-Larch**

Wood Lag Screw Capacity per NDS 2018 Section 11.3

Wet Service Factor: $Cond := "DRY"$ **(e.g. CA = "DRY", AK = "WET")**

$$C_M := \begin{cases} 1.0 & \text{if } Cond = "DRY" \\ 0.7 & \text{if } Cond = "WET" \end{cases} = 1$$ **NDS 2018 Table 11.3.3**

Temperature Factor:
$$C_t := \begin{cases} 0.8 & \text{if } Cond = "DRY" \\ 0.7 & \text{if } Cond = "WET" \end{cases} = 0.8$$ **NDS 2018 Table 11.3.4**

Group Action Factor: $C_g := 0.97$ **NDS 2018 Table 11.3.6C**

Geometry Factor: $C_\Delta := 1.0$ **NDS 2018 Table 12.5.1A,B**

End Grain Factor: $C_{eg} := 1.0$ **NDS 2018 Sec. 12.5.2**

Diaphragm Factor: $C_{di} := 1.0$ **NDS 2018 Sec. 12.5.3**

Toe-Nail Factor: $C_{tn} := 1.0$ **NDS 2018 Sec. 12.5.4**

Format Conversion Factor: $K_F := 3.32$ **NDS 2018 Table 11.3.1**

Resistance Factor: $\phi := 0.65$ **NDS 2018 Table 11.3.1**

Time Effect Factor: $\lambda := 1.0$ **NDS 2018 App N.3.3**

Lateral Design Value: $Z := 130lbs$ **NDS 2018 Table 12K**

Withdrawal Design Value: $W := 305lbs$ **NDS 2018 Table 12.2A**

Lag Screw Diameter: $D_{lag} := \frac{3}{8}in$

Lag Screw Length: $L_{lag} := 4in$

Length of Tapered Tip: $E_{lag} := \frac{7}{32}in$

Lag Screw Penetration: $P_{lag} := 3.78125in$

Eff. Lag Screw Penetration for withdrawal: $P_{\omega.lag} := 2in + \frac{9}{32}in = 2.28 \cdot in$ **NDS 2018 Appx. Table L2**

NDS 2018 Sec. 12.1.4.6

Minimum Penetration DCR <1.0: $DCR_{min.penetration} := \frac{4 \cdot D_{lag}}{P_{\omega.lag}} = 0.66$ $DCR_{min.penetration} = "OK"$

Adj. Lateral Design Value: $Z' := Z \cdot C_M \cdot C_t \cdot C_g \cdot C_\Delta \cdot C_{eg} \cdot C_{di} \cdot C_{tn} \cdot K_F \cdot \phi \cdot \lambda = 218 \cdot lbs$

Adj. Withdrawal Design Value: $W' := W \cdot C_M^{\,2} \cdot C_t \cdot C_{eg} \cdot C_{tn} \cdot K_F \cdot \phi \cdot \lambda = 527 \cdot lbs$ **NDS 2018 Table 11.3.1**

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Number of Lag Screws on the Long Side $N_B := 25 + 2$

Moment Arm for Overturning (Short Side) $B := W_{curb} = 77 \cdot in$

Number of Lag Screws on the Short Side $N_L := 17 + 2$

Moment Arm for Overturning (Long Side) $L := L_{curb} = 113 \cdot in$

Total Number of Lag Screws $N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 84$

Max net Tension Reaction due to Seismic, Fp

$$R_{lag.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 6 \cdot lbs$$

$$R_{lag.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 3 \cdot lbs$$

$$R_{lag.EQ} := MAX+\left[\begin{bmatrix} \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{lag.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{lag.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 359 \\ 343 \end{pmatrix} \cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$R_{lag.W} := MAX+\left[\begin{bmatrix} \frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{L \cdot N_L \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 356 \\ 252 \end{pmatrix} \cdot lbs$$

Tension Design force; SRSS for loading from Each direction $T_{lag} := \max\left(\left|R_{lag.EQ}\right|, \left|R_{lag.W}\right|\right) = 496 \cdot lbs$

Shear load at each anchor location $V_{lag} := \frac{\max\left(V_{base.S} \cdot \sqrt{2}, V_{base.W}\right)}{N_t} = 250 \cdot lbs$

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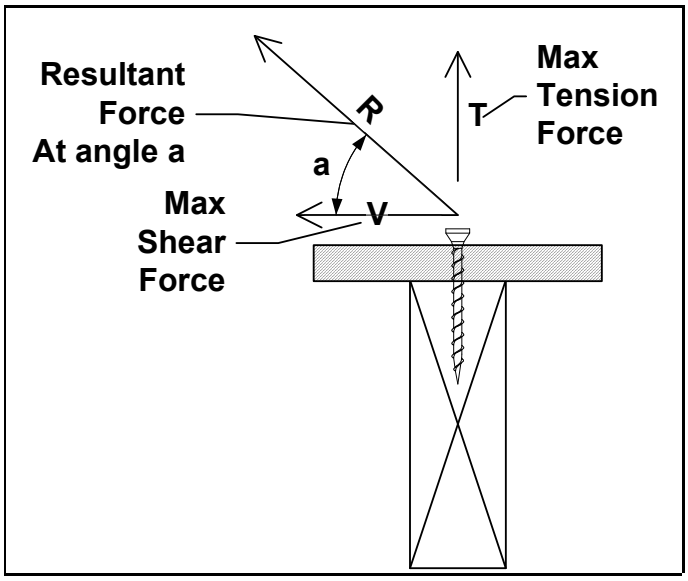
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For Lag Screws Subjected to Combined Lateral and Withdrawal Loading; Design Strength of the Lag Screw Shall Be Adjusted per Hankinson Formula as Prescribed by NDS 2018 Equation 12.4-1



Angle Between Wood Surface and Direction of Resultant Applied Load

$$(\alpha) := \operatorname{atan}\left(\frac{T_{lag}}{V_{lag}}\right) = 63\cdot deg$$

Combined Demand per Lag Screw @ Strength Level

$$R_{lag} := \sqrt{T_{lag}^{2} + V_{lag}^{2}} = 556\cdot lbs$$

Adjusted Capacity per NDS 2018 Equation 12.4-1 @ Strength Level

$$Z'_{\alpha} := \frac{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot Z'}{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot\cos(\alpha)^{2} + Z'\cdot\sin(\alpha)^{2}} = 627\cdot lbs$$

D/C Ratio for the Lag Screw connection to Wood Structure

$$\beta_{Lag} := \frac{R_{lag}}{Z'_{\alpha}} = 89\cdot\%$$

$$Lag_{Screw.Check} := \text{if}\left(\beta_{Lag} < 1.0, \text{"OK"}, \text{"NG"}\right)$$

$Lag_{Screw.Check}$ = "OK"

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Bearing and Tilting in Curb Bolted Connection AISI S100-16

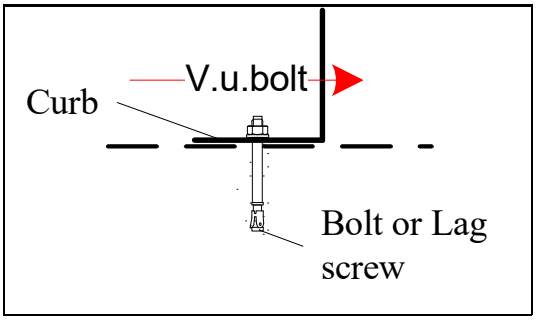
Nominal bolt diameter $d := 0.5in$

Uncoated sheet thickness $t_{curb} := thick("14GA") = 0.079 \cdot in$

Tensile strength of sheet $F_u := 65ksi$

Coefficient for conversion of units $\alpha := 1.0$

Modification Factor $m_f := 1.0$



Modification factor for type of bearing connection, per Table J3.3.1-2; For single shear connection with washers

Bearing Factor $C := \begin{cases} 3 & \text{if } \left(\frac{d}{t_{curb}} < 10\right) \wedge \left(0.024in < t_{curb} < 0.1875in\right) \\ "NG" & \text{if } \frac{d}{t_{curb}} > 10 \end{cases} = 3$

Bearing factor, which shall be determined according to Table J3.3.1-1 For d/t<10 where $d \div t_{curb} = 6$

Bearing Design Strength per AISI S100-16 Eq. J3.3.1-1

$$\phi P_{n_{(0)}} := (0.6) \cdot \left(m_f \cdot C \cdot d \cdot t_{curb} \cdot F_u\right) = 4592 \cdot lbs$$

Bolt Hole Deformation Design Strength per AISI S100-16 Eq. J3.3.2-1

$$\phi P_{n_{(1)}} := (0.65) \cdot \left[4.64 \cdot \left(\frac{\alpha}{in}\right) \cdot t_{curb} + 1.53\right] \cdot d \cdot t_{curb} \cdot F_u = 3141 \cdot lbs$$

Curb Connection Shear Capacity $\phi P_n := \min\left(\phi P_n\right) = 3141 \cdot lbs$

Loading demand at connection $V_{u.bolt} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{6} = 2476 \cdot lbs$

$Curb\_Conn\_Shear := if\left(V_{u.bolt} < \phi P_n, "OK", "NG"\right)$ Curb_Conn_Shear = "OK"

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Thickness of Curb, ISO Rail and Clip

(Per AISC Table 17-10 Galvanized)

Hold Down Clip thickness $t_{Clip} := "12GA"$ $t_{clip} := thick(t_{Clip}) = 0.1084 \cdot in$

Roof Curb thickness $t_{Curb} := "14GA"$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

ISO RAIL thickness $t_{Curb.iso} := "10GA"$ $t_{curb.iso} := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Note: Iso Rail thickness is only used if the curb is isolated. Not used for non-isolated curbs

Sheet Metal Screws (SMS) Equations and References

SMS properties (ESR-2196 Table 5)

$$SMS_{Table} = \begin{pmatrix} "SMS" & "Diameter" & "HeadDiameter" & "Tension" & "Shear" \\ "Size" & "d" & "dw" & "Pts" & "Pss" \\ "\#8" & 0.164 & 0.335 & 1000 & 1170 \\ "\#10" & 0.19 & 0.399 & 1370 & 1215 \\ "\#12" & 0.216 & 0.415 & 2325 & 1880 \\ "\#14" & 0.25 & 0.5 & 4580 & 2440 \end{pmatrix}$$

SMS Tension Eqns

$P_{not} = 0.85 \cdot t \cdot d \cdot F_u$

$P_{nov} = 1.5 \cdot t \cdot d_w \cdot F_u$

$P_{nts} = 0.8 \cdot P_{ts}$

(AISI S100-16 J4.4.1 & J4.4.2)

FOR THE MOST CASES, PULL-OUT CAPACITY IS THE LOWEST

SMS Shearn Eqns

$P_{vnot} = 4.2 \cdot \sqrt{(d \cdot t^3)} \cdot F_u$

$P_{vnov} = 2.7 \cdot t \cdot d \cdot F_u$

$P_{vnss} = 0.8 \cdot P_{ss}$

(AISI S100-16 J4.3.1)

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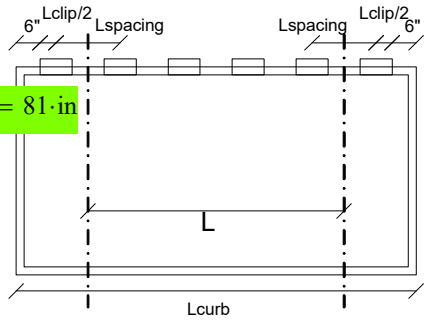
Hold Down Clip Design (Connection of the Mechanical unit to Curb)

Number of Clips on the long side $N_B := 6$

Moment Arm for overturning (Short side) $B := W_{curb} + 1.75in \cdot 2 = 81 \cdot in$

Number of Clips on the Short side. $N_L := 6$

Width of Clips $L_{clip} := 9in$



Curb Centerline Spacing (Long side)

$$L_{spacing} := \frac{L_{curb} - \left(6in + \frac{L_{clip}}{2}\right)\cdot 2}{N_B - 1} = 18.438 \cdot in$$

Moment Arm for overturning (Long side)

$$L := L_{curb} - 2\cdot\left[6in + \frac{L_{clip}}{2} + L_{spacing}\cdot\frac{(N_L - 2)}{4}\right] = 55.313 \cdot in$$

Total Number of Clips

$$N_t := (N_B)\cdot 2sides = 12$$

Max net Tension Reaction due to Seismic, Fp

$$R_{clip.EQ} := MAX+\left[\begin{array}{l}\left[\frac{F_p \cdot Wt_{unit}}{B \cdot N_B}\cdot h_{CG.unit} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{width}}{B \cdot N_B}\right] - \frac{(0.9 - F_v)\cdot Wt_{unit}}{N_t} \\ \left[\frac{F_p \cdot Wt_{unit}}{L \cdot N_L}\cdot h_{CG.unit} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{length}}{L \cdot N_L}\right] - \frac{(0.9 - F_v)\cdot Wt_{unit}}{N_t}\end{array}\right] = \begin{pmatrix}604\\935\end{pmatrix}\cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$R_{clip.W} := MAX+\left(\begin{array}{l}\frac{P_{net}\cdot L_{unit}\cdot\frac{H_{unit}^{\,2}}{2}}{B \cdot N_B} + \frac{P_v \cdot L_{unit.up}\cdot W_{unit}}{N_t} + \frac{0.9\cdot Wt_{unit}\cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{unit}}{N_t} \\ \frac{P_{net}\cdot W_{unit}\cdot\frac{H_{unit}^{\,2}}{2}}{L \cdot N_L} + \frac{P_v \cdot L_{unit.up}\cdot W_{unit}}{N_t} + \frac{0.9\cdot Wt_{unit}\cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{unit}}{N_t}\end{array}\right) = \begin{pmatrix}1029\\1021\end{pmatrix}\cdot lbs$$

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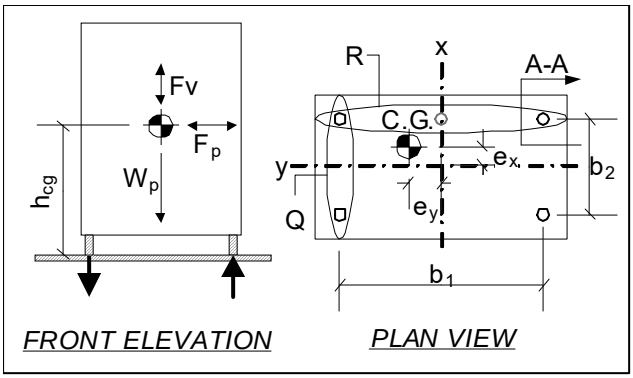
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Project: IBC 2018 Group C Job No. J13001 . 382

Date DEC/12/2018

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Tensile and Shear Load calculation per ASHRAE RP-812



Eccentricity along X-X

$e_x := e_{width} = 6.094 \cdot in$

Eccentricity along Y-Y

$e_y := e_{length} = 3.157 \cdot in$

Distance between Seismic Restraints Along Y-Y

$b_1 := L_{curb} - 2 \cdot 6in = 101 \cdot in$

Distance between Seismic Restraints Along X-X

$b_2 := W_{curb} = 77 \cdot in$

Moment of Inertia about X-X

$$I_{xx} := \frac{N_t \cdot (N_t + 2) \cdot (b_1)^2}{12 \cdot (N_t - 2)} = 14335 \cdot in^2$$

Moment of Inertia about Y-Y

$$I_{yy} := \frac{N_t \cdot (b_2)^2}{4} = 17787 \cdot in^2$$

Angle about Tensile Load

$$\Theta_t := \operatorname{atan}\left[\frac{I_{yy} \cdot (b_1)}{I_{xx} \cdot (b_2)}\right] = 58 \cdot deg$$

Angle about Shear Load

$$\Theta_s := \begin{cases} \operatorname{atan}\left(\frac{e_x}{e_y}\right) & \text{if } e_y \neq 0 \\ 0deg & \text{if } e_y = 0 \end{cases} = 63 \cdot deg$$

Max Net Tensile Load Due to Seismic Load, Fp

$$T_{U.EQ.pt1} := \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} - \frac{(0.9 - F_v) \cdot Wt_{unit}}{b_1 \cdot b_2} \cdot \left(\frac{b_1}{2} \cdot e_x + \frac{b_2}{2} \cdot e_y - e_x \cdot e_y\right) = 59 \cdot lbs$$

$$T_{U.EQ.pt2} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \cos(\Theta_t) \cdot \frac{0.5 \cdot b_2}{I_{yy}} = -404 \cdot lbs$$

$$T_{U.EQ.pt3} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \sin(\Theta_t) \cdot \frac{0.5 \cdot b_1}{I_{xx}} = -1075 \cdot lbs$$

$T_{U.EQ} := T_{U.EQ.pt1} + T_{U.EQ.pt2} + T_{U.EQ.pt3} = -1420 \cdot lbs$

Max Net Shear Load Due to Seismic Load, Fp

$$V_{Ux.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\cos(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_2 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_1 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 524 \cdot lbs$$

$$V_{Uy.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\sin(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_1 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_2 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 893 \cdot lbs$$

$$V_{U.EQ} := \sqrt{V_{Ux.EQ}^2 + V_{Uy.EQ}^2} = 1035 \cdot lbs$$

Tension Design force for Hold Down Clips

$T_{clip} := \max(R_{clip.W_0}, R_{clip.W_1}, |R_{clip.EQ}|, |T_{U.EQ}|) = 1420 \cdot lbs$

$|R_{clip.EQ}| = 1113 \cdot lbs$ $|T_{U.EQ}| = 1420 \cdot lbs$

$T_{clip.EQ.max} := \max(|R_{clip.EQ}|, |T_{U.EQ}|) = 1420 \cdot lbs$

$T_{clip.W.max} := \max(R_{clip.W_0}, R_{clip.W_1}) = 1029 \cdot lbs$

Based on ASCE 7-16 Figure 29.4-1 magnitude of force coefficient,

Wind in diagonal direction to the face of equipment produces less force than that of the wind in perpendicular direction to the face of the equipment. Therefore, wind in diagonal direction does not need to be used

Shear Design force for Hold Down Clips

$$V_{clip} := \max\left(\frac{\max(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit})}{N_t}, |V_{U.EQ}|\right) = 1035 \cdot lbs$$

$F_p \cdot Wt_{unit} \cdot \frac{1}{N_t} = 899 \cdot lbs$ $|V_{U.EQ}| = 1035 \cdot lbs$

$P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t} = 675 \cdot lbs$

$V_{clip.EQ.max} := \max\left[\left(F_p \cdot Wt_{unit} \cdot \frac{1}{N_t}\right), |V_{U.EQ}|\right] = 1035 \cdot lbs$

$V_{clip.W.max} := \max\left(\left(P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t}\right)\right) = 675 \cdot lbs$

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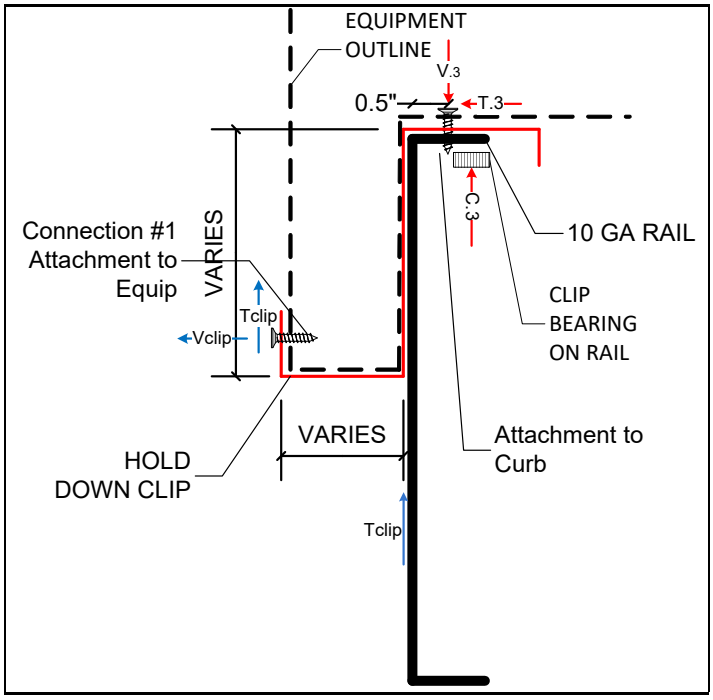
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Loading at Hold Down Clips @ Isolator Curb

$b_{return.iso} := Clip_b \cdot in = 2.125 \cdot in$

$b_{depth.iso} := Clip_c \cdot in = 6 \cdot in$



*For Reference Only

Mu Bending moment in the hold down

$M_u := T_{clip} \cdot b_{return.iso} = 3018 \cdot in \cdot lbs$

Resolve bending moment a T/C couple
Assume 0.5" bearing length
Moment Arm for T/C couple

$d_{T/C} := 1in - 0.5in = 0.5 \cdot in$

V3 is acting as shear on the screws. due to eccentricity of Tension force T

$$V_3 := \frac{T_{clip} \cdot \left[b_{return.iso} + (0) \right]}{d_{T/C}} = 6036 \cdot lbs$$

Additional load from Direct Shear acting out of plane (SRSS)

$V_3 := \sqrt{V_3^{\,2} + V_{clip}^{\,2}} = 6124 \cdot lbs$

Reaction C3 [compression force] is resisted by bearing of the hold down on the curb lip. Assume 0.5" bearing length

$C_3 := V_3 - T_{clip} = 4704 \cdot lbs$

T3 Load due to the shear acting out of plane tension on the screws.

$$T_3 := \left(\max\left(\frac{T_{clip} \cdot b_{return.iso}}{b_{depth.iso}}, V_{clip} \right) \right) = 1035 \cdot lbs$$

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Check Bending in Clip @ Isolator Curb

There are several restraints that prevents the hold down clip for iso-curb to have local bending at the bottom and transfer vertical load demand directly to the face of the curb.

- Hold down is bearing on the face of iso-rail / non-iso curb lip.
- Gasket will act as a "link" member to allow unit base rail and bottom flange to move totegther so flange can't bend unless the unit base rail bends first. However, unit base rail is not likely to bend so bottom flange won't bend

Hold Down Clip thickness

$t_{Clip} = \text{"12GA"}$ $t_{clip} := \text{thick}(t_{Clip}) = 0.1084 \cdot in$

Effective width of hold down clip

$b_c := L_{clip} = 9 \cdot in$

Yield strength of the Clip

$F_{y.c} := 50ksi$

Strength reduction for bending

$\phi_{clip} := 0.9$

Design Bending Capacity (LRFD)

$\phi M_n := \phi_{clip} \cdot F_{y.c} \left(\frac{b_c \cdot t_{clip}^2}{6} \right) = 793 \cdot in \cdot lbs$

Flexural bending demand

$M_{u.clip} := T_{clip} \cdot 0.5in = 710 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.clip}}{\phi M_n} = 0.895$

$Clip_{Bending} = \text{"OK"}$

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Check Flange Bending in Clip @ Isolator Curb

Note:
- **If the curb flange is welded to the 10GA channel and 10GA channel is welded back to the base of the curb, then both tension and compression due to equipment overturning will be taken care by the 10GA channel.**
- **Since the curb will be reinforced with 10GA channel under each isolator, it can be assumed that the loads will trasnferred down to the base structure through the channels. Therefore, flange downward bending at curb due to compressive load does not need to be checked.**

Roof Curb thickness

$t_{Curb} = \text{"14GA"}$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

Clip edge to edge distance

$$b_{edge2edge} := \frac{L_{curb} - \left(6in + \frac{L_{clip}}{2}\right) \cdot 2}{N_B - 1} - L_{clip} = 9.438 \cdot in$$

Effective width of Roof Curb

$b_{curb} := L_{clip} + b_{edge2edge} = 18.44 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\frac{b_{curb} \cdot (t_{curb})^2}{6}\right] = 852 \cdot in \cdot lbs$$

Width of Isolator

$w_{JQ.iso} := 2in$ **2 in. for CQAs**

Flexural bending demand

$$M_{u.Curb} := T_{clip} \cdot \left(\max\left(\frac{1.75in}{2} - 0.5in, \frac{w_{JQ.iso}}{2} - 1in\right)\right) = 533 \cdot in \cdot lbs$$

D/C Ratio for bending

$$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.625$$

$Curb_{Bending} = \text{"OK, Weld 10GA channel ends to curb flange"}$

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Design of Connection#1 Connection of Equipment to hold Down clip

Ultimate SMS screw connection Strength (LRFD)
Strength based on the smallest thickness of Curb and Equipment Housing (min 16 GA) [Fy = 50ksi & Fu=65ksi]

$n_{sms} := 4$ $Size_{ss} := "\#14"$

$t_{ss} := "16GA"$ $F_{u.ss} := 65ksi$

Nominal Tension Strength

$P_{nt} := n_{sms} \cdot T_s(Size_{ss}, t_{ss}, F_{u.ss}) = 3508 \cdot lbs$

$P_{not} := n_{sms} \cdot T_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 3508 \cdot lbs$

$P_{nov} := n_{sms} \cdot T_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 12383 \cdot lbs$

$P_{nts} := n_{sms} \cdot T_{nts}(Size_{ss}, t_{ss}, F_{u.ss}) = 14656 \cdot lbs$

Nominal Shear Strength

$P_{ns} := n_{sms} \cdot V_s(Size_{ss}, t_{ss}, F_{u.ss}) = 7808 \cdot lbs$

$P_{vnot} := n_{sms} \cdot V_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 8737 \cdot lbs$

$P_{vnov} := n_{sms} \cdot V_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 11144 \cdot lbs$

$P_{vnss} := n_{sms} \cdot V_{nss}(Size_{ss}, t_{ss}, F_{u.ss}) = 7808 \cdot lbs$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} V_{clip} \div (\phi_{sms} \cdot P_{nt}) \\ T_{clip} \div (\phi_{sms} \cdot P_{ns}) \end{bmatrix} = \begin{pmatrix} 59 \\ 36 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left[\begin{bmatrix} \left[\frac{T_{clip}}{P_{vnov}} + 0.71\left(\frac{V_{clip}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{T_{clip}}{P_{vnot}} + \left(\frac{V_{clip}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{T_{clip}}{P_{vnss}} + \left(\frac{V_{clip}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right] = 66 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

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Design of Connection#2 Connection of hold Down clip to Curb

Tension loads on SMS connection

$T_{s2} := V_3 = 6124 \cdot lbs$

Shear loads on SMS connection

$V_{s2} := T_3 = 1035 \cdot lbs$

Ultimate SMS screw connection Strength (LRFD)
Strength based on the smallest thickness of Curb and Equipment Housing (min 16 GA) [Fy = 50ksi & Fu=65ksi]

$n_{sms} := 8$ $Size_{ss} := "\#14"$

$t_{ss} := (t_{Curb.iso}) = "10GA"$ $F_{u.ss} := 65ksi$

Nominal Tension Strength

$P_{nt} := n_{sms} \cdot T_s(Size_{ss}, t_{ss}, F_{u.ss}) = 15271 \cdot lbs$

Note:
SMS is getting pulled up so the thicker curb iso rail is engaged for SMS capacity , rather than just the clip itself.

$P_{not} := n_{sms} \cdot T_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 15271 \cdot lbs$

$P_{nov} := n_{sms} \cdot T_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 53898 \cdot lbs$

$P_{nts} := n_{sms} \cdot T_{nts}(Size_{ss}, t_{ss}, F_{u.ss}) = 29312 \cdot lbs$

Nominal Shear Strength

$P_{ns} := n_{sms} \cdot V_s(Size_{ss}, t_{ss}, F_{u.ss}) = 15616 \cdot lbs$

$P_{vnot} := n_{sms} \cdot V_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 56103 \cdot lbs$

$P_{vnov} := n_{sms} \cdot V_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 48508 \cdot lbs$

$P_{vnss} := n_{sms} \cdot V_{nss}(Size_{ss}, t_{ss}, F_{u.ss}) = 15616 \cdot lbs$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} T_{s2} \div (\phi_{sms} \cdot P_{nt}) \\ V_{s2} \div (\phi_{sms} \cdot P_{ns}) \end{bmatrix} = \begin{pmatrix} 80 \\ 13 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left[\begin{bmatrix} \left[\frac{V_{s2}}{P_{vnov}} + 0.71\left(\frac{T_{s2}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{V_{s2}}{P_{vnot}} + \left(\frac{T_{s2}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{V_{s2}}{P_{vnss}} + \left(\frac{T_{s2}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right] = 61 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

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Hold Down clip Bending and Shear Interaction

Diameter of SMS:

$$d_{sms} := \text{vlookup}\left(Size_{ss}, SMS_{Table}, 1\right)_0 \cdot in = 0.25 \cdot in$$

Depth of flat web portion

$$h_{clip.shear} := L_{clip} - n_{sms} \cdot d_{sms} = 7 \cdot in$$

Depth-to-Thickness Ratio:

$$\frac{h_{clip.shear}}{t_{clip}} = 65 \qquad E := 29500ksi \qquad F_y := 50ksi \qquad \mu := 0.3$$

Nominal Shear Stress:
(For unreinforced web)
AISI S100-16 G2.1

$$k_v := 5.34 \qquad \sqrt{\frac{E \cdot k_v}{F_y}} = 56 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 85$$

Area of Web Element:

$$A_w := h_{clip.shear} \cdot t_{clip} = 0.759 \cdot in^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h_{clip.shear}}{t_{clip}}\right)^2} = 34.1 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} \qquad V_y := 0.6 \cdot A_w \cdot F_y = 23\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.937$$

Hole Shear Reduction Factor:
(for circular holes, AISI S100-16 Eq G3-1)

$$c := \frac{h_{clip.shear}}{2} - \frac{d_{sms}}{2.83} = 3.41 \cdot in$$

$$q_s := \begin{cases} 1.0 & \text{if } \frac{c}{t_{clip}} \geq 54 \\ \frac{c}{54 \cdot t_{clip}} & \text{if } 5 \leq \frac{c}{t_{clip}} < 54 \end{cases} = 0.583$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \leq 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \leq 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 19.792 \cdot kip$$

Design Shear Capacity with holes:

$$\phi V_{n.clip} := 0.95 \cdot V_n \cdot q_s = 11 \cdot kip$$

D/C Ratio of V and M per AISI S100-16 Eq H2-1

$$DCR_{V.M.int.clip} := \sqrt{\left(\frac{M_{u.clip}}{\phi M_n}\right)^2 + \left(\frac{\max\left(T_{clip}, V_{clip}\right)}{\phi V_{n.clip}}\right)^2} = 0.9046$$

Demand/Capacity Ratio:

$$VandM_{int.clip} = \text{"OK"}$$

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ISOLATOR DESIGN [PER OPM-0401-13]

OPM-0401-13 is based on allowable stress design

Number of isolators on the long side

$N_B := 8$ $N_{iso.long} := N_B = 8$

Moment Arm for overturning (Short side)

$B := W_{curb} + \frac{1.75in}{2} \cdot 2 = 79 \cdot in$

Number of isolators on the Short side.

$N_L := 6$

Isolator Centerline Spacing (Long side)

$L_{spacing.iso} := \frac{L_{curb} - (6in) \cdot 2}{N_B - 1} = 14.46 \cdot in$

Moment Arm for overturning (Long side)

$L := L_{curb} - 2 \cdot 6in - 2 \cdot L_{spacing.iso} \cdot \frac{(N_L - 2)}{4} = 72 \cdot in$

Total Number of isolators

$N_t := (N_B) \cdot 2sides = 16$

Max net Tension Reaction due to Seismic, Fp

$EQ_{ASD} := \left[0.6 - (0.7 \cdot F_v)\right] \cdot Wt_{unit} = 1.246\ kip$

$$R_{iso.EQ} := MAX+\left[\left[\left[\frac{(0.7F_p) \cdot Wt_{unit}}{B \cdot N_B} \cdot (h_{CG.unit} + 0in) + \frac{EQ_{ASD} \cdot e_{width}}{B \cdot N_B}\right] - \frac{EQ_{ASD}}{N_t}\right]\right] = \begin{pmatrix} 331 \\ 508 \end{pmatrix} \cdot lbs$$

$$\left[\left[\frac{(0.7F_p) \cdot Wt_{unit}}{L \cdot N_L} \cdot (h_{CG.unit} + 0in) + \frac{EQ_{ASD} \cdot e_{length}}{L \cdot N_L}\right] - \frac{EQ_{ASD}}{N_t}\right]$$

Max net Tension Reaction due to Wind load, Pnet

$$F_{wind.B} := \frac{P_{net} \cdot L_{unit} \cdot (H_{unit} + 0in)}{B \cdot N_B} \cdot \left(\frac{1}{2} \cdot H_{unit} + 0in\right) = 426 \cdot lbs$$

$$F_{wind.L} := \frac{P_{net} \cdot W_{unit} \cdot (H_{unit} + 0in)}{L \cdot N_L} \cdot \left(\frac{1}{2} \cdot H_{unit} + 0in\right) = 426 \cdot lbs$$

$$R_{iso.W} := (0.6) \cdot MAX+\left(\begin{pmatrix} F_{wind.B} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{Wt_{unit}}{N_t} \\ F_{wind.L} + \frac{P_v \cdot L_{unit.up} W_{unit}}{N_t} + \frac{Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{Wt_{unit}}{N_t} \end{pmatrix}\right) = \begin{pmatrix} 459 \\ 454 \end{pmatrix} \cdot lbs$$

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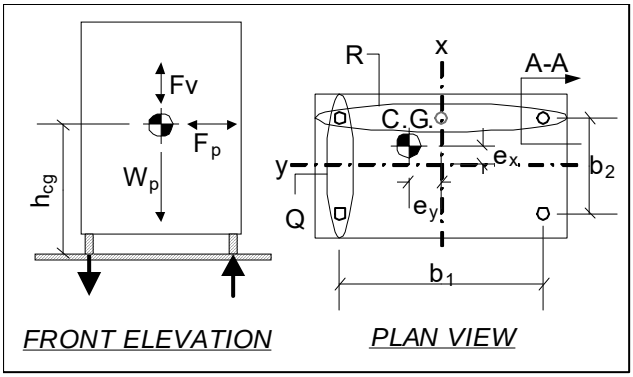
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Tensile and Shear Load calculation per ASHRAE RP-812



Eccentricity along X-X

$e_x := e_{width} = 6.09 \cdot in$

Eccentricity along Y-Y

$e_y := e_{length} = 3.16 \cdot in$

Distance between Seismic Restraints Along Y-Y

$b_1 := L_{curb} - 2 \cdot 6in = 101 \cdot in$

Distance between Seismic Restraints Along X-X

$b_2 := W_{curb} + 2 \cdot \frac{1.75in}{2} = 79 \cdot in$

Moment of Inertia about X-X

$I_{xx} := \frac{N_t \cdot (N_t + 2) \cdot (b_1)^2}{12 \cdot (N_t - 2)} = 17553 \cdot in^2$

Moment of Inertia about Y-Y

$I_{yy} := \frac{N_t \cdot (b_2)^2}{4} = 24806 \cdot in^2$

Angle about Tensile Load

$\Theta_t := \operatorname{atan}\left[\frac{I_{yy} \cdot (b_1)}{I_{xx} \cdot (b_2)}\right] = 61 \cdot deg$

Angle about Shear Load

$$\Theta_s := \begin{cases} \operatorname{atan}\left(\frac{e_x}{e_y}\right) & \text{if } e_y \neq 0 \\ 0deg & \text{if } e_y = 0 \end{cases} = 63 \cdot deg$$

Max Net Tensile Load Due to Seismic Load, Fp

$$T_{U.EQ.pt1} := \frac{(0.6 - 0.7 \cdot F_v) \cdot Wt_{unit}}{N_t} - \frac{(0.6 - 0.7 \cdot F_v) \cdot Wt_{unit}}{b_1 \cdot b_2} \cdot \left(\frac{b_1}{2} \cdot e_x + \frac{b_2}{2} \cdot e_y - e_x \cdot e_y\right) = 13 \cdot lbs$$

$$T_{U.EQ.pt2} := -0.7 \cdot (F_p \cdot Wt_{unit}) \cdot (h_{CG.unit} + 0in) \cdot \cos(\Theta_t) \cdot \frac{0.5 \cdot b_2}{I_{yy}} = -191 \cdot lbs$$

$$T_{U.EQ.pt3} := -0.7 \cdot (F_p \cdot Wt_{unit}) \cdot (h_{CG.unit} + 0in) \cdot \sin(\Theta_t) \cdot \frac{0.5 \cdot b_1}{I_{xx}} = -631 \cdot lbs$$

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$T_{U.EQ} := T_{U.EQ.pt1} + T_{U.EQ.pt2} + T_{U.EQ.pt3} = -810 \cdot lbs$

Max Net Shear Load Due to Seismic Load, Fp

$$V_{Ux.EQ} := 0.7 \cdot F_p \cdot Wt_{unit} \cdot \frac{\cos(\Theta_s)}{N_t} + \frac{0.7 \cdot F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_2 \cdot e_y + 0.7 \cdot F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_1 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 276 \cdot lbs$$

$$V_{Uy.EQ} := 0.7 \cdot F_p \cdot Wt_{unit} \cdot \frac{\sin(\Theta_s)}{N_t} + \frac{0.7 \cdot F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_1 \cdot e_y + 0.7 \cdot F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_2 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 470 \cdot lbs$$

$$V_{U.EQ} := \sqrt{V_{Ux.EQ}^2 + V_{Uy.EQ}^2} = 545 \cdot lbs$$

Tension Design force SRSS for loading from Each direction

$R_{iso.EQ.1.RP812} := \left| T_{U.EQ.pt1} + T_{U.EQ.pt3} \right| = 618 \cdot lbs$

$R_{iso.EQ.0.RP812} := \left| T_{U.EQ.pt1} + T_{U.EQ.pt2} \right| = 178 \cdot lbs$

$$R_{iso.EQ.max_1} := \max\left[\left(R_{iso.EQ.1.RP812} + 0 \cdot R_{iso.EQ.0.RP812}\right), \left(R_{iso.EQ_1} + 0 \cdot R_{iso.EQ_0}\right)\right] = 618 \cdot lbs$$

$$R_{iso.EQ.max_0} := \max\left[\left(R_{iso.EQ.0.RP812} + 0 \cdot R_{iso.EQ.1.RP812}\right), \left(R_{iso.EQ_0} + 0 \cdot R_{iso.EQ_1}\right)\right] = 331 \cdot lbs$$

For the plot:

$R_{iso.EQ.max_1} = 618 \cdot lbs$ $R_{iso.W_1} = 454 \cdot lbs$

$R_{iso.EQ.max_0} = 331 \cdot lbs$ $R_{iso.W_0} = 459 \cdot lbs$

Shear load at each anchor location

For the plot:

$$V_{iso.E} := \max\left[\left[\begin{array}{c} 1.0 \cdot V_{Ux.EQ} + 0 \cdot V_{Uy.EQ} \\ 0.3 \cdot V_{Ux.EQ} + 0 \cdot V_{Uy.EQ} \\ \left[\left(0.7F_p\right) \cdot Wt_{unit} \cdot \frac{1}{N_t}\right] \end{array}\right]\right] = 472 \cdot lbs \qquad V_{iso.W} := 0.6P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t} = 304 \cdot lbs$$

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Isolator Capacity:

$ID_{Iso} := "CQA"$

$T_{n.\Omega} := 2117lbs$ **(ASD)**

$V_{n.\Omega} := 775lbs$ **(ASD)**

Isolator Demand:

$R_{iso.max} := \max\left[\left(R_{iso.EQ.max_1}\right),\left(R_{iso.EQ.max_0}\right),\left(R_{iso.W_1}\right),\left(R_{iso.W_0}\right)\right] = 618\cdot lbs$

$V_{iso.max} := \max\left(V_{iso.E}, V_{iso.W}\right) = 472\cdot lbs$

D/C Ratio of Tension Only.:

$$DCR_{tension} := \frac{R_{iso.max}}{T_{n.\Omega}} = 0.292$$

$DCR_{tension} = "OK"$

D/C Ratio of Shear Only.:

$$DCR_{shear} := \frac{V_{iso.max}}{V_{n.\Omega}} = 0.609$$

$DCR_{shear} = "OK"$

D/C Ratio of Tension Only.:

$$DCR_{Int} := \frac{V_{iso.max}}{V_{n.\Omega}} + \frac{R_{iso.max}}{T_{n.\Omega}} = 0.901$$

$DCR_{Int} = "OK"$

ISOLATOR "SPRING" DESIGN [PER OPM-0401-13]

Factor of Safety of Spring

$FS_{spring} := 0.75$

Compressive Strength of Spring

$$C_{spring.\Omega} := \begin{cases} \left(FS_{spring}\cdot 300lbs\right) & \text{if } ID_{Iso} = "CQA" \\ \left(FS_{spring}\cdot 918lbs\right) & \text{if } ID_{Iso} = "CQB" \\ \left(FS_{spring}\cdot 918lbs\right) & \text{if } ID_{Iso} = "CQBX" \end{cases} = 225\cdot lbs$$

Rated Load per unit self-weight

$$C_{unit.rated.load} := \frac{Wt_{unit}}{N_t} = 200\cdot lbs$$

D/C Ratio of Spring Compression:

$$DCR := \frac{C_{unit.rated.load}}{C_{spring.\Omega}} = 0.888$$

$IsoSpring_{compression} = "OK"$

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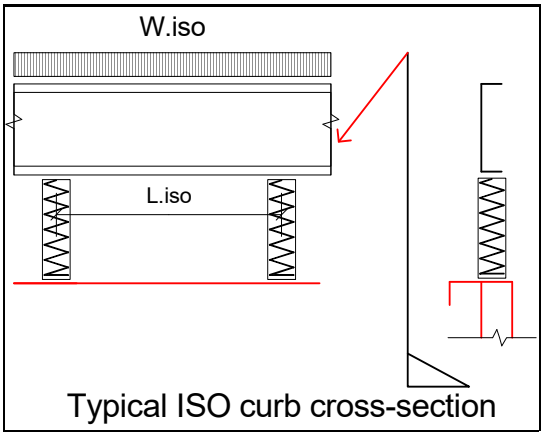
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Check ISO Rail for Bending about Strong and Weak Axis (AISI S100-16 F2.1)



Typical ISO curb cross-section

Thickness of Curb:

$t_{Curb.iso}$ = "10GA" $t := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Inside Bend Radius:

$R := R_{iso} = 0.186 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web:

$h := 7.5in - 2 \cdot (t + R) = 6.85 \cdot in$

Width of Flange:

$h_w := 1in$

Check Curb Bending of Long Side (Strong axis)

Member per CFS: $CFS_{member} :=$ "10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"

Number of Isolators on each Long Side: $N_{iso.long} = 8$

Center-to-Center Spacing of Isolators $L_{iso} := \frac{L_{curb}}{N_{iso.long} - 1} = 16 \cdot in$

Distributed Load $\omega_{iso} := \omega_{x.L.vert} = 1.977\,klf$

Moment Demand on Iso Rail $M_{cx} := \frac{\omega_{iso} \cdot L_{iso}^2}{8} = 5.385 \cdot kip \cdot in$

Curb Elastic Modulus / Yield Stress: $E := 29500ksi$ $F_y := 50ksi$

Curb Shear Modulus: $G := 11300ksi$

Poisson's Ratio $\mu := 0.3$

Section Properties from CFS: $r_x = 2.4893 \cdot in$ $r_o = 2.519 \cdot in$ $C_w = 0.595 \cdot in^6$ $S_x = 1.855 \cdot in^3$

$r_y = 0.2288 \cdot in$ $J = 0.0058 \cdot in^4$ $S_y = 0.3669 \cdot in^3$

$r_{min} := min(r_x, r_y) = 0.2288 \cdot in$

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Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Flanges*

Flat Width:

$$w := h_w - R_{curb} = 0.893 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Unstiffened"}$$

Stress at the end of the Width:

$$f_2 := 11.407ksi \quad f_1 := 11.407ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \frac{f_2}{f_1} = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 0.43$$

Critical Compressive Stress:

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t}{w}\right)^2 = 274.53 \cdot ksi$$

Stress in Compression Element:

$$f := 18ksi$$

Note: Use f from "Elastive Flexural Buckling Stress" on "Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI E2)"

Slenderness Factor:

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 0.26$$

Local reduction factor:

$$\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 0.55$$

Effective Width of the Flanges:

$$b_{eff.flange} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 0.893 \cdot in$$

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Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Web*

Flat Width: $w := h = 6.851 \cdot in$

Stiffened Web Check: $Stiffened_{check} := "Stiffened"$

Stress at the end of the Width: $f_2 := 11.407ksi$ $f_1 := 11.407ksi$

Compressive Stress Ratio (Eq. 1.1.2-1): $\Psi := \frac{f_2}{f_1} = 1$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = "Stiffened" \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = "Unstiffened" \end{cases} = 4$$

Critical Compressive Stress: $F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t}{w}\right)^2 = 43.4 \cdot ksi$

Stress in Compression Element: $f := 18ksi$

Note: Use f from "Elastive Flexural Buckling Stress" on "Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI E2)"

Slenderness Factor: $\lambda := \sqrt{\frac{f}{F_{cr}}} = 0.64$

Local reduction factor: $\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 1.022$

Effective Width of the Web:

$$b_{eff.web} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 6.851 \cdot in$$

Effective Area of the Member: $A_e := 2 \cdot \left(b_{eff.flange} \cdot t\right) + b_{eff.web} \cdot t = 1.194 \cdot in^2$

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For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. F2.1.1-4,5)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(1.0 \cdot L_{iso}\right)^2}\right] = 96 \cdot ksi$$

$$\sigma_{ey} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{iso}}{r_y}\right)^2} = 58 \cdot ksi \qquad \frac{1.0 \cdot L_{iso}}{r_y} = 71$$

KL_r = "KL/r < 200, OK"

Cb per Eq. F2.1.1-2

$$M_A := \frac{\omega_{iso} \cdot \frac{L_{iso}}{4}}{2} \cdot \left(L_{iso} - \frac{L_{iso}}{4}\right) = 4.04 \cdot kip \cdot in$$

$$M_B := M_{cx} = 5.39 \cdot kip \cdot in$$

$$M_C := \frac{\omega_{iso} \cdot \frac{3 \cdot L_{iso}}{4}}{2} \cdot \left(L_{iso} - \frac{3 \cdot L_{iso}}{4}\right) = 4.04 \cdot kip \cdot in$$

$$C_b := \min\left(1.0, \frac{12.5 \cdot M_{cx}}{2.5 \cdot M_{cx} + 3 \cdot M_A + 4 \cdot M_B + 3.M_C}\right) = 1$$

Elastic Critical Lateral-Torsional Buckling Stress per Eq. F2.1.1-1 for Singly Symmetry:

$$F_e := \frac{C_b \cdot r_o \cdot A_e}{S_x} \cdot \sqrt{\sigma_{ey} \cdot \sigma_t} = 121 \cdot ksi$$

LTB Design Stress: Eq. F2.1-3,4,5:

$$F_c := \begin{cases} F_y & \text{if } F_e \geq 2.78 \cdot F_y \\ \frac{10}{9} \cdot F_y \cdot \left(1 - \frac{10 \cdot F_y}{36 \cdot F_e}\right) & \text{if } 2.78 \cdot F_y > F_e > 0.56 \cdot F_y \\ F_e & \text{if } 0.56 \cdot F_y \geq F_e \end{cases} = 49 \cdot ksi$$

Moment Capacity Eq. F2.1-1:

$$\phi M_{nx} := 0.9 \cdot S_x \cdot \min\left(F_c, F_y\right) = 82 \cdot kip \cdot in$$

D/C Ratio of Bending:

$$DCR := \frac{M_{cx}}{\phi M_{nx}} = 0.066$$

$Iso_{Bending}$ = "OK"

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Check Curb Bending of Long Side (Weak axis)

Center-to-Center Spacing of Braces

$$L_{brace} := \frac{L_{curb}}{N_{iso.long} - 1} = 16 \cdot in$$

Note for weak-axis bracing length:
Max weak-axis span length of Iso Rail is larger than L_{brace} per cut sheet. However, the Iso Rail is braced with clip at max 24" O.C. at top and isolator at max 36" O.C. at bottom such that the actual unbraced length is as follows.

Distributed Load

$$\omega_{iso} := \frac{\max\left(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit}\right)}{L_{curb}} = 1.143\ klf$$

Moment Demand on Iso Rail

$$M_{cy} := \frac{\omega_{iso} \cdot L_{brace}^{2}}{8} = 3.114 \cdot kip \cdot in$$

Member per CFS:

$$CFS_{member} = \text{"10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"}$$

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. F2.1.1-4,5)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(1.0 \cdot L_{brace}\right)^2}\right] = 96 \cdot ksi$$

$$\sigma_{ex} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{brace}}{r_x}\right)^2} = 6900 \cdot ksi \qquad \frac{1.0 \cdot L_{brace}}{r_x} = 6$$

$$KL_r = \text{"KL/r < 200, OK"}$$

Cb per Eq. F2.1.1-2

$$M_A := \frac{\omega_{iso} \cdot \frac{L_{brace}}{4}}{2} \cdot \left(L_{brace} - \frac{L_{brace}}{4}\right) = 2.34 \cdot kip \cdot in$$

$$M_B := M_{cy} = 3.11 \cdot kip \cdot in$$

$$M_C := \frac{\omega_{iso} \cdot \frac{3 \cdot L_{brace}}{4}}{2} \cdot \left(L_{brace} - \frac{3 \cdot L_{brace}}{4}\right) = 2.34 \cdot kip \cdot in$$

$$C_b := \min\left(1.0, \frac{12.5 \cdot M_{cx}}{2.5 \cdot M_{cx} + 3 \cdot M_A + 4 \cdot M_B + 3 \cdot M_C}\right) = 1$$

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Elastic Critical Lateral-Torsional Buckling Stress per Eq. F2.1.1-1 for Singly Symmetry:

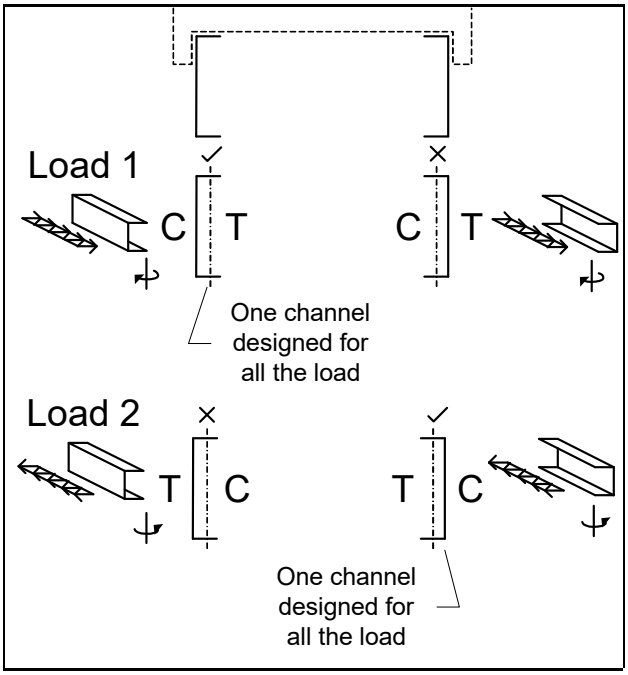
$$F_e := \frac{C_b \cdot r_o \cdot A_e}{S_y} \cdot \sqrt{\sigma_{ey} \cdot \sigma_t} = 613 \cdot ksi$$

LTB Design Stress: Eq. F2.1-3,4,5:

$$2.78 \cdot F_y = 139 \cdot ksi$$

$$0.56 \cdot F_y = 28 \cdot ksi$$

$$F_c := \begin{cases} F_y & \text{if } F_e \geq 2.78 \cdot F_y \\ \frac{10}{9} \cdot F_y \cdot \left(1 - \frac{10 \cdot F_y}{36 \cdot F_e}\right) & \text{if } 2.78 \cdot F_y > F_e > 0.56 \cdot F_y \\ F_e & \text{if } 0.56 \cdot F_y \geq F_e \end{cases} = 50 \cdot ksi$$



Note:

For ISO rail weak-axis bending capacity, rails are oriented and designed so that the stiffer side of ISO rail can take the entire bending load by itself without putting a lot of bending load to the iso rail on the other side

Moment Capacity Eq. F2.1-1:

$$\phi M_{ny} := 0.9 \cdot S_y \cdot \min\left(F_c, F_y\right) = 16.5105 \cdot kip \cdot in$$

D/C Ratio of Bending:

$$DCR := \frac{M_{cy}}{\phi M_{ny}} = 0.189$$

$$Iso_{Bending} := \text{if}\left(M_{cy} < \phi M_{ny}, \text{"OK"}, \text{"NG"}\right)$$

$Iso_{Bending} = \text{"OK"}$

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Web Crippling of ISO Rail (AISI S100-16 G.5)

Governing Compression:

$$P_{web.crip} := \frac{\omega_{x.L.vert} \cdot L_{iso}}{2} = 1332 \cdot lbs$$

Yield Strength:

$$F_y := 50ksi$$

Bearing Length:

$N := 2in$ **2 in. for CQAs**

Thickness of Curb:

$t_{Curb.iso} = \text{"10GA"}$ $t := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Inside Bend Radius:

$R := R_{iso} = 0.186 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web:

$h = 6.85 \cdot in$

Angle btween plane of web and bearing surface:

$\theta := 90deg$

Web Crippling Limit Check (AISI Table G5-2):

$\frac{R}{t} = 1$ $\frac{h}{t} = 50$ $\frac{N}{t} = 14$ $\frac{N}{h} = 0.29$

$$LimitCheck_{webcrippling} := if\left[\left(\frac{h}{t} < 200\right) \wedge \left(\frac{N}{t} < 210\right) \wedge \left(\frac{N}{h} < 2\right) \wedge \left(\frac{R}{t} < 2\right), \text{"OK"}, \text{"NG, Need Reinf"}\right]$$

$LimitCheck_{webcrippling} = \text{"OK"}$

End Case Coefficient Single Web Channel (AISI Table G5-2):

$C := 2$ $C_R := 0.11$ $C_N := 0.37$ $C_h := 0.01$

Reduction Factor Web Crippling Strength:

$\phi_{web.end} := 0.75$

$\phi_{web.int} := 0.8$

(For Unfastened Flanges with Two-Flange Loading or Reaction. Worst Case)

Design Web Crippling Strength:

$$P_{n.end} := C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 3729 \cdot lbs$$

$$\phi P_{n.end} := \phi_{web.end} \cdot P_{n.end} = 2796 \cdot lbs$$

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Interior Case Coefficient Single Web Channel (AISI Table G5-2):

$C := 13$ $C_R := 0.47$ $C_N := 0.25$ $C_h := 0.04$

Design Web Crippling Strength:

$$P_{n.interior} := C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 7905 \cdot lbs$$

$$\phi P_{n.interior} := \left(\phi_{web.int}\right) \cdot P_{n.interior} = 6324 \cdot lbs$$

Design Strength:

$$P_{n.web.crip} := \min\left(P_{n.end}, P_{n.interior}\right) = 3729 \cdot lbs$$

$$\phi P_{n.web.crip} := \min\left(\phi P_{n.end}, \phi P_{n.interior}\right) = 2796 \cdot lbs$$

D/C Ratio of Shear:

$$DCR := \frac{P_{web.crip}}{\phi P_{n.web.crip}} = 0.476$$

Demand/Capacity Ratio:

$$Web_{crippling} := \text{if}\left[\left(P_{web.crip} < \phi P_{n.web.crip}\right) \wedge \left(\phi P_{n.end} > 0\right) \wedge \frac{h}{t} < 200, \text{"OK"}, \text{"NG, Need Reinf"}\right]$$

$Web_{crippling} = \text{"OK"}$

D/C Ratio of Interaction:
AISI Eq. H3-1b

$$DCR_{int.web} := \frac{0.91 \cdot \left(\frac{P_{web.crip}}{P_{n.web.crip}}\right) + \frac{M_{cx}}{\left(\frac{\phi M_{nx}}{0.9}\right)}}{1.33 \cdot 0.9} = 0.321$$

$Iso_{Shear} = \text{"OK"}$

$Iso_{Interaction} = \text{"OK"}$

Per AISI S100-16 H3,
Only x-axis needs to check for interaction

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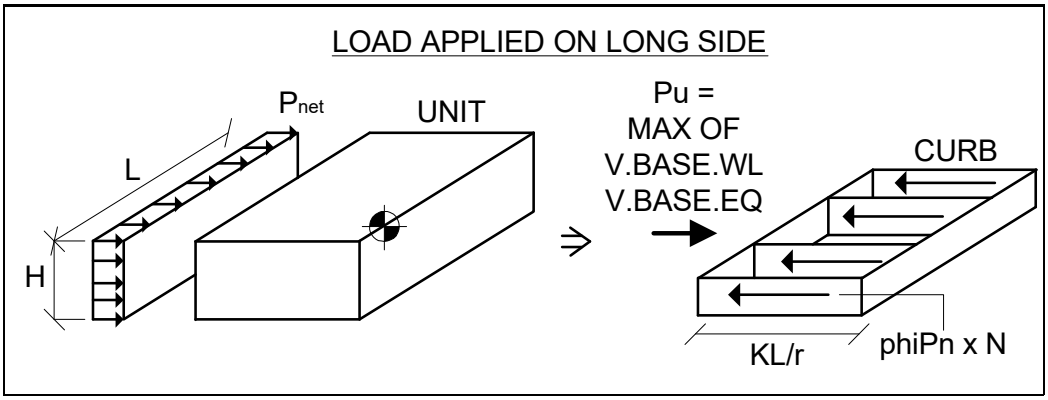
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Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI S100-16 E2)

Curb Axial Load Check due to Load on Long Side



Wind Base Shear of Unit on Long Side: $V_{base.W.L} := P_{net} \cdot L_{unit} \cdot H_{unit} = 8.1\,kip$

Seismic Base Shear of Unit on Long Side: $V_{base.S.L} := F_p \cdot Wt_{unit} = 10.8\,kip$

Max Axial: $P_u := \max\left(V_{base.S.L}, V_{base.W.L}\right) = 10783.46 \cdot lbs$

Member per CFS: $CFS_{member} =$ "10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"

Number of Curb in Length: $n_{iso} := 3$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{iso}} = 3.59\,kip$

Max Braced Length of Member: $L_{member} := W_{curb} = 77 \cdot in$

Effective Length factor: $K := 0.5$

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For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. E2.2-5, E2.2-6)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(K \cdot L_{member}\right)^2}\right] = 24 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2} = 10 \cdot ksi$$

$$\frac{K \cdot L_{member}}{r_{min}} = 168$$

KL_r = "KL/r < 200, OK"

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 7 \cdot ksi$$

Nominal Compressive Stress Capacity (Eq E2-4):

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 2.635$$

$$F_n := \begin{cases} 0.658^{\lambda_c^{\,2}} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^{\,2}}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 6.32 \cdot ksi$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot A_e \cdot F_n = 6.41\,kip$$

D/C Ratio of Compression:

$$DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.561$$

$$Axial_{reinf} := \text{if}\left(P_{u.EAmember} < \phi P_{n.member}, \text{"OK"}, \text{"NG"}\right)$$

$Axial_{reinf}$ = "OK"

Note:
No need to check for interaction since equipment is not attached to the short side

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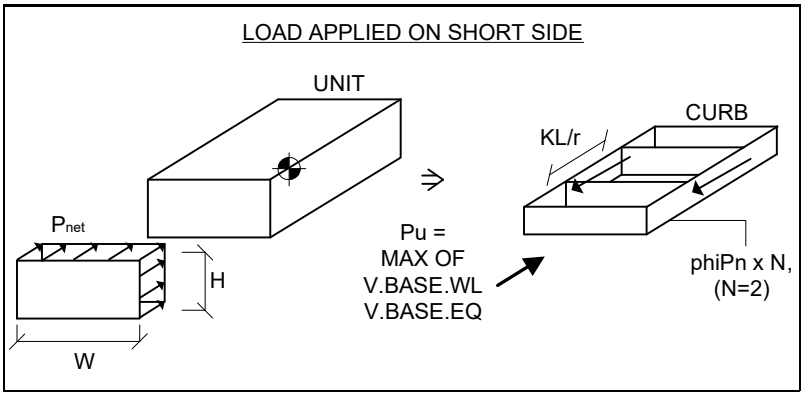
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Curb Axial Load Check due to Load on Short Side



Wind Base Shear on Short Side: $V_{base.W.H} := P_{net} \cdot W_{unit} \cdot H_{unit} = 5.6\,kip$

Seismic Base Shear of Unit on Short Side: $V_{base.S.W} := F_p \cdot Wt_{unit} = 10.8\,kip$

Max Axial: $P_u := \max\left(V_{base.S.W}, V_{base.W.H}\right) = 10783.46 \cdot lbs$

Member per CFS: $CFS_{member} = \text{"10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"}$

Number of Curb in Length: $n_{curb} := 2$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{curb}} = 5.39\,kip$

Max Braced Length of Member: $L_{member} := \frac{L_{curb}}{n_{iso} - 1} = 57 \cdot in$

Effective Length factor: $K := 0.5$

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. E2.2-5, E2.2-6)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(K \cdot L_{member}\right)^2}\right] = 37 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2} = 19 \cdot ksi \qquad \frac{K \cdot L_{member}}{r_{min}} = 124$$

$KL_r = \text{"KL/r < 200, OK"}$

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 13 \cdot ksi$$

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Nominal Compressive Stress Capacity (Eq E2-4):

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 1.993$$

$$F_n := \begin{cases} 0.658^{\lambda_c^2} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^2}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 11.04 \cdot \text{ksi}$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot A_e \cdot F_n = 11.2\,\text{kip}$$

D/C Ratio of Compression:

$$DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.481$$

$$Axial_{reinf} := \text{if}\left(P_{u.EAmember} < \phi P_{n.member}, \text{"OK"}, \text{"NG"}\right)$$

$Axial_{reinf} = \text{"OK"}$

Note:
If the load direction is in perpedicular plane to the short side of the equipment, the channels will only experience axial load and no bending will occur at the channel. Therefore, no need to check for interaction since the channels

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Shear of ISO Rail Webs without Holes (AISI S100-16 G2)

Note: The connection holes are not centered at mid-depth of isolated curb rail so AISI G2 shall be used

Deeper Section (h = depth)

Thickness of Curb: $t := \text{thick}(t_{Curb.iso}) = 0.138 \cdot in$

Depth-to-Thickness Ratio: $\frac{h}{t} = 50$

Curb Elastic Modulus: $E := 29500ksi$

Clear distance b/w transverse stiffeners of reinforced web: $a := L_{iso} = 16 \cdot in$

Clear Distance-to-Thickness Ratio: $\frac{a}{h} = 2.36$

Nominal Shear Stress:

$$k_v := \begin{cases} 5.34 \text{ if } a = L_{iso} \\ 4.00 + \frac{5.34}{\left(\frac{a}{h}\right)^2} \text{ if } \left(\frac{a}{h} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \frac{4.00}{\left(\frac{a}{h}\right)^2} \text{ if } \left(\frac{a}{h} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 6.06$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 60 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 90$$

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Curb Shear Check due to Load on Longer Side

Area of Web Element:

$$A_w := h \cdot t = 0.947 \cdot in^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 65.7 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} = 62\,kip \qquad V_y := 0.6 \cdot A_w \cdot F_y = 28\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.676$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 28.404 \cdot kip$$

Number of Members within Length: $n := 1$ **(Per Curb Design)**

Design Shear Capacity:

$$\phi V_{n.h} := 0.95 \cdot n \cdot V_n = 26.98 \cdot kip$$

Design Shear Demand:

$$V_{u.h} := \frac{\omega_{x.L.vert} \cdot L_{iso}}{2} = 1332.2 \cdot lbs$$

D/C Ratio of Shear:

$$DCR := \frac{V_{u.h}}{\phi V_{n.h}} = 0.049$$

Demand/Capacity Ratio:

$Shear_{in.plane} = \text{"OK"}$

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Shallower Section (h.w = Width)

Thickness of Curb: $t := \text{thick}(t_{Curb.iso}) = 0.138 \cdot in$

Depth-to-Thickness Ratio: $\frac{h_w}{t} = 7$

Curb Elastic Modulus: $E := 29500ksi$

Clear distance b/w transverse stiffeners of reinforced web: $a := L_{brace} = 16 \cdot in$

Clear Distance-to-Thickness Ratio: $\frac{a}{h_w} = 16.17$

Nominal Shear Stress:

$$k_v := \begin{cases} 5.34 & \text{if } a = L_{brace} \\ 4.00 + \frac{5.34}{\left(\frac{a}{h_w}\right)^2} & \text{if } \left(\frac{a}{h_w} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \frac{4.00}{\left(\frac{a}{h_w}\right)^2} & \text{if } \left(\frac{a}{h_w} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 5.36$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 56 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 85$$

Curb Shear Check due to Load on Longer Side

Area of Web Element: $A_w := h_w \cdot t = 0.1382 \cdot in^2$

Number of Members within Length: $n := 1$ **(Per Curb Design)**

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 58.1 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} = 8\,kip \qquad V_y := 0.6 \cdot A_w \cdot F_y = 4\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.719$$

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$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 4.146 \cdot \text{kip}$$

Design Shear Capacity:

$$\phi V_{n.hw} := 0.95 \cdot n \cdot V_n = 3.9 \cdot \text{kip}$$

Design Shear Demand:

$$V_{u.hw} := \frac{\left(\frac{\max\left(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit}\right)}{L_{curb}} \right) \cdot L_{brace}}{2} = 770.2 \cdot \text{lbs}$$

D/C Ratio of Shear:

$$DCR := \frac{V_{u.hw}}{\phi V_{n.hw}} = 0.196$$

Demand/Capacity Ratio:

$Shear_{in.plane}$ = "OK"

D/C Ratio of Vx and Mx:

$$DCR_{V.M.int} := \begin{cases} \left(0.6 \cdot \frac{M_{cx}}{\phi M_{nx}} + \frac{V_{u.h}}{\phi V_{n.h}}\right) \cdot \frac{1}{1.3} & \text{if } \frac{M_{cx}}{\phi M_{nx}} > 0.5 \wedge \frac{V_{u.h}}{\phi V_{n.h}} > 0.7 \\ \sqrt{\left(\frac{M_{cx}}{\phi M_{nx}}\right)^2 + \left(\frac{V_{u.h}}{\phi V_{n.h}}\right)^2} & \text{otherwise} \end{cases} = 0.082$$

Demand/Capacity Ratio:

$VandMx_{int}$ = "OK"

D/C Ratio of Vy and My:

$$DCR_{V.M.int} := \begin{cases} \left(0.6 \cdot \frac{M_{cy}}{\phi M_{ny}} + \frac{V_{u.hw}}{\phi V_{n.hw}}\right) \cdot \frac{1}{1.3} & \text{if } \frac{M_{cy}}{\phi M_{ny}} > 0.5 \wedge \frac{V_{u.hw}}{\phi V_{n.hw}} > 0.7 \\ \sqrt{\left(\frac{M_{cy}}{\phi M_{ny}}\right)^2 + \left(\frac{V_{u.hw}}{\phi V_{n.hw}}\right)^2} & \text{otherwise} \end{cases} = 0.272$$

Demand/Capacity Ratio:

$VandMy_{int}$ = "OK"

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Web Crippling/Compression of Non-iso CanFab Curb (AISI S100-16 G5)

Governing Compression for Non-Isolated Curb:

$$P_{web.crip.int} := \max\left[\frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}}, \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}}\right] \cdot L_{spacing.non.iso} = 5064 \cdot lbs$$

$$P_{web.crip.end} := 0.5 \cdot P_{web.crip.int} = 2532 \cdot lbs$$

Yield Strength: $F_y := 50ksi$

Bearing Length: $N_{bearing} := L_{spacing.non.iso} = 31 \cdot in$

Thickness of Curb: $t_{Curb} = \text{"14GA"}$ $t := thick(t_{Curb}) = 0.0785 \cdot in$

Inside Bend Radius: $R := R_{curb} = 0.107 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web: $h := 22in - 2 \cdot (t + R) = 21.63 \cdot in$

Angle btween plane of web and bearing surface: $\theta := 90deg$

Web Crippling Limit Check (AISI Table G5-2): $\frac{R}{t} = 1$ $\frac{h}{t} = 276$ $\frac{N_{bearing}}{t} = 391$ $\frac{N_{bearing}}{h} = 1.42$

End Case Coefficient Single Web Channel (AISI Table G5-2): $C := 13$ $C_R := 0.32$ $C_N := 0.05$ $C_h := 0.04$

Reduction Factor Web Crippling Strength: $\phi_{web.end} := 0.9$ $\phi_{web.int} := 0.8$ **(For Unfastened partially Stiffened Flanges with Two-Flange Loading or Reaction.)**

Design Web Crippling Strength:

$$\phi P_{n.end} := \left(\phi_{web.end}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 1510 \cdot lbs$$

Interior Case Coefficient Single Web Channel (AISI Table G5-2): $C := 24$ $C_R := 0.52$ $C_N := 0.15$ $C_h := 0.001$

Design Web Crippling Strength:

$$\phi P_{n.interior} := \left(\phi_{web.int}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 9076 \cdot lbs$$

D/C Ratio of Shear: $DCR_{end} := \frac{P_{web.crip.end}}{2 \cdot \phi P_{n.end}} = 0.838$ $DCR_{int} := \frac{P_{web.crip.int}}{\phi P_{n.interior}} = 0.558$

Demand/Capacity Ratio: **Note: Factor of 2 for two ends connected together at the end**

$Web_{crippling} = \text{"OK"}$

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Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Length

Roof Curb thickness

$t_{Curb} = \text{"14GA"}$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

Min width of Roof Curb

$b_{curb} := L_{curb} + W_{curb} \cdot 2 = 267.19 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := L_{curb} + \min\left(\frac{W_{curb}}{2} \cdot 2, \frac{L_{curb}}{2}\right) = 170 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{array}{c} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{array} \right] \right] = 12349 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.L.vert.up} \cdot L_{curb}) \cdot (0.75in) = 7774 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.63$

$Curb_{BotFlangeBending} = \text{"OK"}$

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Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Width

Roof Curb thickness

$t_{Curb} = \text{"14GA"}$ $t_{curb} := thick(t_{Curb}) = 0.0785 \cdot in$

Min width of Roof Curb

$b_{curb} := W_{curb} + \frac{L_{curb}}{4} \cdot 2 + 3in \cdot 2 = 139.59 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := W_{curb} + \min\left(\frac{L_{curb}}{6} \cdot 2, W_{curb}\right) = 115 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{matrix} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{matrix} \right] \right] = 6452 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.W.vert.up} \cdot W_{curb}) \cdot (0.75in) = 4450 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.69$

$Curb_{BotFlangeBending} = \text{"OK"}$

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Web Crippling/Compression of Iso CanFab Curb (AISI S100-16 G5)

Note: Curb stiffeners directly transfer the compressive load from isolator to the base. Therefore, curb web crippling is prevented.

Curb Web with Reinforcement

Max Compression: $Comp_{maxtot} := \max(|C_S|, |C_W|) = 23462.12 \cdot lbs$

Reinforcement per CFS: $CFS_{reinf} :=$ "Single Stiffener 10GA 1"x7"x1" Fy=50ksi 18" Tall on min. 16GA "

Note: min. of 10 GA channel and min. 16 GA curb web

Number of Reinforcement in Length: $n_{reinf} := N_{iso.long} = 8$

Max Compression per Reinf: $Comp_{per.reinf} := \frac{Comp_{maxtot}}{n_{reinf}} = 2.933\ kip$

Spacing: $Spacing := \frac{L_{curb}}{n_{reinf}} = 14 \cdot in$ $KL_r := \frac{1.0 \cdot (H_{curb} - 12.5in)}{0.2339in} = 94$

Factored Nominal Comp. Capacity per reinforcement: $\phi P_{n.reinf} = 21.066 \cdot kip$ **(See attached CFS)**

Total Factored nominal Comp Capacity: $\phi P_{n.tot} := n_{reinf} \cdot \phi P_{n.reinf} = 169 \cdot kip$

D/C Ratio of Compression: $DCR := \frac{Comp_{maxtot}}{\phi P_{n.tot}} = 0.14$

$Comp_{reinf} := if(Comp_{maxtot} < \phi P_{n.tot}, "OK", "NG")$ $Comp_{reinf} = "OK"$

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Check CanFab Curb for Compressive Force due to T/C Coupling of Overturning

Note:
-Since the equipment is only attached to the longer sides of the CanFab Curb, most likely there will be compressive force onto the curb due to T/C coupling.
- Rectangular CanFab Curb will be considered as "Channel" to resist the compressive force.

Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Flanges*

Flat Width:

$$w := \frac{W_{curb}}{2} - R_{curb} = 38.393 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Unstiffened"}$$

Stress at the end of the Width:

$$f_2 := 50ksi \qquad f_1 := 50ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \left| \frac{f_2}{f_1} \right| = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 0.43$$

Critical Compressive Stress (Eq 1.1-4):

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w}\right)^2 = 0.05 \cdot ksi$$

Stress in Compression Element:

$$f := F_y = 50 \cdot ksi \qquad \textbf{(Assume f = Fy)}$$

Slenderness Factor (Eq 1.1-3):

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 32.3$$

Local reduction factor (Eq 1.1-2):

$$\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 0.031$$

Effective Width of the Flanges:

$$b_{eff.flange} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 1.181 \cdot in$$

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Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Web*

Flat Width:

$$w := L_{curb} - R_{curb} \cdot 2 = 112.974 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Stiffened"}$$

Stress at the end of the Width:

$$f_2 := 50ksi \qquad f_1 := 50ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \left| \frac{f_2}{f_1} \right| = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 4$$

Critical Compressive Stress (Eq 1.1-4):

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w} \right)^2 = 0.05 \cdot ksi$$

Stress in Compression Element:

$$f := F_y = 50 \cdot ksi \qquad \textbf{(Assume f = Fy)}$$

Slenderness Factor (Eq 1.1-3):

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 31.16$$

Local reduction factor (Eq 1.1-2):

$$\rho := \left(1 - \frac{0.22}{\lambda}\right) \frac{1}{\lambda} = 0.032$$

Effective Width of the Web:

$$b_{eff.web} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 3.6 \cdot in$$

Effective Area of the Member:

$$A_e := 2 \cdot \left(b_{eff.flange} \cdot t_{curb} \right) + b_{eff.web} \cdot t_{curb} = 0.468 \cdot in^2$$

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Length of the Compressive Member: $L_{curb.web} := h = 21.629 \cdot in$

Young's Modulus for Cold Form Steel: $E := 29500ksi$

Curb Shear Modulus: $G := 11300ksi$

Poisson's Ratio $\mu := 0.3$

Section Properties of the Member (From Section Properties Calculator):

$A_{half.curb} := 13.599in^2$ $r_o := 50.187in$ $I_x := 26250.724in^4$ $I_y := 1949.977in^4$

$J := 0.023in^4$ $r_x := \sqrt{\frac{I_x}{A_{half.curb}}} = 43.936 \cdot in$ $r_y := \sqrt{\frac{I_y}{A_{half.curb}}} = 11.975 \cdot in$

$C_w := 4.431 \cdot 10^6 \cdot in^6$ $r_{min} := \min(r_x, r_y) = 11.975 \cdot in$

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^2}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{(1.0 \cdot L_{curb.web})^2}\right] = 2339737.294 \cdot ksi$$

$$\sigma_{e.y} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_y}\right)^2} = 89240.781 \cdot ksi \qquad \sigma_{e.x} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_x}\right)^2} = 1201365.512 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2} = 89240.781 \cdot ksi$$

$$\frac{1.0 \cdot L_{curb.web}}{r_{min}} = 1.81$$

$KL_r = \text{"KL/r < 200, OK"}$

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 85962.07 \cdot ksi$$

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Nominal Compressive Stress Capacity: (Eq E2-4)

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 0.024$$

$$F_n := \begin{cases} 0.658^{\lambda_c^2} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^2}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 49.99 \cdot \text{ksi}$$

Compressive Capacity:

$$P_{n.member} := A_e \cdot F_n = 23.39 \cdot \text{kip}$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot P_{n.member} = 19.88 \cdot \text{kip}$$

Factored Max Compressive Force:

$$P_{comp.max} := \max\left(\left|C_S\right|, \left|C_W\right|\right) = 23.462\ \text{kip}$$

D/C Ratio of Compression:

$$DCR := \frac{P_{comp.max}}{\phi P_{n.member}} = 1.18$$

$$Axial_{curb.comp} := \text{if}\left(P_{comp.max} < \phi P_{n.member}, \text{"OK"}, \text{"Provide Channel from above as Web Stiffener"}\right)$$

$Axial_{curb.comp}$ = "Provide Channel from above as Web Stiffener"

Note: No need to check for interaction since the curb is only subjected to the compressive force.

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Shear of CanFab Curb Webs without Holes (AISI S100-16 G2)

Note: Since the unit is stiffer than the curb and the curb is firmly attached to the unit and to the base structure, curbs will mainly take the lateral forces as shear and axial load rather than bending.

Thickness of Curb:

$$t := \text{thick}(t_{Curb}) = 0.079 \cdot \text{in}$$

Depth-to-Thickness Ratio:

$$\frac{h}{t} = 276$$

Curb Elastic Modulus:

$$E := 29500\text{ksi}$$

Clear distance b/w transverse stiffeners of reinforced web:

$$a := \max\left(\frac{L_{curb}}{2}, W_{curb}\right) = 77 \cdot \text{in} \qquad \frac{a}{h} = 3.56$$

$$k_v := \begin{cases} 5.34 & \text{if } a = L_{curb} \\ 4.00 + \dfrac{5.34}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \dfrac{4.00}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 5.66$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 58 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 87$$

Curb Shear Check due to Load on Longer Side

Area of Web Element:

$$A_w := W_{curb} \cdot t = 6 \cdot \text{in}^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 2 \cdot \text{ksi}$$

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$V_{cr} := A_w \cdot F_{cr} = 12\,kip$ $V_y := 0.6 \cdot A_w \cdot F_y = 181\,kip$ $\lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 3.886$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 12.006 \cdot kip$$

Number of Members within Length: $n := 2$ **(Per Curb Design)**

Design Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 22811.4 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.H} := P_{net} \cdot L_{unit} \cdot H_{total} = 12315.2 \cdot lbs$

Design Shear Demand: $V_u := \max(V_{base.S}, V_{base.W.H}) = 14857.1 \cdot lbs$

D/C Ratio of Shear: $DCR := \frac{V_u}{\phi V_n} = 0.651$

Demand/Capacity Ratio:

$Shear_{in.plane} := \text{if}(V_u < \phi V_n, \text{"OK"}, \text{"NG"})$

$Shear_{in.plane} = \text{"OK"}$

Curb Shear Check due to Load on Shorter Side

Area of Web Element: $A_w := L_{curb} \cdot t = 9 \cdot in^2$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot (1 - \mu^2) \cdot \left(\frac{h}{t}\right)^2} = 2 \cdot ksi$$

$V_{cr} := A_w \cdot F_{cr} = 18\,kip$ $V_y := 0.6 \cdot A_w \cdot F_y = 267\,kip$ $\lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 3.886$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 17.648 \cdot kip$$

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Number of Members within Length: $n := 2$ **(Per Curb Design)**

Factored Nominal Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 33532.1 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot W_{unit} \cdot H_{total} = 8476.6 \cdot lbs$

Factored Shear Demand: $V_u := \max(V_{base.S}, V_{base.W.L}) = 14857.1 \cdot lbs$

D/C Ratio of Shear: $DCR := \frac{V_u}{\phi V_n} = 0.443$

Demand/Capacity Ratio:

$Shear_{in.plane} := \text{if}(V_u < \phi V_n, \text{"OK"}, \text{"NG"})$

$Shear_{in.plane} = \text{"OK"}$

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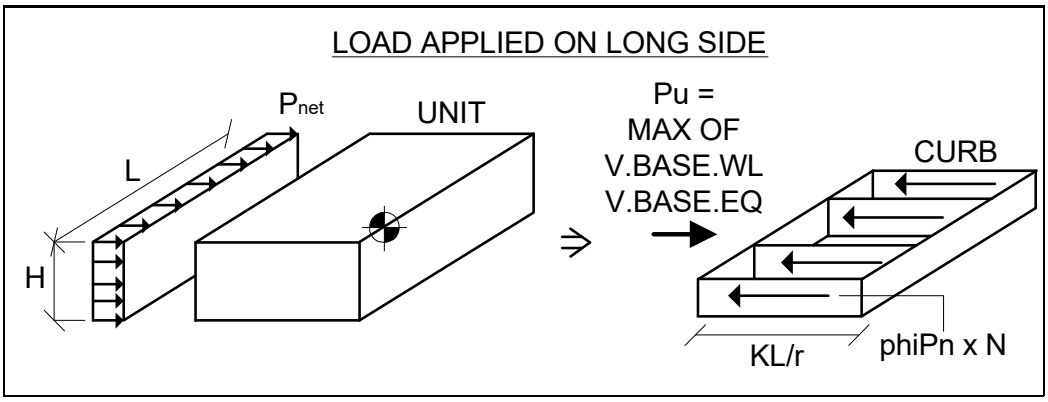
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Check CanFab Curb for In-Plane Axial due to EQ and Wind (AISI S100-16 E2)

Curb Axial Load Check due to Load on Long Side



Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot L_{unit} \cdot H_{total} = 12.3\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.L}) = 14857.09 \cdot lbs$

Member per CFS: $CFS_{member} :=$ "14GA Custom Curb 22" Tall L.b = 63in"

Max Braced Length of Member: $L_{member} := 48in$ **Conservative since the max anchor spacing is 24"**

Number of Curb in Length: $n_{curb.long} := 3$

Radius of gyration in y-axis: $r_{y.curb} := 0.630in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{2} = 7.43\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 76$ $KL_r =$ "KL/r < 200, OK"

Spacing: $Spacing := \frac{L_{curb}}{n_{curb.long}} = 38 \cdot in$

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 9.556 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.777$

$Axial_{short.curb} =$ "OK"

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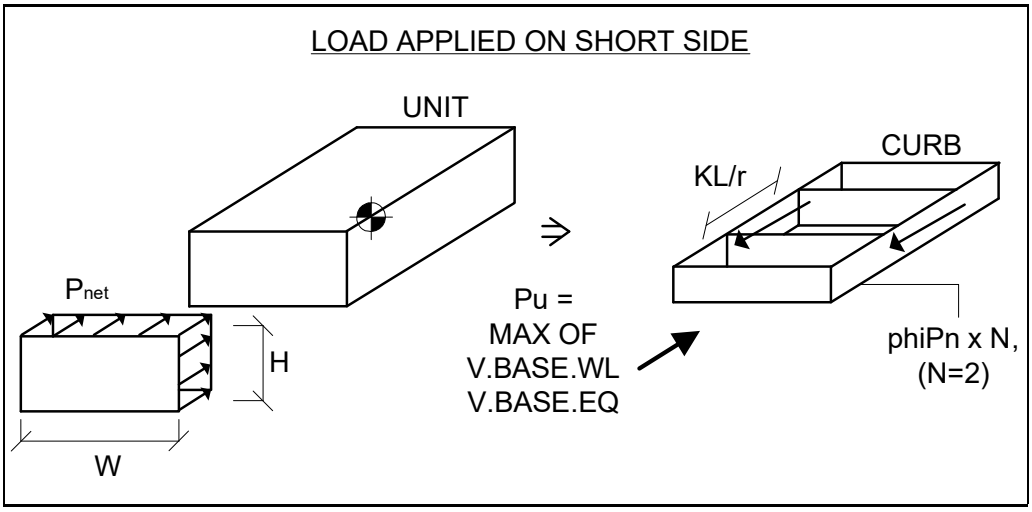
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Curb Axial Load Check due to Load on Short Side



Wind Base Shear on Short Side: $V_{base.W.H} := P_{net} \cdot W_{unit} \cdot H_{total} = 8.5\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.H}) = 14857.09 \cdot lbs$

Member per CFS: CFS_{member} = "14GA Custom Curb 22" Tall L.b = 63in"

Max Braced Length of Member: $L_{member} := \frac{L_{curb}}{n_{curb.long} - 1} = 57 \cdot in$

Number of Curb in Length: $n_{curb} := 2$

Radius of gyration in y-axis: $r_{y.curb} := 0.630\,in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{curb}} = 7.43\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 90$ KL_r = "KL/r < 200, OK"

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 9.556 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.777$

$Axial_{long.curb}$ = "OK"

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DESIGN
for
MAX CURB HEIGHT OF 30"

950 S. GRAND AVENUE, 4TH FLOOR, LOS ANGELES, CALIFORNIA 90015 (213) 483-6490

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Design Wind Loads for Rooftop Equipment (ASCE 7-16 § Table 29.1-1)

$z := 60ft$ **Height above ground level**

$B := 60ft$ **Horizontal dimension of building measured normal to wind direction**

$Exp_{category} := "C"$ **Exposure Category per ASCE 7-16 § 26.7**

$Risk_{category} := "IV"$ **Risk Category per ASCE 7-16 Table 1.5-1**

$$V := \begin{cases} 0mph & \text{if } Risk_{category} = "I" \\ 0mph & \text{if } Risk_{category} = "II" \\ 175mph & \text{otherwise} \end{cases} = 175 \cdot mph$$

Basic Wind Speed per ASCE 7-16 Figure 26.5-1 A,B or C

$K_z = 1.14$ **Velocity Pressure Exposure Coefficient per ASCE 7-16 Table 29.10-1 [Exposure Category "C"]**

$K_{zt} := 1.0$ **Topographic Factor per ASCE 7-16 § 26.8, Figure 26.8-1**

$K_e := 1.0$ **Ground Elevation Factor per ASCE 7-16 § 26.9, Table 26.9-1**

$K_d := 0.85$ **Wind Directionality Factor per ASCE 7-16 § 26.6, Table 26.6-1 (Equipment)**

$q_z := 0.00256 K_z \cdot K_{zt} \cdot K_d \cdot K_e \cdot V^2 = 75.74 \cdot psf$ **Velocity pressure evaluated at height z above ground per ASCE 7-10 § 26.10.2; Eq. 26.10-1**

$GC_{r.lateral.max} := 1.9$ **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.9 for rooftop structures and equipment with Af less than (0.1Bh). (GCr) shall be permitted to be reduced linearly from 1.9 to 1.0 as the value of Af is increased from (0.1Bh) to (Bh)

$GC_{r.vertical.max} := 1.5$ **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.5 for rooftop structures and equipment with A_r less than (0.1*BL*). (GC_r) shall be permitted to be reduced linearly from 1.5 to 1.0 as the value of A_r is increased from (0.1*BL*) to (*BL*)

$P_{net} := q_z \cdot GC_{r.lateral.max} = 143.91 \cdot psf$ **Design Lateral Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-2**

$P_v := q_z \cdot GC_{r.vertical.max} = 113.61 \cdot psf$ **Design Vertical Uplift Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-3**

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Seismic Demands on Nonstructural Components (ASCE 7-16 § 13.3 & 13.6):

$S_{DS} := 1.5$ **Design spectral response acceleration parameter at short periods per USGS map**

$I_p := 1.5$ **Component importance factor ASCE 7-16 § 13.1.3**

$\Omega_0 := 2.0$ **Overstrength factor ASCE 7-16 Table 13.6.1**

Vibr_Isolation = "Yes" **Placement of Unit Vibration Isolated:**

Note: Only "F_p" at seismic concrete anchor has been increased with overstrength factor "Ω_0"

$a_p := 2.5$ $R_p = 2.0$ **Seismic coefficients a_p & R_p**
Per ASCE 7-16 Table 13.6-1 for
Mechanical & Electrical Components

$z = 60\,ft$ **Height in structure of point of attachment of component with respect to the base**

$h := 60ft$ **Average roof height of structure with respect to the base**
Where for roof top equipment:

$z \div h = 1$

F_p: Horizontal Seismic Design Force per *ASCE7-16 § 13.3.1*

F_p shall be takes as $\left(\frac{0.4 \cdot a_p \cdot S_{DS} \cdot I_p}{R_p}\right) \cdot \left(1 + 2 \cdot \frac{z}{h}\right) \cdot W_p = 337.5 \cdot \% \cdot W_p$

F_p is not required to be taken as greater than $\left(1.6 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 360 \cdot \% \cdot W_p$

F_p shall not be taken as less than $\left(0.3 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 67.5 \cdot \% \cdot W_p$

Governing F_p : Horizontal Seismic Design Force $F_p = 337.5 \cdot \% \cdot W_p$

F_v: Vertical Load per ASCE7-16 § 13.3.1.2

Concurrent Vertical Seismic Force: $F_v := 0.2 \cdot S_{DS} \cdot W_p = 30 \cdot \% \cdot W_p$

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Flat Roof Snow Loads (ASCE 7-16 § 7.3):

$Terrain_{CAT} := "C"$ **Terrain Category ASCE 7-16 § 26.7 & Table 7.3-1**

$Exp_{Roof} := "Partially\ Exposed"$ **Exposure of Roof ASCE 7-16 Table 7.3-1**

$C_e = 1$ **Exposure Factor ASCE 7-16 Table 7.3-1**

$Thermal_{condition} := "All\ structures\ except\ below"$ **Thermal Condition ASCE 7-16 Table 7.3-2**

$C_t = 1$ **Thermal Factor ASCE 7-16 Table 7.3-2**

$Risk_{category} = "IV"$ **Risk Category per ASCE 7-16 Table 1.5-1**

$I_s = 1.2$ **Snow Importance Factor ASCE 7-16 Table 1.5-2**

$p_g := 40psf$ **Ground Snow Loads ASCE 7-16 Figure 7.2-1**

$$p_f := \max\left(0.7 \cdot C_e \cdot C_t \cdot I_s \cdot p_g, \text{if}\left(p_g > 20psf, 20psf \cdot I_s, I_s \cdot p_g\right)\right) = 34 \cdot psf$$

Flat Roof Snow Loads ASCE 7-16 Equation 7.3-1 and § 7.3.4

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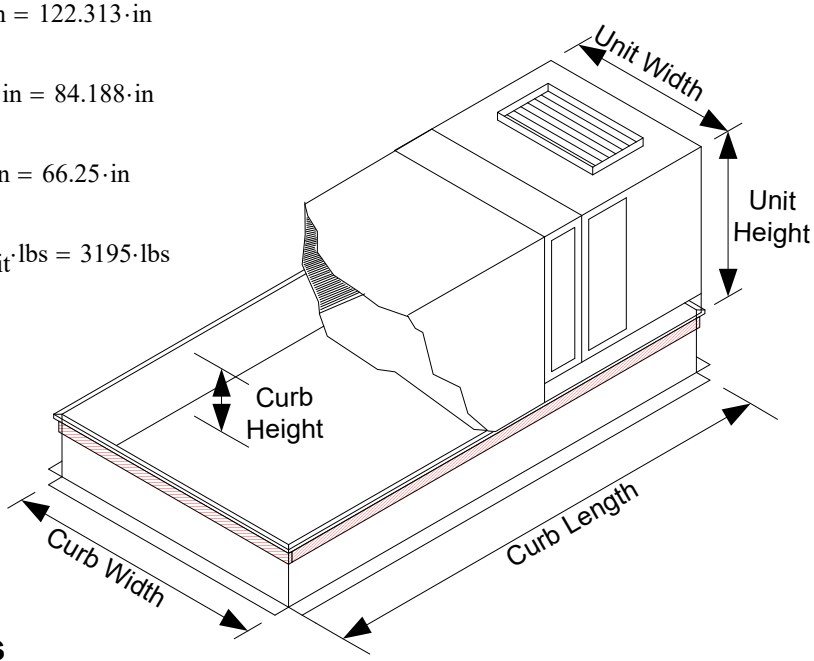
Mechanical Unit Dimensions Curb = "C-6010"

Length of Unit $L_{unit} := L_{unit} \cdot in = 122.313 \cdot in$

Width of Unit $W_{unit} := W_{unit} \cdot in = 84.188 \cdot in$

Height of Unit $H_{unit} := H_{unit} \cdot in = 66.25 \cdot in$

Weight of Unit $Wt_{unit} := Wt_{unit} \cdot lbs = 3195 \cdot lbs$



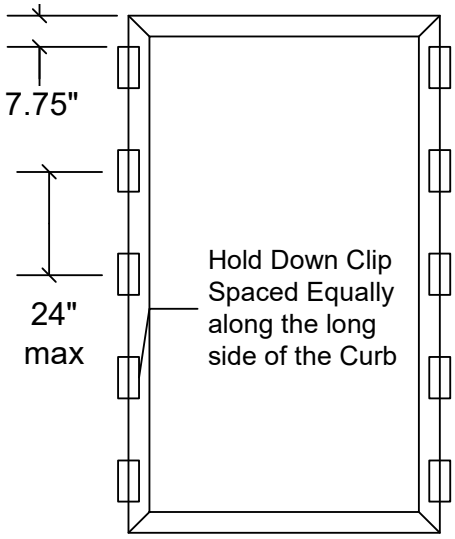
Roof Curb Dimensions

Length of Curb $L_{curb} := L_{curb} \cdot in = 113.188 \cdot in$

Width of Curb $W_{curb} := W_{curb} \cdot in = 77 \cdot in$

Height of Curb $H_{curb} := H_{curb} \cdot in = 42.5 \cdot in$

Weight of Curb $Wt_{curb} := Wt_{curb} \cdot lbs = 1239 \cdot lbs$



Curb Plan

Overall System Dimensions

Total Weight

$Wt_{tot} := Wt_{unit} + Wt_{curb} = 4402 \cdot lbs$

Total height

$H_{total} := H_{unit} + H_{curb} = 108.75 \cdot in$

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Seismic Loading + Snow Loading

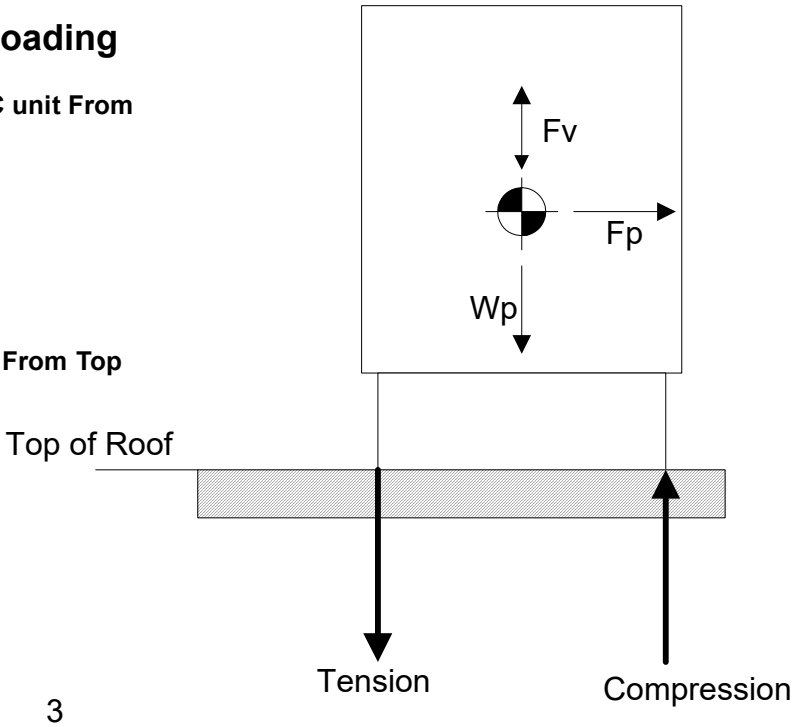
Height for Center of Gravity for HVAC unit From Top of Roof

$h_{CG.unit} := \frac{1}{2} H_{unit} = 33 \cdot in$

$h_{CG} := H_{curb} + h_{CG.unit} = 75.63 \cdot in$

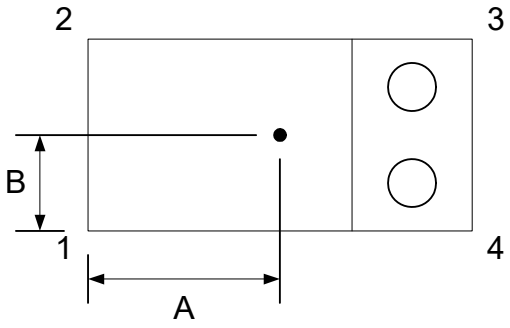
Height for Center of Gravity for Curb From Top of Roof

$h_{CG.curb} := \frac{H_{curb}}{2} = 21.25 \cdot in$



Max Seismic Base Shear

$V_{base.S} := F_p \cdot Wt_{tot} = 14857 \cdot lbs$



Unit C.G. distance in axis parallel to Curb Width $B_{ecc.width} := CG_{short} \cdot in = 36 \cdot in$

Eccentricity in axis parallel to Curb Width

$$e_{width} := \begin{cases} 0in & \text{if } B_{ecc.width} = \text{"N/A"} \\ \left| B_{ecc.width} - \frac{W_{unit}}{2} \right| & \text{otherwise} \end{cases} = 6.09 \cdot in$$

Unit C.G. distance in axis parallel to Curb Length $A_{ecc.length} := CG_{long} \cdot in = 58 \cdot in$

Eccentricity in axis parallel to Curb Length

$$e_{length} := \begin{cases} 0in & \text{if } A_{ecc.length} = \text{"N/A"} \\ \left| A_{ecc.length} - \frac{L_{unit}}{2} \right| & \text{otherwise} \end{cases} = 3.16 \cdot in$$

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Max Net Tension Reaction On Each Side Due To Seismic Loads

$$T_S := \begin{bmatrix} \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{W_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{W_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} \right] \\ \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{L_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{L_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} \right] \end{bmatrix} = \begin{pmatrix} -10546 \\ -6702 \end{pmatrix}\cdot lbs$$

Max Net Compression Reaction On Each Side Due To Seismic Loads

$$C_S := \begin{bmatrix} \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{W_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \\ \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{L_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \end{bmatrix} = \begin{pmatrix} 20195 \\ 15284 \end{pmatrix}\cdot lbs$$

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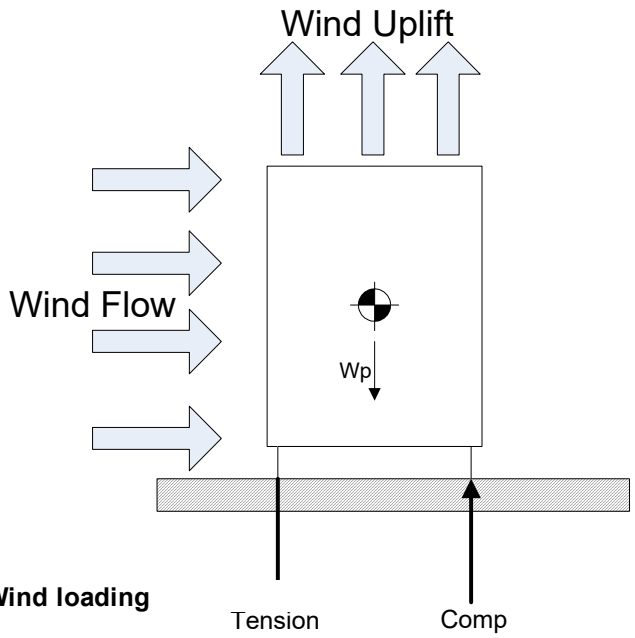
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Wind Loading + Snow Loading



Max Base Shear due to wind loading

$V_{base.W} := P_{net} \cdot L_{unit} \cdot H_{total} = 13293 \cdot lbs$

Max Uplift due to wind loading

$L_{unit.up} := L_{unit} - 0in = 122.313 \cdot in$

$P_{uplift.W} := P_v \cdot L_{unit.up} \cdot W_{unit} = 8124 \cdot lbs$

Max Net Tension Reaction On Each Side Due To Wind loading

$$T_W := \begin{pmatrix} \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} - \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \\ \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} - \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} -11696 \\ -6557 \end{pmatrix} \cdot lbs$$

Max Net Compression Reaction On Each Side Due To Wind loading

$$C_W := \begin{pmatrix} \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} + \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \\ \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} + \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} 14254 \\ 9066 \end{pmatrix} \cdot lbs$$

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Governing Loading @ Curb

Max uplift vertical load along the length of the curb

$$\omega_{x.L.vert.up} := \frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}} = 1240 \cdot plf$$

Max compressive vertical load along the length of the curb

$$\omega_{x.L.vert.comp} := \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}} = 2141 \cdot plf$$

Max vertical load along the length of the curb

$$\omega_{x.L.vert} := \max\left(\omega_{x.L.vert.up}, \omega_{x.L.vert.comp}\right) = 2141 \cdot plf$$

Max uplift vertical load along the width of the curb

$$\omega_{x.W.vert.up} := \frac{\max\left[\left|T_{S_{(1)}}\right|, \left|T_{W_{(1)}}\right|\right]}{W_{curb}} = 1045 \cdot plf$$

Max compressive vertical load along the width of the curb

$$\omega_{x.W.vert.comp} := \frac{\max\left[\left|C_{S_{(1)}}\right|, \left|C_{W_{(1)}}\right|\right]}{W_{curb}} = 2382 \cdot plf$$

Max vertical loading along the width of the curb

$$\omega_{x.W.vert} := \max\left(\omega_{x.W.vert.up}, \omega_{x.W.vert.comp}\right) = 2382 \cdot plf$$

$$\begin{pmatrix} V_{base.S} \\ V_{base.W} \end{pmatrix} = \begin{pmatrix} 14857 \\ 13293 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} \left|T_S\right| \\ \left|C_S\right| \end{pmatrix} = \begin{pmatrix} 12496 \\ 25326 \end{pmatrix} \cdot lbs$$

$$\begin{pmatrix} F_v \cdot Wt_{tot} \\ P_v \cdot L_{unit} \cdot W_{unit} \end{pmatrix} = \begin{pmatrix} 1321 \\ 8124 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} \left|T_W\right| \\ \left|C_W\right| \end{pmatrix} = \begin{pmatrix} 13408 \\ 16893 \end{pmatrix} \cdot lbs$$

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Anchorage To Concrete [Expansion Anchor per ACI 318-14]

Number of connection on the long side

$N_B := 7 + 2$

Moment Arm for overturning (Short side)

$B := W_{curb} + 3in \cdot 2 = 83 \cdot in$

Number of Connection on the Short side.

$N_L := 4 + 2$

Moment Arm for over turning (Long side)

$L := L_{curb} + 3in \cdot 2 = 119 \cdot in$

Total Number of Connections

$N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 22$

Max Net Tension Reaction Due to Seismic Load, Fp

$$R_{c.EQ.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 16 \cdot lbs \qquad R_{c.EQ.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 8 \cdot lbs$$

$$R_{c.EQ} := MAX+\left[\left[\left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{c.EQ.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t}\right]\right] = \begin{pmatrix} 2311 \\ 2411 \end{pmatrix} \cdot lbs$$

$$\left[\left[\left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{c.EQ.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t}\right]\right]$$

Max net Tension Reaction Due to Wind Load, Pnet

$$R_{c.W} := MAX+\left[\left[\begin{array}{l} \frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t} \end{array}\right]\right] = \begin{pmatrix} 1180 \\ 898 \end{pmatrix} \cdot lbs$$

Governing Load Case:

$Govern := if\left(\left|R_{c.EQ}\right| > \left|R_{c.W}\right|, "Seismic", "Wind"\right) = "Seismic"$

Governing Tension Reaction at Each anchor Point:

$R_c := if\left(Govern = "Seismic", R_{c.EQ}, R_{c.W}\right) = \begin{pmatrix} 2311 \\ 2411 \end{pmatrix} \cdot lbs$

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Max Tension on anchor: $N_{ua} := \max(R_c) = 2411 \cdot lbs$

Max Shear on anchor: $V_{ua} := \frac{\max(\Omega_0 \cdot V_{base.S}, V_{base.W})}{N_t} = 1351 \cdot lbs$

Hilti Kwik Bolt TZ – Carbon Steel
5/8" Anchor with min 4" embedment
Base material: 6" thick Cracked concrete w/
Compressive strength fc' = 3000 psi
Min 6" away from the concrete edge
Evaluation Report: ICC-ESR 1917

Loading Condition:	**Seismic**

Design Tension Capacity [ϕN_n]:	3,631	[lbs]
Design Shear Capacity [ϕV_n]:	4,940	[lbs]

$\phi N_n := \phi N_n \cdot lbs = 3631 \cdot lbs$

$\phi V_n := \phi V_n \cdot lbs = 4940 \cdot lbs$

Utilization:

Tension Utilization:

$\beta_N := \frac{N_{ua}}{\phi N_n} = 66 \cdot \%$

Shear Utilization:

$\beta_V := \frac{V_{ua}}{\phi V_n} = 27 \cdot \%$

Interaction of Tensile and Shear Forces:
Per ACI 318-14 Sec. 17.6

$\beta_{NV} := \frac{(\beta_N) + (\beta_V)}{1.2} = 78 \cdot \%$

$$check\_interaction := \begin{pmatrix} if(\beta_N < 1.0, "OK", "NG") \\ if(\beta_V < 1.0, "OK", "NG") \\ if(\beta_{NV} < 1.0, "OK", "NG") \end{pmatrix} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

$$check\_interaction = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

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Anchorage To Structural Steel [Fillet Weld Conn. per AISI S100-16]

Fillet Weld 2" Long Along the Long and Short Side. Min 2 Connections per Side
Spacing: 48" O.C. for Non-Isolated Curbs; 24" for Isolated Curbs

Number of Welds on the Long Side $N_B := 6$

Moment Arm for Overturning (Short Side) $B := W_{curb} = 77 \cdot in$

Number of Welds on the Short Side. $N_L := 4$

Moment Arm for Overturning (Long Side) $L := L_{curb} = 113 \cdot in$

Total Number of Connections $N_t := \left[\left(N_B\right) + \left(N_L\right)\right] \cdot 2sides = 20$

Max Net Tension Reaction due to Seismic Load FP

$$R_{weld.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 25 \cdot lbs$$

$$R_{weld.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 13 \cdot lbs$$

$$R_{weld.EQ} := MAX+\left[\begin{bmatrix}\left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{weld.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{weld.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}1846 \\ 1874\end{pmatrix} \cdot lbs$$

Max Net Tension Reaction due to Wind Load Pnet

$$R_{weld.W} := MAX+\left[\begin{bmatrix}\frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}1811 \\ 1327\end{pmatrix} \cdot lbs$$

Tension Design Force; SRSS for Loading from Each Direction $T_{u.weld} := \max\left(\left|R_{weld.EQ}\right|, \left|R_{weld.W}\right|\right) = 2630 \cdot lbs$

Shear Load at Each Weld Connection $V_{u.weld} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{N_t} = 743 \cdot lbs$

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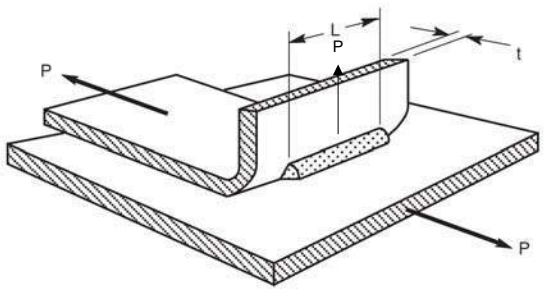
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Total Demand: SRSS of V and T

$$R_{u.weld} := \sqrt{T_{u.weld}^2 + V_{u.weld}^2} = 2733 \cdot lbs$$

Fillet Weld Design per AISI S100-16 Section J2.5

Weld Length at Each Connection Point $L_w := 2in$



Effective Throat Fillet Weld Size

$$t_w := \left(\frac{1}{8}in\right) \cdot 0.707 = 0.088 \cdot in$$

Thickness for the Thinnest Martial Being Welded
Min Curb Thickness = 16GA with Fu=65 ksi

$t_1 := thick("12GA") = 0.1084 \cdot in$

$F_u := 65ksi$

Min weld material strength

$F_{exx} := 70ksi$

For Longitudinal Loading [Parallel capacity is considered to be loading in the direction of the length of the weld] per (Eq. J2.5-1) &(Eq. J2.5-2)

$$\phi P_{long} := \begin{cases} (0.6)\left(1 - \frac{0.01 \cdot L_w}{t_1}\right) \cdot L_w \cdot t_1 \cdot F_u & \text{if } \frac{L_w}{t_1} < 25 \\ (0.5) \cdot 0.75 \cdot t_1 \cdot L_w \cdot F_u & \text{otherwise} \end{cases} = 6895 \cdot lbs$$

where $L_w \div t_1 = 18$

For Transverse Loading per (Eq. J2.5-5)

$$\phi P_{trans} := (0.65) \cdot t_1 \cdot L_w \cdot F_u = 9160 \cdot lbs$$

Strength of Weld Material per (Eq. J2.5-7)

$$\phi P_{weld} := (0.6) \cdot 0.75 \cdot t_w \cdot L_w \cdot F_{exx} = 5568 \cdot lbs$$

Design Strength of Fillet Weld

$$\phi P_n := \min\left(\phi P_{long}, \phi P_{trans}, \phi P_{weld}\right) = 5568 \cdot lbs$$

D/C Ratio for the Welded Connection

$$\beta_{NW} := \frac{R_{u.weld}}{\phi P_n} = 49 \cdot \%$$

$weld_{check} := if\left(\beta_{NW} < 1.0, "OK", "NG"\right)$

$weld_{check} = "OK"$

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Anchorage To Wood Member WITH Lag Screws [NDS-2018 LRFD Strength Design]

*** Use 3/8" Lag Screws along Each Side of the Curb**
*** Assume G=0.5 Douglas Fir-Larch**

Wood Lag Screw Capacity per NDS 2018 Section 11.3

Wet Service Factor: $Cond := "DRY"$ **(e.g. CA = "DRY", AK = "WET")**

$$C_M := \begin{cases} 1.0 & \text{if } Cond = "DRY" \\ 0.7 & \text{if } Cond = "WET" \end{cases} = 1$$ **NDS 2018 Table 11.3.3**

Temperature Factor:
$$C_t := \begin{cases} 0.8 & \text{if } Cond = "DRY" \\ 0.7 & \text{if } Cond = "WET" \end{cases} = 0.8$$ **NDS 2018 Table 11.3.4**

Group Action Factor: $C_g := 0.97$ **NDS 2018 Table 11.3.6C**

Geometry Factor: $C_\Delta := 1.0$ **NDS 2018 Table 12.5.1A,B**

End Grain Factor: $C_{eg} := 1.0$ **NDS 2018 Sec. 12.5.2**

Diaphragm Factor: $C_{di} := 1.0$ **NDS 2018 Sec. 12.5.3**

Toe-Nail Factor: $C_{tn} := 1.0$ **NDS 2018 Sec. 12.5.4**

Format Conversion Factor: $K_F := 3.32$ **NDS 2018 Table 11.3.1**

Resistance Factor: $\phi := 0.65$ **NDS 2018 Table 11.3.1**

Time Effect Factor: $\lambda := 1.0$ **NDS 2018 App N.3.3**

Lateral Design Value: $Z := 130lbs$ **NDS 2018 Table 12K**

Withdrawal Design Value: $W := 305lbs$ **NDS 2018 Table 12.2A**

Lag Screw Diameter: $D_{lag} := \frac{3}{8}in$

Lag Screw Length: $L_{lag} := 4in$

Length of Tapered Tip: $E_{lag} := \frac{7}{32}in$

Lag Screw Penetration: $P_{lag} := 3.78125in$

Eff. Lag Screw Penetration for withdrawal: $P_{\omega.lag} := 2in + \frac{9}{32}in = 2.28 \cdot in$ **NDS 2018 Appx. Table L2**

NDS 2018 Sec. 12.1.4.6

Minimum Penetration DCR <1.0: $DCR_{min.penetration} := \frac{4 \cdot D_{lag}}{P_{\omega.lag}} = 0.66$ $DCR_{min.penetration} = "OK"$

Adj. Lateral Design Value: $Z' := Z \cdot C_M \cdot C_t \cdot C_g \cdot C_\Delta \cdot C_{eg} \cdot C_{di} \cdot C_{tn} \cdot K_F \cdot \phi \cdot \lambda = 218 \cdot lbs$

Adj. Withdrawal Design Value: $W' := W \cdot C_M^{\,2} \cdot C_t \cdot C_{eg} \cdot C_{tn} \cdot K_F \cdot \phi \cdot \lambda = 527 \cdot lbs$ **NDS 2018 Table 11.3.1**

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Number of Lag Screws on the Long Side $N_B := 26 + 2$

Moment Arm for Overturning (Short Side) $B := W_{curb} = 77 \cdot in$

Number of Lag Screws on the Short Side $N_L := 18 + 2$

Moment Arm for Overturning (Long Side) $L := L_{curb} = 113 \cdot in$

Total Number of Lag Screws $N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 88$

Max net Tension Reaction due to Seismic, Fp

$$R_{lag.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 5 \cdot lbs$$

$$R_{lag.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 3 \cdot lbs$$

$$R_{lag.EQ} := MAX+\left[\begin{bmatrix} \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{lag.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{lag.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 394 \\ 371 \end{pmatrix} \cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$R_{lag.W} := MAX+\left[\begin{bmatrix} \frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{L \cdot N_L \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 391 \\ 271 \end{pmatrix} \cdot lbs$$

Tension Design force; SRSS for loading from Each direction $T_{lag} := \max\left(\left|R_{lag.EQ}\right|, \left|R_{lag.W}\right|\right) = 541 \cdot lbs$

Shear load at each anchor location $V_{lag} := \frac{\max\left(V_{base.S} \cdot \sqrt{2}, V_{base.W}\right)}{N_t} = 239 \cdot lbs$

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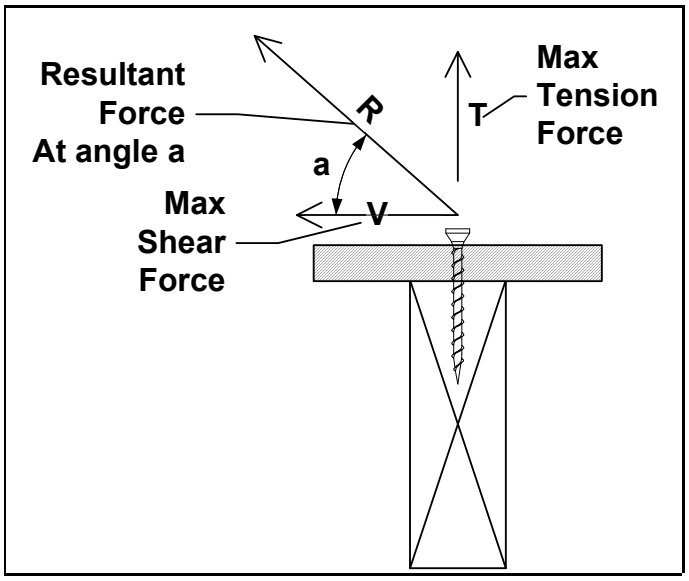
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For Lag Screws Subjected to Combined Lateral and Withdrawal Loading; Design Strength of the Lag Screw Shall Be Adjusted per Hankinson Formula as Prescribed by NDS 2018 Equation 12.4-1



Angle Between Wood Surface and Direction of Resultant Applied Load

$$(\alpha) := \operatorname{atan}\left(\frac{T_{lag}}{V_{lag}}\right) = 66\cdot\text{deg}$$

Combined Demand per Lag Screw @ Strength Level

$$R_{lag} := \sqrt{T_{lag}^{2} + V_{lag}^{2}} = 591\cdot\text{lbs}$$

Adjusted Capacity per NDS 2018 Equation 12.4-1 @ Strength Level

$$Z'_{\alpha} := \frac{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot Z'}{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot\cos(\alpha)^{2} + Z'\cdot\sin(\alpha)^{2}} = 692\cdot\text{lbs}$$

D/C Ratio for the Lag Screw connection to Wood Structure

$$\beta_{Lag} := \frac{R_{lag}}{Z'_{\alpha}} = 85\cdot\%$$

$$\text{Lag}_{Screw.Check} := \text{if}\left(\beta_{Lag} < 1.0, \text{"OK"}, \text{"NG"}\right)$$

$\text{Lag}_{Screw.Check} = \text{"OK"}$

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Bearing and Tilting in Curb Bolted Connection AISI S100-16

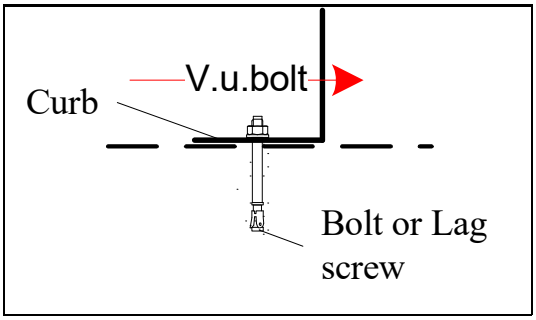
Nominal bolt diameter $d := 0.5in$

Uncoated sheet thickness $t_{curb} := thick("12GA") = 0.108 \cdot in$

Tensile strength of sheet $F_u := 65ksi$

Coefficient for conversion of units $\alpha := 1.0$

Modification Factor $m_f := 1.0$



Modification factor for type of bearing connection, per Table J3.3.1-2; For single shear connection with washers

Bearing Factor $C := \begin{cases} 3 \text{ if } \left(\frac{d}{t_{curb}} < 10\right) \wedge \left(0.024in < t_{curb} < 0.1875in\right) = 3 \\ "NG" \text{ if } \frac{d}{t_{curb}} > 10 \end{cases}$

Bearing factor, which shall be determined according to Table J3.3.1-1 For d/t<10 where $d \div t_{curb} = 5$

Bearing Design Strength per AISI S100-16 Eq. J3.3.1-1

$$\phi P_{n_{(0)}} := (0.6) \cdot \left(m_f \cdot C \cdot d \cdot t_{curb} \cdot F_u\right) = 6341 \cdot lbs$$

Bolt Hole Deformation Design Strength per AISI S100-16 Eq. J3.3.2-1

$$\phi P_{n_{(1)}} := (0.65) \cdot \left[4.64 \cdot \left(\frac{\alpha}{in}\right) \cdot t_{curb} + 1.53\right] \cdot d \cdot t_{curb} \cdot F_u = 4655 \cdot lbs$$

Curb Connection Shear Capacity $\phi P_n := \min\left(\phi P_n\right) = 4655 \cdot lbs$

Loading demand at connection $V_{u.bolt} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{6} = 2476 \cdot lbs$

$Curb\_Conn\_Shear := \text{if}\left(V_{u.bolt} < \phi P_n, "OK", "NG"\right)$ Curb_Conn_Shear = "OK"

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Thickness of Curb, ISO Rail and Clip

(Per AISC Table 17-10 Galvanized)

Hold Down Clip thickness

$t_{Clip} := "12GA"$ $t_{clip} := thick(t_{Clip}) = 0.1084 \cdot in$

Roof Curb thickness

$t_{Curb} := "12GA"$ $t_{curb} := thick(t_{Curb}) = 0.1084 \cdot in$

ISO RAIL thickness

$t_{Curb.iso} := "10GA"$ $t_{curb.iso} := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Note: Iso Rail thickness is only used if the curb is isolated. Not used for non-isolated curbs

Sheet Metal Screws (SMS) Equations and References

SMS properties (ESR-2196 Table 5)

$SMS_{Table} =$

"SMS"	"Diameter"	"HeadDiameter"	"Tension"	"Shear"
"Size"	"d"	"dw"	"Pts"	"Pss"
"#8"	0.164	0.335	1000	1170
"#10"	0.19	0.399	1370	1215
"#12"	0.216	0.415	2325	1880
"#14"	0.25	0.5	4580	2440

SMS Tension Eqns

$P_{not} = 0.85 \cdot t \cdot d \cdot F_u$ **(AISI S100-16 J4.4.1 & J4.4.2)**

$P_{nov} = 1.5 \cdot t \cdot d_w \cdot F_u$ **FOR THE MOST CASES, PULL-OUT CAPACITY IS THE LOWEST**

$P_{nts} = 0.8 \cdot P_{ts}$

SMS Shearn Eqns

$P_{vnot} = 4.2 \cdot \sqrt{(d \cdot t^3)} \cdot F_u$ **(AISI S100-16 J4.3.1)**

$P_{vnov} = 2.7 \cdot t \cdot d \cdot F_u$

$P_{vnss} = 0.8 \cdot P_{ss}$

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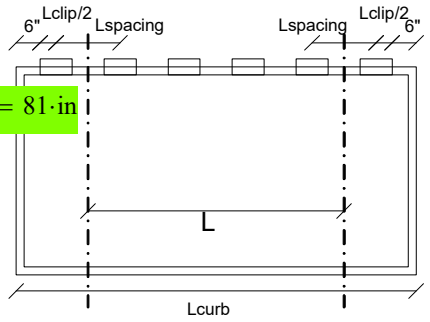
Hold Down Clip Design (Connection of the Mechanical unit to Curb)

Number of Clips on the long side $N_B := 6$

Moment Arm for overturning (Short side) $B := W_{curb} + 1.75in \cdot 2 = 81 \cdot in$

Number of Clips on the Short side. $N_L := 6$

Width of Clips $L_{clip} := 9in$



Curb Centerline Spacing (Long side)

$$L_{spacing} := \frac{L_{curb} - \left(6in + \frac{L_{clip}}{2}\right) \cdot 2}{N_B - 1} = 18.438 \cdot in$$

Moment Arm for overturning (Long side)

$$L := L_{curb} - 2 \cdot \left[6in + \frac{L_{clip}}{2} + L_{spacing} \cdot \frac{(N_L - 2)}{4}\right] = 55.313 \cdot in$$

Total Number of Clips

$$N_t := (N_B) \cdot 2sides = 12$$

Max net Tension Reaction due to Seismic, Fp

$$R_{clip.EQ} := MAX+\left[\begin{array}{l} \left[\frac{F_p \cdot Wt_{unit}}{B \cdot N_B} \cdot h_{CG.unit} + \frac{(0.9 - F_v) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B}\right] - \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} \\ \left[\frac{F_p \cdot Wt_{unit}}{L \cdot N_L} \cdot h_{CG.unit} + \frac{(0.9 - F_v) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L}\right] - \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} \end{array}\right] = \begin{pmatrix} 604 \\ 935 \end{pmatrix} \cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$R_{clip.W} := MAX+\left(\begin{array}{l} \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{unit}^2}{2}}{B \cdot N_B} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{unit}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{unit}^2}{2}}{L \cdot N_L} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{unit}}{N_t} \end{array}\right) = \begin{pmatrix} 1029 \\ 1021 \end{pmatrix} \cdot lbs$$

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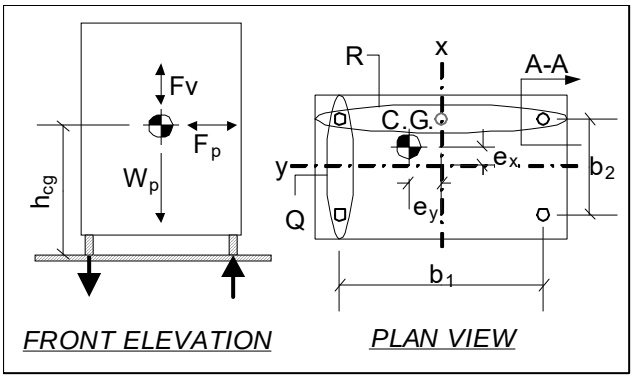
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Tensile and Shear Load calculation per ASHRAE RP-812



Eccentricity along X-X

$e_x := e_{width} = 6.094 \cdot in$

Eccentricity along Y-Y

$e_y := e_{length} = 3.157 \cdot in$

Distance between Seismic Restraints Along Y-Y

$b_1 := L_{curb} - 2 \cdot 6in = 101 \cdot in$

Distance between Seismic Restraints Along X-X

$b_2 := W_{curb} = 77 \cdot in$

Moment of Inertia about X-X

$$I_{xx} := \frac{N_t \cdot (N_t + 2) \cdot (b_1)^2}{12 \cdot (N_t - 2)} = 14335 \cdot in^2$$

Moment of Inertia about Y-Y

$$I_{yy} := \frac{N_t \cdot (b_2)^2}{4} = 17787 \cdot in^2$$

Angle about Tensile Load

$$\Theta_t := \operatorname{atan}\left[\frac{I_{yy} \cdot (b_1)}{I_{xx} \cdot (b_2)}\right] = 58 \cdot deg$$

Angle about Shear Load

$$\Theta_s := \begin{cases} \operatorname{atan}\left(\frac{e_x}{e_y}\right) & \text{if } e_y \neq 0 \\ 0deg & \text{if } e_y = 0 \end{cases} = 63 \cdot deg$$

Max Net Tensile Load Due to Seismic Load, Fp

$$T_{U.EQ.pt1} := \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} - \frac{(0.9 - F_v) \cdot Wt_{unit}}{b_1 \cdot b_2} \cdot \left(\frac{b_1}{2} \cdot e_x + \frac{b_2}{2} \cdot e_y - e_x \cdot e_y\right) = 59 \cdot lbs$$

$$T_{U.EQ.pt2} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \cos(\Theta_t) \cdot \frac{0.5 \cdot b_2}{I_{yy}} = -404 \cdot lbs$$

$$T_{U.EQ.pt3} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \sin(\Theta_t) \cdot \frac{0.5 \cdot b_1}{I_{xx}} = -1075 \cdot lbs$$

$T_{U.EQ} := T_{U.EQ.pt1} + T_{U.EQ.pt2} + T_{U.EQ.pt3} = -1420 \cdot lbs$

Max Net Shear Load Due to Seismic Load, Fp

$$V_{Ux.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\cos(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_2 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_1 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 524 \cdot lbs$$

$$V_{Uy.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\sin(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_1 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_2 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 893 \cdot lbs$$

$$V_{U.EQ} := \sqrt{V_{Ux.EQ}^2 + V_{Uy.EQ}^2} = 1035 \cdot lbs$$

Tension Design force for Hold Down Clips

$T_{clip} := \max(R_{clip.W_0}, R_{clip.W_1}, |R_{clip.EQ}|, |T_{U.EQ}|) = 1420 \cdot lbs$

$|R_{clip.EQ}| = 1113 \cdot lbs$ $|T_{U.EQ}| = 1420 \cdot lbs$

$T_{clip.EQ.max} := \max(|R_{clip.EQ}|, |T_{U.EQ}|) = 1420 \cdot lbs$

$T_{clip.W.max} := \max(R_{clip.W_0}, R_{clip.W_1}) = 1029 \cdot lbs$

Based on ASCE 7-16 Figure 29.4-1 magnitude of force coefficient,

Wind in diagonal direction to the face of equipment produces less force than that of the wind in perpendicular direction to the face of the equipment. Therefore, wind in diagonal direction does not need to be used

Shear Design force for Hold Down Clips

$$V_{clip} := \max\left(\frac{\max(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit})}{N_t}, |V_{U.EQ}|\right) = 1035 \cdot lbs$$

$F_p \cdot Wt_{unit} \cdot \frac{1}{N_t} = 899 \cdot lbs$ $|V_{U.EQ}| = 1035 \cdot lbs$

$P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t} = 675 \cdot lbs$

$V_{clip.EQ.max} := \max\left[\left(F_p \cdot Wt_{unit} \cdot \frac{1}{N_t}\right), |V_{U.EQ}|\right] = 1035 \cdot lbs$

$V_{clip.W.max} := \max\left(\left(P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t}\right)\right) = 675 \cdot lbs$

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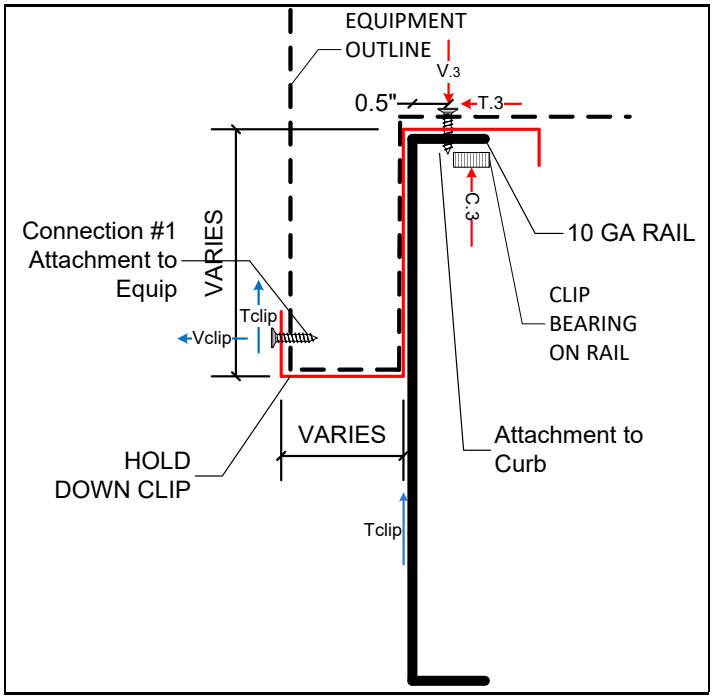
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Loading at Hold Down Clips @ Isolator Curb

$b_{return.iso} := Clip_b \cdot in = 2.125 \cdot in$

$b_{depth.iso} := Clip_c \cdot in = 6 \cdot in$



*For Reference Only

Mu Bending moment in the hold down

$M_u := T_{clip} \cdot b_{return.iso} = 3018 \cdot in \cdot lbs$

Resolve bending moment a T/C couple
Assume 0.5" bearing length
Moment Arm for T/C couple

$d_{T/C} := 1in - 0.5in = 0.5 \cdot in$

V3 is acting as shear on the screws. due to eccentricity of Tension force T

$$V_3 := \frac{T_{clip} \cdot \left[b_{return.iso} + (0) \right]}{d_{T/C}} = 6036 \cdot lbs$$

Additional load from Direct Shear acting out of plane (SRSS)

$V_3 := \sqrt{V_3^{\,2} + V_{clip}^{\,2}} = 6124 \cdot lbs$

Reaction C3 [compression force] is resisted by bearing of the hold down on the curb lip. Assume 0.5" bearing length

$C_3 := V_3 - T_{clip} = 4704 \cdot lbs$

T3 Load due to the shear acting out of plane tension on the screws.

$$T_3 := \left(\max\left(\frac{T_{clip} \cdot b_{return.iso}}{b_{depth.iso}}, V_{clip} \right) \right) = 1035 \cdot lbs$$

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Check Bending in Clip @ Isolator Curb

There are several restraints that prevents the hold down clip for iso-curb to have local bending at the bottom and transfer vertical load demand directly to the face of the curb.

- Hold down is bearing on the face of iso-rail / non-iso curb lip.
- Gasket will act as a "link" member to allow unit base rail and bottom flange to move totegther so flange can't bend unless the unit base rail bends first. However, unit base rail is not likely to bend so bottom flange won't bend

Hold Down Clip thickness

$t_{Clip} = \text{"12GA"}$ $t_{clip} := \text{thick}(t_{Clip}) = 0.1084 \cdot in$

Effective width of hold down clip

$b_c := L_{clip} = 9 \cdot in$

Yield strength of the Clip

$F_{y.c} := 50ksi$

Strength reduction for bending

$\phi_{clip} := 0.9$

Design Bending Capacity (LRFD)

$\phi M_n := \phi_{clip} \cdot F_{y.c} \left(\frac{b_c \cdot t_{clip}^2}{6} \right) = 793 \cdot in \cdot lbs$

Flexural bending demand

$M_{u.clip} := T_{clip} \cdot 0.5in = 710 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.clip}}{\phi M_n} = 0.895$

$Clip_{Bending} = \text{"OK"}$

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Check Flange Bending in Clip @ Isolator Curb

Note:
- **If the curb flange is welded to the 10GA channel and 10GA channel is welded back to the base of the curb, then both tension and compression due to equipment overturning will be taken care by the 10GA channel.**
- **Since the curb will be reinforced with 10GA channel under each isolator, it can be assumed that the loads will trasnferred down to the base structure through the channels. Therefore, flange downward bending at curb due to compressive load does not need to be checked.**

Roof Curb thickness

$t_{Curb} = \text{"12GA"}$ $t_{curb} := \text{thick}(t_{Curb}) = 0.1084 \cdot \text{in}$

Clip edge to edge distance

$$b_{edge2edge} := \frac{L_{curb} - \left(6\text{in} + \frac{L_{clip}}{2}\right)\cdot 2}{N_B - 1} - L_{clip} = 9.438 \cdot \text{in}$$

Effective width of Roof Curb

$b_{curb} := L_{clip} + b_{edge2edge} = 18.44 \cdot \text{in}$

Yield strength of the Curb

$F_{y.curb} := 50\text{ksi}$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb}\left[\frac{b_{curb}\cdot(t_{curb})^2}{6}\right] = 1625 \cdot \text{in}\cdot\text{lbs}$$

Width of Isolator

$w_{JQ.iso} := 2\text{in}$ **2 in. for CQAs**

Flexural bending demand

$$M_{u.Curb} := T_{clip}\cdot\left(\max\left(\frac{1.75\text{in}}{2} - 0.5\text{in}, \frac{w_{JQ.iso}}{2} - 1\text{in}\right)\right) = 533 \cdot \text{in}\cdot\text{lbs}$$

D/C Ratio for bending

$$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.328$$

$Curb_{Bending} = \text{"OK, Weld 10GA channel ends to curb flange"}$

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Design of Connection#1 Connection of Equipment to hold Down clip

Ultimate SMS screw connection Strength (LRFD)
Strength based on the smallest thickness of Curb and Equipment Housing (min 16 GA) [Fy = 50ksi & Fu=65ksi]

$n_{sms} := 4$ $Size_{ss} := "\#14"$

$t_{ss} := "16GA"$ $F_{u.ss} := 65ksi$

Nominal Tension Strength

$$P_{nt} := n_{sms} \cdot T_s(Size_{ss}, t_{ss}, F_{u.ss}) = 3508 \cdot lbs$$

$$P_{not} := n_{sms} \cdot T_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 3508 \cdot lbs$$

$$P_{nov} := n_{sms} \cdot T_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 12383 \cdot lbs$$

$$P_{nts} := n_{sms} \cdot T_{nts}(Size_{ss}, t_{ss}, F_{u.ss}) = 14656 \cdot lbs$$

Nominal Shear Strength

$$P_{ns} := n_{sms} \cdot V_s(Size_{ss}, t_{ss}, F_{u.ss}) = 7808 \cdot lbs$$

$$P_{vnot} := n_{sms} \cdot V_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 8737 \cdot lbs$$

$$P_{vnov} := n_{sms} \cdot V_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 11144 \cdot lbs$$

$$P_{vnss} := n_{sms} \cdot V_{nss}(Size_{ss}, t_{ss}, F_{u.ss}) = 7808 \cdot lbs$$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} V_{clip} \div (\phi_{sms} \cdot P_{nt}) \\ T_{clip} \div (\phi_{sms} \cdot P_{ns}) \end{bmatrix} = \begin{pmatrix} 59 \\ 36 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left[\begin{bmatrix} \left[\frac{T_{clip}}{P_{vnov}} + 0.71\left(\frac{V_{clip}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{T_{clip}}{P_{vnot}} + \left(\frac{V_{clip}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{T_{clip}}{P_{vnss}} + \left(\frac{V_{clip}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right] = 66 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

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Design of Connection#2 Connection of hold Down clip to Curb

Tension loads on SMS connection

$T_{s2} := V_3 = 6124 \cdot lbs$

Shear loads on SMS connection

$V_{s2} := T_3 = 1035 \cdot lbs$

Ultimate SMS screw connection Strength (LRFD)
Strength based on the smallest thickness of Curb and Equipment Housing (min 16 GA) [Fy = 50ksi & Fu=65ksi]

$n_{sms} := 8$ $Size_{ss} := "\#14"$

$t_{ss} := (t_{Curb.iso}) = "10GA"$ $F_{u.ss} := 65ksi$

Nominal Tension Strength

$P_{nt} := n_{sms} \cdot T_s(Size_{ss}, t_{ss}, F_{u.ss}) = 15271 \cdot lbs$

Note:
SMS is getting pulled up so the thicker curb iso rail is engaged for SMS capacity , rather than just the clip itself.

$P_{not} := n_{sms} \cdot T_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 15271 \cdot lbs$

$P_{nov} := n_{sms} \cdot T_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 53898 \cdot lbs$

$P_{nts} := n_{sms} \cdot T_{nts}(Size_{ss}, t_{ss}, F_{u.ss}) = 29312 \cdot lbs$

Nominal Shear Strength

$P_{ns} := n_{sms} \cdot V_s(Size_{ss}, t_{ss}, F_{u.ss}) = 15616 \cdot lbs$

$P_{vnot} := n_{sms} \cdot V_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 56103 \cdot lbs$

$P_{vnov} := n_{sms} \cdot V_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 48508 \cdot lbs$

$P_{vnss} := n_{sms} \cdot V_{nss}(Size_{ss}, t_{ss}, F_{u.ss}) = 15616 \cdot lbs$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} T_{s2} \div (\phi_{sms} \cdot P_{nt}) \\ V_{s2} \div (\phi_{sms} \cdot P_{ns}) \end{bmatrix} = \begin{pmatrix} 80 \\ 13 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left[\begin{bmatrix} \left[\frac{V_{s2}}{P_{vnov}} + 0.71\left(\frac{T_{s2}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{V_{s2}}{P_{vnot}} + \left(\frac{T_{s2}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{V_{s2}}{P_{vnss}} + \left(\frac{T_{s2}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right] = 61 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

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Hold Down clip Bending and Shear Interaction

Diameter of SMS:

$$d_{sms} := \text{vlookup}\left(Size_{ss}, SMS_{Table}, 1\right)_0 \cdot in = 0.25 \cdot in$$

Depth of flat web portion

$$h_{clip.shear} := L_{clip} - n_{sms} \cdot d_{sms} = 7 \cdot in$$

Depth-to-Thickness Ratio:

$$\frac{h_{clip.shear}}{t_{clip}} = 65 \qquad E := 29500ksi \qquad F_y := 50ksi \qquad \mu := 0.3$$

Nominal Shear Stress:
(For unreinforced web)
AISI S100-16 G2.1

$$k_v := 5.34 \qquad \sqrt{\frac{E \cdot k_v}{F_y}} = 56 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 85$$

Area of Web Element:

$$A_w := h_{clip.shear} \cdot t_{clip} = 0.759 \cdot in^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h_{clip.shear}}{t_{clip}}\right)^2} = 34.1 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} \qquad V_y := 0.6 \cdot A_w \cdot F_y = 23\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.937$$

Hole Shear Reduction Factor:
(for circular holes, AISI S100-16 Eq G3-1)

$$c := \frac{h_{clip.shear}}{2} - \frac{d_{sms}}{2.83} = 3.41 \cdot in$$

$$q_s := \begin{cases} 1.0 & \text{if } \frac{c}{t_{clip}} \geq 54 \\ \frac{c}{54 \cdot t_{clip}} & \text{if } 5 \leq \frac{c}{t_{clip}} < 54 \end{cases} = 0.583$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \leq 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \leq 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 19.792 \cdot kip$$

Design Shear Capacity with holes:

$$\phi V_{n.clip} := 0.95 \cdot V_n \cdot q_s = 11 \cdot kip$$

D/C Ratio of V and M per AISI S100-16 Eq H2-1

$$DCR_{V.M.int.clip} := \sqrt{\left(\frac{M_{u.clip}}{\phi M_n}\right)^2 + \left(\frac{\max\left(T_{clip}, V_{clip}\right)}{\phi V_{n.clip}}\right)^2} = 0.9046$$

Demand/Capacity Ratio:

$$VandM_{int.clip} = \text{"OK"}$$

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ISOLATOR DESIGN [PER OPM-0401-13]

OPM-0401-13 is based on allowable stress design

Number of isolators on the long side

$N_B := 8$ $N_{iso.long} := N_B = 8$

Moment Arm for overturning (Short side)

$B := W_{curb} + \frac{1.75in}{2} \cdot 2 = 79 \cdot in$

Number of isolators on the Short side.

$N_L := 6$

Isolator Centerline Spacing (Long side)

$L_{spacing.iso} := \frac{L_{curb} - (6in) \cdot 2}{N_B - 1} = 14.46 \cdot in$

Moment Arm for overturning (Long side)

$L := L_{curb} - 2 \cdot 6in - 2 \cdot L_{spacing.iso} \cdot \frac{(N_L - 2)}{4} = 72 \cdot in$

Total Number of isolators

$N_t := (N_B) \cdot 2sides = 16$

Max net Tension Reaction due to Seismic, Fp

$EQ_{ASD} := \left[0.6 - (0.7 \cdot F_v)\right] \cdot Wt_{unit} = 1.246\ kip$

$$R_{iso.EQ} := MAX+\left[\begin{bmatrix}\left[\frac{(0.7F_p) \cdot Wt_{unit}}{B \cdot N_B} \cdot (h_{CG.unit} + 0in) + \frac{EQ_{ASD} \cdot e_{width}}{B \cdot N_B}\right] - \frac{EQ_{ASD}}{N_t} \\ \left[\frac{(0.7F_p) \cdot Wt_{unit}}{L \cdot N_L} \cdot (h_{CG.unit} + 0in) + \frac{EQ_{ASD} \cdot e_{length}}{L \cdot N_L}\right] - \frac{EQ_{ASD}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}331 \\ 508\end{pmatrix} \cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$F_{wind.B} := \frac{P_{net} \cdot L_{unit} \cdot (H_{unit} + 0in)}{B \cdot N_B} \cdot \left(\frac{1}{2} \cdot H_{unit} + 0in\right) = 426 \cdot lbs$$

$$F_{wind.L} := \frac{P_{net} \cdot W_{unit} \cdot (H_{unit} + 0in)}{L \cdot N_L} \cdot \left(\frac{1}{2} \cdot H_{unit} + 0in\right) = 426 \cdot lbs$$

$$R_{iso.W} := (0.6) \cdot MAX+\left(\begin{pmatrix}F_{wind.B} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{Wt_{unit}}{N_t} \\ F_{wind.L} + \frac{P_v \cdot L_{unit.up} W_{unit}}{N_t} + \frac{Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{Wt_{unit}}{N_t}\end{pmatrix}\right) = \begin{pmatrix}459 \\ 454\end{pmatrix} \cdot lbs$$

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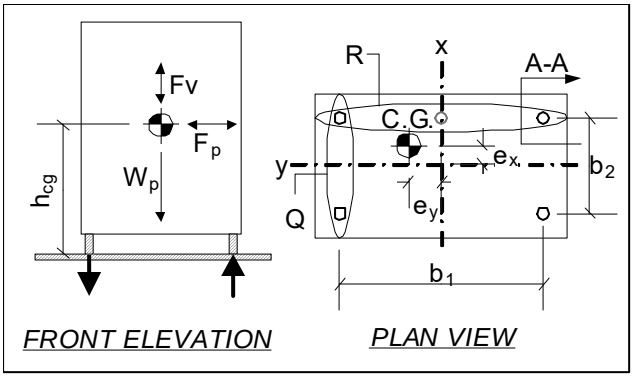
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Tensile and Shear Load calculation per ASHRAE RP-812



Eccentricity along X-X

$e_x := e_{width} = 6.09 \cdot in$

Eccentricity along Y-Y

$e_y := e_{length} = 3.16 \cdot in$

Distance between Seismic Restraints Along Y-Y

$b_1 := L_{curb} - 2 \cdot 6in = 101 \cdot in$

Distance between Seismic Restraints Along X-X

$b_2 := W_{curb} + 2 \cdot \frac{1.75in}{2} = 79 \cdot in$

Moment of Inertia about X-X

$I_{xx} := \frac{N_t \cdot (N_t + 2) \cdot (b_1)^2}{12 \cdot (N_t - 2)} = 17553 \cdot in^2$

Moment of Inertia about Y-Y

$I_{yy} := \frac{N_t \cdot (b_2)^2}{4} = 24806 \cdot in^2$

Angle about Tensile Load

$\Theta_t := \operatorname{atan}\left[\frac{I_{yy} \cdot (b_1)}{I_{xx} \cdot (b_2)}\right] = 61 \cdot deg$

Angle about Shear Load

$\Theta_s := \begin{cases} \operatorname{atan}\left(\frac{e_x}{e_y}\right) & \text{if } e_y \neq 0 \\ 0deg & \text{if } e_y = 0 \end{cases} = 63 \cdot deg$

Max Net Tensile Load Due to Seismic Load, Fp

$T_{U.EQ.pt1} := \frac{(0.6 - 0.7 \cdot F_v) \cdot Wt_{unit}}{N_t} - \frac{(0.6 - 0.7 \cdot F_v) \cdot Wt_{unit}}{b_1 \cdot b_2} \cdot \left(\frac{b_1}{2} \cdot e_x + \frac{b_2}{2} \cdot e_y - e_x \cdot e_y\right) = 13 \cdot lbs$

$T_{U.EQ.pt2} := -0.7 \cdot (F_p \cdot Wt_{unit}) \cdot (h_{CG.unit} + 0in) \cdot \cos(\Theta_t) \cdot \frac{0.5 \cdot b_2}{I_{yy}} = -191 \cdot lbs$

$T_{U.EQ.pt3} := -0.7 \cdot (F_p \cdot Wt_{unit}) \cdot (h_{CG.unit} + 0in) \cdot \sin(\Theta_t) \cdot \frac{0.5 \cdot b_1}{I_{xx}} = -631 \cdot lbs$

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$T_{U.EQ} := T_{U.EQ.pt1} + T_{U.EQ.pt2} + T_{U.EQ.pt3} = -810 \cdot lbs$

Max Net Shear Load Due to Seismic Load, Fp

$$V_{Ux.EQ} := 0.7 \cdot F_p \cdot Wt_{unit} \cdot \frac{\cos(\Theta_s)}{N_t} + \frac{0.7 \cdot F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_2 \cdot e_y + 0.7 \cdot F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_1 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 276 \cdot lbs$$

$$V_{Uy.EQ} := 0.7 \cdot F_p \cdot Wt_{unit} \cdot \frac{\sin(\Theta_s)}{N_t} + \frac{0.7 \cdot F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_1 \cdot e_y + 0.7 \cdot F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_2 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 470 \cdot lbs$$

$$V_{U.EQ} := \sqrt{V_{Ux.EQ}^2 + V_{Uy.EQ}^2} = 545 \cdot lbs$$

Tension Design force SRSS for loading from Each direction

$R_{iso.EQ.1.RP812} := \left| T_{U.EQ.pt1} + T_{U.EQ.pt3} \right| = 618 \cdot lbs$

$R_{iso.EQ.0.RP812} := \left| T_{U.EQ.pt1} + T_{U.EQ.pt2} \right| = 178 \cdot lbs$

$$R_{iso.EQ.max_1} := \max\left[\left(R_{iso.EQ.1.RP812} + 0 \cdot R_{iso.EQ.0.RP812}\right), \left(R_{iso.EQ_1} + 0 \cdot R_{iso.EQ_0}\right)\right] = 618 \cdot lbs$$

$$R_{iso.EQ.max_0} := \max\left[\left(R_{iso.EQ.0.RP812} + 0 \cdot R_{iso.EQ.1.RP812}\right), \left(R_{iso.EQ_0} + 0 \cdot R_{iso.EQ_1}\right)\right] = 331 \cdot lbs$$

For the plot:

$R_{iso.EQ.max_1} = 618 \cdot lbs$ $R_{iso.W_1} = 454 \cdot lbs$

$R_{iso.EQ.max_0} = 331 \cdot lbs$ $R_{iso.W_0} = 459 \cdot lbs$

Shear load at each anchor location

For the plot:

$$V_{iso.E} := \max\left[\left[\begin{array}{c} 1.0 \cdot V_{Ux.EQ} + 0 \cdot V_{Uy.EQ} \\ 0.3 \cdot V_{Ux.EQ} + 0 \cdot V_{Uy.EQ} \\ \left[\left(0.7F_p\right) \cdot Wt_{unit} \cdot \frac{1}{N_t}\right] \end{array}\right]\right] = 472 \cdot lbs \qquad V_{iso.W} := 0.6P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t} = 304 \cdot lbs$$

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Isolator Capacity:

$ID_{Iso} := "CQA"$

$T_{n.\Omega} := 2117lbs$ **(ASD)**

$V_{n.\Omega} := 775lbs$ **(ASD)**

Isolator Demand:

$R_{iso.max} := \max\left[\left(R_{iso.EQ.max_1}\right), \left(R_{iso.EQ.max_0}\right), \left(R_{iso.W_1}\right), \left(R_{iso.W_0}\right)\right] = 618 \cdot lbs$

$V_{iso.max} := \max\left(V_{iso.E}, V_{iso.W}\right) = 472 \cdot lbs$

D/C Ratio of Tension Only.:

$$DCR_{tension} := \frac{R_{iso.max}}{T_{n.\Omega}} = 0.292$$

$DCR_{tension} = "OK"$

D/C Ratio of Shear Only.:

$$DCR_{shear} := \frac{V_{iso.max}}{V_{n.\Omega}} = 0.609$$

$DCR_{shear} = "OK"$

D/C Ratio of Tension Only.:

$$DCR_{Int} := \frac{V_{iso.max}}{V_{n.\Omega}} + \frac{R_{iso.max}}{T_{n.\Omega}} = 0.901$$

$DCR_{Int} = "OK"$

ISOLATOR "SPRING" DESIGN [PER OPM-0401-13]

Factor of Safety of Spring

$FS_{spring} := 0.75$

Compressive Strength of Spring

$$C_{spring.\Omega} := \begin{cases} \left(FS_{spring} \cdot 300lbs\right) & \text{if } ID_{Iso} = "CQA" \\ \left(FS_{spring} \cdot 918lbs\right) & \text{if } ID_{Iso} = "CQB" \\ \left(FS_{spring} \cdot 918lbs\right) & \text{if } ID_{Iso} = "CQBX" \end{cases} = 225 \cdot lbs$$

Rated Load per unit self-weight

$$C_{unit.rated.load} := \frac{Wt_{unit}}{N_t} = 200 \cdot lbs$$

D/C Ratio of Spring Compression:

$$DCR := \frac{C_{unit.rated.load}}{C_{spring.\Omega}} = 0.888$$

$IsoSpring_{compression} = "OK"$

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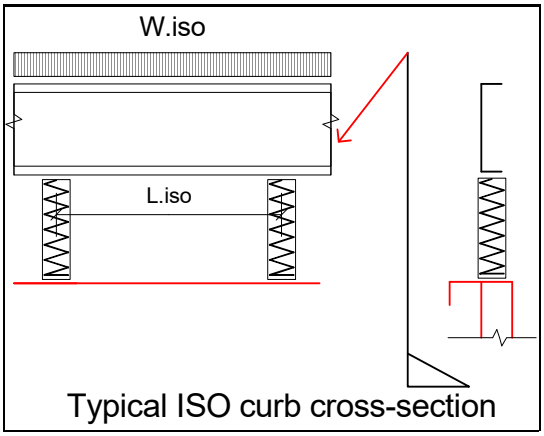
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Check ISO Rail for Bending about Strong and Weak Axis (AISI S100-16 F2.1)



Typical ISO curb cross-section

Thickness of Curb:

$t_{Curb.iso}$ = "10GA" $t := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Inside Bend Radius:

$R := R_{iso} = 0.186 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web:

$h := 7.5in - 2 \cdot (t + R) = 6.85 \cdot in$

Width of Flange:

$h_w := 1in$

Check Curb Bending of Long Side (Strong axis)

Member per CFS: $CFS_{member} :=$ "10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"

Number of Isolators on each Long Side: $N_{iso.long} = 8$

Center-to-Center Spacing of Isolators $L_{iso} := \frac{L_{curb}}{N_{iso.long} - 1} = 16 \cdot in$

Distributed Load $\omega_{iso} := \omega_{x.L.vert} = 2.141\ klf$

Moment Demand on Iso Rail $M_{cx} := \frac{\omega_{iso} \cdot L_{iso}^2}{8} = 5.831 \cdot kip \cdot in$

Curb Elastic Modulus / Yield Stress: $E := 29500ksi$ $F_y := 50ksi$

Curb Shear Modulus: $G := 11300ksi$

Poisson's Ratio $\mu := 0.3$

Section Properties from CFS: $r_x = 2.4893 \cdot in$ $r_o = 2.519 \cdot in$ $C_w = 0.595 \cdot in^6$ $S_x = 1.855 \cdot in^3$

$r_y = 0.2288 \cdot in$ $J = 0.0058 \cdot in^4$ $S_y = 0.3669 \cdot in^3$

$r_{min} := min(r_x, r_y) = 0.2288 \cdot in$

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Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Flanges*

Flat Width:

$$w := h_w - R_{curb} = 0.847 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Unstiffened"}$$

Stress at the end of the Width:

$$f_2 := 11.407ksi \quad f_1 := 11.407ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \frac{f_2}{f_1} = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 0.43$$

Critical Compressive Stress:

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t}{w}\right)^2 = 304.86 \cdot ksi$$

Stress in Compression Element:

$$f := 18ksi$$

Note: Use f from "Elastive Flexural Buckling Stress" on "Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI E2)"

Slenderness Factor:

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 0.24$$

Local reduction factor:

$$\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 0.389$$

Effective Width of the Flanges:

$$b_{eff.flange} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 0.847 \cdot in$$

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Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Web*

Flat Width: $w := h = 6.851 \cdot in$

Stiffened Web Check: $Stiffened_{check} := "Stiffened"$

Stress at the end of the Width: $f_2 := 11.407ksi$ $f_1 := 11.407ksi$

Compressive Stress Ratio (Eq. 1.1.2-1): $\Psi := \frac{f_2}{f_1} = 1$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = "Stiffened" \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = "Unstiffened" \end{cases} = 4$$

Critical Compressive Stress: $F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t}{w}\right)^2 = 43.4 \cdot ksi$

Stress in Compression Element: $f := 18ksi$

Note: Use f from "Elastive Flexural Buckling Stress" on "Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI E2)"

Slenderness Factor: $\lambda := \sqrt{\frac{f}{F_{cr}}} = 0.64$

Local reduction factor: $\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 1.022$

Effective Width of the Web:

$$b_{eff.web} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 6.851 \cdot in$$

Effective Area of the Member: $A_e := 2 \cdot \left(b_{eff.flange} \cdot t\right) + b_{eff.web} \cdot t = 1.181 \cdot in^2$

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For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. F2.1.1-4,5)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(1.0 \cdot L_{iso}\right)^2}\right] = 97 \cdot ksi$$

$$\sigma_{ey} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{iso}}{r_y}\right)^2} = 58 \cdot ksi \qquad \frac{1.0 \cdot L_{iso}}{r_y} = 71$$

KL_r = "KL/r < 200, OK"

Cb per Eq. F2.1.1-2

$$M_A := \frac{\omega_{iso} \cdot \frac{L_{iso}}{4}}{2} \cdot \left(L_{iso} - \frac{L_{iso}}{4}\right) = 4.37 \cdot kip \cdot in$$

$$M_B := M_{cx} = 5.83 \cdot kip \cdot in$$

$$M_C := \frac{\omega_{iso} \cdot \frac{3 \cdot L_{iso}}{4}}{2} \cdot \left(L_{iso} - \frac{3 \cdot L_{iso}}{4}\right) = 4.37 \cdot kip \cdot in$$

$$C_b := \min\left(1.0, \frac{12.5 \cdot M_{cx}}{2.5 \cdot M_{cx} + 3 \cdot M_A + 4 \cdot M_B + 3.M_C}\right) = 1$$

Elastic Critical Lateral-Torsional Buckling Stress per Eq. F2.1.1-1 for Singly Symmetry:

$$F_e := \frac{C_b \cdot r_o \cdot A_e}{S_x} \cdot \sqrt{\sigma_{ey} \cdot \sigma_t} = 121 \cdot ksi$$

LTB Design Stress: Eq. F2.1-3,4,5:

$$F_c := \begin{cases} F_y & \text{if } F_e \geq 2.78 \cdot F_y \\ \frac{10}{9} \cdot F_y \cdot \left(1 - \frac{10 \cdot F_y}{36 \cdot F_e}\right) & \text{if } 2.78 \cdot F_y > F_e > 0.56 \cdot F_y \\ F_e & \text{if } 0.56 \cdot F_y \geq F_e \end{cases} = 49 \cdot ksi$$

Moment Capacity Eq. F2.1-1:

$$\phi M_{nx} := 0.9 \cdot S_x \cdot \min\left(F_c, F_y\right) = 82 \cdot kip \cdot in$$

D/C Ratio of Bending:

$$DCR := \frac{M_{cx}}{\phi M_{nx}} = 0.071$$

$Iso_{Bending}$ = "OK"

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Check Curb Bending of Long Side (Weak axis)

Center-to-Center Spacing of Braces

$$L_{brace} := \frac{L_{curb}}{N_{iso.long} - 1} = 16 \cdot in$$

Note for weak-axis bracing length:
Max weak-axis span length of Iso Rail is larger than L_{brace} per cut sheet. However, the Iso Rail is braced with clip at max 24" O.C. at top and isolator at max 36" O.C. at bottom such that the actual unbraced length is as follows.

Distributed Load

$$\omega_{iso} := \frac{\max\left(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit}\right)}{L_{curb}} = 1.143\ klf$$

Moment Demand on Iso Rail

$$M_{cy} := \frac{\omega_{iso} \cdot L_{brace}^{2}}{8} = 3.114 \cdot kip \cdot in$$

Member per CFS:

$$CFS_{member} = \text{"10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"}$$

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. F2.1.1-4,5)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(1.0 \cdot L_{brace}\right)^2}\right] = 97 \cdot ksi$$

$$\sigma_{ex} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{brace}}{r_x}\right)^2} = 6900 \cdot ksi \qquad \frac{1.0 \cdot L_{brace}}{r_x} = 6$$

$$KL_r = \text{"KL/r < 200, OK"}$$

Cb per Eq. F2.1.1-2

$$M_A := \frac{\omega_{iso} \cdot \frac{L_{brace}}{4}}{2} \cdot \left(L_{brace} - \frac{L_{brace}}{4}\right) = 2.34 \cdot kip \cdot in$$

$$M_B := M_{cy} = 3.11 \cdot kip \cdot in$$

$$M_C := \frac{\omega_{iso} \cdot \frac{3 \cdot L_{brace}}{4}}{2} \cdot \left(L_{brace} - \frac{3 \cdot L_{brace}}{4}\right) = 2.34 \cdot kip \cdot in$$

$$C_b := \min\left(1.0, \frac{12.5 \cdot M_{cx}}{2.5 \cdot M_{cx} + 3 \cdot M_A + 4 \cdot M_B + 3 \cdot M_C}\right) = 1$$

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Elastic Critical Lateral-Torsional Buckling Stress per Eq. F2.1.1-1 for Singly Symmetry:

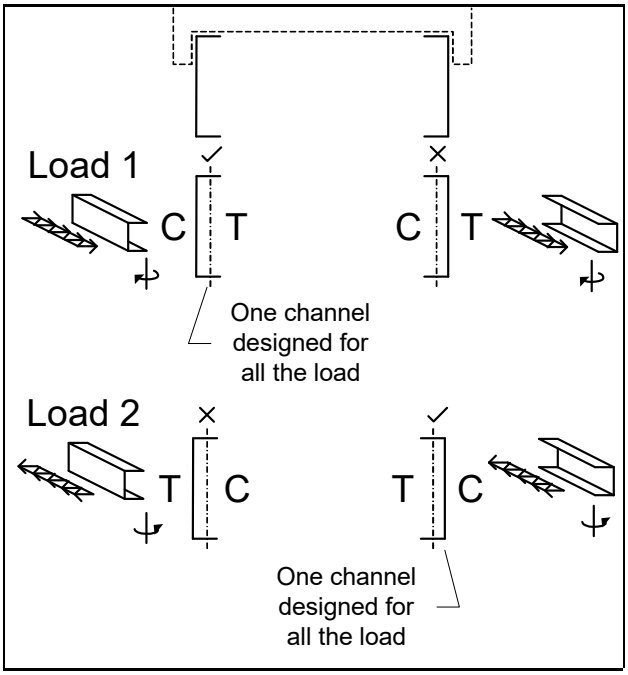
$$F_e := \frac{C_b \cdot r_o \cdot A_e}{S_y} \cdot \sqrt{\sigma_{ey} \cdot \sigma_t} = 610 \cdot ksi$$

LTB Design Stress: Eq. F2.1-3,4,5:

$$2.78 \cdot F_y = 139 \cdot ksi$$

$$0.56 \cdot F_y = 28 \cdot ksi$$

$$F_c := \begin{cases} F_y & \text{if } F_e \geq 2.78 \cdot F_y \\ \frac{10}{9} \cdot F_y \cdot \left(1 - \frac{10 \cdot F_y}{36 \cdot F_e}\right) & \text{if } 2.78 \cdot F_y > F_e > 0.56 \cdot F_y \\ F_e & \text{if } 0.56 \cdot F_y \geq F_e \end{cases} = 50 \cdot ksi$$



Note:

For ISO rail weak-axis bending capacity, rails are oriented and designed so that the stiffer side of ISO rail can take the entire bending load by itself without putting a lot of bending load to the iso rail on the other side

Moment Capacity Eq. F2.1-1:

$$\phi M_{ny} := 0.9 \cdot S_y \cdot \min\left(F_c, F_y\right) = 16.5105 \cdot kip \cdot in$$

D/C Ratio of Bending:

$$DCR := \frac{M_{cy}}{\phi M_{ny}} = 0.189$$

$$Iso_{Bending} := \text{if}\left(M_{cy} < \phi M_{ny}, \text{"OK"}, \text{"NG"}\right)$$

$Iso_{Bending} = \text{"OK"}$

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Web Crippling of ISO Rail (AISI S100-16 G.5)

Governing Compression:

$$P_{web.crip} := \frac{\omega_{x.L.vert} \cdot L_{iso}}{2} = 1442 \cdot lbs$$

Yield Strength:

$$F_y := 50ksi$$

Bearing Length:

$N := 2in$ **2 in. for CQAs**

Thickness of Curb:

$t_{Curb.iso} = \text{"10GA"}$ $t := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Inside Bend Radius:

$R := R_{iso} = 0.186 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web:

$h = 6.85 \cdot in$

Angle btween plane of web and bearing surface:

$\theta := 90deg$

Web Crippling Limit Check (AISI Table G5-2):

$$\frac{R}{t} = 1 \quad \frac{h}{t} = 50 \quad \frac{N}{t} = 14 \quad \frac{N}{h} = 0.29$$

$$LimitCheck_{webcrippling} := if\left[\left(\frac{h}{t} < 200\right) \wedge \left(\frac{N}{t} < 210\right) \wedge \left(\frac{N}{h} < 2\right) \wedge \left(\frac{R}{t} < 2\right), \text{"OK"}, \text{"NG, Need Reinf"}\right]$$

$LimitCheck_{webcrippling} = \text{"OK"}$

End Case Coefficient Single Web Channel (AISI Table G5-2):

$C := 2$ $C_R := 0.11$ $C_N := 0.37$ $C_h := 0.01$

Reduction Factor Web Crippling Strength:

$\phi_{web.end} := 0.75$ **(For Unfastened Flanges with Two-Flange Loading or Reaction. Worst Case)**

$\phi_{web.int} := 0.8$

Design Web Crippling Strength:

$$P_{n.end} := C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 3729 \cdot lbs$$

$$\phi P_{n.end} := \phi_{web.end} \cdot P_{n.end} = 2796 \cdot lbs$$

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Interior Case Coefficient Single Web Channel (AISI Table G5-2):

$C := 13$ $C_R := 0.47$ $C_N := 0.25$ $C_h := 0.04$

Design Web Crippling Strength:

$$P_{n.interior} := C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 7905 \cdot lbs$$

$$\phi P_{n.interior} := \left(\phi_{web.int}\right) \cdot P_{n.interior} = 6324 \cdot lbs$$

Design Strength:

$$P_{n.web.crip} := \min\left(P_{n.end}, P_{n.interior}\right) = 3729 \cdot lbs$$

$$\phi P_{n.web.crip} := \min\left(\phi P_{n.end}, \phi P_{n.interior}\right) = 2796 \cdot lbs$$

D/C Ratio of Shear:

$$DCR := \frac{P_{web.crip}}{\phi P_{n.web.crip}} = 0.516$$

Demand/Capacity Ratio:

$$Web_{crippling} := if\left[\left(P_{web.crip} < \phi P_{n.web.crip}\right) \wedge \left(\phi P_{n.end} > 0\right) \wedge \frac{h}{t} < 200, "OK", "NG, Need Reinf"\right]$$

$Web_{crippling} = "OK"$

D/C Ratio of Interaction:
AISI Eq. H3-1b

$$DCR_{int.web} := \frac{0.91 \cdot \left(\frac{P_{web.crip}}{P_{n.web.crip}}\right) + \frac{M_{cx}}{\left(\frac{\phi M_{nx}}{0.9}\right)}}{1.33 \cdot 0.9} = 0.348$$

$Iso_{Shear} = "OK"$

$Iso_{Interaction} = "OK"$

Per AISI S100-16 H3,
Only x-axis needs to check for interaction

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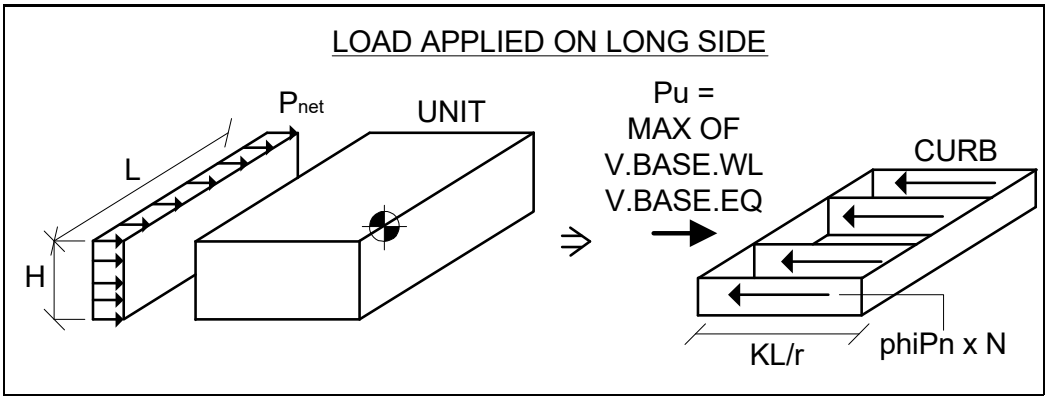
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Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI S100-16 E2)

Curb Axial Load Check due to Load on Long Side



Wind Base Shear of Unit on Long Side: $V_{base.W.L} := P_{net} \cdot L_{unit} \cdot H_{unit} = 8.1\,kip$

Seismic Base Shear of Unit on Long Side: $V_{base.S.L} := F_p \cdot Wt_{unit} = 10.8\,kip$

Max Axial: $P_u := \max\left(V_{base.S.L}, V_{base.W.L}\right) = 10783.46 \cdot lbs$

Member per CFS: $CFS_{member} =$ "10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"

Number of Curb in Length: $n_{iso} := 3$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{iso}} = 3.59\,kip$

Max Braced Length of Member: $L_{member} := W_{curb} = 77 \cdot in$

Effective Length factor: $K := 0.5$

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For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. E2.2-5, E2.2-6)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(K \cdot L_{member}\right)^2}\right] = 24 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2} = 10 \cdot ksi$$

$$\frac{K \cdot L_{member}}{r_{min}} = 168$$

KL_r = "KL/r < 200, OK"

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 7 \cdot ksi$$

Nominal Compressive Stress Capacity (Eq E2-4):

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 2.631$$

$$F_n := \begin{cases} 0.658^{\lambda_c^{\,2}} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^{\,2}}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 6.34 \cdot ksi$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot A_e \cdot F_n = 6.36\,kip$$

D/C Ratio of Compression:

$$DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.565$$

Note:
No need to check for interaction since equipment is not attached to the short side

$$Axial_{reinf} := \text{if}\left(P_{u.EAmember} < \phi P_{n.member}, \text{"OK"}, \text{"NG"}\right)$$

$Axial_{reinf}$ = "OK"

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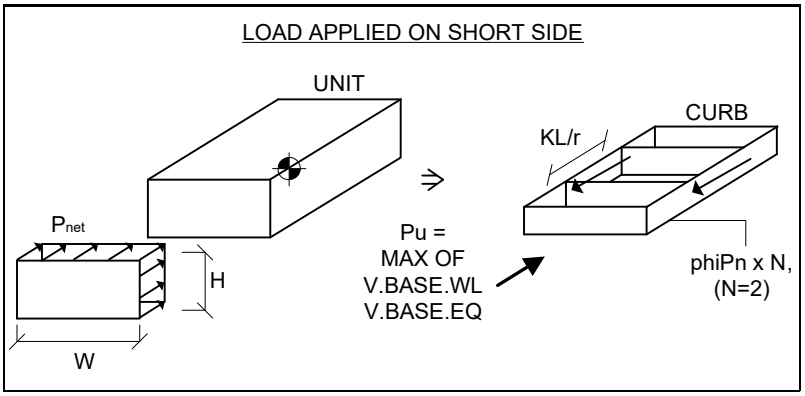
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Curb Axial Load Check due to Load on Short Side



Wind Base Shear on Short Side: $V_{base.W.H} := P_{net} \cdot W_{unit} \cdot H_{unit} = 5.6\,kip$

Seismic Base Shear of Unit on Short Side: $V_{base.S.W} := F_p \cdot Wt_{unit} = 10.8\,kip$

Max Axial: $P_u := \max\left(V_{base.S.W}, V_{base.W.H}\right) = 10783.46 \cdot lbs$

Member per CFS: $CFS_{member} = \text{"10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"}$

Number of Curb in Length: $n_{curb} := 2$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{curb}} = 5.39\,kip$

Max Braced Length of Member: $L_{member} := \frac{L_{curb}}{n_{iso} - 1} = 57 \cdot in$

Effective Length factor: $K := 0.5$

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. E2.2-5, E2.2-6)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(K \cdot L_{member}\right)^2}\right] = 38 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2} = 19 \cdot ksi \qquad \frac{K \cdot L_{member}}{r_{min}} = 124$$

$KL_r = \text{"KL/r < 200, OK"}$

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 13 \cdot ksi$$

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Nominal Compressive Stress Capacity (Eq E2-4):

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 1.989$$

$$F_n := \begin{cases} 0.658^{\lambda_c^2} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^2}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 11.08 \cdot \text{ksi}$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot A_e \cdot F_n = 11.12\,\text{kip}$$

D/C Ratio of Compression:

$$DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.485$$

$$Axial_{reinf} := \text{if}\left(P_{u.EAmember} < \phi P_{n.member}, \text{"OK"}, \text{"NG"}\right)$$

$Axial_{reinf} = \text{"OK"}$

Note:
If the load direction is in perpedicular plane to the short side of the equipment, the channels will only experience axial load and no bending will occur at the channel. Therefore, no need to check for interaction since the channels

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Shear of ISO Rail Webs without Holes (AISI S100-16 G2)

Note: The connection holes are not centered at mid-depth of isolated curb rail so AISI G2 shall be used

Deeper Section (h = depth)

Thickness of Curb: $t := \text{thick}(t_{Curb.iso}) = 0.138 \cdot in$

Depth-to-Thickness Ratio: $\frac{h}{t} = 50$

Curb Elastic Modulus: $E := 29500ksi$

Clear distance b/w transverse stiffeners of reinforced web: $a := L_{iso} = 16 \cdot in$

Clear Distance-to-Thickness Ratio: $\frac{a}{h} = 2.36$

Nominal Shear Stress:

$$k_v := \begin{cases} 5.34 \text{ if } a = L_{iso} \\ 4.00 + \frac{5.34}{\left(\frac{a}{h}\right)^2} \text{ if } \left(\frac{a}{h} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \frac{4.00}{\left(\frac{a}{h}\right)^2} \text{ if } \left(\frac{a}{h} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 6.06$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 60 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 90$$

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Curb Shear Check due to Load on Longer Side

Area of Web Element:

$$A_w := h \cdot t = 0.947 \cdot in^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 65.7 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} = 62\,kip \qquad V_y := 0.6 \cdot A_w \cdot F_y = 28\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.676$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 28.404 \cdot kip$$

Number of Members within Length: $n := 1$ **(Per Curb Design)**

Design Shear Capacity:

$$\phi V_{n.h} := 0.95 \cdot n \cdot V_n = 26.98 \cdot kip$$

Design Shear Demand:

$$V_{u.h} := \frac{\omega_{x.L.vert} \cdot L_{iso}}{2} = 1442.5 \cdot lbs$$

D/C Ratio of Shear:

$$DCR := \frac{V_{u.h}}{\phi V_{n.h}} = 0.053$$

Demand/Capacity Ratio:

$Shear_{in.plane} = \text{"OK"}$

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Shallower Section (h.w = Width)

Thickness of Curb: $t := thick(t_{Curb.iso}) = 0.138 \cdot in$

Depth-to-Thickness Ratio: $\frac{h_w}{t} = 7$

Curb Elastic Modulus: $E := 29500ksi$

Clear distance b/w transverse stiffeners of reinforced web: $a := L_{brace} = 16 \cdot in$

Clear Distance-to-Thickness Ratio: $\frac{a}{h_w} = 16.17$

Nominal Shear Stress:

$$k_v := \begin{cases} 5.34 & \text{if } a = L_{brace} \\ 4.00 + \frac{5.34}{\left(\frac{a}{h_w}\right)^2} & \text{if } \left(\frac{a}{h_w} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \frac{4.00}{\left(\frac{a}{h_w}\right)^2} & \text{if } \left(\frac{a}{h_w} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 5.36$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 56 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 85$$

Curb Shear Check due to Load on Longer Side

Area of Web Element: $A_w := h_w \cdot t = 0.1382 \cdot in^2$

Number of Members within Length: $n := 1$ **(Per Curb Design)**

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 58.1 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} = 8\,kip \qquad V_y := 0.6 \cdot A_w \cdot F_y = 4\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.719$$

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$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 4.146 \cdot \text{kip}$$

Design Shear Capacity:

$$\phi V_{n.hw} := 0.95 \cdot n \cdot V_n = 3.9 \cdot \text{kip}$$

Design Shear Demand:

$$V_{u.hw} := \frac{\left(\frac{\max\left(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit}\right)}{L_{curb}} \right) \cdot L_{brace}}{2} = 770.2 \cdot \text{lbs}$$

D/C Ratio of Shear:

$$DCR := \frac{V_{u.hw}}{\phi V_{n.hw}} = 0.196$$

Demand/Capacity Ratio:

$Shear_{in.plane}$ = "OK"

D/C Ratio of Vx and Mx:

$$DCR_{V.M.int} := \begin{cases} \left(0.6 \cdot \frac{M_{cx}}{\phi M_{nx}} + \frac{V_{u.h}}{\phi V_{n.h}}\right) \cdot \frac{1}{1.3} & \text{if } \frac{M_{cx}}{\phi M_{nx}} > 0.5 \wedge \frac{V_{u.h}}{\phi V_{n.h}} > 0.7 \\ \sqrt{\left(\frac{M_{cx}}{\phi M_{nx}}\right)^2 + \left(\frac{V_{u.h}}{\phi V_{n.h}}\right)^2} & \text{otherwise} \end{cases} = 0.089$$

Demand/Capacity Ratio:

$VandMx_{int}$ = "OK"

D/C Ratio of Vy and My:

$$DCR_{V.M.int} := \begin{cases} \left(0.6 \cdot \frac{M_{cy}}{\phi M_{ny}} + \frac{V_{u.hw}}{\phi V_{n.hw}}\right) \cdot \frac{1}{1.3} & \text{if } \frac{M_{cy}}{\phi M_{ny}} > 0.5 \wedge \frac{V_{u.hw}}{\phi V_{n.hw}} > 0.7 \\ \sqrt{\left(\frac{M_{cy}}{\phi M_{ny}}\right)^2 + \left(\frac{V_{u.hw}}{\phi V_{n.hw}}\right)^2} & \text{otherwise} \end{cases} = 0.272$$

Demand/Capacity Ratio:

$VandMy_{int}$ = "OK"

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Web Crippling/Compression of Non-iso CanFab Curb (AISI S100-16 G5)

Governing Compression for Non-Isolated Curb:

$$P_{web.crip.int} := \max\left[\frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}}, \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}}\right] \cdot L_{spacing.non.iso} = 5483 \cdot lbs$$

$$P_{web.crip.end} := 0.5 \cdot P_{web.crip.int} = 2741 \cdot lbs$$

Yield Strength: $F_y := 50ksi$

Bearing Length: $N_{bearing} := L_{spacing.non.iso} = 31 \cdot in$

Thickness of Curb: $t_{Curb} = \text{"12GA"}$ $t := thick(t_{Curb}) = 0.1084 \cdot in$

Inside Bend Radius: $R := R_{curb} = 0.153 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web: $h := 30in - 2 \cdot (t + R) = 29.48 \cdot in$

Angle btween plane of web and bearing surface: $\theta := 90deg$

Web Crippling Limit Check (AISI Table G5-2): $\frac{R}{t} = 1$ $\frac{h}{t} = 272$ $\frac{N_{bearing}}{t} = 283$ $\frac{N_{bearing}}{h} = 1.04$

End Case Coefficient Single Web Channel (AISI Table G5-2): $C := 13$ $C_R := 0.32$ $C_N := 0.05$ $C_h := 0.04$

Reduction Factor Web Crippling Strength: $\phi_{web.end} := 0.9$ $\phi_{web.int} := 0.8$ **(For Unfastened partially Stiffened Flanges with Two-Flange Loading or Reaction.)**

Design Web Crippling Strength:

$$\phi P_{n.end} := \left(\phi_{web.end}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 2674 \cdot lbs$$

Interior Case Coefficient Single Web Channel (AISI Table G5-2): $C := 24$ $C_R := 0.52$ $C_N := 0.15$ $C_h := 0.001$

Design Web Crippling Strength:

$$\phi P_{n.interior} := \left(\phi_{web.int}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 14990 \cdot lbs$$

D/C Ratio of Shear: $DCR_{end} := \frac{P_{web.crip.end}}{2 \cdot \phi P_{n.end}} = 0.513$ $DCR_{int} := \frac{P_{web.crip.int}}{\phi P_{n.interior}} = 0.366$

Demand/Capacity Ratio: **Note: Factor of 2 for two ends connected together at the end**

$Web_{crippling} = \text{"OK"}$

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Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Length

Roof Curb thickness

$t_{Curb} = \text{"12GA"}$ $t_{curb} := thick(t_{Curb}) = 0.1084 \cdot in$

Min width of Roof Curb

$b_{curb} := L_{curb} + W_{curb} \cdot 2 = 267.19 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := L_{curb} + \min\left(\frac{W_{curb}}{2} \cdot 2, \frac{L_{curb}}{2}\right) = 170 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{matrix} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{matrix} \right] \right] = 23547 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.L.vert.up} \cdot L_{curb}) \cdot (0.75in) = 8772 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.373$

$Curb_{BotFlangeBending} = \text{"OK"}$

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Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Width

Roof Curb thickness

$t_{Curb} = \text{"12GA"}$ $t_{curb} := thick(t_{Curb}) = 0.1084 \cdot in$

Min width of Roof Curb

$b_{curb} := W_{curb} + \frac{L_{curb}}{4} \cdot 2 + 3in \cdot 2 = 139.59 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := W_{curb} + \min\left(\frac{L_{curb}}{6} \cdot 2, W_{curb}\right) = 115 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{matrix} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{matrix} \right] \right] = 12302 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.W.vert.up} \cdot W_{curb}) \cdot (0.75in) = 5027 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.409$

$Curb_{BotFlangeBending} = \text{"OK"}$

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Web Crippling/Compression of Iso CanFab Curb (AISI S100-16 G5)

Note: Curb stiffeners directly transfer the compressive load from isolator to the base. Therefore, curb web crippling is prevented.

Curb Web with Reinforcement

Max Compression: $Comp_{maxtot} := \max(|C_S|, |C_W|) = 25326.47 \cdot lbs$

Reinforcement per CFS: $CFS_{reinf} :=$ "Single Stiffener 10GA 1"x7"x1" Fy=50ksi 18" Tall on min. 16GA "

Note: min. of 10 GA channel and min. 16 GA curb web

Number of Reinforcement in Length: $n_{reinf} := N_{iso.long} = 8$

Max Compression per Reinf: $Comp_{per.reinf} := \frac{Comp_{maxtot}}{n_{reinf}} = 3.166\,kip$

Spacing: $Spacing := \frac{L_{curb}}{n_{reinf}} = 14 \cdot in$ $KL_r := \frac{1.0 \cdot (H_{curb} - 12.5in)}{0.2339in} = 128$

Factored Nominal Comp. Capacity per reinforcement: $\phi P_{n.reinf} = 21.066 \cdot kip$ **(See attached CFS)**

Total Factored nominal Comp Capacity: $\phi P_{n.tot} := n_{reinf} \cdot \phi P_{n.reinf} = 169 \cdot kip$

D/C Ratio of Compression: $DCR := \frac{Comp_{maxtot}}{\phi P_{n.tot}} = 0.15$

$Comp_{reinf} := if(Comp_{maxtot} < \phi P_{n.tot}, "OK", "NG")$ $Comp_{reinf} = "OK"$

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Check CanFab Curb for Compressive Force due to T/C Coupling of Overturning

Note:
-Since the equipment is only attached to the longer sides of the CanFab Curb, most likely there will be compressive force onto the curb due to T/C coupling.
- Rectangular CanFab Curb will be considered as "Channel" to resist the compressive force.

Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Flanges*

Flat Width:

$$w := \frac{W_{curb}}{2} - R_{curb} = 38.348 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Unstiffened"}$$

Stress at the end of the Width:

$$f_2 := 50ksi \qquad f_1 := 50ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \left| \frac{f_2}{f_1} \right| = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 0.43$$

Critical Compressive Stress (Eq 1.1-4):

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w}\right)^2 = 0.09 \cdot ksi$$

Stress in Compression Element:

$$f := F_y = 50 \cdot ksi \qquad \textbf{(Assume f = Fy)}$$

Slenderness Factor (Eq 1.1-3):

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 23.36$$

Local reduction factor (Eq 1.1-2):

$$\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 0.042$$

Effective Width of the Flanges:

$$b_{eff.flange} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 1.626 \cdot in$$

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Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Web*

Flat Width:

$$w := L_{curb} - R_{curb} \cdot 2 = 112.883 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Stiffened"}$$

Stress at the end of the Width:

$$f_2 := 50ksi \qquad f_1 := 50ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \left| \frac{f_2}{f_1} \right| = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 4$$

Critical Compressive Stress (Eq 1.1-4):

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w} \right)^2 = 0.1 \cdot ksi$$

Stress in Compression Element:

$$f := F_y = 50 \cdot ksi \qquad \textbf{(Assume f = Fy)}$$

Slenderness Factor (Eq 1.1-3):

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 22.55$$

Local reduction factor (Eq 1.1-2):

$$\rho := \left(1 - \frac{0.22}{\lambda}\right) \frac{1}{\lambda} = 0.044$$

Effective Width of the Web:

$$b_{eff.web} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 4.958 \cdot in$$

Effective Area of the Member:

$$A_e := 2 \cdot \left(b_{eff.flange} \cdot t_{curb} \right) + b_{eff.web} \cdot t_{curb} = 0.89 \cdot in^2$$

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Length of the Compressive Member: $L_{curb.web} := h = 29.478 \cdot in$

Young's Modulus for Cold Form Steel: $E := 29500 ksi$

Curb Shear Modulus: $G := 11300 ksi$

Poisson's Ratio $\mu := 0.3$

Section Properties of the Member (From Section Properties Calculator):

$A_{half.curb} := 13.599 in^2$ $r_o := 50.187 in$ $I_x := 26250.724 in^4$ $I_y := 1949.977 in^4$

$J := 0.023 in^4$ $r_x := \sqrt{\frac{I_x}{A_{half.curb}}} = 43.936 \cdot in$ $r_y := \sqrt{\frac{I_y}{A_{half.curb}}} = 11.975 \cdot in$

$C_w := 4.431 \cdot 10^6 \cdot in^6$ $r_{min} := \min(r_x, r_y) = 11.975 \cdot in$

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^2}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{(1.0 \cdot L_{curb.web})^2}\right] = 662356.96 \cdot ksi$$

$$\sigma_{e.y} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_y}\right)^2} = 48044.354 \cdot ksi \qquad \sigma_{e.x} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_x}\right)^2} = 646776.38 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2} = 48044.354 \cdot ksi$$

$$\frac{1.0 \cdot L_{curb.web}}{r_{min}} = 2.46$$

$KL_r = "KL/r < 200, OK"$

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 44795.12 \cdot ksi$$

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Nominal Compressive Stress Capacity: (Eq E2-4)

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 0.033$$

$$F_n := \begin{cases} 0.658^{\lambda_c^2} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^2}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 49.98 \cdot \text{ksi}$$

Compressive Capacity:

$$P_{n.member} := A_e \cdot F_n = 44.47 \cdot \text{kip}$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot P_{n.member} = 37.8 \cdot \text{kip}$$

Factored Max Compressive Force:

$$P_{comp.max} := \max\left(\left|C_S\right|, \left|C_W\right|\right) = 25.326\,\text{kip}$$

D/C Ratio of Compression:

$$DCR := \frac{P_{comp.max}}{\phi P_{n.member}} = 0.67$$

$$Axial_{curb.comp} := \text{if}\left(P_{comp.max} < \phi P_{n.member}, \text{"OK"}, \text{"Provide Channel from above as Web Stiffener"}\right)$$

$Axial_{curb.comp} = \text{"OK"}$

Note: No need to check for interaction since the curb is only subjected to the compressive force.

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Shear of CanFab Curb Webs without Holes (AISI S100-16 G2)

Note: Since the unit is stiffer than the curb and the curb is firmly attached to the unit and to the base structure, curbs will mainly take the lateral forces as shear and axial load rather than bending.

Thickness of Curb:

$$t := \text{thick}(t_{Curb}) = 0.108 \cdot \text{in}$$

Depth-to-Thickness Ratio:

$$\frac{h}{t} = 272$$

Curb Elastic Modulus:

$$E := 29500\text{ksi}$$

Clear distance b/w transverse stiffeners of reinforced web:

$$a := \max\left(\frac{L_{curb}}{2}, W_{curb}\right) = 77 \cdot \text{in} \qquad \frac{a}{h} = 2.61$$

$$k_v := \begin{cases} 5.34 & \text{if } a = L_{curb} \\ 4.00 + \dfrac{5.34}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \dfrac{4.00}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 5.93$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 59 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 89$$

Curb Shear Check due to Load on Longer Side

Area of Web Element:

$$A_w := W_{curb} \cdot t = 8 \cdot \text{in}^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 2.1 \cdot \text{ksi}$$

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$V_{cr} := A_w \cdot F_{cr} = 18\,kip \quad V_y := 0.6 \cdot A_w \cdot F_y = 250\,kip \quad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 3.747$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 17.834 \cdot kip$$

Number of Members within Length: $n := 2$ **(Per Curb Design)**

Design Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 33885.1 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.H} := P_{net} \cdot L_{unit} \cdot H_{total} = 13293.1 \cdot lbs$

Design Shear Demand: $V_u := \max(V_{base.S}, V_{base.W.H}) = 14857.1 \cdot lbs$

D/C Ratio of Shear: $DCR := \frac{V_u}{\phi V_n} = 0.438$

Demand/Capacity Ratio:

$Shear_{in.plane} := \text{if}(V_u < \phi V_n, \text{"OK"}, \text{"NG"})$

$Shear_{in.plane} = \text{"OK"}$

Curb Shear Check due to Load on Shorter Side

Area of Web Element: $A_w := L_{curb} \cdot t = 12 \cdot in^2$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 2.1 \cdot ksi$$

$V_{cr} := A_w \cdot F_{cr} = 26\,kip \quad V_y := 0.6 \cdot A_w \cdot F_y = 368\,kip \quad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 3.747$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 26.216 \cdot kip$$

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Number of Members within Length: $n := 2$ **(Per Curb Design)**

Factored Nominal Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 49810.3 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot W_{unit} \cdot H_{total} = 9149.6 \cdot lbs$

Factored Shear Demand: $V_u := \max(V_{base.S}, V_{base.W.L}) = 14857.1 \cdot lbs$

D/C Ratio of Shear: $DCR := \frac{V_u}{\phi V_n} = 0.298$

Demand/Capacity Ratio:

$Shear_{in.plane} := \text{if}(V_u < \phi V_n, \text{"OK"}, \text{"NG"})$

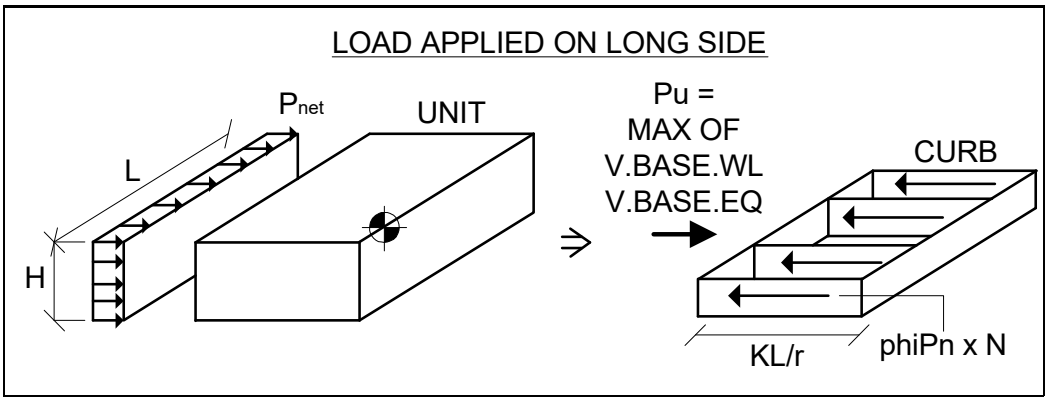
$Shear_{in.plane} = \text{"OK"}$

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Check CanFab Curb for In-Plane Axial due to EQ and Wind (AISI S100-16 E2)

Curb Axial Load Check due to Load on Long Side



Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot L_{unit} \cdot H_{total} = 13.3\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.L}) = 14857.09 \cdot lbs$

Member per CFS: $CFS_{member} :=$ "12GA Custom Curb 30" Tall L.b = 63in"

Max Braced Length of Member: $L_{member} := 48in$ **Conservative since the max anchor spacing is 24"**

Number of Curb in Length: $n_{curb.long} := 3$

Radius of gyration in y-axis: $r_{y.curb} := 0.558in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{2} = 7.43\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 86$ $KL_r =$ "KL/r < 200, OK"

Spacing: $Spacing := \frac{L_{curb}}{n_{curb.long}} = 38 \cdot in$

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 12.036 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.617$

$Axial_{short.curb} =$ "OK"

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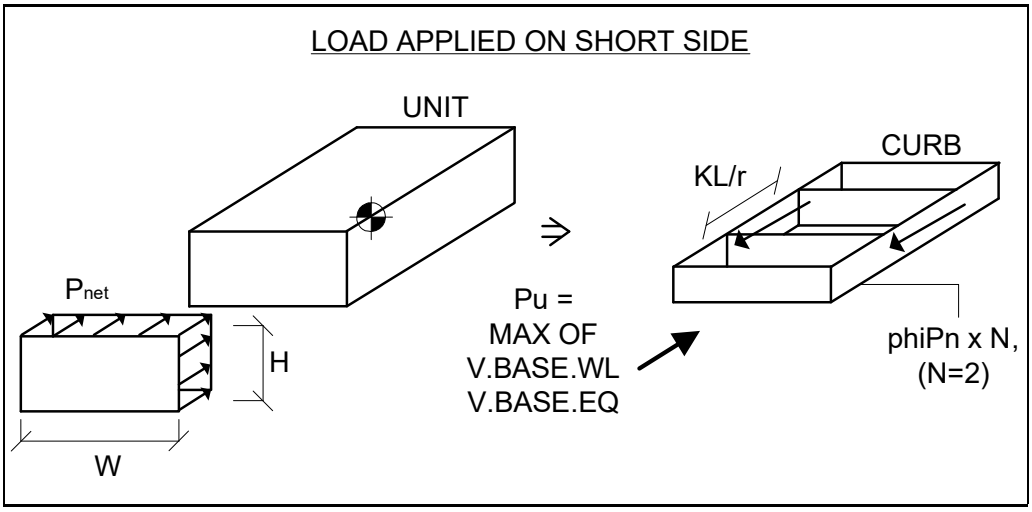
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Curb Axial Load Check due to Load on Short Side



Wind Base Shear on Short Side: $V_{base.W.H} := P_{net} \cdot W_{unit} \cdot H_{total} = 9.1\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.H}) = 14857.09 \cdot lbs$

Member per CFS: CFS_{member} = "12GA Custom Curb 30" Tall L.b = 63in"

Max Braced Length of Member: $L_{member} := \frac{L_{curb}}{n_{curb.long} - 1} = 57 \cdot in$

Number of Curb in Length: $n_{curb} := 2$

Radius of gyration in y-axis: $r_{y.curb} := 0.558\,in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{curb}} = 7.43\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 101$ KL_r = "KL/r < 200, OK"

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 12.036 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.617$

$Axial_{long.curb}$ = "OK"

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for
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Design Wind Loads for Rooftop Equipment (ASCE 7-16 § Table 29.1-1)

$z := 60ft$ **Height above ground level**

$B := 60ft$ **Horizontal dimension of building measured normal to wind direction**

$Exp_{category} := "C"$ **Exposure Category per ASCE 7-16 § 26.7**

$Risk_{category} := "IV"$ **Risk Category per ASCE 7-16 Table 1.5-1**

$$V := \begin{cases} 0mph & \text{if } Risk_{category} = "I" \\ 0mph & \text{if } Risk_{category} = "II" \\ 175mph & \text{otherwise} \end{cases} = 175 \cdot mph$$

Basic Wind Speed per ASCE 7-16 Figure 26.5-1 A,B or C

$K_z = 1.14$ **Velocity Pressure Exposure Coefficient per ASCE 7-16 Table 29.10-1 [Exposure Category "C"]**

$K_{zt} := 1.0$ **Topographic Factor per ASCE 7-16 § 26.8, Figure 26.8-1**

$K_e := 1.0$ **Ground Elevation Factor per ASCE 7-16 § 26.9, Table 26.9-1**

$K_d := 0.85$ **Wind Directionality Factor per ASCE 7-16 § 26.6, Table 26.6-1 (Equipment)**

$q_z := 0.00256 K_z \cdot K_{zt} \cdot K_d \cdot K_e \cdot V^2 = 75.74 \cdot psf$ **Velocity pressure evaluated at height z above ground per ASCE 7-10 § 26.10.2; Eq. 26.10-1**

$GC_{r.lateral.max} := 1.9$ **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.9 for rooftop structures and equipment with Af less than (0.1Bh). (GCr) shall be permitted to be reduced linearly from 1.9 to 1.0 as the value of Af is increased from (0.1Bh) to (Bh)

$GC_{r.vertical.max} := 1.5$ **Per ASCE 7-16 § 29.4.1**
(GCr) shall be taken as 1.5 for rooftop structures and equipment with A_r less than (0.1*BL*). (GC_r) shall be permitted to be reduced linearly from 1.5 to 1.0 as the value of A_r is increased from (0.1*BL*) to (*BL*)

$P_{net} := q_z \cdot GC_{r.lateral.max} = 143.91 \cdot psf$ **Design Lateral Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-2**

$P_v := q_z \cdot GC_{r.vertical.max} = 113.61 \cdot psf$ **Design Vertical Uplift Wind Loads for Roof top Equipment per ASCE 7-16 § § 29.4.1; Eq. 29.4-3**

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Seismic Demands on Nonstructural Components (ASCE 7-16 § 13.3 & 13.6):

$S_{DS} := 1.5$ **Design spectral response acceleration parameter at short periods per USGS map**

$I_p := 1.5$ **Component importance factor ASCE 7-16 § 13.1.3**

$\Omega_0 := 2.0$ **Overstrength factor ASCE 7-16 Table 13.6.1**

Vibr_Isolation = "Yes" **Placement of Unit Vibration Isolated:**

Note: Only "F_p" at seismic concrete anchor has been increased with overstrength factor "Ω_0"

$a_p := 2.5$ $R_p = 2.0$ **Seismic coefficients a_p & R_p**
Per ASCE 7-16 Table 13.6-1 for
Mechanical & Electrical Components

$z = 60\,ft$ **Height in structure of point of attachment of component with respect to the base**

$h := 60ft$ **Average roof height of structure with respect to the base**
Where for roof top equipment:

$z \div h = 1$

F_p: Horizontal Seismic Design Force per *ASCE7-16 § 13.3.1*

F_p shall be takes as $\left(\frac{0.4 \cdot a_p \cdot S_{DS} \cdot I_p}{R_p}\right) \cdot \left(1 + 2 \cdot \frac{z}{h}\right) \cdot W_p = 337.5 \cdot \% \cdot W_p$

F_p is not required to be taken as greater than $\left(1.6 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 360 \cdot \% \cdot W_p$

F_p shall not be taken as less than $\left(0.3 \cdot S_{DS} \cdot I_p\right) \cdot W_p = 67.5 \cdot \% \cdot W_p$

Governing F_p : Horizontal Seismic Design Force $F_p = 337.5 \cdot \% \cdot W_p$

F_v: Vertical Load per ASCE7-16 § 13.3.1.2

Concurrent Vertical Seismic Force: $F_v := 0.2 \cdot S_{DS} \cdot W_p = 30 \cdot \% \cdot W_p$

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Flat Roof Snow Loads (ASCE 7-16 § 7.3):

$Terrain_{CAT} := "C"$ **Terrain Category ASCE 7-16 § 26.7 & Table 7.3-1**

$Exp_{Roof} := "Partially Exposed"$ **Exposure of Roof ASCE 7-16 Table 7.3-1**

$C_e = 1$ **Exposure Factor ASCE 7-16 Table 7.3-1**

$Thermal_{condition} := "All structures except below"$ **Thermal Condition ASCE 7-16 Table 7.3-2**

$C_t = 1$ **Thermal Factor ASCE 7-16 Table 7.3-2**

$Risk_{category} = "IV"$ **Risk Category per ASCE 7-16 Table 1.5-1**

$I_s = 1.2$ **Snow Importance Factor ASCE 7-16 Table 1.5-2**

$p_g := 40psf$ **Ground Snow Loads ASCE 7-16 Figure 7.2-1**

$$p_f := \max\left(0.7 \cdot C_e \cdot C_t \cdot I_s \cdot p_g, \text{if}\left(p_g > 20psf, 20psf \cdot I_s, I_s \cdot p_g\right)\right) = 34 \cdot psf$$

Flat Roof Snow Loads ASCE 7-16 Equation 7.3-1 and § 7.3.4

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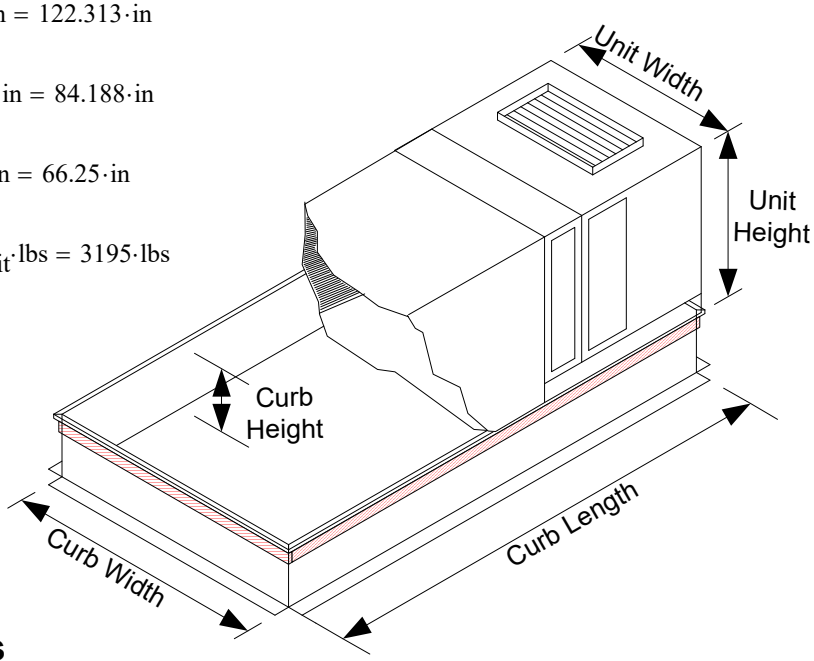
Mechanical Unit Dimensions Curb = "C-6010"

Length of Unit $L_{unit} := L_{unit} \cdot in = 122.313 \cdot in$

Width of Unit $W_{unit} := W_{unit} \cdot in = 84.188 \cdot in$

Height of Unit $H_{unit} := H_{unit} \cdot in = 66.25 \cdot in$

Weight of Unit $Wt_{unit} := Wt_{unit} \cdot lbs = 3195 \cdot lbs$



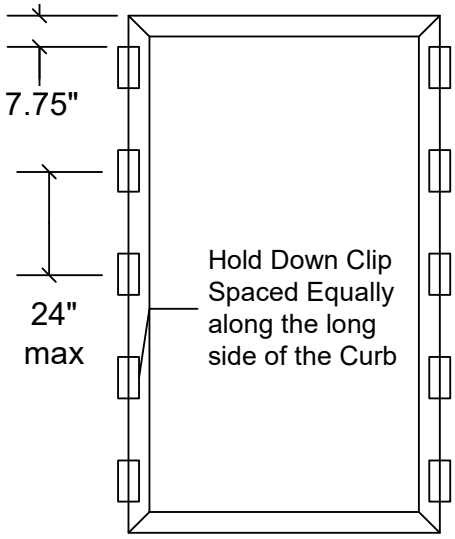
Roof Curb Dimensions

Length of Curb $L_{curb} := L_{curb} \cdot in = 113.188 \cdot in$

Width of Curb $W_{curb} := W_{curb} \cdot in = 77 \cdot in$

Height of Curb $H_{curb} := H_{curb} \cdot in = 48.5 \cdot in$

Weight of Curb $Wt_{curb} := Wt_{curb} \cdot lbs = 1239 \cdot lbs$



Curb Plan

Overall System Dimensions

Total Weight

$Wt_{tot} := Wt_{unit} + Wt_{curb} = 4402 \cdot lbs$

Total height

$H_{total} := H_{unit} + H_{curb} = 114.75 \cdot in$

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Seismic Loading + Snow Loading

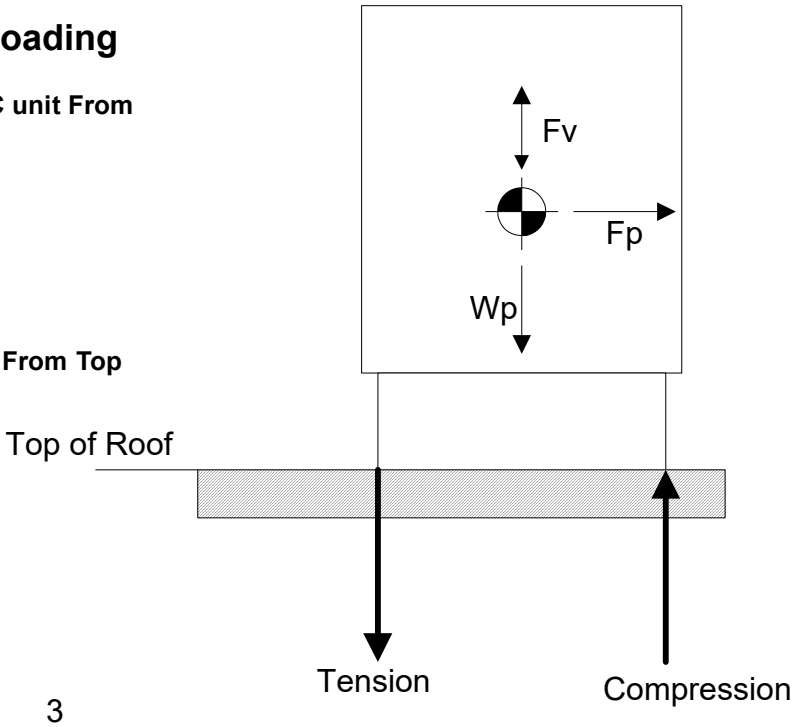
Height for Center of Gravity for HVAC unit From Top of Roof

$h_{CG.unit} := \frac{1}{2} H_{unit} = 33 \cdot in$

$h_{CG} := H_{curb} + h_{CG.unit} = 81.63 \cdot in$

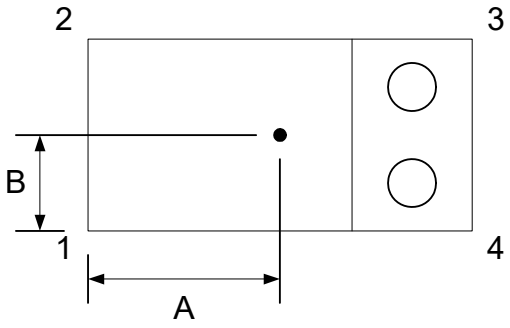
Height for Center of Gravity for Curb From Top of Roof

$h_{CG.curb} := \frac{H_{curb}}{2} = 24.25 \cdot in$



Max Seismic Base Shear

$V_{base.S} := F_p \cdot Wt_{tot} = 14857 \cdot lbs$



Unit C.G. distance in axis parallel to Curb Width $B_{ecc.width} := CG_{short} \cdot in = 36 \cdot in$

Eccentricity in axis parallel to Curb Width

$$e_{width} := \begin{cases} 0in & \text{if } B_{ecc.width} = \text{"N/A"} \\ \left| B_{ecc.width} - \frac{W_{unit}}{2} \right| & \text{otherwise} \end{cases} = 6.09 \cdot in$$

Unit C.G. distance in axis parallel to Curb Length $A_{ecc.length} := CG_{long} \cdot in = 58 \cdot in$

Eccentricity in axis parallel to Curb Length

$$e_{length} := \begin{cases} 0in & \text{if } A_{ecc.length} = \text{"N/A"} \\ \left| A_{ecc.length} - \frac{L_{unit}}{2} \right| & \text{otherwise} \end{cases} = 3.16 \cdot in$$

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Max Net Tension Reaction On Each Side Due To Seismic Loads

$$T_S := \begin{bmatrix} \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{W_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{W_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} \right] \\ \frac{(0.9 - F_v)\cdot Wt_{tot}}{2\cdot sides} - \left[\frac{F_p\cdot Wt_{unit}\cdot h_{CG}}{L_{curb}} + \frac{F_p\cdot Wt_{curb}\cdot h_{CG.curb}}{L_{curb}} + \frac{(0.9 - F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} \right] \end{bmatrix} = \begin{pmatrix} -11545 \\ -7382 \end{pmatrix}\cdot lbs$$

Max Net Compression Reaction On Each Side Due To Seismic Loads

$$C_S := \begin{bmatrix} \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{W_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{width}}{W_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \\ \frac{(1.2 + F_v)\cdot Wt_{tot}}{2\cdot sides} + \frac{F_p\cdot Wt_{tot}\cdot h_{CG}}{L_{curb}} + \frac{(1.2 + F_v)\cdot Wt_{unit}\cdot e_{length}}{L_{curb}} + 1.6\cdot\frac{p_f\cdot L_{unit}\cdot W_{unit}}{2\cdot sides} \end{bmatrix} = \begin{pmatrix} 21353 \\ 16072 \end{pmatrix}\cdot lbs$$

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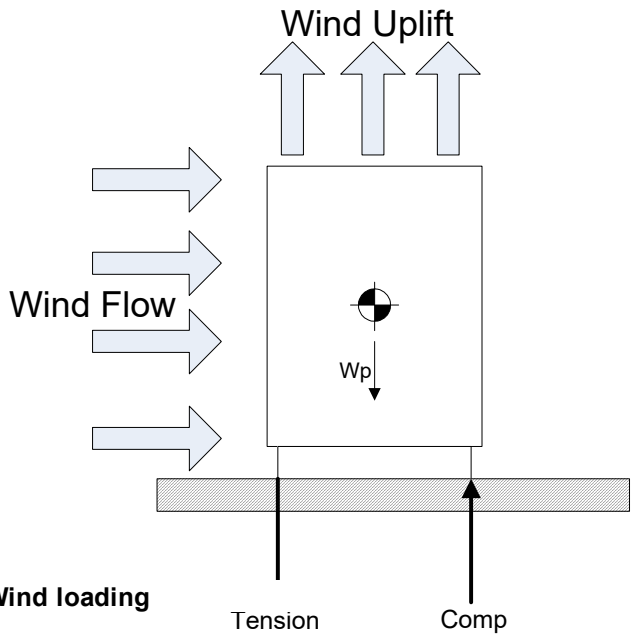
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Wind Loading + Snow Loading



Max Base Shear due to wind loading

$V_{base.W} := P_{net} \cdot L_{unit} \cdot H_{total} = 14026 \cdot lbs$

Max Uplift due to wind loading

$L_{unit.up} := L_{unit} - 0in = 122.313 \cdot in$

$P_{uplift.W} := P_v \cdot L_{unit.up} \cdot W_{unit} = 8124 \cdot lbs$

Max Net Tension Reaction On Each Side Due To Wind loading

$$T_W := \begin{pmatrix} \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} - \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \\ \frac{0.9Wt_{tot}}{2 \cdot sides} - \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} - \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} - \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} -12760 \\ -7055 \end{pmatrix} \cdot lbs$$

Max Net Compression Reaction On Each Side Due To Wind loading

$$C_W := \begin{pmatrix} \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{width}}{W_{curb}} + \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{total}^2}{2}}{W_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \\ \frac{1.2Wt_{tot}}{2 \cdot sides} + \frac{1.2 \cdot Wt_{unit} \cdot e_{length}}{L_{curb}} + \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{total}^2}{2}}{L_{curb}} + 1.6 \cdot \frac{p_f \cdot L_{unit} \cdot W_{unit}}{2 \cdot sides} \end{pmatrix} = \begin{pmatrix} 15318 \\ 9564 \end{pmatrix} \cdot lbs$$

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Governing Loading @ Curb

Max uplift vertical load along the length of the curb

$$\omega_{x.L.vert.up} := \frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}} = 1353 \cdot plf$$

Max compressive vertical load along the length of the curb

$$\omega_{x.L.vert.comp} := \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}} = 2264 \cdot plf$$

Max vertical load along the length of the curb

$$\omega_{x.L.vert} := \max\left(\omega_{x.L.vert.up}, \omega_{x.L.vert.comp}\right) = 2264 \cdot plf$$

Max uplift vertical load along the width of the curb

$$\omega_{x.W.vert.up} := \frac{\max\left[\left|T_{S_{(1)}}\right|, \left|T_{W_{(1)}}\right|\right]}{W_{curb}} = 1150 \cdot plf$$

Max compressive vertical load along the width of the curb

$$\omega_{x.W.vert.comp} := \frac{\max\left[\left|C_{S_{(1)}}\right|, \left|C_{W_{(1)}}\right|\right]}{W_{curb}} = 2505 \cdot plf$$

Max vertical loading along the width of the curb

$$\omega_{x.W.vert} := \max\left(\omega_{x.W.vert.up}, \omega_{x.W.vert.comp}\right) = 2505 \cdot plf$$

$$\begin{pmatrix} V_{base.S} \\ V_{base.W} \end{pmatrix} = \begin{pmatrix} 14857 \\ 14026 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} |T_S| \\ |C_S| \end{pmatrix} = \begin{pmatrix} 13703 \\ 26725 \end{pmatrix} \cdot lbs$$

$$\begin{pmatrix} F_v \cdot Wt_{tot} \\ P_v \cdot L_{unit} \cdot W_{unit} \end{pmatrix} = \begin{pmatrix} 1321 \\ 8124 \end{pmatrix} \cdot lbs \qquad \begin{pmatrix} |T_W| \\ |C_W| \end{pmatrix} = \begin{pmatrix} 14581 \\ 18059 \end{pmatrix} \cdot lbs$$

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Anchorage To Concrete [Expansion Anchor per ACI 318-14]

Number of connection on the long side

$N_B := 7 + 2$

Moment Arm for overturning (Short side)

$B := W_{curb} + 3in \cdot 2 = 83 \cdot in$

Number of Connection on the Short side.

$N_L := 5 + 2$

Moment Arm for over turning (Long side)

$L := L_{curb} + 3in \cdot 2 = 119 \cdot in$

Total Number of Connections

$N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 24$

Max Net Tension Reaction Due to Seismic Load, Fp

$$R_{c.EQ.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 16 \cdot lbs \qquad R_{c.EQ.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 7 \cdot lbs$$

$$R_{c.EQ} := MAX+\left[\begin{bmatrix}\left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{c.EQ.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{\Omega_0 \cdot F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{c.EQ.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}2527 \\ 2244\end{pmatrix} \cdot lbs$$

Max net Tension Reaction Due to Wind Load, Pnet

$$R_{c.W} := MAX+\left[\begin{bmatrix}\frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}1274 \\ 848\end{pmatrix} \cdot lbs$$

Governing Load Case:

$Govern := if\left(\left|R_{c.EQ}\right| > \left|R_{c.W}\right|, "Seismic", "Wind"\right) = "Seismic"$

Governing Tension Reaction at Each anchor Point:

$R_c := if\left(Govern = "Seismic", R_{c.EQ}, R_{c.W}\right) = \begin{pmatrix}2527 \\ 2244\end{pmatrix} \cdot lbs$

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Max Tension on anchor: $N_{ua} := \max(R_c) = 2527 \cdot lbs$

Max Shear on anchor: $V_{ua} := \frac{\max(\Omega_0 \cdot V_{base.S}, V_{base.W})}{N_t} = 1238 \cdot lbs$

Hilti Kwik Bolt TZ – Carbon Steel
5/8" Anchor with min 4" embedment
Base material: 6" thick Cracked concrete w/
Compressive strength fc' = 3000 psi
Min 6" away from the concrete edge
Evaluation Report: ICC-ESR 1917

Loading Condition:	**Seismic**

Design Tension Capacity [ϕN_n]:	3,631	[lbs]
Design Shear Capacity [ϕV_n]:	4,940	[lbs]

$\phi N_n := \phi N_n \cdot lbs = 3631 \cdot lbs$

$\phi V_n := \phi V_n \cdot lbs = 4940 \cdot lbs$

Utilization:

Tension Utilization:

$\beta_N := \frac{N_{ua}}{\phi N_n} = 70 \cdot \%$

Shear Utilization:

$\beta_V := \frac{V_{ua}}{\phi V_n} = 25 \cdot \%$

Interaction of Tensile and Shear Forces:
Per ACI 318-14 Sec. 17.6

$\beta_{NV} := \frac{(\beta_N) + (\beta_V)}{1.2} = 79 \cdot \%$

$$check\_interaction := \begin{pmatrix} if(\beta_N < 1.0, "OK", "NG") \\ if(\beta_V < 1.0, "OK", "NG") \\ if(\beta_{NV} < 1.0, "OK", "NG") \end{pmatrix} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

$$check\_interaction = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

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Anchorage To Structural Steel [Fillet Weld Conn. per AISI S100-16]

Fillet Weld 2" Long Along the Long and Short Side. Min 2 Connections per Side
Spacing: 48" O.C. for Non-Isolated Curbs; 24" for Isolated Curbs

Number of Welds on the Long Side $N_B := 6$

Moment Arm for Overturning (Short Side) $B := W_{curb} = 77 \cdot in$

Number of Welds on the Short Side. $N_L := 4$

Moment Arm for Overturning (Long Side) $L := L_{curb} = 113 \cdot in$

Total Number of Connections $N_t := \left[\left(N_B\right) + \left(N_L\right)\right] \cdot 2sides = 20$

Max Net Tension Reaction due to Seismic Load FP

$$R_{weld.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 25 \cdot lbs$$

$$R_{weld.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 13 \cdot lbs$$

$$R_{weld.EQ} := MAX+\left[\begin{bmatrix}\left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{weld.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{weld.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}2012 \\ 2044\end{pmatrix} \cdot lbs$$

Max Net Tension Reaction due to Wind Load Pnet

$$R_{weld.W} := MAX+\left[\begin{bmatrix}\frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{\left(L \cdot N_L\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}1988 \\ 1452\end{pmatrix} \cdot lbs$$

Tension Design Force; SRSS for Loading from Each Direction $T_{u.weld} := \max\left(\left|R_{weld.EQ}\right|, \left|R_{weld.W}\right|\right) = 2868 \cdot lbs$

Shear Load at Each Weld Connection $V_{u.weld} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{N_t} = 743 \cdot lbs$

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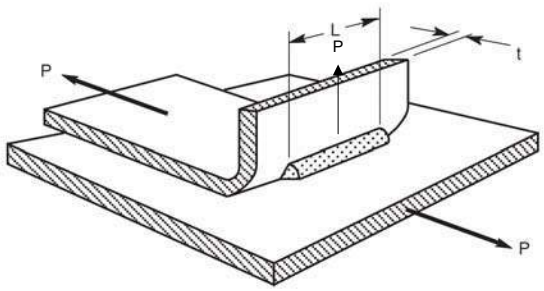
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Total Demand: SRSS of V and T

$$R_{u.weld} := \sqrt{T_{u.weld}^2 + V_{u.weld}^2} = 2963 \cdot lbs$$

Fillet Weld Design per AISI S100-16 Section J2.5

Weld Length at Each Connection Point $L_w := 2in$



Effective Throat Fillet Weld Size

$$t_w := \left(\frac{1}{8}in\right) \cdot 0.707 = 0.088 \cdot in$$

Thickness for the Thinnest Martial Being Welded
Min Curb Thickness = 16GA with Fu=65 ksi

$t_1 := thick("12GA") = 0.1084 \cdot in$

$F_u := 65ksi$

Min weld material strength

$F_{exx} := 70ksi$

For Longitudinal Loading [Parallel capacity is considered to be loading in the direction of the length of the weld] per (Eq. J2.5-1) &(Eq. J2.5-2)

$$\phi P_{long} := \begin{cases} (0.6)\left(1 - \frac{0.01 \cdot L_w}{t_1}\right) \cdot L_w \cdot t_1 \cdot F_u & \text{if } \frac{L_w}{t_1} < 25 \\ (0.5) \cdot 0.75 \cdot t_1 \cdot L_w \cdot F_u & \text{otherwise} \end{cases} = 6895 \cdot lbs$$

where $L_w \div t_1 = 18$

For Transverse Loading per (Eq. J2.5-5)

$$\phi P_{trans} := (0.65) \cdot t_1 \cdot L_w \cdot F_u = 9160 \cdot lbs$$

Strength of Weld Material per (Eq. J2.5-7)

$$\phi P_{weld} := (0.6) \cdot 0.75 \cdot t_w \cdot L_w \cdot F_{exx} = 5568 \cdot lbs$$

Design Strength of Fillet Weld

$$\phi P_n := \min\left(\phi P_{long}, \phi P_{trans}, \phi P_{weld}\right) = 5568 \cdot lbs$$

D/C Ratio for the Welded Connection

$$\beta_{NW} := \frac{R_{u.weld}}{\phi P_n} = 53 \cdot \%$$

$weld_{check} := if\left(\beta_{NW} < 1.0, "OK", "NG"\right)$

$weld_{check} = "OK"$

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Anchorage To Wood Member WITH Lag Screws [NDS-2018 LRFD Strength Design]

*** Use 3/8" Lag Screws along Each Side of the Curb**
*** Assume G=0.5 Douglas Fir-Larch**

Wood Lag Screw Capacity per NDS 2018 Section 11.3

Wet Service Factor: $Cond := "DRY"$ **(e.g. CA = "DRY", AK = "WET")**

$$C_M := \begin{cases} 1.0 & \text{if } Cond = "DRY" \\ 0.7 & \text{if } Cond = "WET" \end{cases} = 1$$ **NDS 2018 Table 11.3.3**

Temperature Factor:
$$C_t := \begin{cases} 0.8 & \text{if } Cond = "DRY" \\ 0.7 & \text{if } Cond = "WET" \end{cases} = 0.8$$ **NDS 2018 Table 11.3.4**

Group Action Factor: $C_g := 0.97$ **NDS 2018 Table 11.3.6C**

Geometry Factor: $C_\Delta := 1.0$ **NDS 2018 Table 12.5.1A,B**

End Grain Factor: $C_{eg} := 1.0$ **NDS 2018 Sec. 12.5.2**

Diaphragm Factor: $C_{di} := 1.0$ **NDS 2018 Sec. 12.5.3**

Toe-Nail Factor: $C_{tn} := 1.0$ **NDS 2018 Sec. 12.5.4**

Format Conversion Factor: $K_F := 3.32$ **NDS 2018 Table 11.3.1**

Resistance Factor: $\phi := 0.65$ **NDS 2018 Table 11.3.1**

Time Effect Factor: $\lambda := 1.0$ **NDS 2018 App N.3.3**

Lateral Design Value: $Z := 130lbs$ **NDS 2018 Table 12K**

Withdrawal Design Value: $W := 305lbs$ **NDS 2018 Table 12.2A**

Lag Screw Diameter: $D_{lag} := \frac{3}{8}in$

Lag Screw Length: $L_{lag} := 4in$

Length of Tapered Tip: $E_{lag} := \frac{7}{32}in$

Lag Screw Penetration: $P_{lag} := 3.78125in$

Eff. Lag Screw Penetration for withdrawal: $P_{\omega.lag} := 2in + \frac{9}{32}in = 2.28 \cdot in$ **NDS 2018 Appx. Table L2**

NDS 2018 Sec. 12.1.4.6

Minimum Penetration DCR <1.0: $DCR_{min.penetration} := \frac{4 \cdot D_{lag}}{P_{\omega.lag}} = 0.66$ $DCR_{min.penetration} = "OK"$

Adj. Lateral Design Value: $Z' := Z \cdot C_M \cdot C_t \cdot C_g \cdot C_\Delta \cdot C_{eg} \cdot C_{di} \cdot C_{tn} \cdot K_F \cdot \phi \cdot \lambda = 218 \cdot lbs$

Adj. Withdrawal Design Value: $W' := W \cdot C_M^{\,2} \cdot C_t \cdot C_{eg} \cdot C_{tn} \cdot K_F \cdot \phi \cdot \lambda = 527 \cdot lbs$ **NDS 2018 Table 11.3.1**

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Number of Lag Screws on the Long Side $N_B := 28 + 2$

Moment Arm for Overturning (Short Side) $B := W_{curb} = 77 \cdot in$

Number of Lag Screws on the Short Side $N_L := 19 + 2$

Moment Arm for Overturning (Long Side) $L := L_{curb} = 113 \cdot in$

Total Number of Lag Screws $N_t := \left[\left(N_B - 2\right) + \left(N_L - 2\right)\right] \cdot 2sides = 94$

Max net Tension Reaction due to Seismic, Fp

$$R_{lag.e.width} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} = 5 \cdot lbs$$

$$R_{lag.e.length} := \frac{\left(0.9 - F_v\right) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} = 3 \cdot lbs$$

$$R_{lag.EQ} := MAX+\left[\begin{bmatrix} \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{B \cdot N_B} + R_{lag.e.width}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \\ \left[\frac{F_p \cdot \left(Wt_{unit} \cdot h_{CG} + Wt_{curb} \cdot h_{CG.curb}\right)}{L \cdot N_L} + R_{lag.e.length}\right] - \frac{\left(0.9 - F_v\right) \cdot Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 401 \\ 386 \end{pmatrix} \cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$R_{lag.W} := MAX+\left[\begin{bmatrix} \frac{P_{net} \cdot L_{unit} \cdot H_{total}^{\,2}}{\left(B \cdot N_B\right) \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{tot}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot H_{total}^{\,2}}{L \cdot N_L \cdot 2} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{tot}}{N_t} \end{bmatrix}\right] = \begin{pmatrix} 400 \\ 281 \end{pmatrix} \cdot lbs$$

Tension Design force; SRSS for loading from Each direction $T_{lag} := \max\left(\left|R_{lag.EQ}\right|, \left|R_{lag.W}\right|\right) = 557 \cdot lbs$

Shear load at each anchor location $V_{lag} := \frac{\max\left(V_{base.S} \cdot \sqrt{2}, V_{base.W}\right)}{N_t} = 224 \cdot lbs$

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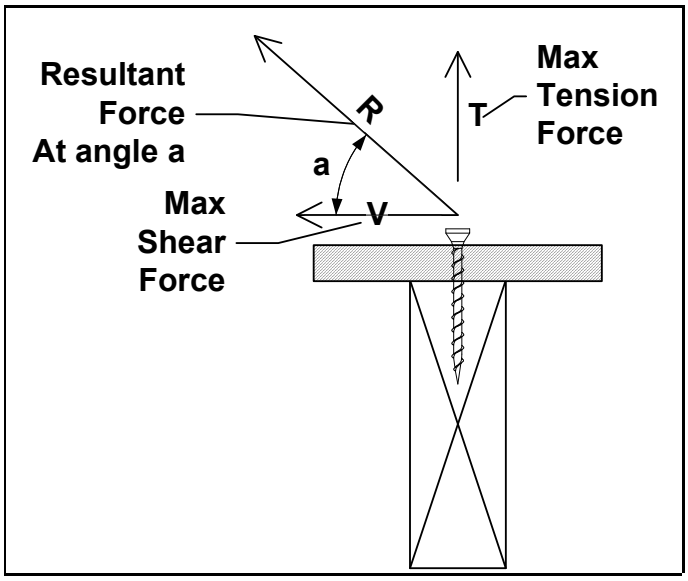
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For Lag Screws Subjected to Combined Lateral and Withdrawal Loading; Design Strength of the Lag Screw Shall Be Adjusted per Hankinson Formula as Prescribed by NDS 2018 Equation 12.4-1



Angle Between Wood Surface and Direction of Resultant Applied Load

$$(\alpha) := \operatorname{atan}\left(\frac{T_{lag}}{V_{lag}}\right) = 68\cdot\text{deg}$$

Combined Demand per Lag Screw @ Strength Level

$$R_{lag} := \sqrt{T_{lag}^{2} + V_{lag}^{2}} = 600\cdot\text{lbs}$$

Adjusted Capacity per NDS 2018 Equation 12.4-1 @ Strength Level

$$Z'_{\alpha} := \frac{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot Z'}{\left(W'\cdot\frac{P_{\omega.lag}}{in}\right)\cdot\cos(\alpha)^{2} + Z'\cdot\sin(\alpha)^{2}} = 738\cdot\text{lbs}$$

D/C Ratio for the Lag Screw connection to Wood Structure

$$\beta_{Lag} := \frac{R_{lag}}{Z'_{\alpha}} = 81\cdot\%$$

$$\text{Lag}_{Screw.Check} := \text{if}\left(\beta_{Lag} < 1.0, \text{"OK"}, \text{"NG"}\right)$$

$\text{Lag}_{Screw.Check} = \text{"OK"}$

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Bearing and Tilting in Curb Bolted Connection AISI S100-16

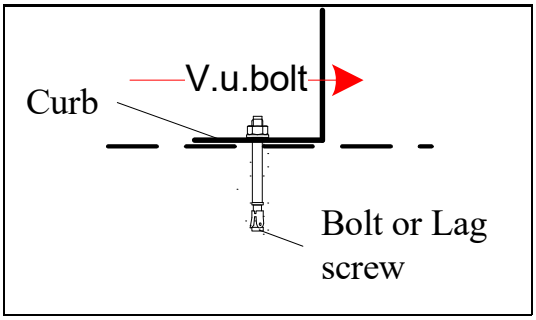
Nominal bolt diameter $d := 0.5in$

Uncoated sheet thickness $t_{curb} := thick("12GA") = 0.108 \cdot in$

Tensile strength of sheet $F_u := 65ksi$

Coefficient for conversion of units $\alpha := 1.0$

Modification Factor $m_f := 1.0$



Modification factor for type of bearing connection, per Table J3.3.1-2; For single shear connection with washers

Bearing Factor $C := \begin{cases} 3 \text{ if } \left(\frac{d}{t_{curb}} < 10\right) \wedge \left(0.024in < t_{curb} < 0.1875in\right) = 3 \\ "NG" \text{ if } \frac{d}{t_{curb}} > 10 \end{cases}$

Bearing factor, which shall be determined according to Table J3.3.1-1 For d/t<10 where $d \div t_{curb} = 5$

Bearing Design Strength per AISI S100-16 Eq. J3.3.1-1

$$\phi P_{n_{(0)}} := (0.6) \cdot \left(m_f \cdot C \cdot d \cdot t_{curb} \cdot F_u\right) = 6341 \cdot lbs$$

Bolt Hole Deformation Design Strength per AISI S100-16 Eq. J3.3.2-1

$$\phi P_{n_{(1)}} := (0.65) \cdot \left[4.64 \cdot \left(\frac{\alpha}{in}\right) \cdot t_{curb} + 1.53\right] \cdot d \cdot t_{curb} \cdot F_u = 4655 \cdot lbs$$

Curb Connection Shear Capacity $\phi P_n := \min\left(\phi P_n\right) = 4655 \cdot lbs$

Loading demand at connection $V_{u.bolt} := \frac{\max\left(V_{base.S}, V_{base.W}\right)}{6} = 2476 \cdot lbs$

$Curb\_Conn\_Shear := \text{if}\left(V_{u.bolt} < \phi P_n, "OK", "NG"\right)$ Curb_Conn_Shear = "OK"

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Thickness of Curb, ISO Rail and Clip

(Per AISC Table 17-10 Galvanized)

Hold Down Clip thickness

$t_{Clip} := "12GA"$ $t_{clip} := thick(t_{Clip}) = 0.1084 \cdot in$

Roof Curb thickness

$t_{Curb} := "12GA"$ $t_{curb} := thick(t_{Curb}) = 0.1084 \cdot in$

ISO RAIL thickness

$t_{Curb.iso} := "10GA"$ $t_{curb.iso} := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Note: Iso Rail thickness is only used if the curb is isolated. Not used for non-isolated curbs

Sheet Metal Screws (SMS) Equations and References

SMS properties (ESR-2196 Table 5)

$SMS_{Table} =$

"SMS"	"Diameter"	"HeadDiameter"	"Tension"	"Shear"
"Size"	"d"	"dw"	"Pts"	"Pss"
"#8"	0.164	0.335	1000	1170
"#10"	0.19	0.399	1370	1215
"#12"	0.216	0.415	2325	1880
"#14"	0.25	0.5	4580	2440

SMS Tension Eqns

$P_{not} = 0.85 \cdot t \cdot d \cdot F_u$ **(AISI S100-16 J4.4.1 & J4.4.2)**

$P_{nov} = 1.5 \cdot t \cdot d_w \cdot F_u$ **FOR THE MOST CASES, PULL-OUT CAPACITY IS THE LOWEST**

$P_{nts} = 0.8 \cdot P_{ts}$

SMS Shearn Eqns

$P_{vnot} = 4.2 \cdot \sqrt{(d \cdot t^3)} \cdot F_u$ **(AISI S100-16 J4.3.1)**

$P_{vnov} = 2.7 \cdot t \cdot d \cdot F_u$

$P_{vnss} = 0.8 \cdot P_{ss}$

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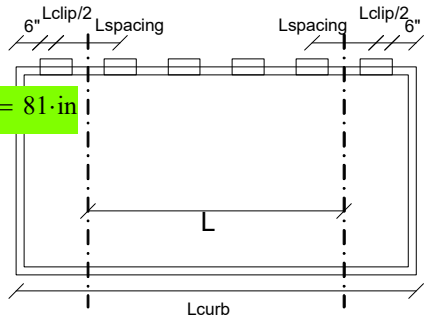
Hold Down Clip Design (Connection of the Mechanical unit to Curb)

Number of Clips on the long side $N_B := 6$

Moment Arm for overturning (Short side) $B := W_{curb} + 1.75in \cdot 2 = 81 \cdot in$

Number of Clips on the Short side. $N_L := 6$

Width of Clips $L_{clip} := 9in$



Curb Centerline Spacing (Long side)

$$L_{spacing} := \frac{L_{curb} - \left(6in + \frac{L_{clip}}{2}\right) \cdot 2}{N_B - 1} = 18.438 \cdot in$$

Moment Arm for overturning (Long side)

$$L := L_{curb} - 2 \cdot \left[6in + \frac{L_{clip}}{2} + L_{spacing} \cdot \frac{(N_L - 2)}{4}\right] = 55.313 \cdot in$$

Total Number of Clips

$$N_t := (N_B) \cdot 2sides = 12$$

Max net Tension Reaction due to Seismic, Fp

$$R_{clip.EQ} := MAX+\left[\begin{array}{l} \left[\frac{F_p \cdot Wt_{unit}}{B \cdot N_B} \cdot h_{CG.unit} + \frac{(0.9 - F_v) \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B}\right] - \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} \\ \left[\frac{F_p \cdot Wt_{unit}}{L \cdot N_L} \cdot h_{CG.unit} + \frac{(0.9 - F_v) \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L}\right] - \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} \end{array}\right] = \begin{pmatrix} 604 \\ 935 \end{pmatrix} \cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$R_{clip.W} := MAX+\left(\begin{array}{l} \frac{P_{net} \cdot L_{unit} \cdot \frac{H_{unit}^2}{2}}{B \cdot N_B} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{0.9 Wt_{unit}}{N_t} \\ \frac{P_{net} \cdot W_{unit} \cdot \frac{H_{unit}^2}{2}}{L \cdot N_L} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{0.9 \cdot Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{0.9 Wt_{unit}}{N_t} \end{array}\right) = \begin{pmatrix} 1029 \\ 1021 \end{pmatrix} \cdot lbs$$

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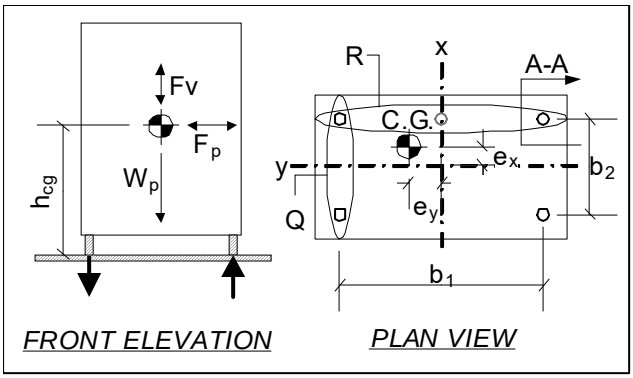
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Tensile and Shear Load calculation per ASHRAE RP-812



Eccentricity along X-X

$e_x := e_{width} = 6.094 \cdot in$

Eccentricity along Y-Y

$e_y := e_{length} = 3.157 \cdot in$

Distance between Seismic Restraints Along Y-Y

$b_1 := L_{curb} - 2 \cdot 6in = 101 \cdot in$

Distance between Seismic Restraints Along X-X

$b_2 := W_{curb} = 77 \cdot in$

Moment of Inertia about X-X

$$I_{xx} := \frac{N_t \cdot (N_t + 2) \cdot (b_1)^2}{12 \cdot (N_t - 2)} = 14335 \cdot in^2$$

Moment of Inertia about Y-Y

$$I_{yy} := \frac{N_t \cdot (b_2)^2}{4} = 17787 \cdot in^2$$

Angle about Tensile Load

$$\Theta_t := \operatorname{atan}\left[\frac{I_{yy} \cdot (b_1)}{I_{xx} \cdot (b_2)}\right] = 58 \cdot deg$$

Angle about Shear Load

$$\Theta_s := \begin{cases} \operatorname{atan}\left(\frac{e_x}{e_y}\right) & \text{if } e_y \neq 0 \\ 0deg & \text{if } e_y = 0 \end{cases} = 63 \cdot deg$$

Max Net Tensile Load Due to Seismic Load, Fp

$$T_{U.EQ.pt1} := \frac{(0.9 - F_v) \cdot Wt_{unit}}{N_t} - \frac{(0.9 - F_v) \cdot Wt_{unit}}{b_1 \cdot b_2} \cdot \left(\frac{b_1}{2} \cdot e_x + \frac{b_2}{2} \cdot e_y - e_x \cdot e_y\right) = 59 \cdot lbs$$

$$T_{U.EQ.pt2} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \cos(\Theta_t) \cdot \frac{0.5 \cdot b_2}{I_{yy}} = -404 \cdot lbs$$

$$T_{U.EQ.pt3} := -F_p \cdot \left[Wt_{unit} \cdot (h_{CG.unit})\right] \cdot \sin(\Theta_t) \cdot \frac{0.5 \cdot b_1}{I_{xx}} = -1075 \cdot lbs$$

$T_{U.EQ} := T_{U.EQ.pt1} + T_{U.EQ.pt2} + T_{U.EQ.pt3} = -1420 \cdot lbs$

Max Net Shear Load Due to Seismic Load, Fp

$$V_{Ux.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\cos(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_2 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_1 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 524 \cdot lbs$$

$$V_{Uy.EQ} := F_p \cdot Wt_{unit} \cdot \frac{\sin(\Theta_s)}{N_t} + \frac{F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_1 \cdot e_y + F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_2 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 893 \cdot lbs$$

$$V_{U.EQ} := \sqrt{V_{Ux.EQ}^2 + V_{Uy.EQ}^2} = 1035 \cdot lbs$$

Tension Design force for Hold Down Clips

$T_{clip} := \max(R_{clip.W_0}, R_{clip.W_1}, |R_{clip.EQ}|, |T_{U.EQ}|) = 1420 \cdot lbs$

$|R_{clip.EQ}| = 1113 \cdot lbs$ $|T_{U.EQ}| = 1420 \cdot lbs$

$T_{clip.EQ.max} := \max(|R_{clip.EQ}|, |T_{U.EQ}|) = 1420 \cdot lbs$

$T_{clip.W.max} := \max(R_{clip.W_0}, R_{clip.W_1}) = 1029 \cdot lbs$

Based on ASCE 7-16 Figure 29.4-1 magnitude of force coefficient,

Wind in diagonal direction to the face of equipment produces less force than that of the wind in perpendicular direction to the face of the equipment. Therefore, wind in diagonal direction does not need to be used

Shear Design force for Hold Down Clips

$$V_{clip} := \max\left(\frac{\max(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit})}{N_t}, |V_{U.EQ}|\right) = 1035 \cdot lbs$$

$F_p \cdot Wt_{unit} \cdot \frac{1}{N_t} = 899 \cdot lbs$ $|V_{U.EQ}| = 1035 \cdot lbs$

$P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t} = 675 \cdot lbs$

$V_{clip.EQ.max} := \max\left[\left(F_p \cdot Wt_{unit} \cdot \frac{1}{N_t}\right), |V_{U.EQ}|\right] = 1035 \cdot lbs$

$V_{clip.W.max} := \max\left(\left(P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t}\right)\right) = 675 \cdot lbs$

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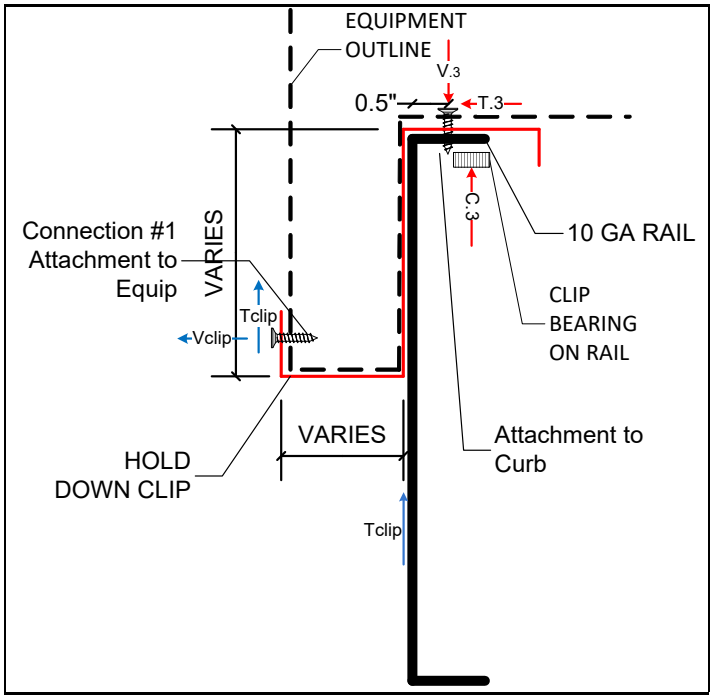
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Loading at Hold Down Clips @ Isolator Curb

$b_{return.iso} := Clip_b \cdot in = 2.125 \cdot in$

$b_{depth.iso} := Clip_c \cdot in = 6 \cdot in$



*For Reference Only

Mu Bending moment in the hold down

$M_u := T_{clip} \cdot b_{return.iso} = 3018 \cdot in \cdot lbs$

Resolve bending moment a T/C couple
Assume 0.5" bearing length
Moment Arm for T/C couple

$d_{T/C} := 1in - 0.5in = 0.5 \cdot in$

V3 is acting as shear on the screws. due to eccentricity of Tension force T

$$V_3 := \frac{T_{clip} \cdot \left[b_{return.iso} + (0) \right]}{d_{T/C}} = 6036 \cdot lbs$$

Additional load from Direct Shear acting out of plane (SRSS)

$V_3 := \sqrt{V_3^{\,2} + V_{clip}^{\,2}} = 6124 \cdot lbs$

Reaction C3 [compression force] is resisted by bearing of the hold down on the curb lip. Assume 0.5" bearing length

$C_3 := V_3 - T_{clip} = 4704 \cdot lbs$

T3 Load due to the shear acting out of plane tension on the screws.

$$T_3 := \left(\max\left(\frac{T_{clip} \cdot b_{return.iso}}{b_{depth.iso}}, V_{clip} \right) \right) = 1035 \cdot lbs$$

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Check Bending in Clip @ Isolator Curb

There are several restraints that prevents the hold down clip for iso-curb to have local bending at the bottom and transfer vertical load demand directly to the face of the curb.

- Hold down is bearing on the face of iso-rail / non-iso curb lip.
- Gasket will act as a "link" member to allow unit base rail and bottom flange to move totegther so flange can't bend unless the unit base rail bends first. However, unit base rail is not likely to bend so bottom flange won't bend

Hold Down Clip thickness

$t_{Clip} = \text{"12GA"}$ $t_{clip} := \text{thick}(t_{Clip}) = 0.1084 \cdot in$

Effective width of hold down clip

$b_c := L_{clip} = 9 \cdot in$

Yield strength of the Clip

$F_{y.c} := 50ksi$

Strength reduction for bending

$\phi_{clip} := 0.9$

Design Bending Capacity (LRFD)

$\phi M_n := \phi_{clip} \cdot F_{y.c} \left(\frac{b_c \cdot t_{clip}^2}{6} \right) = 793 \cdot in \cdot lbs$

Flexural bending demand

$M_{u.clip} := T_{clip} \cdot 0.5in = 710 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.clip}}{\phi M_n} = 0.895$

$Clip_{Bending} = \text{"OK"}$

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Check Flange Bending in Clip @ Isolator Curb

Note:
- **If the curb flange is welded to the 10GA channel and 10GA channel is welded back to the base of the curb, then both tension and compression due to equipment overturning will be taken care by the 10GA channel.**
- **Since the curb will be reinforced with 10GA channel under each isolator, it can be assumed that the loads will trasnferred down to the base structure through the channels. Therefore, flange downward bending at curb due to compressive load does not need to be checked.**

Roof Curb thickness

$t_{Curb} = \text{"12GA"}$ $t_{curb} := thick(t_{Curb}) = 0.1084 \cdot in$

Clip edge to edge distance

$$b_{edge2edge} := \frac{L_{curb} - \left(6in + \frac{L_{clip}}{2}\right) \cdot 2}{N_B - 1} - L_{clip} = 9.438 \cdot in$$

Effective width of Roof Curb

$b_{curb} := L_{clip} + b_{edge2edge} = 18.44 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\frac{b_{curb} \cdot (t_{curb})^2}{6}\right] = 1625 \cdot in \cdot lbs$$

Width of Isolator

$w_{JQ.iso} := 2in$ **2 in. for CQAs**

Flexural bending demand

$$M_{u.Curb} := T_{clip} \cdot \left(\max\left(\frac{1.75in}{2} - 0.5in, \frac{w_{JQ.iso}}{2} - 1in\right)\right) = 533 \cdot in \cdot lbs$$

D/C Ratio for bending

$$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.328$$

$Curb_{Bending} = \text{"OK, Weld 10GA channel ends to curb flange"}$

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Design of Connection#1 Connection of Equipment to hold Down clip

Ultimate SMS screw connection Strength (LRFD)
Strength based on the smallest thickness of Curb and Equipment Housing (min 16 GA) [Fy = 50ksi & Fu=65ksi]

$n_{sms} := 4$ $Size_{ss} := "\#14"$

$t_{ss} := "16GA"$ $F_{u.ss} := 65ksi$

Nominal Tension Strength

$P_{nt} := n_{sms} \cdot T_s(Size_{ss}, t_{ss}, F_{u.ss}) = 3508 \cdot lbs$

$P_{not} := n_{sms} \cdot T_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 3508 \cdot lbs$

$P_{nov} := n_{sms} \cdot T_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 12383 \cdot lbs$

$P_{nts} := n_{sms} \cdot T_{nts}(Size_{ss}, t_{ss}, F_{u.ss}) = 14656 \cdot lbs$

Nominal Shear Strength

$P_{ns} := n_{sms} \cdot V_s(Size_{ss}, t_{ss}, F_{u.ss}) = 7808 \cdot lbs$

$P_{vnot} := n_{sms} \cdot V_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 8737 \cdot lbs$

$P_{vnov} := n_{sms} \cdot V_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 11144 \cdot lbs$

$P_{vnss} := n_{sms} \cdot V_{nss}(Size_{ss}, t_{ss}, F_{u.ss}) = 7808 \cdot lbs$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} V_{clip} \div (\phi_{sms} \cdot P_{nt}) \\ T_{clip} \div (\phi_{sms} \cdot P_{ns}) \end{bmatrix} = \begin{pmatrix} 59 \\ 36 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left[\begin{bmatrix} \left[\frac{T_{clip}}{P_{vnov}} + 0.71\left(\frac{V_{clip}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{T_{clip}}{P_{vnot}} + \left(\frac{V_{clip}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{T_{clip}}{P_{vnss}} + \left(\frac{V_{clip}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right] = 66 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

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Design of Connection#2 Connection of hold Down clip to Curb

Tension loads on SMS connection

$T_{s2} := V_3 = 6124 \cdot lbs$

Shear loads on SMS connection

$V_{s2} := T_3 = 1035 \cdot lbs$

Ultimate SMS screw connection Strength (LRFD)
Strength based on the smallest thickness of Curb and Equipment Housing (min 16 GA) [Fy = 50ksi & Fu=65ksi]

$n_{sms} := 8$ $Size_{ss} := "\#14"$

$t_{ss} := (t_{Curb.iso}) = "10GA"$ $F_{u.ss} := 65ksi$

Nominal Tension Strength

$P_{nt} := n_{sms} \cdot T_s(Size_{ss}, t_{ss}, F_{u.ss}) = 15271 \cdot lbs$

Note:
SMS is getting pulled up so the thicker curb iso rail is engaged for SMS capacity , rather than just the clip itself.

$P_{not} := n_{sms} \cdot T_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 15271 \cdot lbs$

$P_{nov} := n_{sms} \cdot T_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 53898 \cdot lbs$

$P_{nts} := n_{sms} \cdot T_{nts}(Size_{ss}, t_{ss}, F_{u.ss}) = 29312 \cdot lbs$

Nominal Shear Strength

$P_{ns} := n_{sms} \cdot V_s(Size_{ss}, t_{ss}, F_{u.ss}) = 15616 \cdot lbs$

$P_{vnot} := n_{sms} \cdot V_{not}(Size_{ss}, t_{ss}, F_{u.ss}) = 56103 \cdot lbs$

$P_{vnov} := n_{sms} \cdot V_{nov}(Size_{ss}, t_{ss}, F_{u.ss}) = 48508 \cdot lbs$

$P_{vnss} := n_{sms} \cdot V_{nss}(Size_{ss}, t_{ss}, F_{u.ss}) = 15616 \cdot lbs$

Tension and Shear Strength Check

$$\begin{pmatrix} \beta_{ts} \\ \beta_{ss} \end{pmatrix} := \begin{bmatrix} T_{s2} \div (\phi_{sms} \cdot P_{nt}) \\ V_{s2} \div (\phi_{sms} \cdot P_{ns}) \end{bmatrix} = \begin{pmatrix} 80 \\ 13 \end{pmatrix} \cdot \%$$

D/C Ratio for the Screw connection to Deck for combined Tension and Shear Loads per AISI S100-16 J.4.5.1, J.4.5.2, J.4.5.3

$$\beta_{SMS} := \max\left[\begin{bmatrix} \left[\frac{V_{s2}}{P_{vnov}} + 0.71\left(\frac{T_{s2}}{P_{nov}}\right)\right] \div (1.1 \cdot 0.65) \\ \left[\frac{V_{s2}}{P_{vnot}} + \left(\frac{T_{s2}}{P_{not}}\right)\right] \div (1.15 \cdot 0.6) \\ \left[\frac{V_{s2}}{P_{vnss}} + \left(\frac{T_{s2}}{P_{nts}}\right)\right] \div (1.3 \cdot 0.5) \end{bmatrix}\right] = 61 \cdot \%$$

$$Deck\_Screw_{Check} = \begin{pmatrix} "OK" \\ "OK" \\ "OK" \end{pmatrix}$$

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Hold Down clip Bending and Shear Interaction

Diameter of SMS:

$$d_{sms} := \text{vlookup}\left(Size_{ss}, SMS_{Table}, 1\right)_0 \cdot in = 0.25 \cdot in$$

Depth of flat web portion

$$h_{clip.shear} := L_{clip} - n_{sms} \cdot d_{sms} = 7 \cdot in$$

Depth-to-Thickness Ratio:

$$\frac{h_{clip.shear}}{t_{clip}} = 65 \qquad E := 29500ksi \qquad F_y := 50ksi \qquad \mu := 0.3$$

Nominal Shear Stress:
(For unreinforced web)
AISI S100-16 G2.1

$$k_v := 5.34 \qquad \sqrt{\frac{E \cdot k_v}{F_y}} = 56 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 85$$

Area of Web Element:

$$A_w := h_{clip.shear} \cdot t_{clip} = 0.759 \cdot in^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h_{clip.shear}}{t_{clip}}\right)^2} = 34.1 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} \qquad V_y := 0.6 \cdot A_w \cdot F_y = 23\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.937$$

Hole Shear Reduction Factor:
(for circular holes, AISI S100-16 Eq G3-1)

$$c := \frac{h_{clip.shear}}{2} - \frac{d_{sms}}{2.83} = 3.41 \cdot in$$

$$q_s := \begin{cases} 1.0 & \text{if } \frac{c}{t_{clip}} \geq 54 \\ \frac{c}{54 \cdot t_{clip}} & \text{if } 5 \leq \frac{c}{t_{clip}} < 54 \end{cases} = 0.583$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \leq 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \leq 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 19.792 \cdot kip$$

Design Shear Capacity with holes:

$$\phi V_{n.clip} := 0.95 \cdot V_n \cdot q_s = 11 \cdot kip$$

D/C Ratio of V and M per AISI S100-16 Eq H2-1

$$DCR_{V.M.int.clip} := \sqrt{\left(\frac{M_{u.clip}}{\phi M_n}\right)^2 + \left(\frac{\max\left(T_{clip}, V_{clip}\right)}{\phi V_{n.clip}}\right)^2} = 0.9046$$

Demand/Capacity Ratio:

$VandM_{int.clip} = \text{"OK"}$

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ISOLATOR DESIGN [PER OPM-0401-13]

OPM-0401-13 is based on allowable stress design

Number of isolators on the long side

$N_B := 8$ $N_{iso.long} := N_B = 8$

Moment Arm for overturning (Short side)

$B := W_{curb} + \frac{1.75in}{2} \cdot 2 = 79 \cdot in$

Number of isolators on the Short side.

$N_L := 6$

Isolator Centerline Spacing (Long side)

$L_{spacing.iso} := \frac{L_{curb} - (6in) \cdot 2}{N_B - 1} = 14.46 \cdot in$

Moment Arm for overturning (Long side)

$L := L_{curb} - 2 \cdot 6in - 2 \cdot L_{spacing.iso} \cdot \frac{(N_L - 2)}{4} = 72 \cdot in$

Total Number of isolators

$N_t := (N_B) \cdot 2sides = 16$

Max net Tension Reaction due to Seismic, Fp

$EQ_{ASD} := \left[0.6 - (0.7 \cdot F_v)\right] \cdot Wt_{unit} = 1.246\ kip$

$$R_{iso.EQ} := MAX+\left[\begin{bmatrix}\left[\frac{(0.7F_p) \cdot Wt_{unit}}{B \cdot N_B} \cdot (h_{CG.unit} + 0in) + \frac{EQ_{ASD} \cdot e_{width}}{B \cdot N_B}\right] - \frac{EQ_{ASD}}{N_t} \\ \left[\frac{(0.7F_p) \cdot Wt_{unit}}{L \cdot N_L} \cdot (h_{CG.unit} + 0in) + \frac{EQ_{ASD} \cdot e_{length}}{L \cdot N_L}\right] - \frac{EQ_{ASD}}{N_t}\end{bmatrix}\right] = \begin{pmatrix}331 \\ 508\end{pmatrix} \cdot lbs$$

Max net Tension Reaction due to Wind load, Pnet

$$F_{wind.B} := \frac{P_{net} \cdot L_{unit} \cdot (H_{unit} + 0in)}{B \cdot N_B} \cdot \left(\frac{1}{2} \cdot H_{unit} + 0in\right) = 426 \cdot lbs$$

$$F_{wind.L} := \frac{P_{net} \cdot W_{unit} \cdot (H_{unit} + 0in)}{L \cdot N_L} \cdot \left(\frac{1}{2} \cdot H_{unit} + 0in\right) = 426 \cdot lbs$$

$$R_{iso.W} := (0.6) \cdot MAX+\left(\begin{pmatrix}F_{wind.B} + \frac{P_v \cdot L_{unit.up} \cdot W_{unit}}{N_t} + \frac{Wt_{unit} \cdot e_{width}}{B \cdot N_B} - \frac{Wt_{unit}}{N_t} \\ F_{wind.L} + \frac{P_v \cdot L_{unit.up} W_{unit}}{N_t} + \frac{Wt_{unit} \cdot e_{length}}{L \cdot N_L} - \frac{Wt_{unit}}{N_t}\end{pmatrix}\right) = \begin{pmatrix}459 \\ 454\end{pmatrix} \cdot lbs$$

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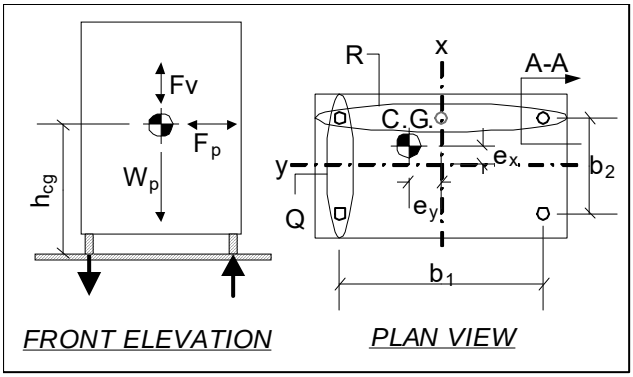
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Tensile and Shear Load calculation per ASHRAE RP-812



Eccentricity along X-X

$e_x := e_{width} = 6.09 \cdot in$

Eccentricity along Y-Y

$e_y := e_{length} = 3.16 \cdot in$

Distance between Seismic Restraints Along Y-Y

$b_1 := L_{curb} - 2 \cdot 6in = 101 \cdot in$

Distance between Seismic Restraints Along X-X

$b_2 := W_{curb} + 2 \cdot \frac{1.75in}{2} = 79 \cdot in$

Moment of Inertia about X-X

$I_{xx} := \frac{N_t \cdot (N_t + 2) \cdot (b_1)^2}{12 \cdot (N_t - 2)} = 17553 \cdot in^2$

Moment of Inertia about Y-Y

$I_{yy} := \frac{N_t \cdot (b_2)^2}{4} = 24806 \cdot in^2$

Angle about Tensile Load

$\Theta_t := \operatorname{atan}\left[\frac{I_{yy} \cdot (b_1)}{I_{xx} \cdot (b_2)}\right] = 61 \cdot deg$

Angle about Shear Load

$\Theta_s := \begin{cases} \operatorname{atan}\left(\frac{e_x}{e_y}\right) & \text{if } e_y \neq 0 \\ 0deg & \text{if } e_y = 0 \end{cases} = 63 \cdot deg$

Max Net Tensile Load Due to Seismic Load, Fp

$T_{U.EQ.pt1} := \frac{(0.6 - 0.7 \cdot F_v) \cdot Wt_{unit}}{N_t} - \frac{(0.6 - 0.7 \cdot F_v) \cdot Wt_{unit}}{b_1 \cdot b_2} \cdot \left(\frac{b_1}{2} \cdot e_x + \frac{b_2}{2} \cdot e_y - e_x \cdot e_y\right) = 13 \cdot lbs$

$T_{U.EQ.pt2} := -0.7 \cdot (F_p \cdot Wt_{unit}) \cdot (h_{CG.unit} + 0in) \cdot \cos(\Theta_t) \cdot \frac{0.5 \cdot b_2}{I_{yy}} = -191 \cdot lbs$

$T_{U.EQ.pt3} := -0.7 \cdot (F_p \cdot Wt_{unit}) \cdot (h_{CG.unit} + 0in) \cdot \sin(\Theta_t) \cdot \frac{0.5 \cdot b_1}{I_{xx}} = -631 \cdot lbs$

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$T_{U.EQ} := T_{U.EQ.pt1} + T_{U.EQ.pt2} + T_{U.EQ.pt3} = -810 \cdot lbs$

Max Net Shear Load Due to Seismic Load, Fp

$$V_{Ux.EQ} := 0.7 \cdot F_p \cdot Wt_{unit} \cdot \frac{\cos(\Theta_s)}{N_t} + \frac{0.7 \cdot F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_2 \cdot e_y + 0.7 \cdot F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_1 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 276 \cdot lbs$$

$$V_{Uy.EQ} := 0.7 \cdot F_p \cdot Wt_{unit} \cdot \frac{\sin(\Theta_s)}{N_t} + \frac{0.7 \cdot F_p \cdot Wt_{unit} \cdot \cos(\Theta_s) \cdot b_1 \cdot e_y + 0.7 \cdot F_p \cdot Wt_{unit} \cdot \sin(\Theta_s) \cdot b_2 \cdot e_x}{2 \cdot (I_{yy} + I_{xx})} = 470 \cdot lbs$$

$$V_{U.EQ} := \sqrt{V_{Ux.EQ}^2 + V_{Uy.EQ}^2} = 545 \cdot lbs$$

Tension Design force SRSS for loading from Each direction

$R_{iso.EQ.1.RP812} := \left| T_{U.EQ.pt1} + T_{U.EQ.pt3} \right| = 618 \cdot lbs$

$R_{iso.EQ.0.RP812} := \left| T_{U.EQ.pt1} + T_{U.EQ.pt2} \right| = 178 \cdot lbs$

$$R_{iso.EQ.max_1} := \max\left[\left(R_{iso.EQ.1.RP812} + 0 \cdot R_{iso.EQ.0.RP812}\right), \left(R_{iso.EQ_1} + 0 \cdot R_{iso.EQ_0}\right)\right] = 618 \cdot lbs$$

$$R_{iso.EQ.max_0} := \max\left[\left(R_{iso.EQ.0.RP812} + 0 \cdot R_{iso.EQ.1.RP812}\right), \left(R_{iso.EQ_0} + 0 \cdot R_{iso.EQ_1}\right)\right] = 331 \cdot lbs$$

For the plot:

$R_{iso.EQ.max_1} = 618 \cdot lbs$ $R_{iso.W_1} = 454 \cdot lbs$

$R_{iso.EQ.max_0} = 331 \cdot lbs$ $R_{iso.W_0} = 459 \cdot lbs$

Shear load at each anchor location

For the plot:

$$V_{iso.E} := \max\left[\left[\begin{array}{c} 1.0 \cdot V_{Ux.EQ} + 0 \cdot V_{Uy.EQ} \\ 0.3 \cdot V_{Ux.EQ} + 0 \cdot V_{Uy.EQ} \\ \left[\left(0.7F_p\right) \cdot Wt_{unit} \cdot \frac{1}{N_t}\right] \end{array}\right]\right] = 472 \cdot lbs \qquad V_{iso.W} := 0.6P_{net} \cdot L_{unit} \cdot H_{unit} \cdot \frac{1}{N_t} = 304 \cdot lbs$$

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Isolator Capacity:

$ID_{Iso} := "CQA"$

$T_{n.\Omega} := 2117lbs$ **(ASD)**

$V_{n.\Omega} := 775lbs$ **(ASD)**

Isolator Demand:

$R_{iso.max} := \max\left[\left(R_{iso.EQ.max_1}\right),\left(R_{iso.EQ.max_0}\right),\left(R_{iso.W_1}\right),\left(R_{iso.W_0}\right)\right] = 618\cdot lbs$

$V_{iso.max} := \max\left(V_{iso.E}, V_{iso.W}\right) = 472\cdot lbs$

D/C Ratio of Tension Only.:

$$DCR_{tension} := \frac{R_{iso.max}}{T_{n.\Omega}} = 0.292$$

$DCR_{tension} = "OK"$

D/C Ratio of Shear Only.:

$$DCR_{shear} := \frac{V_{iso.max}}{V_{n.\Omega}} = 0.609$$

$DCR_{shear} = "OK"$

D/C Ratio of Tension Only.:

$$DCR_{Int} := \frac{V_{iso.max}}{V_{n.\Omega}} + \frac{R_{iso.max}}{T_{n.\Omega}} = 0.901$$

$DCR_{Int} = "OK"$

ISOLATOR "SPRING" DESIGN [PER OPM-0401-13]

Factor of Safety of Spring

$FS_{spring} := 0.75$

Compressive Strength of Spring

$$C_{spring.\Omega} := \begin{cases} \left(FS_{spring}\cdot 300lbs\right) & \text{if } ID_{Iso} = "CQA" \\ \left(FS_{spring}\cdot 918lbs\right) & \text{if } ID_{Iso} = "CQB" \\ \left(FS_{spring}\cdot 918lbs\right) & \text{if } ID_{Iso} = "CQBX" \end{cases} = 225\cdot lbs$$

Rated Load per unit self-weight

$$C_{unit.rated.load} := \frac{Wt_{unit}}{N_t} = 200\cdot lbs$$

D/C Ratio of Spring Compression:

$$DCR := \frac{C_{unit.rated.load}}{C_{spring.\Omega}} = 0.888$$

$IsoSpring_{compression} = "OK"$

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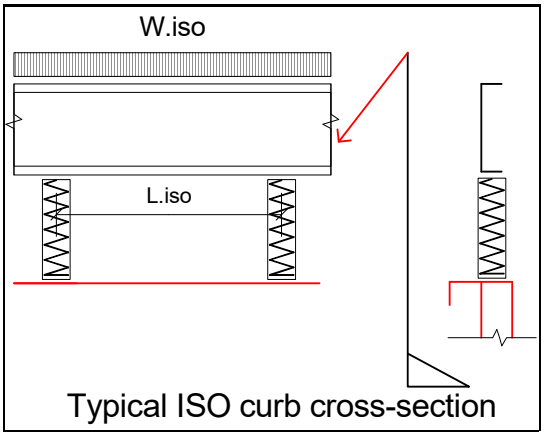
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Check ISO Rail for Bending about Strong and Weak Axis (AISI S100-16 F2.1)



Typical ISO curb cross-section

Thickness of Curb:

$t_{Curb.iso}$ = "10GA" $t := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Inside Bend Radius:

$R := R_{iso} = 0.186 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web:

$h := 7.5in - 2 \cdot (t + R) = 6.85 \cdot in$

Width of Flange:

$h_w := 1in$

Check Curb Bending of Long Side (Strong axis)

Member per CFS: $CFS_{member} :=$ "10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"

Number of Isolators on each Long Side: $N_{iso.long} = 8$

Center-to-Center Spacing of Isolators $L_{iso} := \frac{L_{curb}}{N_{iso.long} - 1} = 16 \cdot in$

Distributed Load $\omega_{iso} := \omega_{x.L.vert} = 2.264\,klf$

Moment Demand on Iso Rail $M_{cx} := \frac{\omega_{iso} \cdot L_{iso}^2}{8} = 6.165 \cdot kip \cdot in$

Curb Elastic Modulus / Yield Stress: $E := 29500ksi$ $F_y := 50ksi$

Curb Shear Modulus: $G := 11300ksi$

Poisson's Ratio $\mu := 0.3$

Section Properties from CFS: $r_x = 2.4893 \cdot in$ $r_o = 2.519 \cdot in$ $C_w = 0.595 \cdot in^6$ $S_x = 1.855 \cdot in^3$

$r_y = 0.2288 \cdot in$ $J = 0.0058 \cdot in^4$ $S_y = 0.3669 \cdot in^3$

$r_{min} := \min(r_x, r_y) = 0.2288 \cdot in$

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Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Flanges*

Flat Width:

$$w := h_w - R_{curb} = 0.847 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Unstiffened"}$$

Stress at the end of the Width:

$$f_2 := 11.407ksi \quad f_1 := 11.407ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \frac{f_2}{f_1} = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 0.43$$

Critical Compressive Stress:

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t}{w}\right)^2 = 304.86 \cdot ksi$$

Stress in Compression Element:

$$f := 18ksi$$

Note: Use f from "Elastive Flexural Buckling Stress" on "Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI E2)"

Slenderness Factor:

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 0.24$$

Local reduction factor:

$$\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 0.389$$

Effective Width of the Flanges:

$$b_{eff.flange} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 0.847 \cdot in$$

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Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Web*

Flat Width:

$w := h = 6.851 \cdot in$

Stiffened Web Check:

$Stiffened_{check} := "Stiffened"$

Stress at the end of the Width:

$f_2 := 11.407ksi$ $f_1 := 11.407ksi$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \frac{f_2}{f_1} = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = "Stiffened" \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = "Unstiffened" \end{cases} = 4$$

Critical Compressive Stress:

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t}{w}\right)^2 = 43.4 \cdot ksi$$

Stress in Compression Element:

$f := 18ksi$

Note: Use f from "Elastive Flexural Buckling Stress" on "Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI E2)"

Slenderness Factor:

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 0.64$$

Local reduction factor:

$$\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 1.022$$

Effective Width of the Web:

$$b_{eff.web} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 6.851 \cdot in$$

Effective Area of the Member:

$$A_e := 2 \cdot \left(b_{eff.flange} \cdot t\right) + b_{eff.web} \cdot t = 1.181 \cdot in^2$$

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For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. F2.1.1-4,5)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(1.0 \cdot L_{iso}\right)^2}\right] = 97 \cdot ksi$$

$$\sigma_{ey} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{iso}}{r_y}\right)^2} = 58 \cdot ksi \qquad \frac{1.0 \cdot L_{iso}}{r_y} = 71$$

KL_r = "KL/r < 200, OK"

Cb per Eq. F2.1.1-2

$$M_A := \frac{\omega_{iso} \cdot \frac{L_{iso}}{4}}{2} \cdot \left(L_{iso} - \frac{L_{iso}}{4}\right) = 4.62 \cdot kip \cdot in$$

$$M_B := M_{cx} = 6.17 \cdot kip \cdot in$$

$$M_C := \frac{\omega_{iso} \cdot \frac{3 \cdot L_{iso}}{4}}{2} \cdot \left(L_{iso} - \frac{3 \cdot L_{iso}}{4}\right) = 4.62 \cdot kip \cdot in$$

$$C_b := \min\left(1.0, \frac{12.5 \cdot M_{cx}}{2.5 \cdot M_{cx} + 3 \cdot M_A + 4 \cdot M_B + 3.M_C}\right) = 1$$

Elastic Critical Lateral-Torsional Buckling Stress per Eq. F2.1.1-1 for Singly Symmetry:

$$F_e := \frac{C_b \cdot r_o \cdot A_e}{S_x} \cdot \sqrt{\sigma_{ey} \cdot \sigma_t} = 121 \cdot ksi$$

LTB Design Stress: Eq. F2.1-3,4,5:

$$F_c := \begin{cases} F_y & \text{if } F_e \geq 2.78 \cdot F_y \\ \frac{10}{9} \cdot F_y \cdot \left(1 - \frac{10 \cdot F_y}{36 \cdot F_e}\right) & \text{if } 2.78 \cdot F_y > F_e > 0.56 \cdot F_y \\ F_e & \text{if } 0.56 \cdot F_y \geq F_e \end{cases} = 49 \cdot ksi$$

Moment Capacity Eq. F2.1-1:

$$\phi M_{nx} := 0.9 \cdot S_x \cdot \min\left(F_c, F_y\right) = 82 \cdot kip \cdot in$$

D/C Ratio of Bending:

$$DCR := \frac{M_{cx}}{\phi M_{nx}} = 0.075$$

$Iso_{Bending}$ = "OK"

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Check Curb Bending of Long Side (Weak axis)

Center-to-Center Spacing of Braces

$$L_{brace} := \frac{L_{curb}}{N_{iso.long} - 1} = 16 \cdot in$$

Note for weak-axis bracing length:
Max weak-axis span length of Iso Rail is larger than L_{brace} per cut sheet. However, the Iso Rail is braced with clip at max 24" O.C. at top and isolator at max 36" O.C. at bottom such that the actual unbraced length is as follows.

Distributed Load

$$\omega_{iso} := \frac{\max\left(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit}\right)}{L_{curb}} = 1.143\ klf$$

Moment Demand on Iso Rail

$$M_{cy} := \frac{\omega_{iso} \cdot L_{brace}^{2}}{8} = 3.114 \cdot kip \cdot in$$

Member per CFS:

$$CFS_{member} = \text{"10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"}$$

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. F2.1.1-4,5)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(1.0 \cdot L_{brace}\right)^2}\right] = 97 \cdot ksi$$

$$\sigma_{ex} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{brace}}{r_x}\right)^2} = 6900 \cdot ksi \qquad \frac{1.0 \cdot L_{brace}}{r_x} = 6$$

$$KL_r = \text{"KL/r < 200, OK"}$$

Cb per Eq. F2.1.1-2

$$M_A := \frac{\omega_{iso} \cdot \frac{L_{brace}}{4}}{2} \cdot \left(L_{brace} - \frac{L_{brace}}{4}\right) = 2.34 \cdot kip \cdot in$$

$$M_B := M_{cy} = 3.11 \cdot kip \cdot in$$

$$M_C := \frac{\omega_{iso} \cdot \frac{3 \cdot L_{brace}}{4}}{2} \cdot \left(L_{brace} - \frac{3 \cdot L_{brace}}{4}\right) = 2.34 \cdot kip \cdot in$$

$$C_b := \min\left(1.0, \frac{12.5 \cdot M_{cx}}{2.5 \cdot M_{cx} + 3 \cdot M_A + 4 \cdot M_B + 3 \cdot M_C}\right) = 1$$

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Elastic Critical Lateral-Torsional Buckling Stress per Eq. F2.1.1-1 for Singly Symmetry:

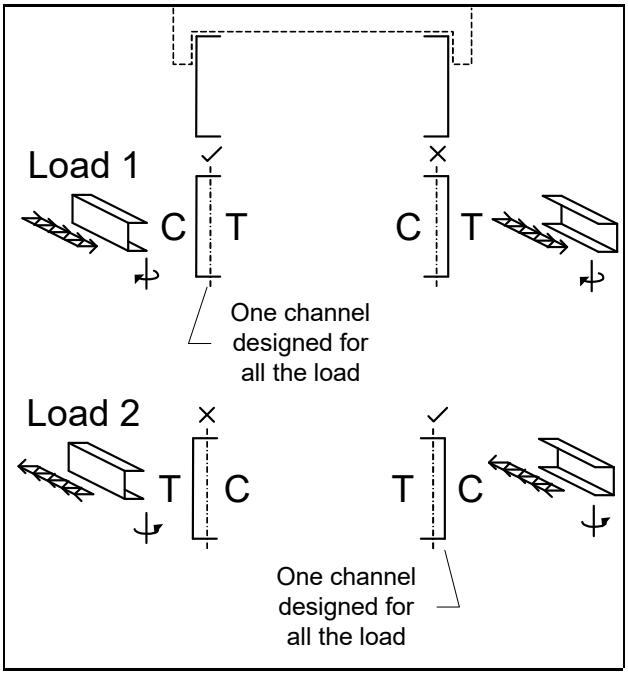
$$F_e := \frac{C_b \cdot r_o \cdot A_e}{S_y} \cdot \sqrt{\sigma_{ey} \cdot \sigma_t} = 610 \cdot ksi$$

LTB Design Stress: Eq. F2.1-3,4,5:

$$2.78 \cdot F_y = 139 \cdot ksi$$

$$0.56 \cdot F_y = 28 \cdot ksi$$

$$F_c := \begin{cases} F_y & \text{if } F_e \geq 2.78 \cdot F_y \\ \frac{10}{9} \cdot F_y \cdot \left(1 - \frac{10 \cdot F_y}{36 \cdot F_e}\right) & \text{if } 2.78 \cdot F_y > F_e > 0.56 \cdot F_y \\ F_e & \text{if } 0.56 \cdot F_y \geq F_e \end{cases} = 50 \cdot ksi$$



Note:

For ISO rail weak-axis bending capacity, rails are oriented and designed so that the stiffer side of ISO rail can take the entire bending load by itself without putting a lot of bending load to the iso rail on the other side

Moment Capacity Eq. F2.1-1:

$$\phi M_{ny} := 0.9 \cdot S_y \cdot \min(F_c, F_y) = 16.5105 \cdot kip \cdot in$$

D/C Ratio of Bending:

$$DCR := \frac{M_{cy}}{\phi M_{ny}} = 0.189$$

$$Iso_{Bending} := \text{if}(M_{cy} < \phi M_{ny}, \text{"OK"}, \text{"NG"})$$

$Iso_{Bending} = \text{"OK"}$

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Web Crippling of ISO Rail (AISI S100-16 G.5)

Governing Compression:

$$P_{web.crip} := \frac{\omega_{x.L.vert} \cdot L_{iso}}{2} = 1525 \cdot lbs$$

Yield Strength:

$$F_y := 50ksi$$

Bearing Length:

$N := 2in$ **2 in. for CQAs**

Thickness of Curb:

$t_{Curb.iso} = \text{"10GA"}$ $t := thick(t_{Curb.iso}) = 0.1382 \cdot in$

Inside Bend Radius:

$R := R_{iso} = 0.186 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web:

$h = 6.85 \cdot in$

Angle btween plane of web and bearing surface:

$\theta := 90deg$

Web Crippling Limit Check (AISI Table G5-2):

$\frac{R}{t} = 1$ $\frac{h}{t} = 50$ $\frac{N}{t} = 14$ $\frac{N}{h} = 0.29$

$$LimitCheck_{webcrippling} := if\left[\left(\frac{h}{t} < 200\right) \wedge \left(\frac{N}{t} < 210\right) \wedge \left(\frac{N}{h} < 2\right) \wedge \left(\frac{R}{t} < 2\right), \text{"OK"}, \text{"NG, Need Reinf"}\right]$$

$LimitCheck_{webcrippling} = \text{"OK"}$

End Case Coefficient Single Web Channel (AISI Table G5-2):

$C := 2$ $C_R := 0.11$ $C_N := 0.37$ $C_h := 0.01$

Reduction Factor Web Crippling Strength:

$\phi_{web.end} := 0.75$ **(For Unfastened Flanges with Two-Flange Loading or Reaction. Worst Case)**

$\phi_{web.int} := 0.8$

Design Web Crippling Strength:

$$P_{n.end} := C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 3729 \cdot lbs$$

$$\phi P_{n.end} := \phi_{web.end} \cdot P_{n.end} = 2796 \cdot lbs$$

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Interior Case Coefficient Single Web Channel (AISI Table G5-2):

$C := 13$ $C_R := 0.47$ $C_N := 0.25$ $C_h := 0.04$

Design Web Crippling Strength:

$$P_{n.interior} := C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 7905 \cdot lbs$$

$$\phi P_{n.interior} := \left(\phi_{web.int}\right) \cdot P_{n.interior} = 6324 \cdot lbs$$

Design Strength:

$$P_{n.web.crip} := \min\left(P_{n.end}, P_{n.interior}\right) = 3729 \cdot lbs$$

$$\phi P_{n.web.crip} := \min\left(\phi P_{n.end}, \phi P_{n.interior}\right) = 2796 \cdot lbs$$

D/C Ratio of Shear:

$$DCR := \frac{P_{web.crip}}{\phi P_{n.web.crip}} = 0.545$$

Demand/Capacity Ratio:

$$Web_{crippling} := if\left[\left(P_{web.crip} < \phi P_{n.web.crip}\right) \wedge \left(\phi P_{n.end} > 0\right) \wedge \frac{h}{t} < 200, "OK", "NG, Need Reinf"\right]$$

$Web_{crippling} = "OK"$

D/C Ratio of Interaction:
AISI Eq. H3-1b

$$DCR_{int.web} := \frac{0.91 \cdot \left(\frac{P_{web.crip}}{P_{n.web.crip}}\right) + \frac{M_{cx}}{\left(\frac{\phi M_{nx}}{0.9}\right)}}{1.33 \cdot 0.9} = 0.367$$

$Iso_{Shear} = "OK"$

$Iso_{Interaction} = "OK"$

Per AISI S100-16 H3,
Only x-axis needs to check for interaction

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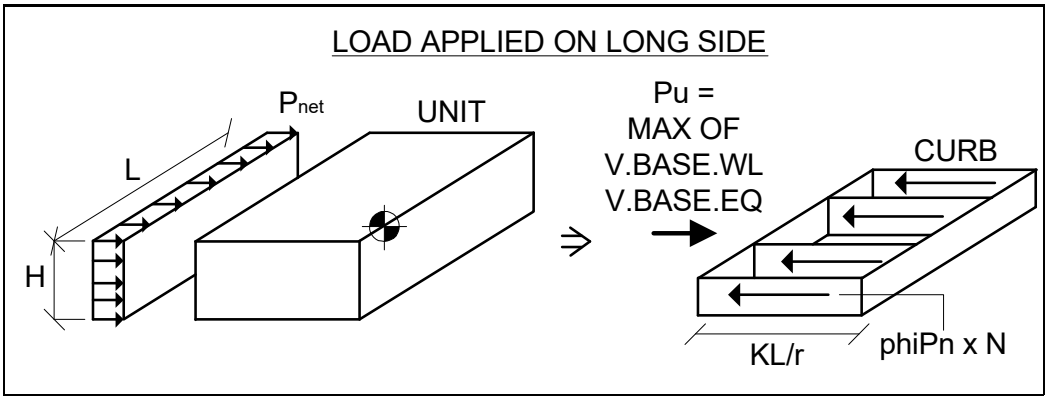
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Check ISO Rail for In-Plane Axial due to Seismic and Wind (AISI S100-16 E2)

Curb Axial Load Check due to Load on Long Side



Wind Base Shear of Unit on Long Side: $V_{base.W.L} := P_{net} \cdot L_{unit} \cdot H_{unit} = 8.1\,kip$

Seismic Base Shear of Unit on Long Side: $V_{base.S.L} := F_p \cdot Wt_{unit} = 10.8\,kip$

Max Axial: $P_u := \max\left(V_{base.S.L}, V_{base.W.L}\right) = 10783.46 \cdot lbs$

Member per CFS: $CFS_{member} =$ "10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"

Number of Curb in Length: $n_{iso} := 3$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{iso}} = 3.59\,kip$

Max Braced Length of Member: $L_{member} := W_{curb} = 77 \cdot in$

Effective Length factor: $K := 0.5$

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For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. E2.2-5, E2.2-6)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(K \cdot L_{member}\right)^2}\right] = 24 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2} = 10 \cdot ksi$$

$$\frac{K \cdot L_{member}}{r_{min}} = 168$$

KL_r = "KL/r < 200, OK"

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 7 \cdot ksi$$

Nominal Compressive Stress Capacity (Eq E2-4):

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 2.631$$

$$F_n := \begin{cases} 0.658^{\lambda_c^{\,2}} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^{\,2}}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 6.34 \cdot ksi$$

Strength reduction for Compression: $\phi_c := 0.85$

Factored Compressive Capacity: $\phi P_{n.member} := \phi_c \cdot A_e \cdot F_n = 6.36\,kip$

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.565$

$Axial_{reinf} := \text{if}\left(P_{u.EAmember} < \phi P_{n.member}, \text{"OK"}, \text{"NG"}\right)$

$Axial_{reinf}$ = "OK"

Note:
No need to check for interaction since equipment is not attached to the short side

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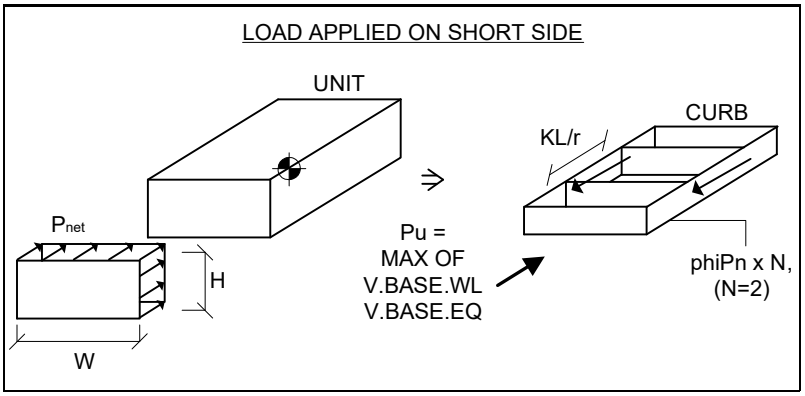
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Curb Axial Load Check due to Load on Short Side



Wind Base Shear on Short Side: $V_{base.W.H} := P_{net} \cdot W_{unit} \cdot H_{unit} = 5.6\,kip$

Seismic Base Shear of Unit on Short Side: $V_{base.S.W} := F_p \cdot Wt_{unit} = 10.8\,kip$

Max Axial: $P_u := \max\left(V_{base.S.W}, V_{base.W.H}\right) = 10783.46 \cdot lbs$

Member per CFS: $CFS_{member} = \text{"10GA ISO RAIL 7.5" Deep 1"Flanges 50ksi"}$

Number of Curb in Length: $n_{curb} := 2$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{curb}} = 5.39\,kip$

Max Braced Length of Member: $L_{member} := \frac{L_{curb}}{n_{iso} - 1} = 57 \cdot in$

Effective Length factor: $K := 0.5$

For Singly-Symmetric Sections Subject to Torsional or Flextural-Torsional Buckling (AISI Eq. E2.2-5, E2.2-6)

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^{\,2}}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{\left(K \cdot L_{member}\right)^2}\right] = 38 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2} = 19 \cdot ksi \qquad \frac{K \cdot L_{member}}{r_{min}} = 124$$

$KL_r = \text{"KL/r < 200, OK"}$

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{K \cdot L_{member}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 13 \cdot ksi$$

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Nominal Compressive Stress Capacity (Eq E2-4):

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 1.989$$

$$F_n := \begin{cases} 0.658^{\lambda_c^2} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^2}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 11.08 \cdot \text{ksi}$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot A_e \cdot F_n = 11.12\,\text{kip}$$

D/C Ratio of Compression:

$$DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.485$$

$$Axial_{reinf} := \text{if}\left(P_{u.EAmember} < \phi P_{n.member}, \text{"OK"}, \text{"NG"}\right)$$

$Axial_{reinf} = \text{"OK"}$

Note:
If the load direction is in perpedicular plane to the short side of the equipment, the channels will only experience axial load and no bending will occur at the channel. Therefore, no need to check for interaction since the channels

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Shear of ISO Rail Webs without Holes (AISI S100-16 G2)

Note: The connection holes are not centered at mid-depth of isolated curb rail so AISI G2 shall be used

Deeper Section (h = depth)

Thickness of Curb: $t := \text{thick}(t_{Curb.iso}) = 0.138 \cdot in$

Depth-to-Thickness Ratio: $\frac{h}{t} = 50$

Curb Elastic Modulus: $E := 29500ksi$

Clear distance b/w transverse stiffeners of reinforced web: $a := L_{iso} = 16 \cdot in$

Clear Distance-to-Thickness Ratio: $\frac{a}{h} = 2.36$

Nominal Shear Stress:

$$k_v := \begin{cases} 5.34 \text{ if } a = L_{iso} \\ 4.00 + \frac{5.34}{\left(\frac{a}{h}\right)^2} \text{ if } \left(\frac{a}{h} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \frac{4.00}{\left(\frac{a}{h}\right)^2} \text{ if } \left(\frac{a}{h} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 6.06$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 60 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 90$$

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Curb Shear Check due to Load on Longer Side

Area of Web Element:

$$A_w := h \cdot t = 0.947 \cdot in^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 65.7 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} = 62\,kip \qquad V_y := 0.6 \cdot A_w \cdot F_y = 28\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.676$$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 28.404 \cdot kip$$

Number of Members within Length: $n := 1$ **(Per Curb Design)**

Design Shear Capacity:

$$\phi V_{n.h} := 0.95 \cdot n \cdot V_n = 26.98 \cdot kip$$

Design Shear Demand:

$$V_{u.h} := \frac{\omega_{x.L.vert} \cdot L_{iso}}{2} = 1525.2 \cdot lbs$$

D/C Ratio of Shear:

$$DCR := \frac{V_{u.h}}{\phi V_{n.h}} = 0.057$$

Demand/Capacity Ratio:

$Shear_{in.plane} = \text{"OK"}$

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Shallower Section (h.w = Width)

Thickness of Curb: $t := thick(t_{Curb.iso}) = 0.138 \cdot in$

Depth-to-Thickness Ratio: $\frac{h_w}{t} = 7$

Curb Elastic Modulus: $E := 29500ksi$

Clear distance b/w transverse stiffeners of reinforced web: $a := L_{brace} = 16 \cdot in$

Clear Distance-to-Thickness Ratio: $\frac{a}{h_w} = 16.17$

Nominal Shear Stress:

$$k_v := \begin{cases} 5.34 & \text{if } a = L_{brace} \\ 4.00 + \frac{5.34}{\left(\frac{a}{h_w}\right)^2} & \text{if } \left(\frac{a}{h_w} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \frac{4.00}{\left(\frac{a}{h_w}\right)^2} & \text{if } \left(\frac{a}{h_w} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 5.36$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 56 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 85$$

Curb Shear Check due to Load on Longer Side

Area of Web Element: $A_w := h_w \cdot t = 0.1382 \cdot in^2$

Number of Members within Length: $n := 1$ **(Per Curb Design)**

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 58.1 \cdot ksi$$

$$V_{cr} := A_w \cdot F_{cr} = 8\,kip \qquad V_y := 0.6 \cdot A_w \cdot F_y = 4\,kip \qquad \lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 0.719$$

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$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 4.146 \cdot \text{kip}$$

Design Shear Capacity:

$$\phi V_{n.hw} := 0.95 \cdot n \cdot V_n = 3.9 \cdot \text{kip}$$

Design Shear Demand:

$$V_{u.hw} := \frac{\left(\frac{\max\left(F_p \cdot Wt_{unit}, P_{net} \cdot L_{unit} \cdot H_{unit}\right)}{L_{curb}} \right) \cdot L_{brace}}{2} = 770.2 \cdot \text{lbs}$$

D/C Ratio of Shear:

$$DCR := \frac{V_{u.hw}}{\phi V_{n.hw}} = 0.196$$

Demand/Capacity Ratio:

$Shear_{in.plane}$ = "OK"

D/C Ratio of Vx and Mx:

$$DCR_{V.M.int} := \begin{cases} \left(0.6 \cdot \frac{M_{cx}}{\phi M_{nx}} + \frac{V_{u.h}}{\phi V_{n.h}}\right) \cdot \frac{1}{1.3} & \text{if } \frac{M_{cx}}{\phi M_{nx}} > 0.5 \wedge \frac{V_{u.h}}{\phi V_{n.h}} > 0.7 \\ \sqrt{\left(\frac{M_{cx}}{\phi M_{nx}}\right)^2 + \left(\frac{V_{u.h}}{\phi V_{n.h}}\right)^2} & \text{otherwise} \end{cases} = 0.094$$

Demand/Capacity Ratio:

$VandMx_{int}$ = "OK"

D/C Ratio of Vy and My:

$$DCR_{V.M.int} := \begin{cases} \left(0.6 \cdot \frac{M_{cy}}{\phi M_{ny}} + \frac{V_{u.hw}}{\phi V_{n.hw}}\right) \cdot \frac{1}{1.3} & \text{if } \frac{M_{cy}}{\phi M_{ny}} > 0.5 \wedge \frac{V_{u.hw}}{\phi V_{n.hw}} > 0.7 \\ \sqrt{\left(\frac{M_{cy}}{\phi M_{ny}}\right)^2 + \left(\frac{V_{u.hw}}{\phi V_{n.hw}}\right)^2} & \text{otherwise} \end{cases} = 0.272$$

Demand/Capacity Ratio:

$VandMy_{int}$ = "OK"

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Web Crippling/Compression of Non-iso CanFab Curb (AISI S100-16 G5)

Governing Compression for Non-Isolated Curb:

$$P_{web.crip.int} := \max\left[\frac{\max\left[\left|T_{S_{(0)}}\right|, \left|T_{W_{(0)}}\right|\right]}{L_{curb}}, \frac{\max\left[\left|C_{S_{(0)}}\right|, \left|C_{W_{(0)}}\right|\right]}{L_{curb}}\right] \cdot L_{spacing.non.iso} = 5797 \cdot lbs$$

$$P_{web.crip.end} := 0.5 \cdot P_{web.crip.int} = 2898 \cdot lbs$$

Yield Strength: $F_y := 50ksi$

Bearing Length: $N_{bearing} := L_{spacing.non.iso} = 31 \cdot in$

Thickness of Curb: $t_{Curb} = \text{"12GA"}$ $t := thick(t_{Curb}) = 0.1084 \cdot in$

Inside Bend Radius: $R := R_{curb} = 0.153 \cdot in$ **(Per CFS Default)**

Flat Dimension of Web: $h := 36in - 2 \cdot (t + R) = 35.48 \cdot in$

Angle btween plane of web and bearing surface: $\theta := 90deg$

Web Crippling Limit Check (AISI Table G5-2): $\frac{R}{t} = 1$ $\frac{h}{t} = 327$ $\frac{N_{bearing}}{t} = 283$ $\frac{N_{bearing}}{h} = 0.87$

End Case Coefficient Single Web Channel (AISI Table G5-2): $C := 13$ $C_R := 0.32$ $C_N := 0.05$ $C_h := 0.04$

Reduction Factor Web Crippling Strength: $\phi_{web.end} := 0.9$ $\phi_{web.int} := 0.8$ **(For Unfastened partially Stiffened Flanges with Two-Flange Loading or Reaction.)**

Design Web Crippling Strength:

$$\phi P_{n.end} := \left(\phi_{web.end}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 2171 \cdot lbs$$

Interior Case Coefficient Single Web Channel (AISI Table G5-2): $C := 24$ $C_R := 0.52$ $C_N := 0.15$ $C_h := 0.001$

Design Web Crippling Strength:

$$\phi P_{n.interior} := \left(\phi_{web.int}\right) \cdot C \cdot t^2 \cdot F_y \cdot \sin(\theta) \cdot \left(1 - C_R \cdot \sqrt{\frac{R}{t}}\right) \cdot \left(1 + C_N \cdot \sqrt{\frac{N_{bearing}}{t}}\right) \cdot \left(1 - C_h \cdot \sqrt{\frac{h}{t}}\right) = 14965 \cdot lbs$$

D/C Ratio of Shear: $DCR_{end} := \frac{P_{web.crip.end}}{2 \cdot \phi P_{n.end}} = 0.668$ $DCR_{int} := \frac{P_{web.crip.int}}{\phi P_{n.interior}} = 0.387$

Demand/Capacity Ratio: **Note: Factor of 2 for two ends connected together at the end**

$Web_{crippling} = \text{"OK"}$

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Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Length

Roof Curb thickness

$t_{Curb} = \text{"12GA"}$ $t_{curb} := thick(t_{Curb}) = 0.1084 \cdot in$

Min width of Roof Curb

$b_{curb} := L_{curb} + \frac{W_{curb}}{2} \cdot 2 + 3in \cdot 2 \cdot 2 = 202.19 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := L_{curb} + \min\left(\frac{W_{curb}}{2} \cdot 2, \frac{L_{curb}}{2}\right) = 170 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{matrix} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{matrix} \right] \right] = 17819 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.L.vert.up} \cdot L_{curb}) \cdot (0.75in) = 9570 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.537$

$Curb_{BotFlangeBending} = \text{"OK"}$

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Curb Bot Flange Bending Check for Tension at Anchorage to Structure: Width

Roof Curb thickness

$t_{Curb} = \text{"12GA"}$ $t_{curb} := thick(t_{Curb}) = 0.1084 \cdot in$

Min width of Roof Curb

$b_{curb} := W_{curb} + \frac{L_{curb}}{4} \cdot 2 + 3in \cdot 2 = 139.59 \cdot in$

Yield strength of the Curb

$F_{y.curb} := 50ksi$

Strength reduction for bending

$\phi_{curb} := 0.9$

Design Bending Capacity (LRFD)

$L_{reinf} := W_{curb} + \min\left(\frac{L_{curb}}{6} \cdot 2, W_{curb}\right) = 115 \cdot in$

$N_{reinf} := 0$

$t_{reinf} := thick(\text{"16GA"}) = 0.0635 \cdot in$

$$\phi M_{n.curb} := \phi_{curb} \cdot F_{y.curb} \left[\max \left[\begin{matrix} \frac{b_{curb} \cdot (t_{curb})^2}{6} + N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf})^2}{6} \\ N_{reinf} \cdot \frac{L_{reinf} \cdot (t_{reinf} + t_{curb})^2}{6} \end{matrix} \right] \right] = 12302 \cdot in \cdot lbs$$

Flexural bending demand

$M_{u.Curb} := (\omega_{x.W.vert.up} \cdot W_{curb}) \cdot (0.75in) = 5537 \cdot in \cdot lbs$

D/C Ratio for bending

$DCR := \frac{M_{u.Curb}}{\phi M_{n.curb}} = 0.45$

$Curb_{BotFlangeBending} = \text{"OK"}$

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Web Crippling/Compression of Iso CanFab Curb (AISI S100-16 G5)

Note: Curb stiffeners directly transfer the compressive load from isolator to the base. Therefore, curb web crippling is prevented.

Curb Web with Reinforcement

Max Compression: $Comp_{maxtot} := \max(|C_S|, |C_W|) = 26724.96 \cdot lbs$

Reinforcement per CFS: $CFS_{reinf} :=$ "Single Stiffener 10GA 1"x7"x1" Fy=50ksi 36" Tall on min. 16GA "

Note: min. of 10 GA channel and min. 16 GA curb web

Number of Reinforcement in Length: $n_{reinf} := N_{iso.long} = 8$

Max Compression per Reinf: $Comp_{per.reinf} := \frac{Comp_{maxtot}}{n_{reinf}} = 3.341\ kip$

Spacing: $Spacing := \frac{L_{curb}}{n_{reinf}} = 14 \cdot in$ $KL_r := \frac{1.0 \cdot (H_{curb} - 12.5in)}{0.2339in} = 154$

Factored Nominal Comp. Capacity per reinforcement: $\phi P_{n.reinf} = 9.719 \cdot kip$ **(See attached CFS)**

Total Factored nominal Comp Capacity: $\phi P_{n.tot} := n_{reinf} \cdot \phi P_{n.reinf} = 78 \cdot kip$

D/C Ratio of Compression: $DCR := \frac{Comp_{maxtot}}{\phi P_{n.tot}} = 0.34$

$Comp_{reinf} := if(Comp_{maxtot} < \phi P_{n.tot}, "OK", "NG")$ $Comp_{reinf} = "OK"$

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Check CanFab Curb for Compressive Force due to T/C Coupling of Overturning

Note:
-Since the equipment is only attached to the longer sides of the CanFab Curb, most likely there will be compressive force onto the curb due to T/C coupling.
- Rectangular CanFab Curb will be considered as "Channel" to resist the compressive force.

Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Flanges*

Flat Width:

$$w := \frac{W_{curb}}{2} - R_{curb} = 38.348 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Unstiffened"}$$

Stress at the end of the Width:

$$f_2 := 50ksi \qquad f_1 := 50ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \left| \frac{f_2}{f_1} \right| = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 0.43$$

Critical Compressive Stress (Eq 1.1-4):

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w}\right)^2 = 0.09 \cdot ksi$$

Stress in Compression Element:

$$f := F_y = 50 \cdot ksi \qquad \textbf{(Assume f = Fy)}$$

Slenderness Factor (Eq 1.1-3):

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 23.36$$

Local reduction factor (Eq 1.1-2):

$$\rho := \left(1 - \frac{0.22}{\lambda}\right)\frac{1}{\lambda} = 0.042$$

Effective Width of the Flanges:

$$b_{eff.flange} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 1.626 \cdot in$$

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Effective Widths of Stiffened Elements AISI S100-16 Appx 1.1 (a) Strength Determination: *Web*

Flat Width:

$$w := L_{curb} - R_{curb} \cdot 2 = 112.883 \cdot in$$

Stiffened Web Check:

$$Stiffened_{check} := \text{"Stiffened"}$$

Stress at the end of the Width:

$$f_2 := 50ksi \qquad f_1 := 50ksi$$

Compressive Stress Ratio (Eq. 1.1.2-1):

$$\Psi := \left| \frac{f_2}{f_1} \right| = 1$$

Plate Buckling Coefficient (Eq. 1.2.2-5):

$$k_{fcr} := \begin{cases} 4 & \text{if } Stiffened_{check} = \text{"Stiffened"} \\ 0.57 - 0.21 \cdot \Psi + 0.07 \cdot \Psi^2 & \text{if } Stiffened_{check} = \text{"Unstiffened"} \end{cases} = 4$$

Critical Compressive Stress (Eq 1.1-4):

$$F_{cr} := k_{fcr} \cdot \frac{\pi^2 \cdot E}{12 \cdot \left(1 - \mu^2\right)} \cdot \left(\frac{t_{curb}}{w} \right)^2 = 0.1 \cdot ksi$$

Stress in Compression Element:

$$f := F_y = 50 \cdot ksi \qquad \textbf{(Assume f = Fy)}$$

Slenderness Factor (Eq 1.1-3):

$$\lambda := \sqrt{\frac{f}{F_{cr}}} = 22.55$$

Local reduction factor (Eq 1.1-2):

$$\rho := \left(1 - \frac{0.22}{\lambda}\right) \frac{1}{\lambda} = 0.044$$

Effective Width of the Web:

$$b_{eff.web} := \begin{cases} w & \text{if } \lambda \le 0.673 \\ \rho \cdot w & \text{if } \lambda > 0.673 \end{cases} = 4.958 \cdot in$$

Effective Area of the Member:

$$A_e := 2 \cdot \left(b_{eff.flange} \cdot t_{curb} \right) + b_{eff.web} \cdot t_{curb} = 0.89 \cdot in^2$$

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Length of the Compressive Member: $L_{curb.web} := h = 35.478 \cdot in$

Young's Modulus for Cold Form Steel: $E := 29500ksi$

Curb Shear Modulus: $G := 11300ksi$

Poisson's Ratio $\mu := 0.3$

Section Properties of the Member (From Section Properties Calculator):

$A_{half.curb} := 13.599in^2$ $r_o := 50.187in$ $I_x := 26250.724in^4$ $I_y := 1949.977in^4$

$J := 0.023in^4$ $r_x := \sqrt{\frac{I_x}{A_{half.curb}}} = 43.936 \cdot in$ $r_y := \sqrt{\frac{I_y}{A_{half.curb}}} = 11.975 \cdot in$

$C_w := 4.431 \cdot 10^6 \cdot in^6$ $r_{min} := \min(r_x, r_y) = 11.975 \cdot in$

$$\sigma_t := \left(\frac{1}{A_e \cdot r_o^2}\right) \cdot \left[G \cdot J + \frac{\pi^2 \cdot E \cdot C_w}{(1.0 \cdot L_{curb.web})^2}\right] = 457268.1 \cdot ksi$$

$$\sigma_{e.y} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_y}\right)^2} = 33168.14 \cdot ksi \qquad \sigma_{e.x} := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_x}\right)^2} = 446511.777 \cdot ksi$$

$$\sigma_e := \frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2} = 33168.14 \cdot ksi$$

$$\frac{1.0 \cdot L_{curb.web}}{r_{min}} = 2.96$$

$KL_r = \text{"KL/r < 200, OK"}$

Elastive Flexural Buckling Stress (Eq E2.1-1, E2.2-2):

$$F_e := \min\left[\frac{\pi^2 \cdot E}{\left(\frac{1.0 \cdot L_{curb.web}}{r_{min}}\right)^2}, \frac{\sigma_t \cdot \sigma_e}{\sigma_t + \sigma_e}\right] = 30924.983 \cdot ksi$$

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Nominal Compressive Stress Capacity: (Eq E2-4)

$$\lambda_c := \sqrt{\frac{F_y}{F_e}} = 0.04$$

$$F_n := \begin{cases} 0.658^{\lambda_c^2} \cdot F_y & \text{if } \lambda_c \le 1.5 \\ \left(\frac{0.877}{\lambda_c^2}\right) \cdot F_y & \text{if } \lambda_c > 1.5 \end{cases} = 49.97 \cdot \text{ksi}$$

Compressive Capacity:

$$P_{n.member} := A_e \cdot F_n = 44.47 \cdot \text{kip}$$

Strength reduction for Compression:

$$\phi_c := 0.85$$

Factored Compressive Capacity:

$$\phi P_{n.member} := \phi_c \cdot P_{n.member} = 37.8 \cdot \text{kip}$$

Factored Max Compressive Force:

$$P_{comp.max} := \max\left(\left|C_S\right|, \left|C_W\right|\right) = 26.725\ \text{kip}$$

D/C Ratio of Compression:

$$DCR := \frac{P_{comp.max}}{\phi P_{n.member}} = 0.707$$

$$Axial_{curb.comp} := \text{if}\left(P_{comp.max} < \phi P_{n.member}, \text{"OK"}, \text{"Provide Channel from above as Web Stiffener"}\right)$$

$Axial_{curb.comp} = \text{"OK"}$

Note: No need to check for interaction since the curb is only subjected to the compressive force.

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Shear of CanFab Curb Webs without Holes (AISI S100-16 G2)

Note: Since the unit is stiffer than the curb and the curb is firmly attached to the unit and to the base structure, curbs will mainly take the lateral forces as shear and axial load rather than bending.

Thickness of Curb:

$$t := \text{thick}(t_{Curb}) = 0.108 \cdot \text{in}$$

Depth-to-Thickness Ratio:

$$\frac{h}{t} = 327$$

Curb Elastic Modulus:

$$E := 29500\text{ksi}$$

Clear distance b/w transverse stiffeners of reinforced web:

$$a := \max\left(\frac{L_{curb}}{2}, W_{curb}\right) = 77 \cdot \text{in} \qquad \frac{a}{h} = 2.17$$

$$k_v := \begin{cases} 5.34 & \text{if } a = L_{curb} \\ 4.00 + \dfrac{5.34}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} < 1.0\right) \wedge \left(a \neq L_{curb}\right) \\ 5.34 + \dfrac{4.00}{\left(\frac{a}{h}\right)^2} & \text{if } \left(\frac{a}{h} > 1.0\right) \wedge \left(a \neq L_{curb}\right) \end{cases} = 6.19$$

$$\sqrt{\frac{E \cdot k_v}{F_y}} = 60 \qquad 1.51 \cdot \sqrt{\frac{E \cdot k_v}{F_y}} = 91$$

Curb Shear Check due to Load on Longer Side

Area of Web Element:

$$A_w := W_{curb} \cdot t = 8 \cdot \text{in}^2$$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 1.5 \cdot \text{ksi}$$

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$V_{cr} := A_w \cdot F_{cr} = 13\,kip$ $V_y := 0.6 \cdot A_w \cdot F_y = 250\,kip$ $\lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 4.413$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 12.858 \cdot kip$$

Number of Members within Length: $n := 2$ **(Per Curb Design)**

Design Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 24431 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.H} := P_{net} \cdot L_{unit} \cdot H_{total} = 14026.5 \cdot lbs$

Design Shear Demand: $V_u := \max(V_{base.S}, V_{base.W.H}) = 14857.1 \cdot lbs$

D/C Ratio of Shear: $DCR := \frac{V_u}{\phi V_n} = 0.608$

Demand/Capacity Ratio:

$Shear_{in.plane} := \text{if}(V_u < \phi V_n, \text{"OK"}, \text{"NG"})$

$Shear_{in.plane} = \text{"OK"}$

Curb Shear Check due to Load on Shorter Side

Area of Web Element: $A_w := L_{curb} \cdot t = 12 \cdot in^2$

$$F_{cr} := \frac{\pi^2 \cdot E \cdot k_v}{12 \cdot \left(1 - \mu^2\right) \cdot \left(\frac{h}{t}\right)^2} = 1.5 \cdot ksi$$

$V_{cr} := A_w \cdot F_{cr} = 19\,kip$ $V_y := 0.6 \cdot A_w \cdot F_y = 368\,kip$ $\lambda_v := \sqrt{\frac{V_y}{V_{cr}}} = 4.413$

$$V_n := \begin{cases} V_y & \text{if } \lambda_v \le 0.815 \\ 0.815 \cdot \sqrt{V_{cr} \cdot V_y} & \text{if } 0.815 < \lambda_v \le 1.227 \\ V_{cr} & \text{otherwise} \end{cases} = 18.902 \cdot kip$$

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Number of Members within Length: $n := 2$ **(Per Curb Design)**

Factored Nominal Shear Capacity: $\phi V_n := 0.95 \cdot n \cdot V_n = 35913 \cdot lbs$

Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot W_{unit} \cdot H_{total} = 9654.4 \cdot lbs$

Factored Shear Demand: $V_u := \max(V_{base.S}, V_{base.W.L}) = 14857.1 \cdot lbs$

D/C Ratio of Shear: $DCR := \frac{V_u}{\phi V_n} = 0.414$

Demand/Capacity Ratio:

$Shear_{in.plane} := \text{if}(V_u < \phi V_n, \text{"OK"}, \text{"NG"})$

$Shear_{in.plane} = \text{"OK"}$

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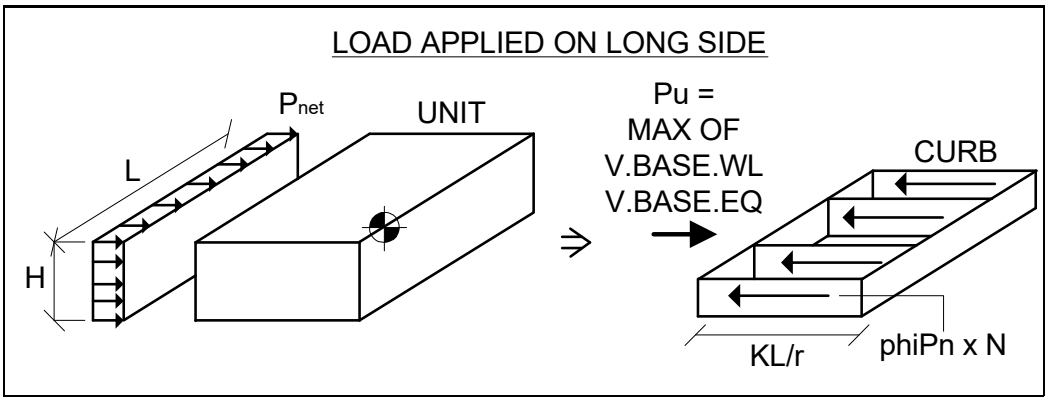
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Check CanFab Curb for In-Plane Axial due to EQ and Wind (AISI S100-16 E2)

Curb Axial Load Check due to Load on Long Side



Wind Base Shear on Long Side: $V_{base.W.L} := P_{net} \cdot L_{unit} \cdot H_{total} = 14\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.L}) = 14857.09 \cdot lbs$

Member per CFS: $CFS_{member} :=$ "12GA Custom Curb 36" Tall L.b = 80in"

Max Braced Length of Member: $L_{member} := 48in$ **Conservative since the max anchor spacing is 24"**

Number of Curb in Length: $n_{curb.long} := 3$

Radius of gyration in y-axis: $r_{y.curb} := 0.521\,in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{2} = 7.43\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 92$ $KL_r =$ "KL/r < 200, OK"

Spacing: $Spacing := \frac{L_{curb}}{n_{curb.long}} = 38 \cdot in$

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 9.846 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.754$

$Axial_{short.curb} =$ "OK"

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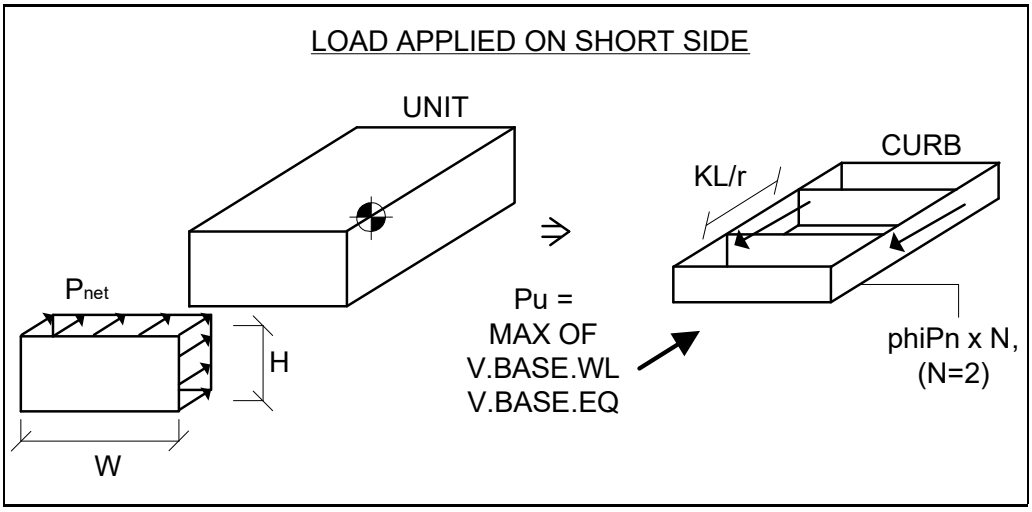
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Curb Axial Load Check due to Load on Short Side



Wind Base Shear on Short Side: $V_{base.W.H} := P_{net} \cdot W_{unit} \cdot H_{total} = 9.7\,kip$

Max Axial: $P_u := \max(V_{base.S}, V_{base.W.H}) = 14857.09 \cdot lbs$

Member per CFS: CFS_{member} = "12GA Custom Curb 36" Tall L.b = 80in"

Max Braced Length of Member: $L_{member} := \frac{L_{curb}}{n_{curb.long} - 1} = 57 \cdot in$

Number of Curb in Length: $n_{curb} := 2$

Radius of gyration in y-axis: $r_{y.curb} := 0.521\,in$

Effective Length Factor: $K := 1.0$

Max Axial on Each Member: $P_{u.EAmember} := \frac{P_u}{n_{curb}} = 7.43\,kip$

Slenderness Check KL/r: $\frac{K \cdot L_{member}}{r_{y.curb}} = 109$ KL_r = "KL/r < 200, OK"

Factored Nominal Comp. Capacity per Member: $\phi P_{n.member} = 9.846 \cdot kip$ **(See attached CFS)**

D/C Ratio of Compression: $DCR := \frac{P_{u.EAmember}}{\phi P_{n.member}} = 0.754$

$Axial_{long.curb}$ = "OK"

A241

JOHN A. MARTIN and ASSOCIATES, INC. ☐ STRUCTURAL ENGINEERS

Architect: CANNON FABRICATION, INC. Sheet

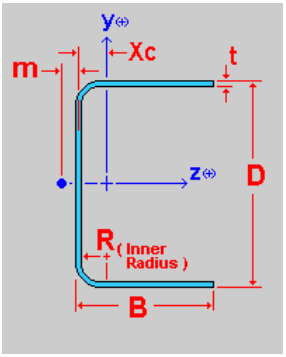
Project: IBC 2018 Group C Job No. J13001 . 382

Date DEC/12/2018

CURB & ANCHORAGE DESIGN Engineer LK

REFERENCE

Shape Name : **Canfab 6009 14GA**
Database : **AISI Custom**
Shape Type : **CU**
Material : **Cold Formed**

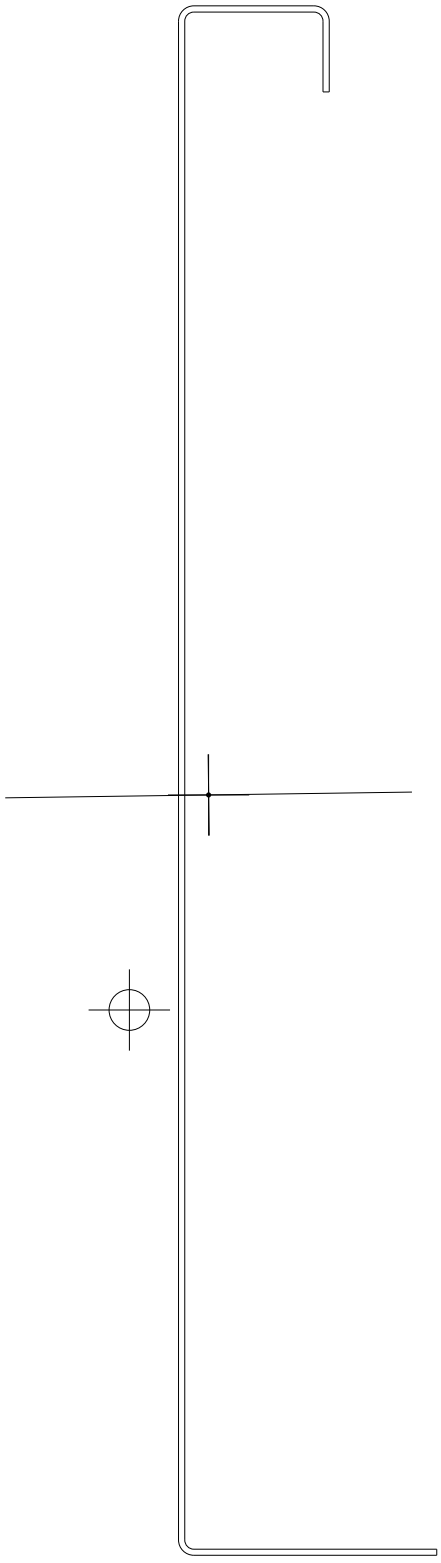


D	: 113	in	J	: .023	in^4
B	: 39	in	Cw	: 4.431e+6	in^6
t	: .071	in	ro	: 50.187	in
R	: .107	in	Xc	: 7.96	in
Area	: 13.599	in^2	m	: 13.137	in
Iyy	: 1949.977	in^4	j	: 63.338	in
Izz	: 26250.724	in^4			

CFS Version 10.0.0
Section: Section 1.cfss
Channel 18x3x1-14 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 12/11/2018 11:53:09 PM
By: Leonard Kim
Printed: 12/12/2018 12:00:18 AM



CFS Version 10.0.0
Section: Section 1.cfss
Channel 18x3x1-14 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 12/11/2018 11:53:09 PM
By: Leonard Kim
Printed: 12/12/2018 12:00:18 AM

Section Inputs

```
Material: A653 SS Grade 50/1
No strength increase from cold work of forming.
Modulus of Elasticity, E           29500 ksi
Yield Strength, Fy                    50 ksi
Tensile Strength, Fu                  65 ksi
Warping Constant Override, Cw          0 in^6
Torsion Constant Override, J           0 in^4

Stiffened Channel, Thickness 0.0713 in (14 Gage)
Placement of Part from Origin:
X to center of gravity           0 in
Y to center of gravity           0 in
Outside dimensions, Open shape
        Length      Angle     Radius  Web      k    Hole Size   Distance
          (in)      (deg)       (in)         Coef.       (in)       (in)
  1      3.000    180.000    0.10690 Single  0.000      0.000      1.500
  2     18.000     90.000    0.10690 Cee     0.000      0.000      9.000
  3      1.750      0.000    0.10690 Single  0.000      0.000      0.875
  4      1.000    -90.000    0.10690 None    0.000      0.000      0.500
```

Full Section Properties

```
Area      1.6650 in^2   Wt.    0.0056611 k/ft   Width     23.353 in

Ix        64.695 in^4   rx         6.233 in     Ixy       -0.908 in^4
Sx(t)     7.0576 in^3   y(t)       9.167 in     α          0.813 deg
Sx(b)     7.3241 in^3   y(b)       8.833 in
                       Height    18.000 in
Iy         0.750 in^4   ry         0.671 in     xo        -0.921 in
Sy(l)     2.1476 in^3   x(l)       0.349 in     yo        -2.498 in
Sy(r)     0.2828 in^3   x(r)       2.651 in     jx        15.499 in
                       Width      3.000 in     jy         2.726 in
I1        64.708 in^4   r1         6.234 in
I2         0.737 in^4   r2         0.665 in
Ic        65.445 in^4   rc         6.269 in     Cw        42.375 in^6
Io        77.246 in^4   ro         6.811 in     J      0.0028215 in^4
```

Member Check - 2016 North American Specification - US (LRFD)

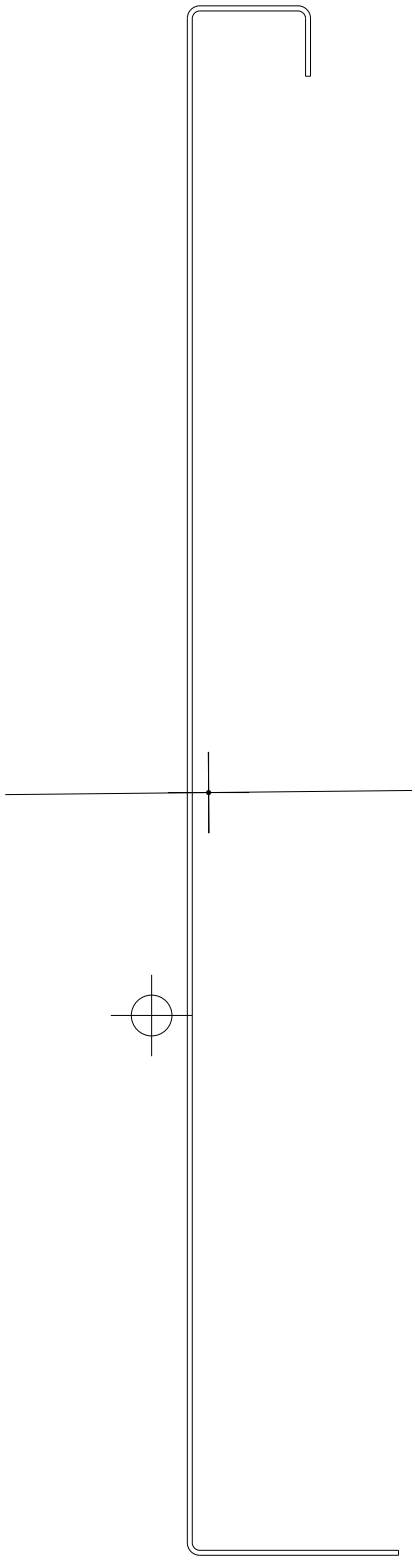
```
Material Type: A653 SS Grade 50/1, Fy=50 ksi
Design Parameters:
Lx        5.2500 ft     Ly        5.2500 ft     Lt        5.2500 ft
Kx        1.0000        Ky        1.0000        Kt        1.0000
Cbx       1.0000        Cby       1.0000        ex        0.0000 in
Cmx       1.0000        Cmy       1.0000        ey        0.0000 in
Braced Flange: None     kϕ             0 k
Red. Factor, R: 0       Lm        5.2500 ft

Loads:           P         Mx         Vy         My         Vx
                (k)     (k-in)        (k)     (k-in)        (k)
Entered       0.000       0.00      0.000       0.00      0.000
Applied       0.000       0.00      0.000       0.00      0.000
Strength     11.417     150.13      2.340       8.82      8.566
```

CFS Version 10.0.0
Section: Section 1.cfss
Channel 22x3x1-14 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 12/12/2018 12:14:09 AM
By: Leonard Kim
Printed: 12/12/2018 12:15:26 AM



CFS Version 10.0.0
Section: Section 1.cfss
Channel 22x3x1-14 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 12/12/2018 12:14:09 AM
By: Leonard Kim
Printed: 12/12/2018 12:15:26 AM

Section Inputs

```
Material: A653 SS Grade 50/1
No strength increase from cold work of forming.
Modulus of Elasticity, E           29500 ksi
Yield Strength, Fy                    50 ksi
Tensile Strength, Fu                  65 ksi
Warping Constant Override, Cw          0 in^6
Torsion Constant Override, J           0 in^4

Stiffened Channel, Thickness 0.0713 in (14 Gage)
Placement of Part from Origin:
X to center of gravity           0 in
Y to center of gravity           0 in
Outside dimensions, Open shape
        Length      Angle     Radius  Web      k    Hole Size   Distance
          (in)      (deg)       (in)         Coef.       (in)       (in)
  1      3.000    180.000    0.10690 Single  0.000      0.000      1.500
  2     22.000     90.000    0.10690 Cee     0.000      0.000     11.000
  3      1.750      0.000    0.10690 Single  0.000      0.000      0.875
  4      1.000    -90.000    0.10690 None    0.000      0.000      0.500
```

Full Section Properties

```
Area      1.9502 in^2   Wt.    0.0066308 k/ft   Width     27.353 in

Ix        108.38 in^4   rx         7.455 in     Ixy        -1.12 in^4
Sx(t)      9.702 in^3   y(t)      11.170 in     α          0.594 deg
Sx(b)     10.007 in^3   y(b)      10.830 in
                       Height    22.000 in
Iy          0.77 in^4   ry         0.630 in     xo        -0.810 in
Sy(l)      2.552 in^3   x(l)       0.303 in     yo        -3.165 in
Sy(r)      0.287 in^3   x(r)       2.697 in     jx        22.700 in
                       Width      3.000 in     jy         3.415 in
I1        108.39 in^4   r1         7.455 in
I2          0.76 in^4   r2         0.625 in
Ic        109.15 in^4   rc         7.481 in     Cw        66.606 in^6
Io        129.97 in^4   ro         8.163 in     J      0.0033048 in^4
```

Member Check - 2016 North American Specification - US (LRFD)

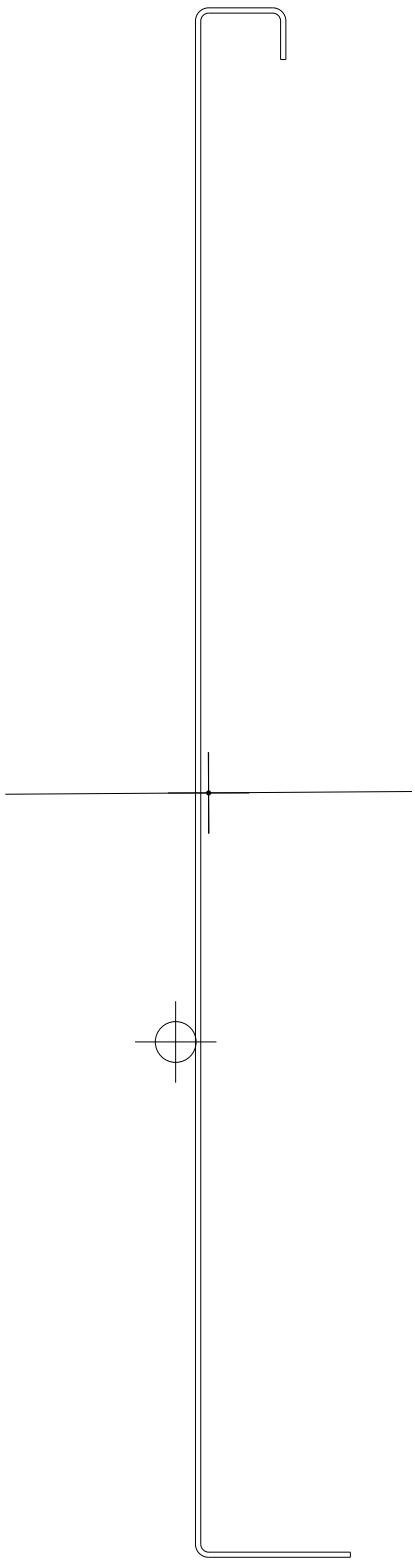
```
Material Type: A653 SS Grade 50/1, Fy=50 ksi
Design Parameters:
Lx        5.2500 ft     Ly        5.2500 ft     Lt        5.2500 ft
Kx        1.0000        Ky        1.0000        Kt        1.0000
Cbx       1.0000        Cby       1.0000        ex        0.0000 in
Cmx       1.0000        Cmy       1.0000        ey        0.0000 in
Braced Flange: None     kϕ             0 k
Red. Factor, R: 0       Lm        5.2500 ft

Loads:           P         Mx         Vy         My         Vx
                (k)     (k-in)        (k)     (k-in)        (k)
Entered      0.0000       0.00     0.0000       0.00     0.0000
Applied      0.0000       0.00     0.0000       0.00     0.0000
Strength     9.5558     175.80     1.9075       8.85     8.5659
```

CFS Version 10.0.0
Section: Section 1.cfss
Channel 30x3x1-12 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 12/12/2018 12:28:48 AM
By: Leonard Kim
Printed: 12/12/2018 12:29:59 AM



CFS Version 10.0.0
Section: Section 1.cfss
Channel 30x3x1-12 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 12/12/2018 12:28:48 AM
By: Leonard Kim
Printed: 12/12/2018 12:29:59 AM

Section Inputs

```
Material: A653 SS Grade 50/1
No strength increase from cold work of forming.
Modulus of Elasticity, E           29500 ksi
Yield Strength, Fy                    50 ksi
Tensile Strength, Fu                  65 ksi
Warping Constant Override, Cw          0 in^6
Torsion Constant Override, J           0 in^4

Stiffened Channel, Thickness 0.1017 in (12 Gage)
Placement of Part from Origin:
X to center of gravity           0 in
Y to center of gravity           0 in
Outside dimensions, Open shape
        Length      Angle     Radius  Web      k    Hole Size   Distance
          (in)      (deg)       (in)         Coef.       (in)       (in)
  1      3.000    180.000    0.15250 Single  0.000      0.000      1.500
  2     30.000     90.000    0.15250 Cee     0.000      0.000     15.000
  3      1.750      0.000    0.15250 Single  0.000      0.000      0.875
  4      1.000    -90.000    0.15250 None    0.000      0.000      0.500
```

Full Section Properties

```
Area      3.5781 in^2   Wt.     0.012166 k/ft   Width     35.183 in

Ix        345.11 in^4   rx         9.821 in     Ixy        -2.32 in^4
Sx(t)     22.706 in^3   y(t)      15.199 in     α          0.387 deg
Sx(b)     23.318 in^3   y(b)      14.801 in
                       Height    30.000 in
Iy          1.11 in^4   ry         0.558 in     xo        -0.637 in
Sy(l)      4.397 in^3   x(l)       0.254 in     yo        -4.823 in
Sy(r)      0.406 in^3   x(r)       2.747 in     jx        41.980 in
                       Width      3.000 in     jy         5.132 in
I1        345.13 in^4   r1         9.821 in
I2          1.10 in^4   r2         0.554 in
Ic        346.23 in^4   rc         9.837 in     Cw        180.01 in^6
Io        430.90 in^4   ro        10.974 in     J       0.012336 in^4
```

Member Check - 2016 North American Specification - US (LRFD)

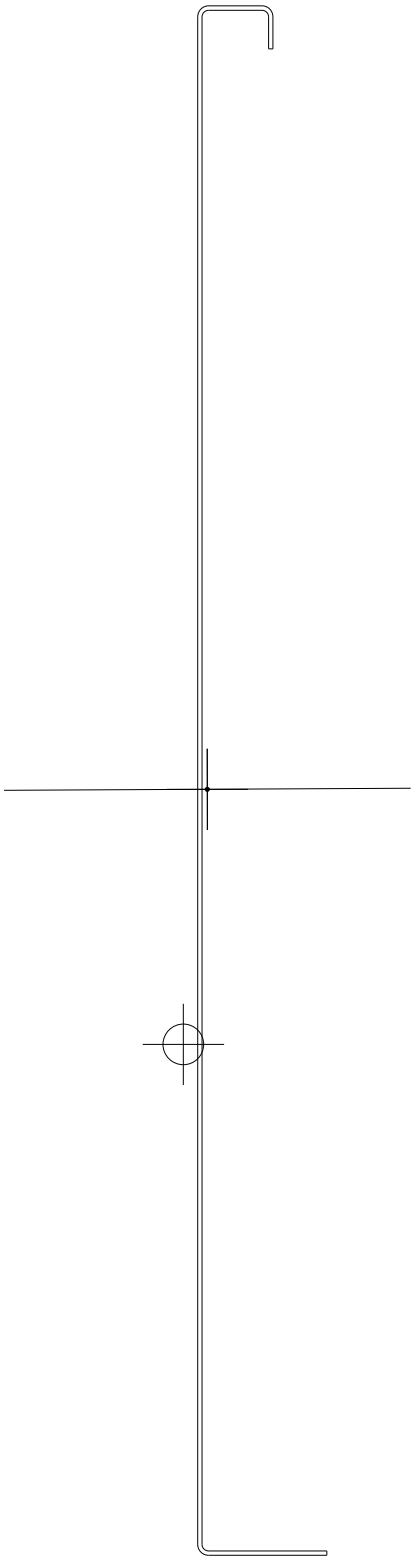
```
Material Type: A653 SS Grade 50/1, Fy=50 ksi
Design Parameters:
Lx        5.2500 ft     Ly        5.2500 ft     Lt        5.2500 ft
Kx        1.0000        Ky        1.0000        Kt        1.0000
Cbx       1.0000        Cby       1.0000        ex        0.0000 in
Cmx       1.0000        Cmy       1.0000        ey        0.0000 in
Braced Flange: None     kϕ             0 k
Red. Factor, R: 0       Lm        5.2500 ft

Loads:           P         Mx         Vy         My         Vx
                (k)     (k-in)        (k)     (k-in)        (k)
Entered       0.000       0.00      0.000       0.00      0.000
Applied       0.000       0.00      0.000       0.00      0.000
Strength     12.036     360.35      4.063      12.80     11.557
```

CFS Version 10.0.0
Section: Section 1.cfss
Channel 36x3x1-12 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 12/12/2018 12:47:10 AM
By: Leonard Kim
Printed: 12/12/2018 12:53:22 AM



CFS Version 10.0.0
Section: Section 1.cfss
Channel 36x3x1-12 Gage

Leonard Kim
John A. Martin & Associates

Rev. Date: 12/12/2018 12:47:10 AM
By: Leonard Kim
Printed: 12/12/2018 12:53:22 AM

Section Inputs

```
Material: A653 SS Grade 50/1
No strength increase from cold work of forming.
Modulus of Elasticity, E           29500 ksi
Yield Strength, Fy                    50 ksi
Tensile Strength, Fu                  65 ksi
Warping Constant Override, Cw          0 in^6
Torsion Constant Override, J           0 in^4

Stiffened Channel, Thickness 0.1017 in (12 Gage)
Placement of Part from Origin:
X to center of gravity           0 in
Y to center of gravity           0 in
Outside dimensions, Open shape
        Length      Angle     Radius  Web      k    Hole Size   Distance
          (in)      (deg)       (in)         Coef.       (in)       (in)
  1      3.000    180.000    0.15250 Single  0.000      0.000      1.500
  2     36.000     90.000    0.15250 Cee     0.000      0.000     18.000
  3      1.750      0.000    0.15250 Single  0.000      0.000      0.875
  4      1.000    -90.000    0.15250 None    0.000      0.000      0.500
```

Full Section Properties

```
Area      4.1883 in^2   Wt.     0.014240 k/ft   Width     41.183 in

Ix        563.41 in^4   rx        11.598 in     Ixy        -2.80 in^4
Sx(t)     30.953 in^3   y(t)      18.202 in     α          0.285 deg
Sx(b)     31.657 in^3   y(b)      17.798 in
                       Height    36.000 in
Iy          1.14 in^4   ry         0.521 in     xo        -0.556 in
Sy(l)      5.074 in^3   x(l)       0.224 in     yo        -5.928 in
Sy(r)      0.409 in^3   x(r)       2.776 in     jx        60.364 in
                       Width      3.000 in     jy         6.254 in
I1        563.43 in^4   r1        11.598 in
I2          1.12 in^4   r2         0.518 in
Ic        564.55 in^4   rc        11.610 in     Cw        269.37 in^6
Io        713.01 in^4   ro        13.048 in     J       0.014440 in^4
```

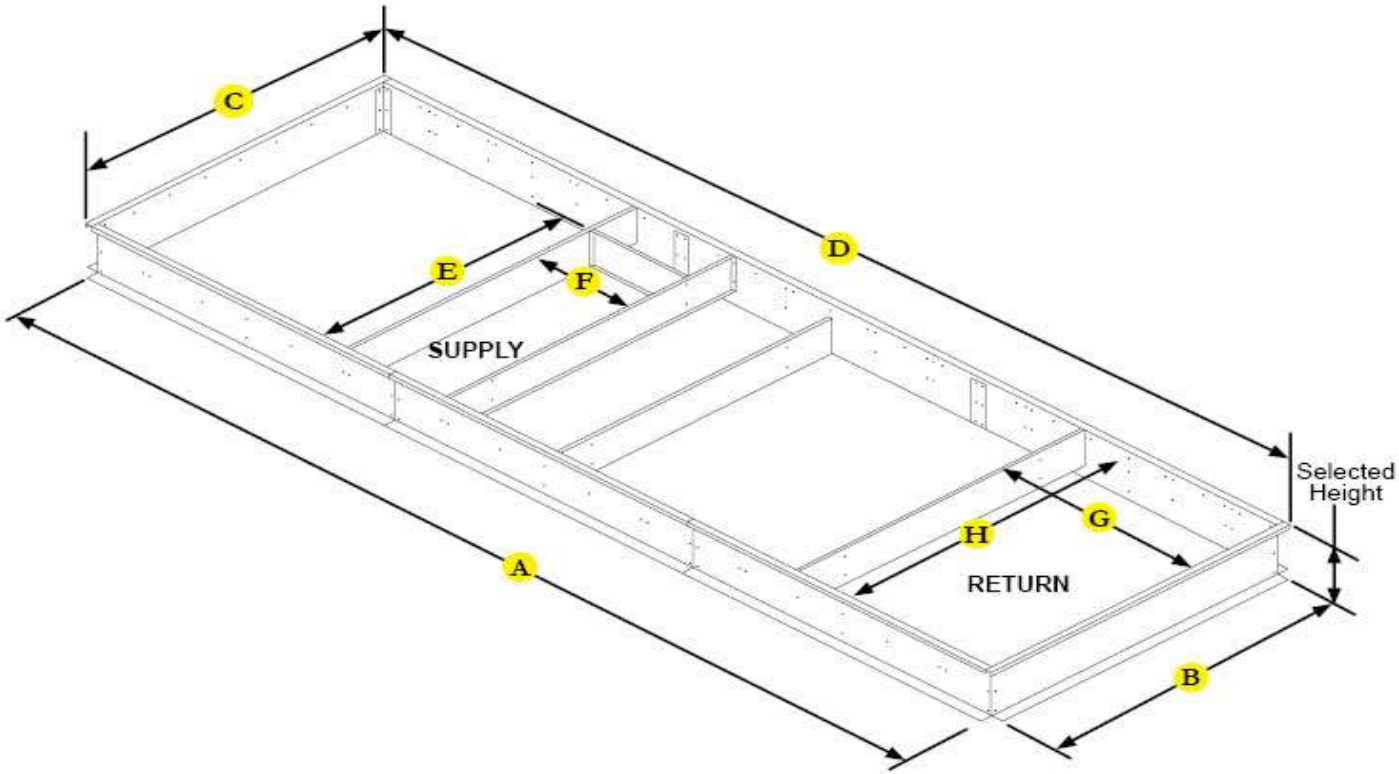
Member Check - 2016 North American Specification - US (LRFD)

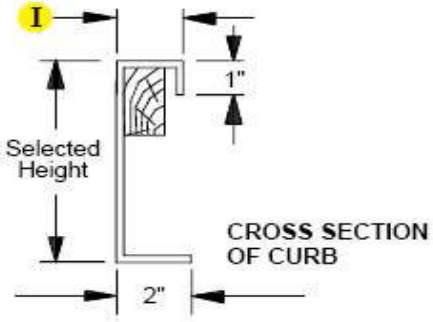
```
Material Type: A653 SS Grade 50/1, Fy=50 ksi
Design Parameters:
Lx        6.6700 ft     Ly        6.6700 ft     Lt        6.6700 ft
Kx        1.0000        Ky        1.0000        Kt        1.0000
Cbx       1.0000        Cby       1.0000        ex        0.0000 in
Cmx       1.0000        Cmy       1.0000        ey        0.0000 in
Braced Flange: None     kϕ             0 k
Red. Factor, R: 0       Lm        6.6700 ft

Loads:           P         Mx         Vy         My         Vx
                (k)     (k-in)        (k)     (k-in)        (k)
Entered       0.000       0.00      0.000       0.00      0.000
Applied       0.000       0.00      0.000       0.00      0.000
Strength      9.846     283.04      3.376      12.87     11.557
```

MicroMetl	Date:	Weight: 407lbs (US) 184.61kg (Metric)	Part Number: WCRB-P3035-EXP-14
	RTU:		
Submitted to:		Approved by:	Notes:

Welded Curb - 14 Inches Tall Non Insulated Full Perimeter Welded Roof Curb Welded Perimeter, Without Pitch, Insulated Deck Pan If Applicable, Includes Wood Nailer.





A - I.D.	B - I.D.	C - O.D.	D - O.D.	E	F	G	H	I
245.56	80.56	84.06	249.06	26.68	67.25	54.06	80.56	1.75

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Master Revision: 0001A

Page Revision: 0001A

SMMS-e / SHRM-e VRF Indoor Unit
MMD-AP0481HF2-UL—Outside Air Unit

TOSHIBA
Carrier

Submittal Data

Job Data _____ Location _____
Buyer _____ Buyer PO # _____ Carrier # _____
Unit Number _____ Model Number _____
Performance Data Certified By _____ Date _____



STANDARD FEATURES

- R-410A Refrigerant
- Three sizes from 48,000 to 96,000 Btu/h
- Rear return
- 208/230 V PSC (Permanent Split Capacitor) motor
- Five-year parts limited warranty

INDOOR UNIT MODEL		MMD-AP0481HF2UL
PERFORMANCE		
Cooling Rated Capacity	Btu/h	48,000
Heating Rated Capacity	Btu/h	30,000
Fan Type (Qty)	Centrifugal (1)	
Standard Airflow	CFM	636
Sound Pressure (H / M / L)	208V (dBA)	44 / 43 / 36
	230V (dBA)	46 / 45 / 42
External Static Pressure (ESP) (H / M / L)*	208V (WG)	0.75 / 0.55 / 0.16
	230V (WG)	1.06 / 0.86 / 0.50
ELECTRICAL		
Power Supply	V/Ph/Hz	208-230/1/60
Power Consumption (208V / 230V)	kW	0.31 / 0.34
Full Load Amps (FLA)	A	1.84
Minimum Circuit Amps (MCA)	A	2.30
Maximum Overcurrent Protection	A	15.0

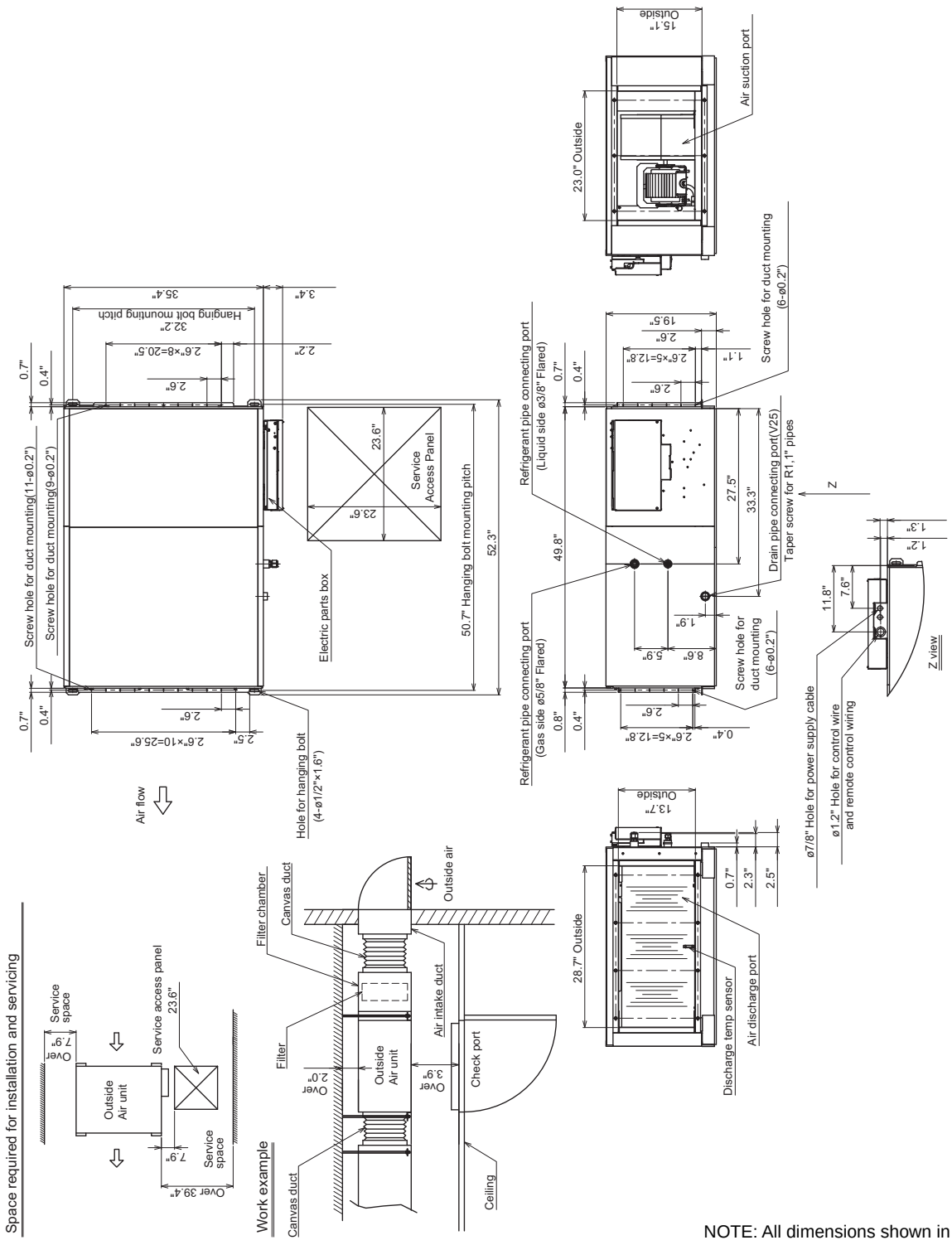
MOTOR		
Motor Type	PSC	
Motor Watts	W	160
PHYSICAL DATA		
Pipe Connection Size - Liquid	in.	3/8 (OD)
Pipe Connection Size - Suction	in.	5/8 (OD)
Pipe Connection Size - Drain	in.	1-1/4 (OD)
Refrigerant		R-410A
Unit Width	in.	35-3/8
Unit Height	in.	19-1/2
Unit Depth	in.	49-3/4
Net Weight	lb	212

* Medium Tap set from factory.

ACCESSORIES

- ☐ Wired Remote Controller (7-Day Programmable) - RBC-AMS54E-UL
- ☐ Simple Wired Remote Control - RBC-AS41UL
- ☐ Stand Alone Receiver with Wireless Remote TCB-AX32UL
- ☐ Remote Sensor TCB-TC41LUL
- ☐ Wired Remote Controller - RBC-AMT32UL

DIMENSIONAL DRAWING
OUTSIDE AIR INDOOR UNIT – MMD-AP0481HF2-UL



NOTE: All dimensions shown in inches.

© Carrier Corporation 2017

SMMS-*e* Single VRF Outdoor Unit
MMY-MAP0966HT6P-UL - Heat Pump

TOSHIBA
Carrier

Submittal Data

Job Data _____ Location _____
Buyer _____ Buyer PO # _____ Carrier # _____
Unit Number _____ Model Number _____
Performance Data Certified By _____ Date _____



SMMS-*e* VRF Heat Pump Features

- 6, 8, 10, 12, & 14-ton modules available
- Modules have 2 inverter-driven twin rotary compressors
- Backup capability due to multiple compressors
- Compressor speed varied in 0.1 Hz increments for comfort and efficiency
- Direct drive, inverter-driven 64-step outdoor motor
- Modules can be combined to form larger systems, up to 38 tons
- 985 ft (300 m) actual total system piping (liquid line)
- 623 ft (190 m) actual piping length from outdoor unit to furthest fan coil
- Up to 330 ft (100 m) control wiring between outdoor units
- Up to 6560 ft (2000 m) control wiring between the outdoor units and indoor units
- Operating temperature range
  Cooling (db): 14 to 122 F (–10 to 50 C)
  Heating (wb): –13 to 60 F (–25 to 15.6 C)
- Protection: high pressure switch, low pressure sensor and switch, process controller board fuse, inverter overload protection
- 7-year compressor limited warranty, 5-year parts limited warranty

Header Unit Model	MMY-MAP0966HT6P-UL	
PERFORMANCE		
Nominal Cooling Capacity	Btu/h	96,000
Nominal Heating Capacity	Btu/h	108,000
Maximum Total Connected Indoor Unit Capacity*		Up to 150%
COOLING EFFICIENCY†		
EER/IEER, Ducted FCUs		13.50/23.10
EER/IEER, Ductless FCUs		12.60/28.00
HEATING EFFICIENCY†		
COP at 47 F, Ducted FCUs		4.10
COP at 47 F, Ductless FCUs		4.50
Fan Type (Qty)		Propeller (1)
Airflow, Standard Range	CFM	7480
Sound Pressure, Cooling/Heating	dBA	61/61
External Static Pressure**	in. wg	0.16
ELECTRICAL		
Power Supply	V/Ph/Hz	460/3/60
Minimum Circuit Amps (MCA)	A	20
Recommended Fuse Size	A	25

COMPRESSORS		
Type (Number)		Inverter Twin Rotary (2)
Motor Output	kW	2 x 3.0
FAN MOTOR		
Motor Type (Steps)	Inverter Direct Driven (64)	
Motor Output	kW	1.0
PHYSICAL DATA		
Pipe Connection Size - Liquid (High Pressure)	in.	1/2 (Flare)
Pipe Connection Size - Gas (Low Pressure)	in.	7/8 (Brazed)
Balance	in.	3/8 (Flare)
Refrigerant		R-410A
Factory Charge††	lb	25.4
External Finish	Munsell 1Y8.5/0.5	
Unit Width	in.	47-9/16
Unit Height	in.	72-7/8
Unit Depth	in.	30-11/16
Unit Net Weight	lb	684

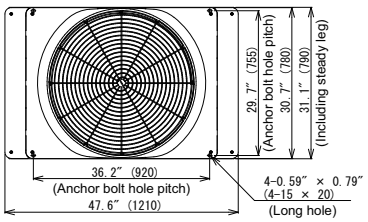
LEGEND

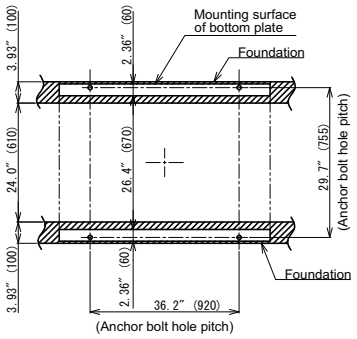
db — Dry Bulb
COP — Coefficient of Performance
EER — Energy Efficiency Ratio
FCU — Fan Coil Unit
IEER — Integrated Energy Efficiency Ratio
wb — Wet Bulb

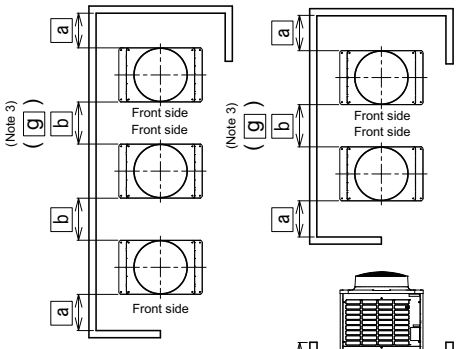
*When total connected indoor unit capacity exceeds 135%, number and types of indoor units are limited.
†Rated per AHRI (Air-Conditioning, Heating and Refrigeration Institute) 1230 Standard.
Cooling: Indoor 80 F (27 C) db/67 F (20 C) wb; Outdoor 95 F (35 C) db
Heating: Indoor 70 F (21 C) db; Outdoor 47 F (8 C) db/43 F (6 C) wb
**Requires setting by DIP switches.
††Additional charge required.
NOTE: Unit cabinet and coil slab shall be capable of withstanding 500-hour salt spray test in accordance with the ASTM (American Society for Testing and Materials, U.S.A.) B-117 Standard.

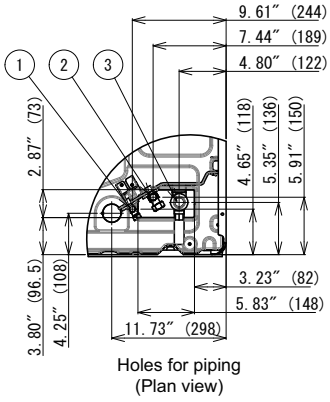
Manufacturer reserves the right to discontinue, or change at any time, specifications or designs without notice and without incurring obligations.

DIMENSIONAL DRAWING
OUTDOOR UNIT HEAT PUMP/SINGLE UNIT MMY-MAP0966HT6P-UL

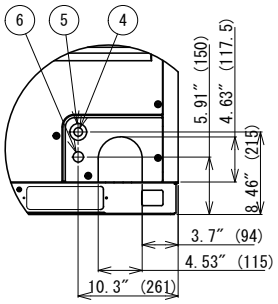




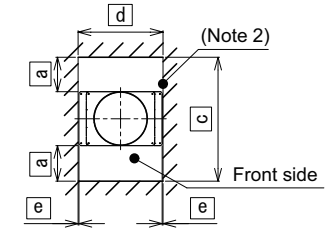




Holes for piping
(Plan view)



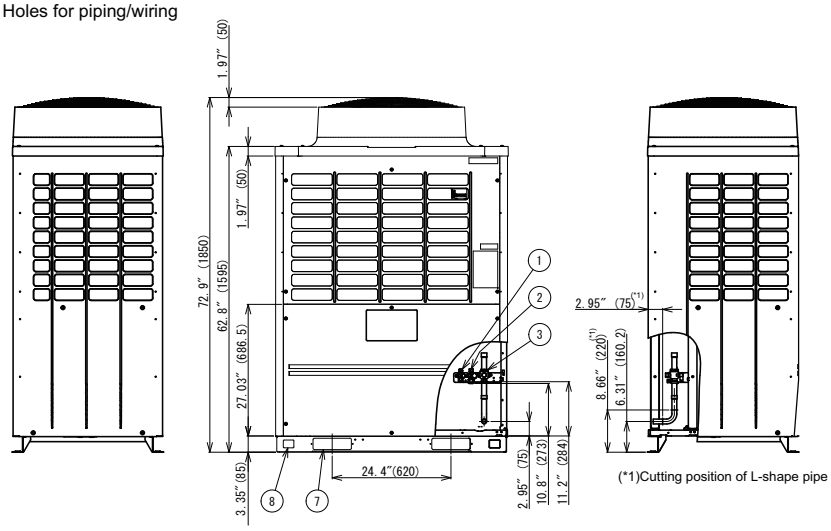
Holes for piping/wiring



Space required for service

a	≥ 19.7" (500)
b	≥ 23.6" (600)
c	≥ 70.1" (1780)
d	≥ 48.4" (1230)
e	≥ 0.39" (10)
g	≥ 39.4" (1000)
h	≤ 31.5" (800)

No	Parts name	Remarks
①	Balance pipe connection port	ϕ3/8" (9.5)
②	Liquid pipe connection port	ϕ1/2" (12.7)
③	Discharge gas pipe connection port	ϕ1" (25.4)
④	Knockout hole for power wiring 1	ϕ0.87" (22.2)
⑤	Knockout hole for power wiring 2	ϕ1.72" (43.7)
⑥	Knockout hole for control wiring	ϕ1.06" (27)
⑦	Square hole (for freight handling)	4-2.36" × 7.87" (4-60×200)
⑧	Square hole (for hanging)	4-1.58" × 2.17" (4-40×55)



(*1)Cutting position of L-shape pipe

NOTES:

1. A minimum clearance of 78.7 in. (2000 mm) is required above the unit.
2. Any wall or barrier should not exceed 31.5 in. (800 mm) from the bottom of the unit.
3. The main pipe in front of the unit must extend at least a minimum of 19.7 in. (500 mm) before it can turn 90 degrees in either left or right direction.
4. Dimensions in parentheses are in millimeters.

AHRI CERTIFIED®
www.ahridirectory.org
Variable Refrigerant Flow (VRF) Multi-Split AC and HP
AHRI Standard 1230

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SMMS-e Single VRF Outdoor Unit
MMY-MAP1446HT6P-UL - Heat Pump

TOSHIBA
Carrier

Submittal Data

Job Data _____ Location _____
Buyer _____ Buyer PO # _____ Carrier # _____
Unit Number _____ Model Number _____
Performance Data Certified By _____ Date _____



SMMS-e VRF Heat Pump Features

- 6, 8, 10, 12, & 14 ton modules are available
- Modules have 2 inverter-driven twin rotary compressors
- Backup capability due to multiple compressors
- Compressor speed varied in 0.1 Hz increments for comfort and efficiency
- Direct drive, inverter-driven 64-step outdoor motor
- Modules can be combined to form larger systems, up to 38 tons
- 985 ft (300 m) actual total system piping (liquid line)
- 623 ft (190 m) actual piping length from outdoor unit to furthest fan coil
- Up to 330 ft (100 m) control wiring between outdoor units
- Up to 6560 ft (2000 m) control wiring between the outdoor unit and indoor units
- Operating temperature range
  Cooling (db): 14 to 122 F (–10 to 50 C)
  Heating (wb): –13 to 60 F (–25 to 15.6 C)
- Protection: high pressure switch, low pressure sensor and switch, process controller board fuse, inverter overload protection
- 7-year compressor limited warranty, 5-year parts limited warranty

Header Unit Model	MMY-MAP1446HT6P-UL	
PERFORMANCE		
Nominal Cooling Capacity	Btu/h	144,000
Nominal Heating Capacity	Btu/h	162,000
Maximum Total Connected Indoor Unit Capacity*		Up to 150%
COOLING EFFICIENCY†		
EER/IEER, Ducted FCUs		11.60/22.10
EER/IEER, Ductless FCUs		12.40/25.60
HEATING EFFICIENCY†		
COP at 47 F, Ducted FCUs		4.00
COP at 47 F, Ductless FCUs		4.12
Fan Type (Qty)		Propeller (2)
Airflow, Standard Range	CFM	9760
Sound Pressure, Cooling/Heating	dBA	63/64
External Static Pressure**	in. wg	0.16
ELECTRICAL		
Power Supply	V/Ph/Hz	460/3/60
Minimum Circuit Amps (MCA)	A	25
Recommended Fuse Size	A	30

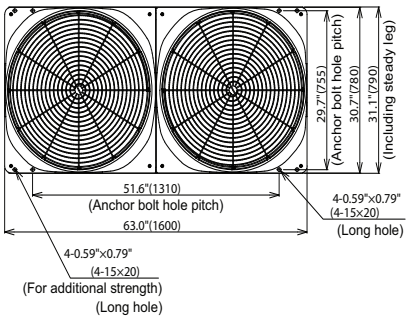
COMPRESSORS		
Type (Number)	Inverter Twin Rotary (2)	
Motor Output	kW	2 x 5.4
FAN MOTOR		
Motor Type (Steps)	Inverter Direct Driven (64)	
Motor Output	kW	1.0 + 1.0
PHYSICAL DATA		
Pipe Connection Size - Liquid (High Pressure)	in.	5/8 (Flare)
Pipe Connection Size - Gas (Low Pressure)	in.	1-1/8 (Brazed)
Balance	in.	3/8 (Flare)
Refrigerant		R-410A
Factory Charge††	lb	25.4
External Finish	Munsell 1Y8.5/0.5	
Header Unit/Width	in.	63
Header Unit/Height	in.	72-7/8
Header Unit/Depth	in.	30-11/16
Header Unit/Net Weight	lb	838

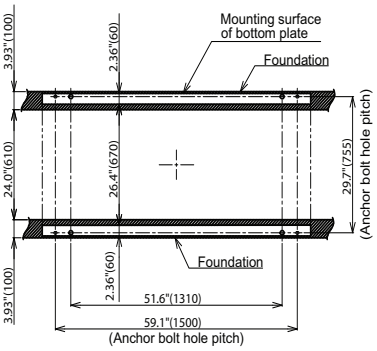
LEGEND

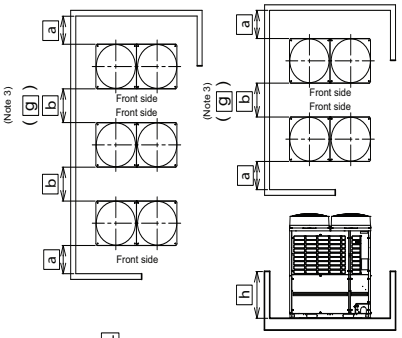
db — Dry Bulb
COP — Coefficient of Performance
EER — Energy Efficiency Ratio
FCU — Fan Coil Unit
IEER — Integrated Energy Efficiency Ratio
wb — Wet Bulb

*When total connected indoor unit capacity exceeds 135%, number and types of indoor unit are limited.
†Rated per AHRI (Air-Conditioning, Heating and Refrigeration Institute) 1230 Standard.
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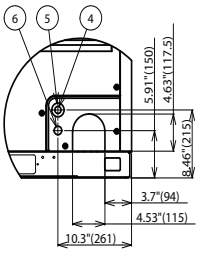
DIMENSIONAL DRAWING
OUTDOOR UNIT COMBINATION: HEAT PUMP/SINGLE UNIT
MMY-AP1446HT6P-UL



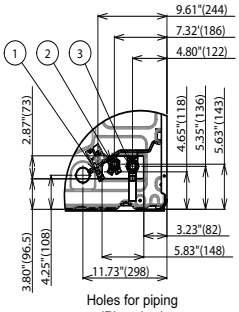




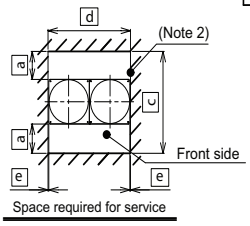
No	Parts name	Remarks
①	Balance pipe connection port	ϕ3/8"(9.5)
②	Liquid pipe connection port	ϕ3/4"(19.1)
③	Discharge gas pipe connection port	ϕ1"(25.4)
④	Knockout hole for power wiring 1	ϕ0.87"(22.2)
⑤	Knockout hole for power wiring 2	ϕ1.72"(43.7)
⑥	Knockout hole for control wiring	ϕ1.06"(27)
⑦	Square hole (for freight handling)	4-2.36"×7.87"(4-60×200)
⑧	Square hole (for hanging)	4-1.58"×2.17"(4-40×55)



Holes for piping/wiring



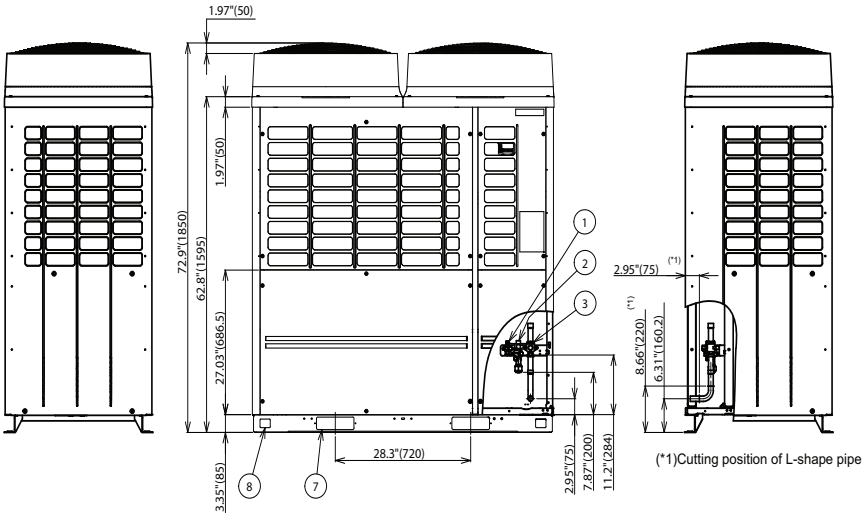
Holes for piping
(Plan view)



a	≥ 19.7"(500)
b	≥ 23.6"(600)
c	≥ 70.1"(1780)
d	≥ 63.8"(1620)
e	≥ 0.39"(10)
g	≥ 39.4"(1000)
h	≤ 31.5"(800)

NOTES:

1. A minimum clearance of 78.7 in. (2000 mm) is required above the unit.
2. Any wall or barrier should not exceed 31.5 in. (800 mm) from the bottom of the unit.
3. The main pipe in front of the unit must extend at least a minimum of 19.7 in. (500 mm) before it can turn 90 degrees in either left or right direction.
4. Dimensions in parentheses are in millimeters.



(*1)Cutting position of L-shape pipe

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Variable Refrigerant Flow (VRF) Multi-Split AC and HP
AHRI Standard 1230

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SMMSe / SHRMe VRF Controls and Accessories
RBC-AMS54E-UL – Wired Remote Controller

TOSHIBA Carrier

Submittal Data

Job Data _____ Location _____
Buyer _____ Buyer PO # _____ Carrier # _____
Unit Number _____ Model Number _____
Performance Data Certified By _____ Date _____

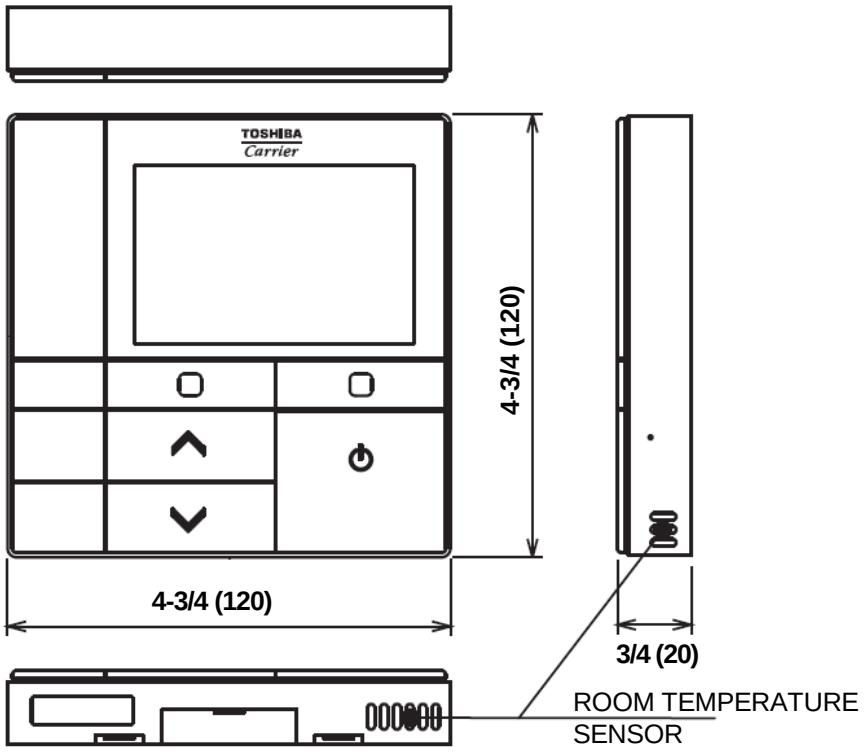


SMMSe / SHRMe VRF Wired Remote Controller Features

- Group control up to 8 indoor units
- Mode of operation
- Fan speed control
- ON/OFF
- Set temperature range limit
- Dual set point (HR only)
- Schedule weekly timer
- Clock setting
- Temperature display in 1ºF
- Individual louver control
- Back lit
- Multiple languages
- DN code setting
- Compatible with Toshiba Carrier VRF and RAV systems

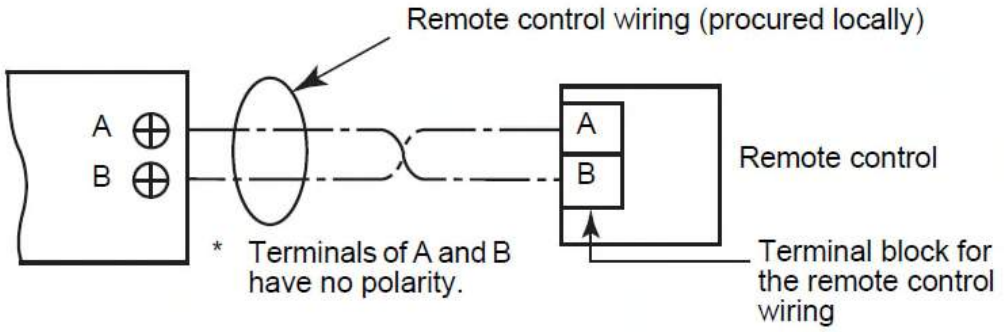
DIMENSIONAL DRAWING

WIRED REMOTE CONTROLLER RBC-AMS54E-UL



NOTE: Dimensions are in inches (mm).

WIRING DIAGRAM



* Use wire of AWG20 to AWG14.
* A crimp-style terminal cannot be used.

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ultraDRY 100% Outside Air Package Unit

Project Name	Channel Islands Bldg K
Quantity	2

Model #	UGC-GC04MHD053M00A-FGVY1
Tag #	DOAS-1,2



UL1995 listed through ETL

COOLING PERFORMANCE	
Total Capacity (MBh)	35.3
Sensible Capacity (MBh)	23.7
Part Load Efficiency (SEER)	16.0
Entering DB Temp ˚F	86.0
Entering WB Temp ˚F	68.0
Leaving DB Temp ˚F	41.5 (Min/Modulating)
Leaving WB Temp ˚F	41.5 (Min/Modulating)
Sound Power (dBA)	79.0

MODULATING REHEAT PERFORMANCE	
Total Capacity (MBh)	17.0
Entering DB Temp ˚F	41.5 (Modulating)
Leaving DB Temp˚F	73 (Modulating)

GAS HEAT PERFORMANCE	
Entering Air Temperature °F	30.0
Leaving Air Temperature °F	128.1 (Max/Modulating)
Gas Heating Output Capacity (MBh)	53.0
Gas Heating Efficiency (%)	80.0
Gas Heating Stages	Modulating (10:1 Turndown)
Total Heat Capacity (Mbh)	53.0
Elevation (ft. above sea level)	0.0

SUPPLY AIR BLOWER PERFORMANCE	
Supply Air (cfm)	500
Outside Air (cfm)	500
External Static Pressure (in-wc)	1.00
Motor Rating (hp)	0.47 BHP
Unit Configuration	Vertical Supply/No Return

WEIGHT
513 lbs

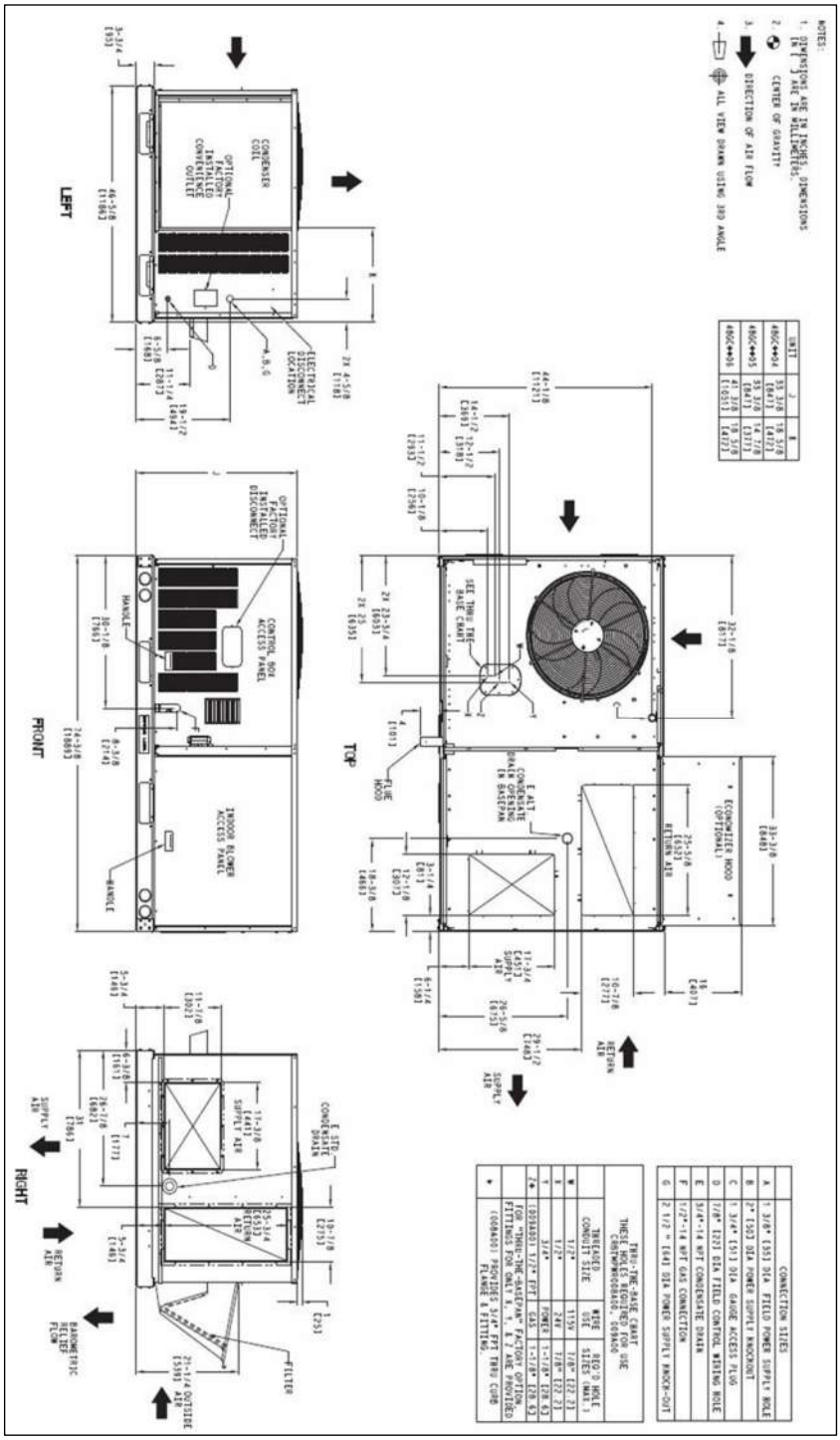
ELECTRICAL DATA					
208v 1 Ph.		230v 1 Ph.		460v 3 Ph.	
208v 3 Ph.	X	230v 3 Ph.			
Motor FLA (amps)			4.5		
Compressor (qty / amps each)			1 / 11.6 , RLA		
Condenser Fan (qty / amps each)			1 / 1.5 FLA		
Min. Circuit Ampacity (amps)			21		
Max. Over-current Protection (amps)			30		
Switch Disconnect	N/A				
Fuse Disconnect	N/A				

WARRANTY
One (1) Year Limited Parts-Only Warranty on the Complete Unit
Five (5) Year Warranty - Compressors & Electric Heater Elements
Fifteen (15) Year Warranty - Stainless Steel Heat Exchanger

STANDARD FEATURES
• Pre-painted exterior panels and primer-coated interior panels tested to 1,000 hours salt spray protection.
• Exclusive non-corrosive composite condensate pan in accordance with ASHRAE 62 Standard.
• Scroll compressors with internal line-break overload protection.
• Standard 2" throwaway filter.
• Liquid line filter-driers.
• Provisions for thru-the-bottom power entry capability as standard.
• 0~100% Outside air applications.
• Fully modulating hot gas reheat.
• Refrigerant management control thru capacity control device.
• Variable frequency drive factory set to specified cfm.
• Evaporator freeze protection on all stages.

RTU OPTIONAL FEATURES			
(0) No Options		(R) Split Unit Power Fuse Disc.	
(A) Ionization		(S) Split Unit Power Switch Disc.	
(B) ultraGUARD Whole Unit		(T) Smoke Sensor SA	
(C) ultraGUARD All Coils		(U) Smoke Sensor RA	
(D) ultraGUARD Condenser Coil		(V) Low Ambient Control	X
(E) ERV		(W) Manual OA Damper	
(F) MERV 13.4" Filters	X	(X) Intertwined Evap. Coil	
(G) 2 Pos OA Damper /w Hood	X	(Y) Start-Up	X
(H) BACnet		(1) 365 Day Annual Timer	X
(J) Hinged Access Doors		(2) Duel Fuel Unit	
(K) DW w/ Poly Insulation		(3) Condensate Float Switch	
(L) SS Drain Pan		(4) Airflow Monitor	
(M) SS Gas Heat Exchanger		(5) Hail Guard	
(N) Dirty Filter Switch		(6) Remote Readout	
(P) Service Outlet (non power)		(7) Phase Monitor	
(Q) Service Outlet (power)		(8) Powered Exhaust	
CONTROLS			
(0) NO CONTROLS		(F) Space w/VAVbuilding	
(A) DAT w/ VAV duct		(G) ultraGROW CONTROL	
(B) DAT w/ VAV building		(H) UD3 w/VAV building	
(C) UD3 w/VAV duct		(S) SPACE CONTROL	
(D) DISCHARGE AIR TEMP. CTRL.	X	(3) ultraDRY 3 temperature control	
(E) Space w/VAVduct			

NOTES


LEFT
FRONT
TOP
RIGHT
CONDENSER COIL
OPTIONAL FACTORY INSTALLED CONVENIENCE OUTLET
ELECTRICAL DISCONNECT LOCATION
CONTROL BOX ACCESS PANEL
INDOOR BLOWER ACCESS PANEL
HANDLE
FLUE HOOD
ECONOMIZER HOOD (OPTIONAL)
RETURN AIR
SUPPLY AIR
CONDENSATE DRAIN
FILTER
BAROMETRIC RELIEF FLOW
OUTSIDE AIR
NOTES:
1. ALL DIMENSIONS ARE IN INCHES. DIMENSIONS IN [ ] ARE IN MILLIMETERS.
2. CENTER OF GRAVITY
3. DIRECTION OF AIR FLOW
4. FULL VIEW DRAWN USING 3RD ANGLE
CONNECTION SIZES
A 7/8" (15) DIA FIELD POWER SUPPLY HOLE
B 2" (50) DIA POWER SUPPLY KNOCKOUT
C 1 3/4" (91) DIA GAUGE ACCESS PLUG
D 7/8" (22) DIA FIELD CONTROL WIRING HOLE
E 3/4"-14 NPT CONDENSATE DRAIN
F 1/2"-14 NPT GAS CONNECTION
G 2 1/2 " (64) DIA POWER SUPPLY KNOCK-OUT
THRU-THE-BASE CHART
THESE PENETRATIONS ARE FOR FACTORY USE ONLY
UNIT
A
B
C
D
E
F
G
48GC*004
48GC*005
48GC*006
55 3/8 [1407]
14 7/8 [377]
18 5/8 [473]
THRU-THE-BASE CHART
THESE PENETRATIONS ARE FOR FACTORY USE ONLY
THREADED CONDUIT SIZE
WIRE SIZES MAX
RIGID/IMC CONDUIT SIZES MAX
1/2"
1156
7/8" (22.2)
3/4"
240
7/8" (22.2)
POWER
1-1/8" (28.6)
GAS
1-1/8" (28.6)
(00584001 1/2" FPT FOR "THRU-THE-BASEPAN" FACTORY OPTION FITTINGS FOR ONLY 4, 5, & 7 ARE PROVIDED
(00584001 PROVIDES 3/4" FPT THRU CURB FLANGE & FITTING

SEQUENCE OF OPERATIONS (choose one Control type below)

Discharge Air Control (DAT)	X

DISCHARGE AIR CONTROL MODEL (DAT)

In the UNOCCUPIED mode, the outside air unit will be off and the outside air damper, if supplied, will be closed. Occupied or Unoccupied is signaled to the IAIRE controller via a normally open or normally closed contact on the OCCUPIED input with a clock or switch. An open contact on the input indicates OCCUPIED, a closed contact indicates UNOCCUPIED.

In the OCCUPIED mode, the outside air damper will open and the supply fan will ramp up to the configured fan speed (dependent on whether the unit is heating or cooling). The Fan input is monitored to determine if fan is operating or not. If not operating, the IAIRE controller will enter into an alarm state, start staging off compressors, and attempt to cycle the fan until it starts.

There is a configurable EAT Heat Lockout (default 58F). If the entering air temperature (EAT) is < or = to the lockout, then the heat stages will cycle to maintain the discharge air temperature DAT setpoint.

There is a configurable EAT Cool Lockout (default 61F). If the EAT is > or = to this lockout than Y1 is always on and Y2-Y4 is staged on depending on demand (if enabled), along with the modulated hot gas valve will be used to maintain the DAT.

If the EAT is > the EAT Heat Lockout (default 58F) and < the EAT Cool Lockout (default 61F), the unit has 3 possible modes of operation. If DAT needs cooling, the unit will free cool. If DAT requires heat, the unit will turn on heat to try to maintain DAT. If there is a call for humidity control (Humidity above the Humidity Stage 1 Set point), (defaulted to 50% RH and user configurable), Y1 will stage on and the modulated Hot Gas will try to maintain DAT.

Space Control Model (Humidity/Temp)	

SPACE CONTROL MODEL (HUMIDITY/TEMP)

In the UNOCCUPIED mode, the outside air unit will be off and the outside air damper, if supplied, will be closed. Occupied or Unoccupied is signaled to the IAIRE controller via a normally open or normally closed contact on the OCCUPIED input with a clock or switch. An open contact on the input indicates OCCUPIED, a closed contact indicates UNOCCUPIED.

In the OCCUPIED mode, the outside air damper will open and the supply fan will start. When equipped with a Variable-Frequency Drive (VFD), the fan will ramp up to the configured fan speed (dependent on whether the unit is heating or cooling).). The Fan input is monitored to determine if fan is operating or not. If not operating, the IAIRE controller will enter into an alarm state, start staging off compressors, and attempt to cycle the fan until it starts.

There is a configurable EAT Heat Lockout (default 58F). If the EAT is < or = to this temperature, the electric heat stages will cycle to maintain the room air temperature setpoint.

There is a configurable EAT Cool Lockout (default 61F). If the EAT is > or = to this temperature than Y1 is always on and Y2-Y4 (if enabled) along with the modulated hot gas valve will be used to maintain the room air temperature.

If the EAT is > the EAT Heat Lockout (default 58F) and < the EAT Cool Lockout (default 61F), the unit has 3 possible modes of operation. If the space needs cooling, the unit will free cool. If the space requires heat, the unit will turn on heat to try to maintain space temperature set point. If there is a call for humidity control (Humidity above the Humidity Stage 1 Set point), (defaulted to 50% RH and user configurable), Y1 will stage on and the modulated Hot Gas will try to maintain the space temperature set point.

ultraDRY3 Control Model	

FAN SPEED CONTROL

These units are equipped with variable speed supply fan control. There is a cooling and heating fan speed set point. In this application, both the cooling and heating fan speed set point should be the same. This should be set by the test and balance contractor to provide and correct CFM for the unit. Once the supply fan speed is initially set, it will not modulate.

NORMAL HOURS (not night set back)

Cooling Mode (humidistat on cooling) –When the temperature gets above the set point temperature by more than 2 degrees, the compressor will come on and start cooling the air. Once the temperature reaches the set-point, the compressor will turn off and the air will continue to circulate in the space without heating or cooling.

Heating Mode (humidistat on heating) – When the temperature gets below the set point temperature by more than 2 degrees, the heat pump will come and begin heating the air. Once the temperature reaches the set point temperature, the heat pump will turn off and the air will continue to circulate in the space without heating or cooling.

Humidity mode – When the unit is not running in cooling or heating and the humidity sensor on the humidistat registers a humidity higher than the set point humidity, the compressor will come on for cooling and the hot gas modulating valves will open to raise the discharge temperature of the air entering the building after cooling to a discharge setpoint. This will help reduce the humidity without cooling the building off too much. Once the humidity is below the set point humidity, the unit compressor and hot gas modulating valves will shut off and the air will continue to circulate in the space without heating or cooling.

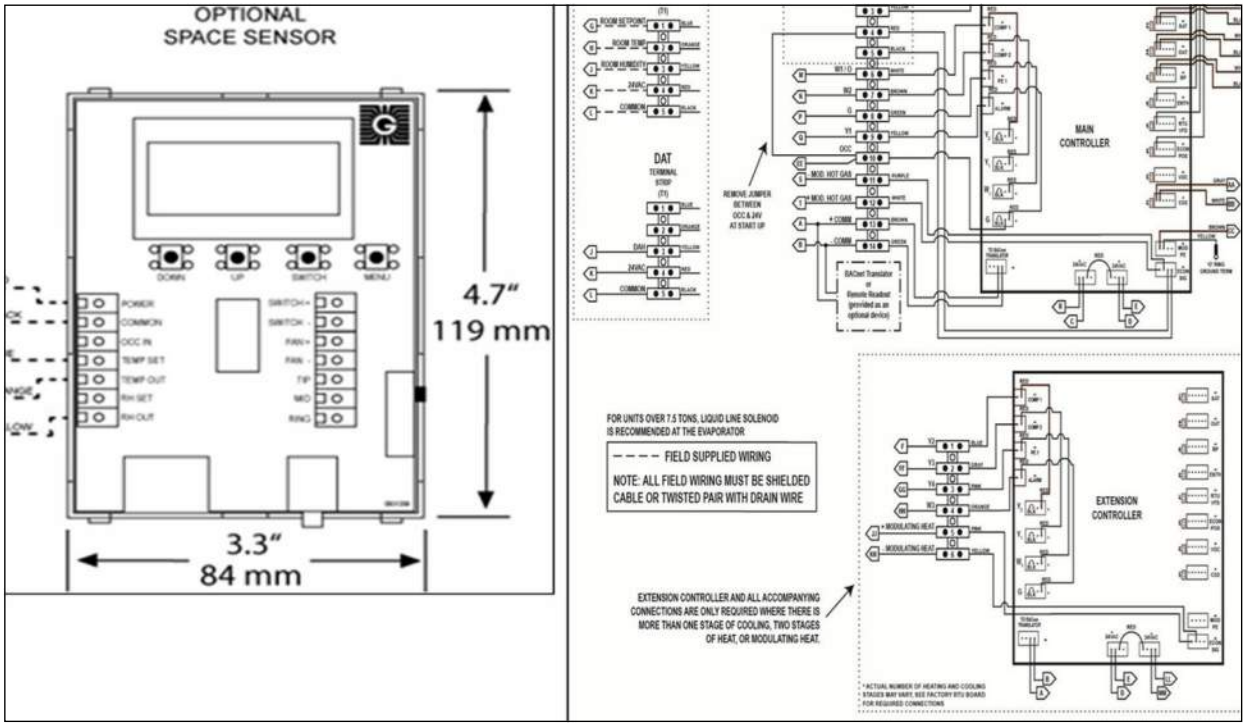
NIGHT SET BACK HOURS

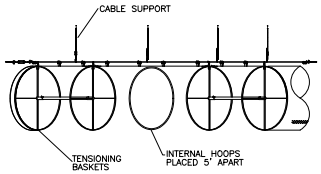
Allows the occupant to set a schedule across the 7 day, 24 hour week to schedule set back temperatures at night to conserve energy.

UNOCCUPIED HOURS

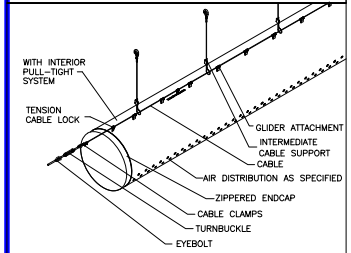
Allows the occupant to set a schedule across the 7 day, 24 hour week to schedule the unit off to conserve energy.

DAT / SPACE CONTROLLER WIRING

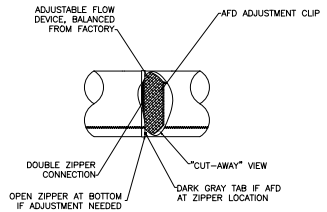




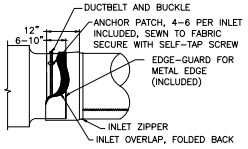
SUSPENSION DETAIL
SKELECORE PULL-TIGHT WITH CABLE SYSTEM DETAIL



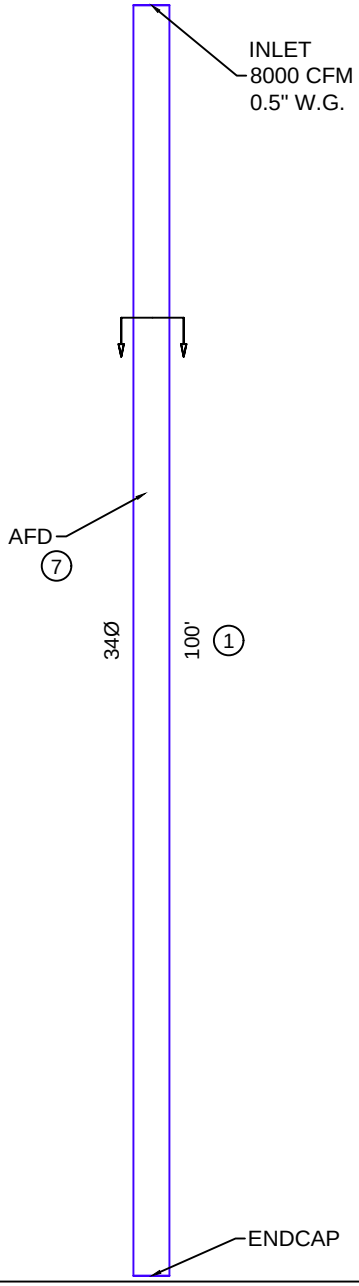
SUSPENSION DETAIL
1 ROW CABLE SUSPENSION AT 12 O'CLOCK
SKELECORE PULL-TIGHT



ADJUSTABLE FLOW DEVICE (AFD)
INSTALLED AT ZIPPER LOCATION AT INLET OR AS SPECIFIED IN OTHER LOCATIONS. ZIPPER TO ZIPPER CONNECTION AS SHOWN. EXTERNAL LABEL IDENTIFIES LOCATION

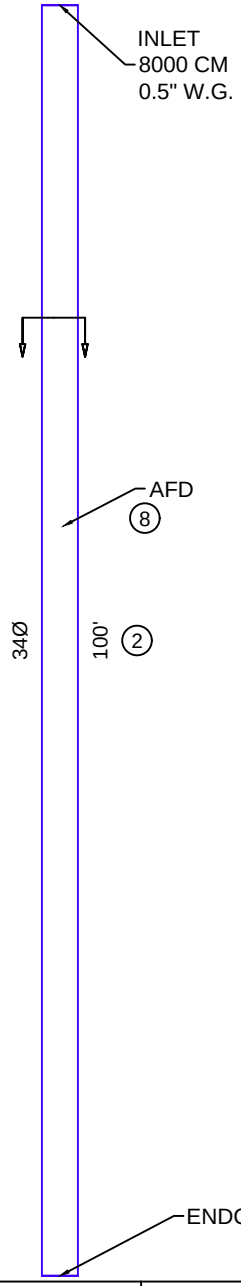


INLET ATTACHMENT DETAIL



SECTION 1 - 8000 CFM
ISOTHERMAL THROW
BASED ON TERMINAL
VELOCITY OF 50, 100, & 150 FPM

SIZE 28 VENT AT 4:30 = 42'-6" 26'-6" 17'-6"
SIZE 28 VENT AT 7:30 = 42'-6" 26'-6" 17'-6"



SECTION 2 - 8000 CFM
ISOTHERMAL THROW
BASED ON TERMINAL
VELOCITY OF 50, 100, & 150 FPM

SIZE 28 VENT AT 4:30 = 42'-6" 26'-6" 17'-6"
SIZE 28 VENT AT 7:30 = 42'-6" 26'-6" 17'-6"

DUCTSOX
TEXTILE AIR DISPERSION PRODUCTS
4343 Chavenelle Rd. PH: 866-382-8769
Dubuque, IA 52002 www.ductsox.com

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UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN FEET AND INCHES
LENGTH TOLERANCES: (+/-) 3" PER INITIAL 10'. (+/-) 1" EVERY 10' AFTER

DRAWING TITLE	DUCTSOX PLAN VIEW
PROJECT NAME	CHANNEL ISLANDS HIGH SCHOOL
REPRESENTATIVE	TORO AIRE
DRAWING NUMBER	DS19-1573
DRAWN BY	KCS
DATE	11 JUN 2019

FABRIC	VERONA	COLOR	NOT SPECIFIED
HANG HEIGHT	BOD = 25'-8" AFF		
SUSPENSION	SKELECORE PULL-TIGHT	FITTING ALIGNMENT	N/A
HARDWARE	GALVANIZED CABLE	SCALE	NTS
REVISION	7	PAGE NUMBER	1 OF 1

REV	DESCRIPTION	BY	DATE
7	CHANGE OF LAYOUT	LJB	26 MAY 2020
5	REVISED LENGTH OF TAGS 1 & 4	KCS	24 APR 2020
6	REVISED FOR 16,000 CFM	KCS	08 MAY 2020

COOK

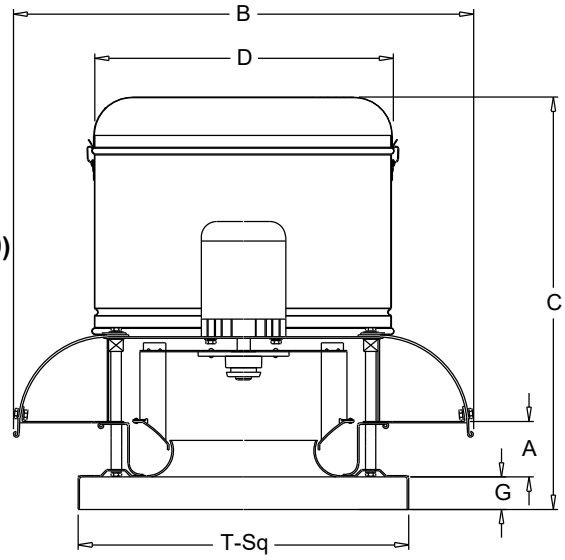
MARK: EF-C35	
PROJECT: CHANNEL ISLAND FAN SELECTION	
DATE: 5/7/2020	

ACE-D

Downblast Centrifugal Exhaust Ventilator Roof Mounted/Direct Drive

STANDARD CONSTRUCTION FEATURES:

All aluminum housing - Backward inclined all aluminum wheel - Two piece top cap with stainless steel quick release latches (sizes 120 - 300) - Welded curb cap corners - Birdscreen - Permanently lubricated ball bearing motors - Corrosion resistant fasteners - Transit tested packaging.



Performance

Qty	Catalog Number	Flow (CFM)	SP (inwc)	Fan RPM	Power (HP)	FEG	Speed Ctrl/Hz
1	120C17D	1120	.375	1275	.149	n/a(<1HP)	VFD/44

Altitude (ft): 0 Temperature (F): 70

Motor Information

HP	RPM	Volts/Ph/Hz	Enclosure	FLA	VFD Rated
1/3	1725	208/3/60	ODP -SE	1.6	Yes

FLA based on NEC (2014) Table 430.250

Sound Data Inlet Sound Power by Octave Band

1	2	3	4	5	6	7	8	LwA	dBA	Sones
68	71	75	65	62	59	53	48	69	58	9.0

Accessories:

BD-14 DAMPER
ROOF CURB RCG 18-13.5H
HINGED BASE KIT
STAINLESS BIRDSCREEN

Dimensions (inches)

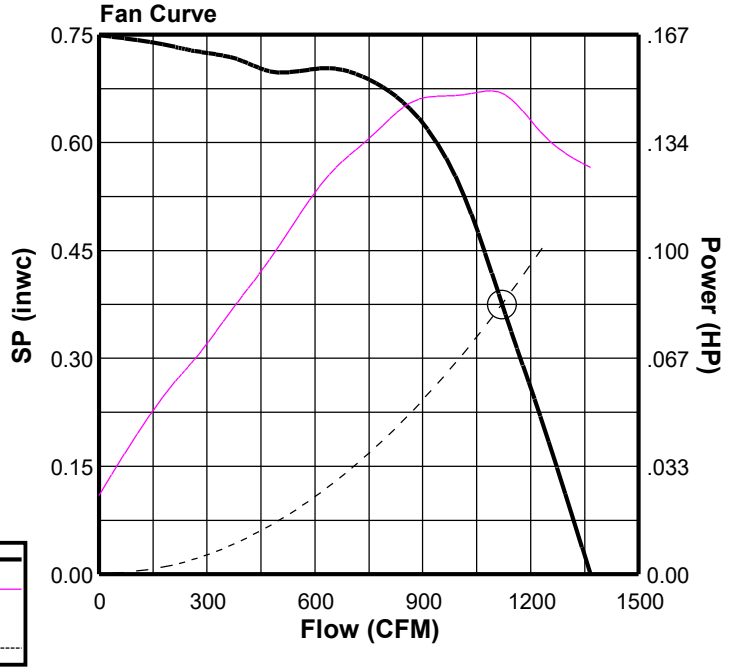
A	1-7/16
B O.D.	28-7/16
C	27-1/16
D O.D.	20-3/8
G	2
T Sq.	20
Roof Open. Sq.*	15-1/2

NOTE: Accessories may affect dimensions shown.

Weight(lbs)***	Shipping	125	Unit	109

* Roof opening size for curbs supplied by Cook only.
***Includes fan, motor & accessories.

Fan Curve



Fan Curve Legend

CFM vs SP	———
CFM vs HP	———
Point of Operation	◯
System Curve	- - - - -

BD

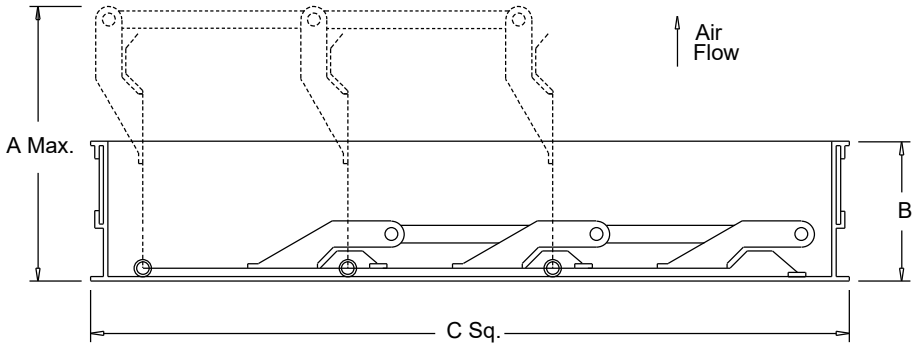
Gravity Backdraft Damper

STANDARD CONSTRUCTION FEATURES:

.020 Aluminum blades - .060 aluminum frame - Aluminum hinge pins - Nylon bushings.

Notes:

Max. operating temperature 200 Deg F (95 Deg C).
Max. discharge velocity 2000 fpm.
Sizes 36 thru 60 are shipped as 2 panels.
Sizes 66 and 78 are shipped as 6 panels.
These may require assembly.



Dimensions (inches)

Mark	Qty	Description	A Max.	B	C Sq.	# Panels
EF-C35	1	BD-14 DAMPER	5-3/16	1-7/8	13-3/4	1

RCG

Galvanized Steel Roof Curb

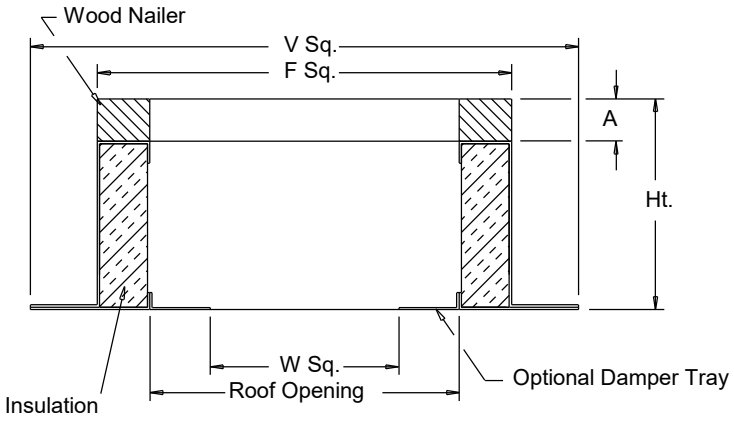
STANDARD CONSTRUCTION FEATURES:

18 gauge galvanized steel - 1-1/2", 3 lbs. density thermal and acoustical insulation - Continuously welded corners - Wood nailer.

Options:(As noted below*)

1) No wood nailer (deduct 1-1/2" for actual height).

2) Damper tray.



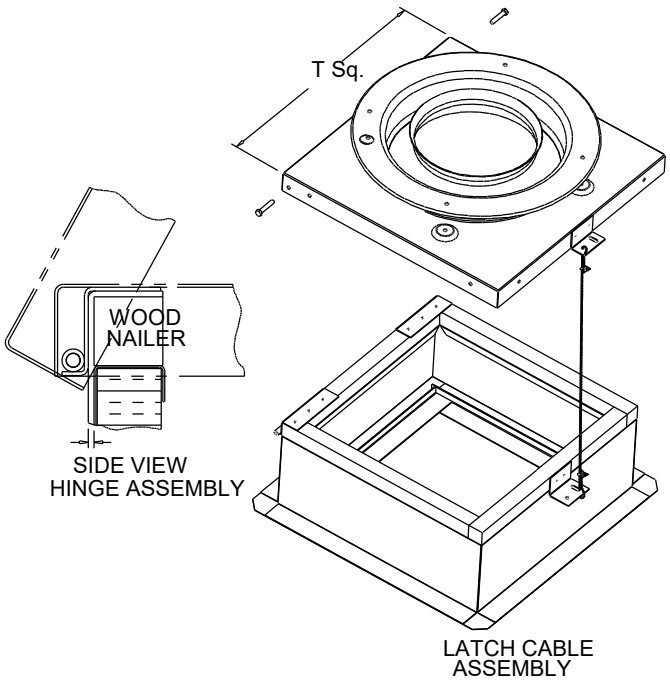
Dimensions (inches)

Mark	Qty	Description	Ht	Options*	A	F Sq.	V Sq.	W Sq.	Roof Opening
EF-C35	1	RCG 18	13.5	-	1-1/2	18-1/2	22-1/2	11-3/4	15-1/2

PROJECT: CHANNEL ISLAND FAN SELECTION
DATE: 5/7/2020

HINGED BASE

Kit Assembly



Dimensions (inches)

Mark	Qty	Description
EF-C35	1	HINGED BASE KIT

COOK

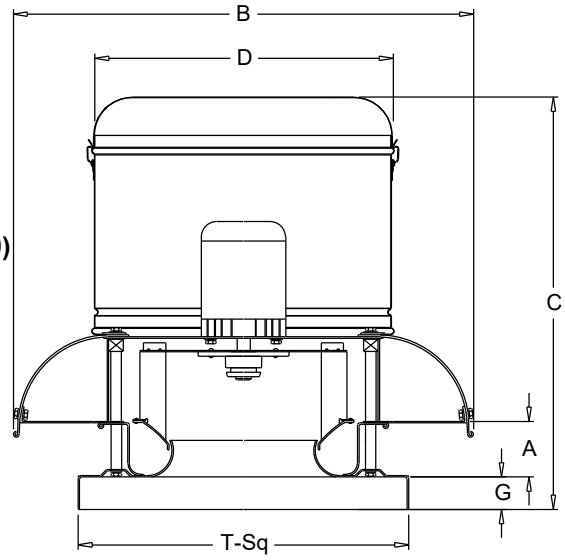
MARK: EF-C38	
PROJECT: CHANNEL ISLAND FAN SELECTION	
DATE: 5/7/2020	

ACE-D

Downblast Centrifugal Exhaust Ventilator Roof Mounted/Direct Drive

STANDARD CONSTRUCTION FEATURES:

All aluminum housing - Backward inclined all aluminum wheel - Two piece top cap with stainless steel quick release latches (sizes 120 - 300) - Welded curb cap corners - Birdscreen - Permanently lubricated ball bearing motors - Corrosion resistant fasteners - Transit tested packaging.



Performance

Qty	Catalog Number	Flow (CFM)	SP (inwc)	Fan RPM	Power (HP)	FEG	Speed Ctrl/Hz
1	120C17D	1200	.375	1338	.170	n/a(<1HP)	VFD/47

Altitude (ft): 0 Temperature (F): 70

Motor Information

HP	RPM	Volts/Ph/Hz	Enclosure	FLA	VFD Rated
1/3	1725	208/3/60	ODP -SE	1.6	Yes

FLA based on NEC (2014) Table 430.250

Sound Data Inlet Sound Power by Octave Band

1	2	3	4	5	6	7	8	LwA	dBA	Sones
69	72	76	67	63	61	54	49	71	59	9.7

Dimensions (inches)

A	1-7/16
B O.D.	28-7/16
C	27-1/16
D O.D.	20-3/8
G	2
T Sq.	20
Roof Open. Sq.*	15-1/2

NOTE: Accessories may affect dimensions shown.

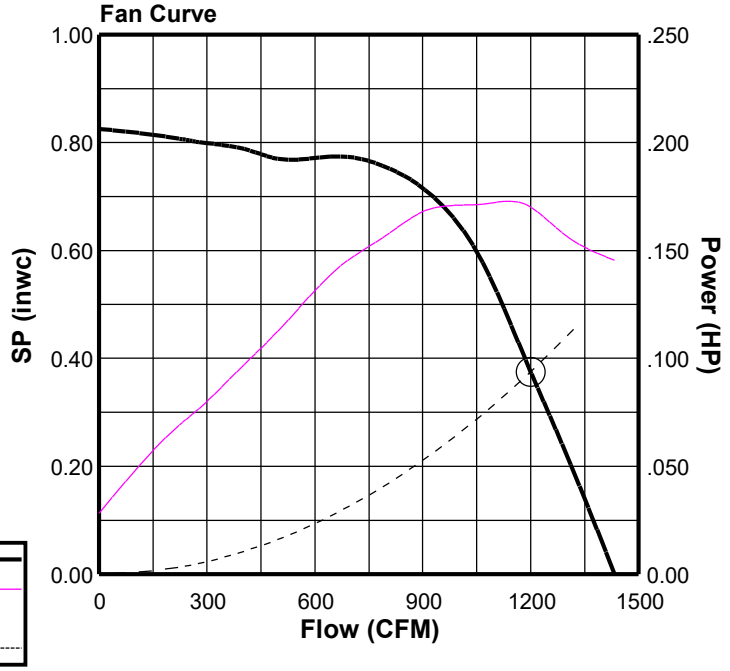
Weight(lbs)***	Shipping	125	Unit	109

* Roof opening size for curbs supplied by Cook only.
***Includes fan, motor & accessories.

Accessories:

BD-14 DAMPER
ROOF CURB RCG 18-13.5H
HINGED BASE KIT
STAINLESS BIRDSCREEN

Fan Curve



Fan Curve Legend

CFM vs SP	———
CFM vs HP	———
Point of Operation	◯
System Curve	- - - - -

BD

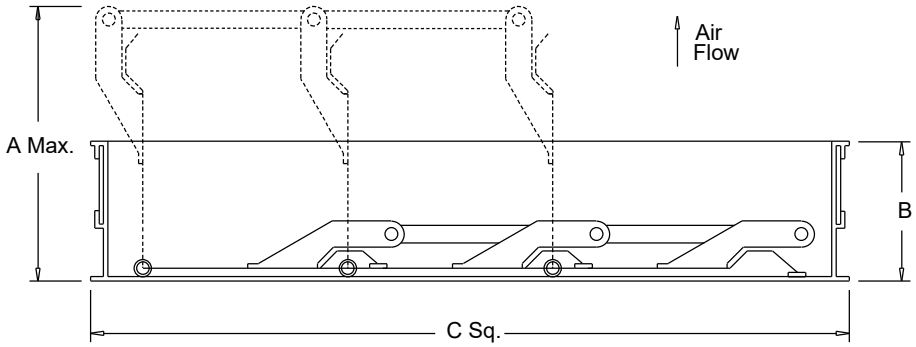
Gravity Backdraft Damper

STANDARD CONSTRUCTION FEATURES:

.020 Aluminum blades - .060 aluminum frame - Aluminum hinge pins - Nylon bushings.

Notes:

Max. operating temperature 200 Deg F (95 Deg C).
Max. discharge velocity 2000 fpm.
Sizes 36 thru 60 are shipped as 2 panels.
Sizes 66 and 78 are shipped as 6 panels.
These may require assembly.



Dimensions (inches)

Mark	Qty	Description	A Max.	B	C Sq.	# Panels
EF-C38	1	BD-14 DAMPER	5-3/16	1-7/8	13-3/4	1

RCG

Galvanized Steel Roof Curb

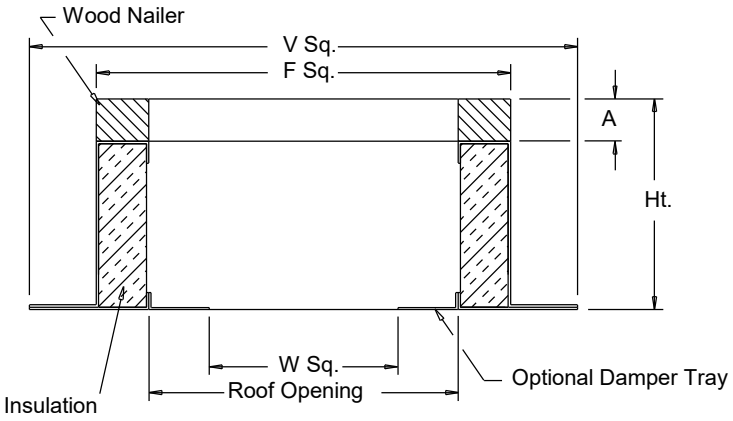
STANDARD CONSTRUCTION FEATURES:

18 gauge galvanized steel - 1-1/2", 3 lbs. density thermal and acoustical insulation - Continuously welded corners - Wood nailer.

Options:(As noted below*)

1) No wood nailer (deduct 1-1/2" for actual height).

2) Damper tray.



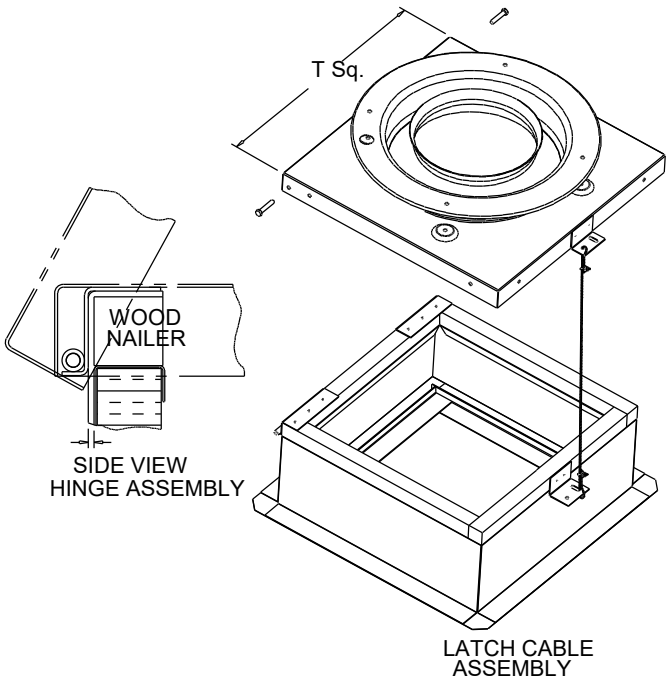
Dimensions (inches)

Mark	Qty	Description	Ht	Options*	A	F Sq.	V Sq.	W Sq.	Roof Opening
EF-C38	1	RCG 18	13.5	-	1-1/2	18-1/2	22-1/2	11-3/4	15-1/2

PROJECT: CHANNEL ISLAND FAN SELECTION
DATE: 5/7/2020

HINGED BASE

Kit Assembly



Dimensions (inches)

Mark	Qty	Description
EF-C38	1	HINGED BASE KIT

COOK

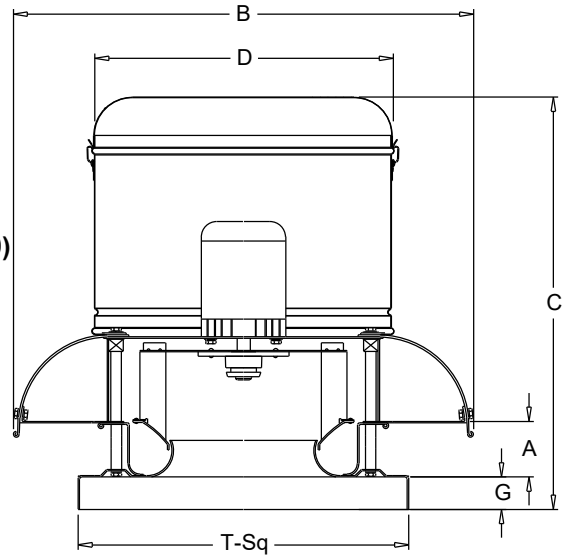
MARK: EF-C40, EF-C41	
PROJECT: CHANNEL ISLAND FAN SELECTION	
DATE: 5/7/2020	

ACE-D

Downblast Centrifugal Exhaust Ventilator Roof Mounted/Direct Drive

STANDARD CONSTRUCTION FEATURES:

All aluminum housing - Backward inclined all aluminum wheel - Two piece top cap with stainless steel quick release latches (sizes 120 - 300) - Welded curb cap corners - Birdscreen - Permanently lubricated ball bearing motors - Corrosion resistant fasteners - Transit tested packaging.



Performance

Qty	Catalog Number	Flow (CFM)	SP (inwc)	Fan RPM	Power (HP)	FEG	Speed Ctrl/Hz
1	120C17D	1200	.375	1338	.170	n/a(<1HP)	VFD/47

Altitude (ft): 0 Temperature (F): 70

Motor Information

HP	RPM	Volts/Ph/Hz	Enclosure	FLA	VFD Rated
1/3	1725	208/3/60	ODP -SE	1.6	Yes

FLA based on NEC (2014) Table 430.250

Sound Data Inlet Sound Power by Octave Band

1	2	3	4	5	6	7	8	LwA	dBA	Sones
69	72	76	67	63	61	54	49	71	59	9.7

Accessories:

BD-14 DAMPER
ROOF CURB RCG 18-13.5H
HINGED BASE KIT
STAINLESS BIRDSCREEN

Dimensions (inches)

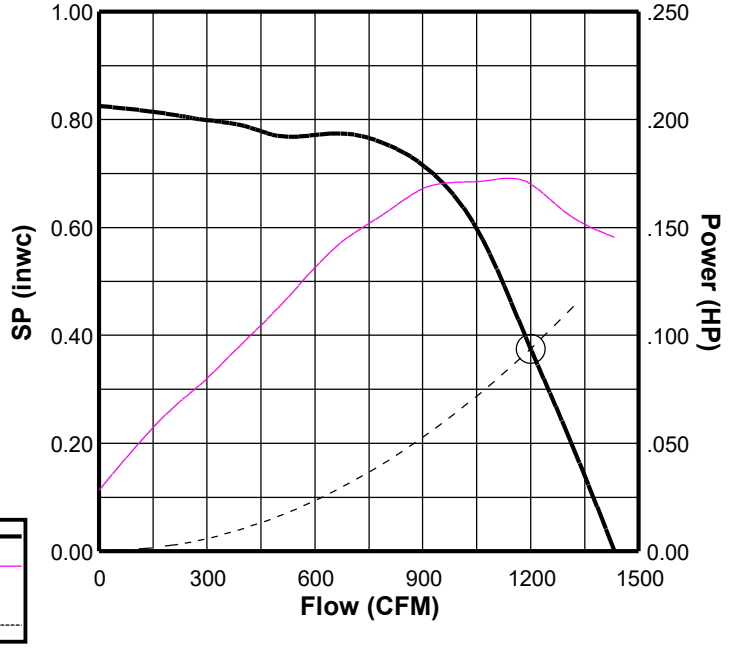
A	1-7/16
B O.D.	28-7/16
C	27-1/16
D O.D.	20-3/8
G	2
T Sq.	20
Roof Open. Sq.*	15-1/2

NOTE: Accessories may affect dimensions shown.

Weight(lbs)***	Shipping	125	Unit	109

* Roof opening size for curbs supplied by Cook only.
***Includes fan, motor & accessories.

Fan Curve



Fan Curve Legend

CFM vs SP	———
CFM vs HP	———
Point of Operation	◯
System Curve	- - - - -

BD

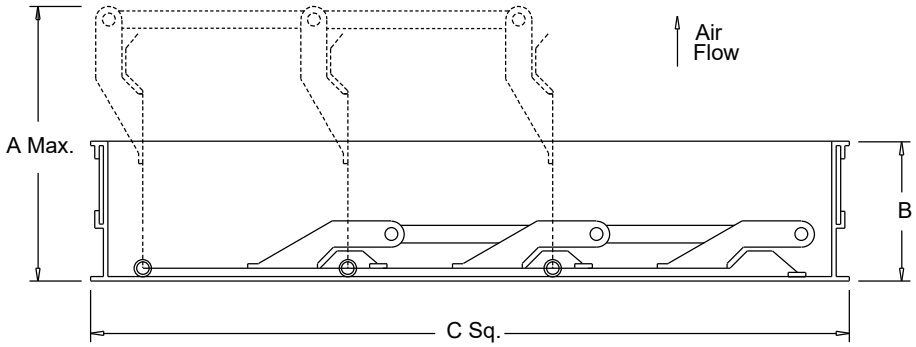
Gravity Backdraft Damper

STANDARD CONSTRUCTION FEATURES:

.020 Aluminum blades - .060 aluminum frame - Aluminum hinge pins - Nylon bushings.

Notes:

Max. operating temperature 200 Deg F (95 Deg C).
Max. discharge velocity 2000 fpm.
Sizes 36 thru 60 are shipped as 2 panels.
Sizes 66 and 78 are shipped as 6 panels.
These may require assembly.



Dimensions (inches)

Mark	Qty	Description	A Max.	B	C Sq.	# Panels
EF-C40, EF-C41	1	BD-14 DAMPER	5-3/16	1-7/8	13-3/4	1

RCG

Galvanized Steel Roof Curb

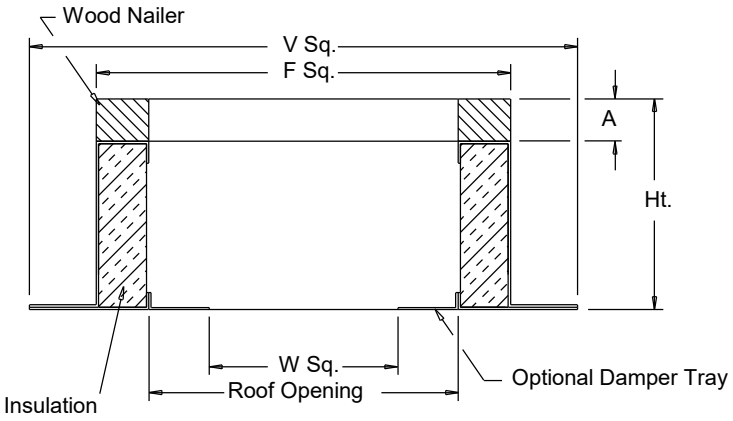
STANDARD CONSTRUCTION FEATURES:

18 gauge galvanized steel - 1-1/2", 3 lbs. density thermal and acoustical insulation - Continuously welded corners - Wood nailer.

Options:(As noted below*)

1) No wood nailer (deduct 1-1/2" for actual height).

2) Damper tray.



Dimensions (inches)

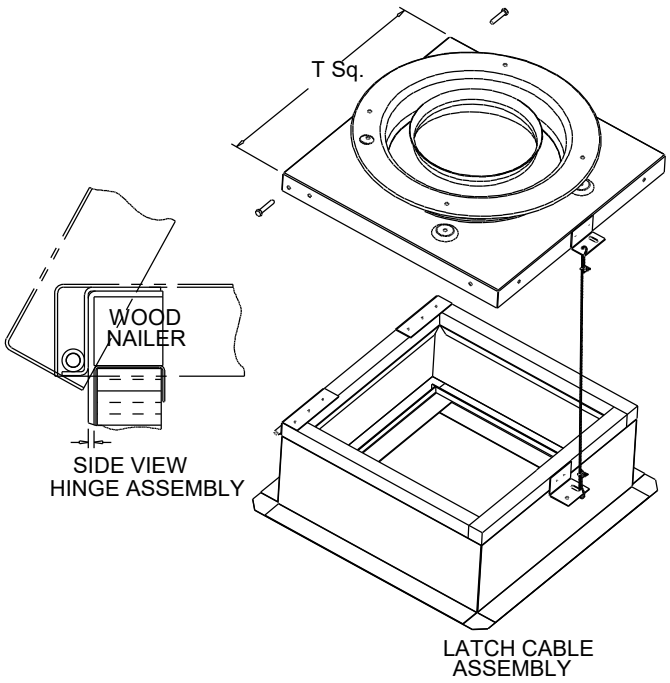
Mark	Qty	Description	Ht	Options*	A	F Sq.	V Sq.	W Sq.	Roof Opening
EF-C40, EF-C41	1	RCG 18	13.5	-	1-1/2	18-1/2	22-1/2	11-3/4	15-1/2

COOK

PROJECT: CHANNEL ISLAND FAN SELECTION
DATE: 5/7/2020

HINGED BASE

Kit Assembly



Dimensions (inches)

Mark	Qty	Description
EF-C40, EF-C41	1	HINGED BASE KIT

COOK

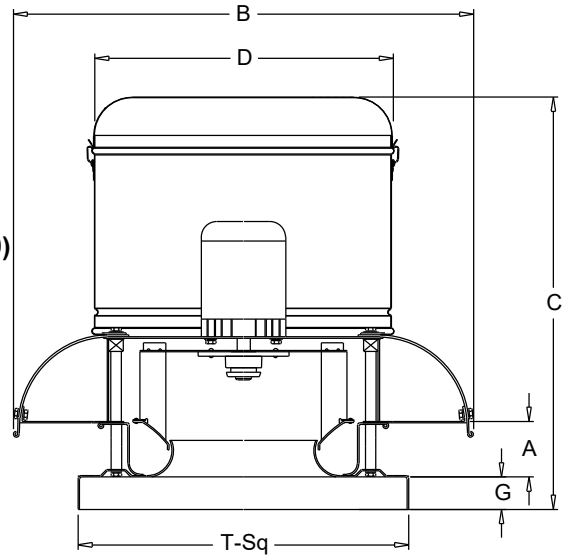
MARK: EF-C42	
PROJECT: CHANNEL ISLAND FAN SELECTION	
DATE: 5/7/2020	

ACE-D

Downblast Centrifugal Exhaust Ventilator Roof Mounted/Direct Drive

STANDARD CONSTRUCTION FEATURES:

All aluminum housing - Backward inclined all aluminum wheel - Two piece top cap with stainless steel quick release latches (sizes 120 - 300) - Welded curb cap corners - Birdscreen - Permanently lubricated ball bearing motors - Corrosion resistant fasteners - Transit tested packaging.



Performance

Qty	Catalog Number	Flow (CFM)	SP (inwc)	Fan RPM	Power (HP)	FEG	Speed Ctrl/Hz
1	120C17D	1200	.375	1338	.170	n/a(<1HP)	VFD/47

Altitude (ft): 0 Temperature (F): 70

Motor Information

HP	RPM	Volts/Ph/Hz	Enclosure	FLA	VFD Rated
1/3	1725	208/3/60	ODP -SE	1.6	Yes

FLA based on NEC (2014) Table 430.250

Sound Data Inlet Sound Power by Octave Band

1	2	3	4	5	6	7	8	LwA	dBA	Sones
69	72	76	67	63	61	54	49	71	59	9.7

Dimensions (inches)

A	1-7/16
B O.D.	28-7/16
C	27-1/16
D O.D.	20-3/8
G	2
T Sq.	20
Roof Open. Sq.*	15-1/2

NOTE: Accessories may affect dimensions shown.

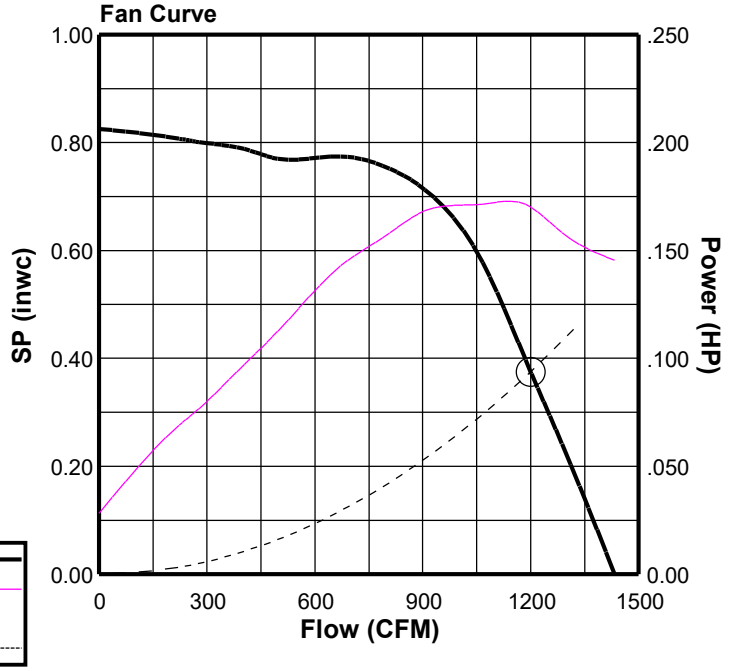
Weight(lbs)***	Shipping	125	Unit	109

* Roof opening size for curbs supplied by Cook only.
***Includes fan, motor & accessories.

Accessories:

BD-14 DAMPER
ROOF CURB RCG 18-13.5H
HINGED BASE KIT
STAINLESS BIRDSCREEN

Fan Curve



Fan Curve Legend

CFM vs SP	———
CFM vs HP	———
Point of Operation	◯
System Curve	- - - - -

BD

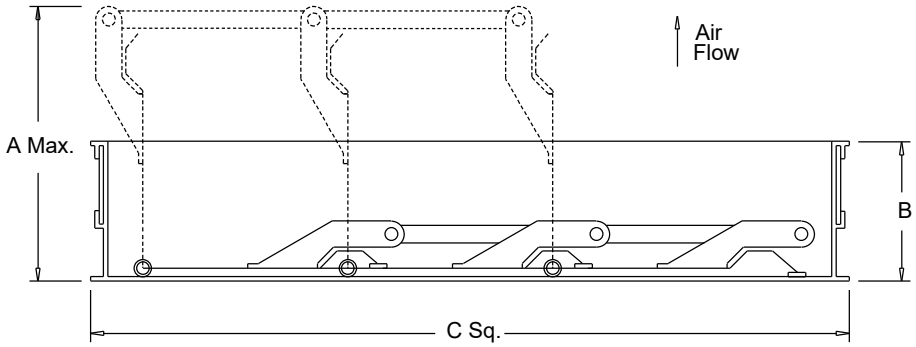
Gravity Backdraft Damper

STANDARD CONSTRUCTION FEATURES:

.020 Aluminum blades - .060 aluminum frame - Aluminum hinge pins - Nylon bushings.

Notes:

Max. operating temperature 200 Deg F (95 Deg C).
Max. discharge velocity 2000 fpm.
Sizes 36 thru 60 are shipped as 2 panels.
Sizes 66 and 78 are shipped as 6 panels.
These may require assembly.



Dimensions (inches)

Mark	Qty	Description	A Max.	B	C Sq.	# Panels
EF-C42	1	BD-14 DAMPER	5-3/16	1-7/8	13-3/4	1

RCG

Galvanized Steel Roof Curb

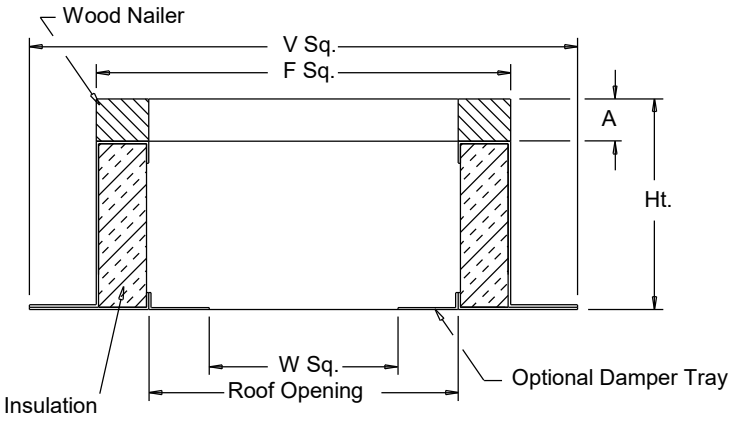
STANDARD CONSTRUCTION FEATURES:

18 gauge galvanized steel - 1-1/2", 3 lbs. density thermal and acoustical insulation - Continuously welded corners - Wood nailer.

Options:(As noted below*)

1) No wood nailer (deduct 1-1/2" for actual height).

2) Damper tray.



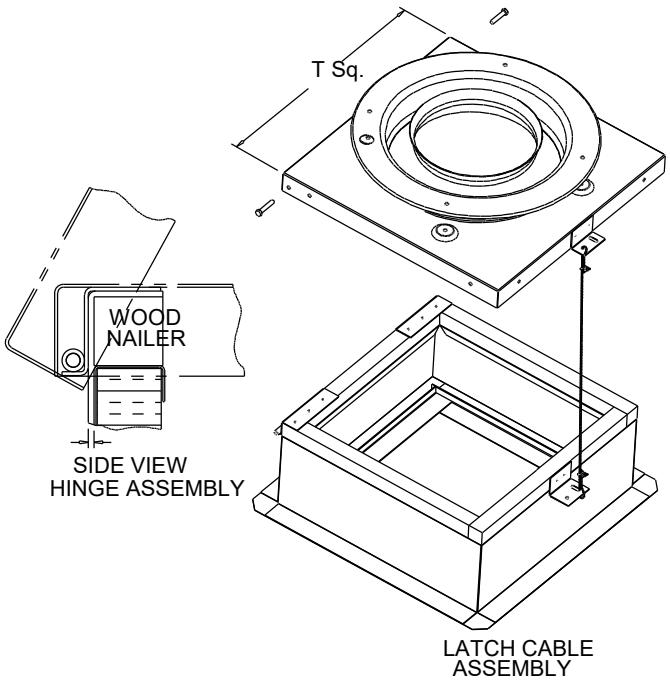
Dimensions (inches)

Mark	Qty	Description	Ht	Options*	A	F Sq.	V Sq.	W Sq.	Roof Opening
EF-C42	1	RCG 18	13.5	-	1-1/2	18-1/2	22-1/2	11-3/4	15-1/2

PROJECT: CHANNEL ISLAND FAN SELECTION
DATE: 5/7/2020

HINGED BASE

Kit Assembly



Dimensions (inches)

Mark	Qty	Description
EF-C42	1	HINGED BASE KIT

COOK

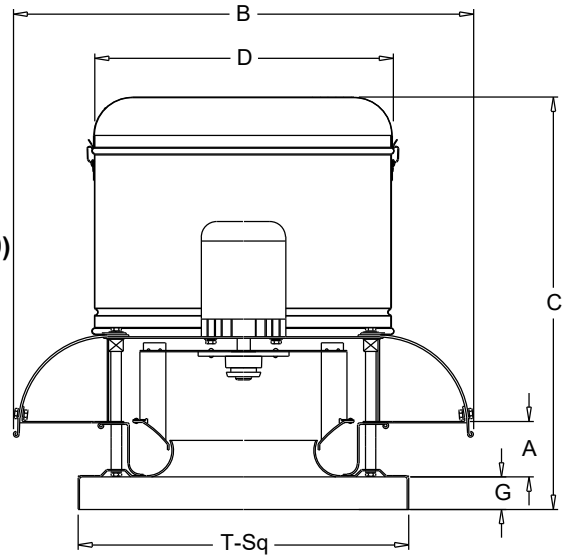
MARK: EF-D58, EF-D59	
PROJECT: CHANNEL ISLAND FAN SELECTION	
DATE: 5/7/2020	

ACE-D

Downblast Centrifugal Exhaust Ventilator Roof Mounted/Direct Drive

STANDARD CONSTRUCTION FEATURES:

All aluminum housing - Backward inclined all aluminum wheel - Two piece top cap with stainless steel quick release latches (sizes 120 - 300) - Welded curb cap corners - Birdscreen - Permanently lubricated ball bearing motors - Corrosion resistant fasteners - Transit tested packaging.



Performance

Qty	Catalog Number	Flow (CFM)	SP (inwc)	Fan RPM	Power (HP)	FEG	Speed Ctrl/Hz
1	120C17D	1200	.250	1270	.138	n/a(<1HP)	VFD/44

Altitude (ft): 0 Temperature (F): 70

Motor Information

HP	RPM	Volts/Ph/Hz	Enclosure	FLA	VFD Rated
1/3	1725	208/3/60	ODP -SE	1.6	Yes

FLA based on NEC (2014) Table 430.250

Sound Data Inlet Sound Power by Octave Band

1	2	3	4	5	6	7	8	LwA	dBA	Sones
68	71	75	66	62	60	53	48	70	59	9.2

Accessories:

BD-14 DAMPER
ROOF CURB RCG 18-13.5H
HINGED BASE KIT
STAINLESS BIRDSCREEN

Dimensions (inches)

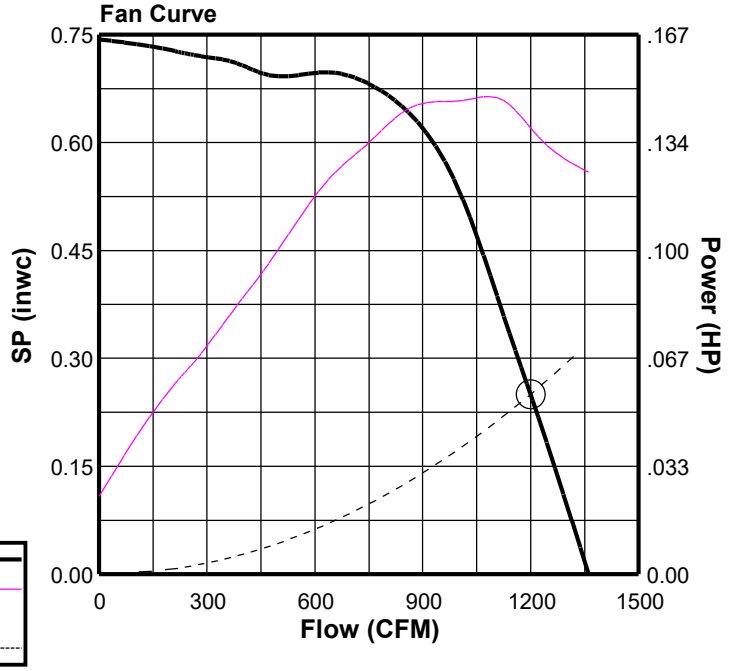
A	1-7/16
B O.D.	28-7/16
C	27-1/16
D O.D.	20-3/8
G	2
T Sq.	20
Roof Open. Sq.*	15-1/2

NOTE: Accessories may affect dimensions shown.

Weight(lbs)***	Shipping	125	Unit	109

* Roof opening size for curbs supplied by Cook only.
***Includes fan, motor & accessories.

Fan Curve



Fan Curve Legend

CFM vs SP	———
CFM vs HP	———
Point of Operation	◯
System Curve	- - - - -

BD

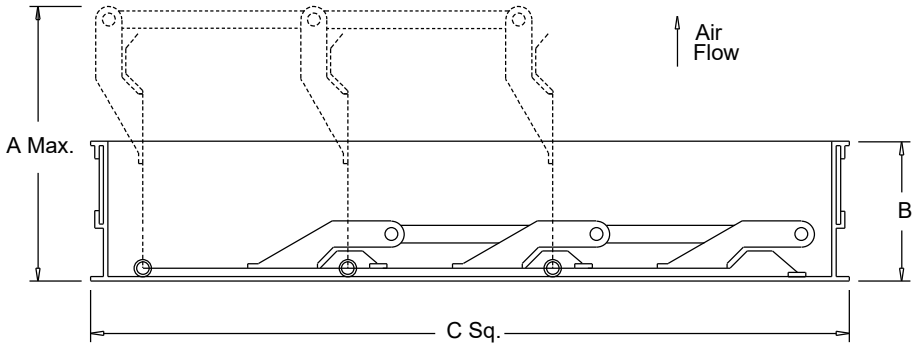
Gravity Backdraft Damper

STANDARD CONSTRUCTION FEATURES:

.020 Aluminum blades - .060 aluminum frame - Aluminum hinge pins - Nylon bushings.

Notes:

Max. operating temperature 200 Deg F (95 Deg C).
Max. discharge velocity 2000 fpm.
Sizes 36 thru 60 are shipped as 2 panels.
Sizes 66 and 78 are shipped as 6 panels.
These may require assembly.



Dimensions (inches)

Mark	Qty	Description	A Max.	B	C Sq.	# Panels
EF-D58, EF-D59	1	BD-14 DAMPER	5-3/16	1-7/8	13-3/4	1

RCG

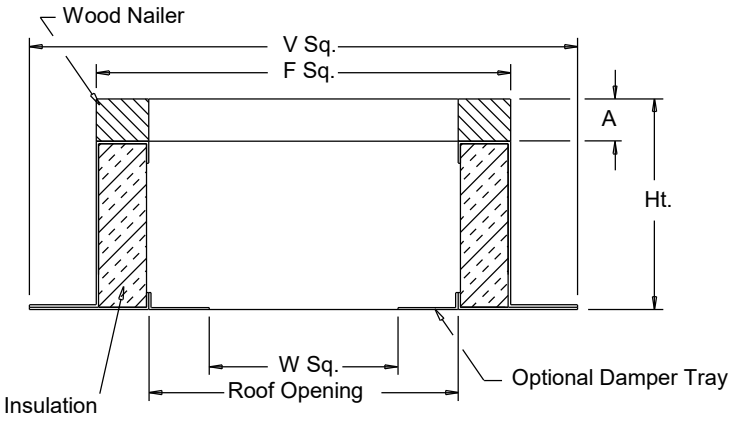
Galvanized Steel Roof Curb

STANDARD CONSTRUCTION FEATURES:

18 gauge galvanized steel - 1-1/2", 3 lbs. density thermal and acoustical insulation - Continuously welded corners - Wood nailer.

Options:(As noted below*)

1) **No wood nailer (deduct 1-1/2" for actual height).**
2) **Damper tray.**



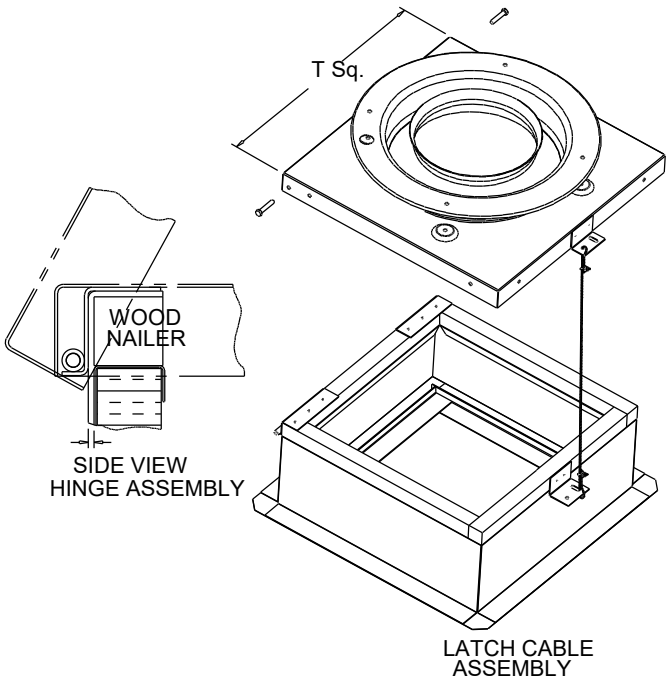
Dimensions (inches)

Mark	Qty	Description	Ht	Options*	A	F Sq.	V Sq.	W Sq.	Roof Opening
EF-D58, EF-D59	1	RCG 18	13.5	-	1-1/2	18-1/2	22-1/2	11-3/4	15-1/2

PROJECT: CHANNEL ISLAND FAN SELECTION
DATE: 5/7/2020

HINGED BASE

Kit Assembly



Dimensions (inches)

Mark	Qty	Description
EF-D58, EF-D59	1	HINGED BASE KIT

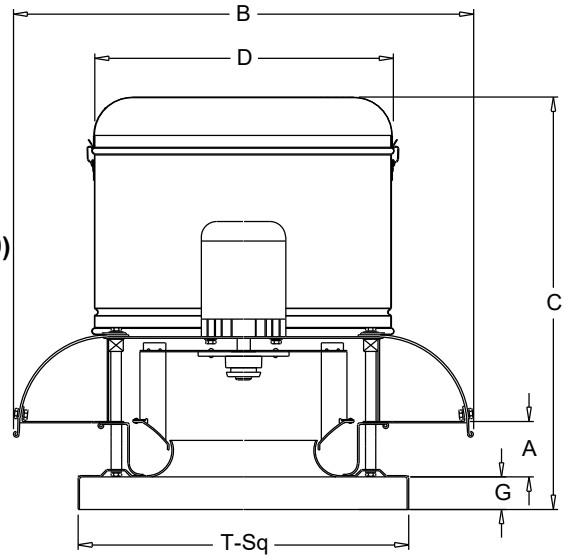
MARK: EF-D60, EF-D61
PROJECT: CHANNEL ISLAND FAN SELECTION
DATE: 5/7/2020

ACE-D

Downblast Centrifugal Exhaust Ventilator Roof Mounted/Direct Drive

STANDARD CONSTRUCTION FEATURES:

All aluminum housing - Backward inclined all aluminum wheel - Two piece top cap with stainless steel quick release latches (sizes 120 - 300) - Welded curb cap corners - Birdscreen - Permanently lubricated ball bearing motors - Corrosion resistant fasteners - Transit tested packaging.



Performance

Qty	Catalog Number	Flow (CFM)	SP (inwc)	Fan RPM	Power (HP)	FEG	Speed Ctrl/Hz
1	120C17D	1200	.250	1270	.138	n/a(<1HP)	VFD/44

Altitude (ft): 0 Temperature (F): 70

Motor Information

HP	RPM	Volts/Ph/Hz	Enclosure	FLA	VFD Rated
1/3	1725	208/3/60	ODP -SE	1.6	Yes

FLA based on NEC (2014) Table 430.250

Sound Data Inlet Sound Power by Octave Band

1	2	3	4	5	6	7	8	LwA	dBA	Sones
68	71	75	66	62	60	53	48	70	59	9.2

Accessories:

BD-14 DAMPER
ROOF CURB RCG 18-13.5H
HINGED BASE KIT
STAINLESS BIRDSCREEN

Dimensions (inches)

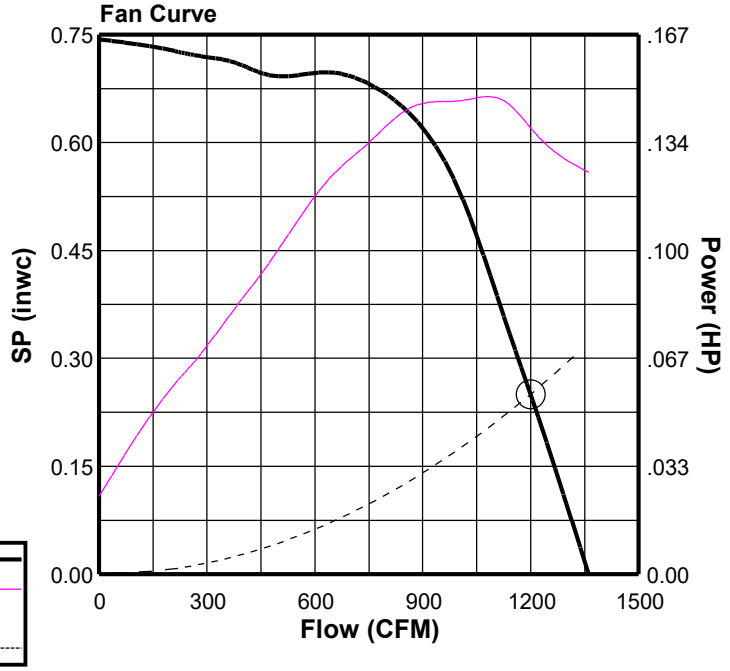
A	1-7/16
B O.D.	28-7/16
C	27-1/16
D O.D.	20-3/8
G	2
T Sq.	20
Roof Open. Sq.*	15-1/2

NOTE: Accessories may affect dimensions shown.

Weight(lbs)***	Shipping	125	Unit	109

* Roof opening size for curbs supplied by Cook only.
***Includes fan, motor & accessories.

Fan Curve



Fan Curve Legend

CFM vs SP	———
CFM vs HP	———
Point of Operation	◯
System Curve	- - - - -

BD

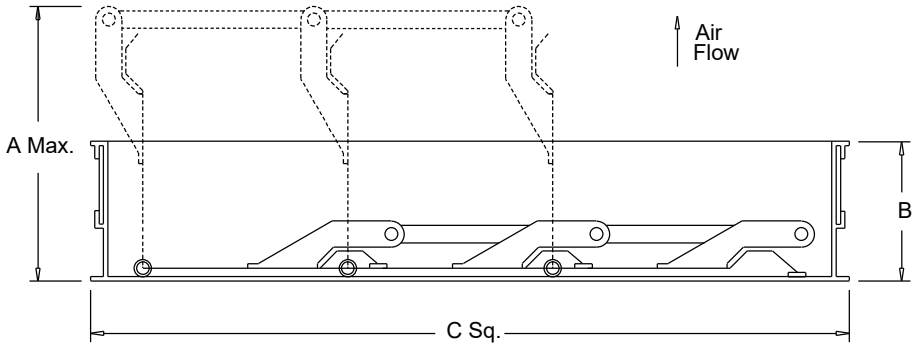
Gravity Backdraft Damper

STANDARD CONSTRUCTION FEATURES:

.020 Aluminum blades - .060 aluminum frame - Aluminum hinge pins - Nylon bushings.

Notes:

Max. operating temperature 200 Deg F (95 Deg C).
Max. discharge velocity 2000 fpm.
Sizes 36 thru 60 are shipped as 2 panels.
Sizes 66 and 78 are shipped as 6 panels.
These may require assembly.



Dimensions (inches)

Mark	Qty	Description	A Max.	B	C Sq.	# Panels
EF-D60, EF-D61	1	BD-14 DAMPER	5-3/16	1-7/8	13-3/4	1

RCG

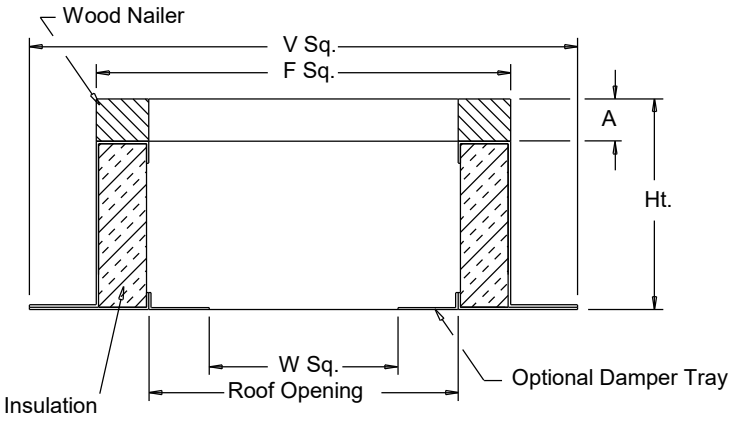
Galvanized Steel Roof Curb

STANDARD CONSTRUCTION FEATURES:

18 gauge galvanized steel - 1-1/2", 3 lbs. density thermal and acoustical insulation - Continuously welded corners - Wood nailer.

Options:(As noted below*)

1) **No wood nailer (deduct 1-1/2" for actual height).**
2) **Damper tray.**



Dimensions (inches)

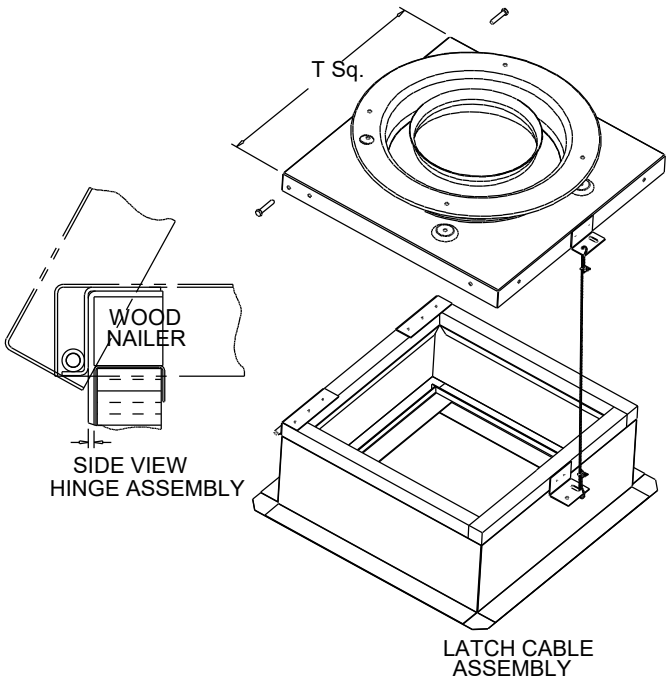
Mark	Qty	Description	Ht	Options*	A	F Sq.	V Sq.	W Sq.	Roof Opening
EF-D60, EF-D61	1	RCG 18	13.5	-	1-1/2	18-1/2	22-1/2	11-3/4	15-1/2

COOK

PROJECT: CHANNEL ISLAND FAN SELECTION
DATE: 5/7/2020

HINGED BASE

Kit Assembly



Dimensions (inches)

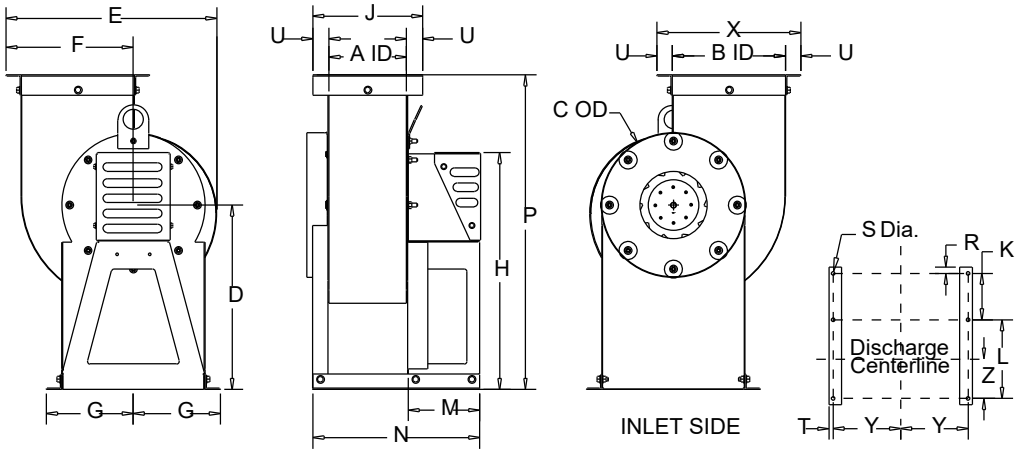
Mark	Qty	Description
EF-D60, EF-D61	1	HINGED BASE KIT

COOK

MARK: EF-C36, EF-C37	
PROJECT: CHANNEL ISLAND FAN SELECTION	
DATE: 5/7/2020	

CPV-EC

Centrifugal Blower
Clockwise Upblast
Electronically Commutated
Vari-Flow® Motor
Arrangement 4



Performance

Qty	Catalog Number	Flow (CFM)	SP (inwc)	Fan RPM	Input Watts	FEG	Speed Control
1	135CPV-EC	1200	.375	1060	140	n/a(<1HP)	EC

Altitude (ft): 0 Temperature (F): 70

Motor Information

HP	RPM	Volts/Ph/Hz	Enclosure
3/4	1725	115/1/60	OPEN -EC

Vari-Flow

Fan Information

Class	OVel(mph)	Rotation	Discharge	Access
I	12.9	CW	Upblast	3:00

Sound Data Sound Power by Octave Band

	1	2	3	4	5	6	7	8	LwA	dBA
Inlet	67	71	70	63	59	58	51	44	66	55
Outlet	79	76	69	64	61	59	51	45	68	56

Accessories:

FAN MOUNTED SPEED CONTROL
STEEL FLANGED INLET
STL INLET COMP FLNGE
INLET FLEX DUCT CONN
ISOLATION RAILS
RS2-100 SET(4) - ISOLATORS

Dimensions (inches)

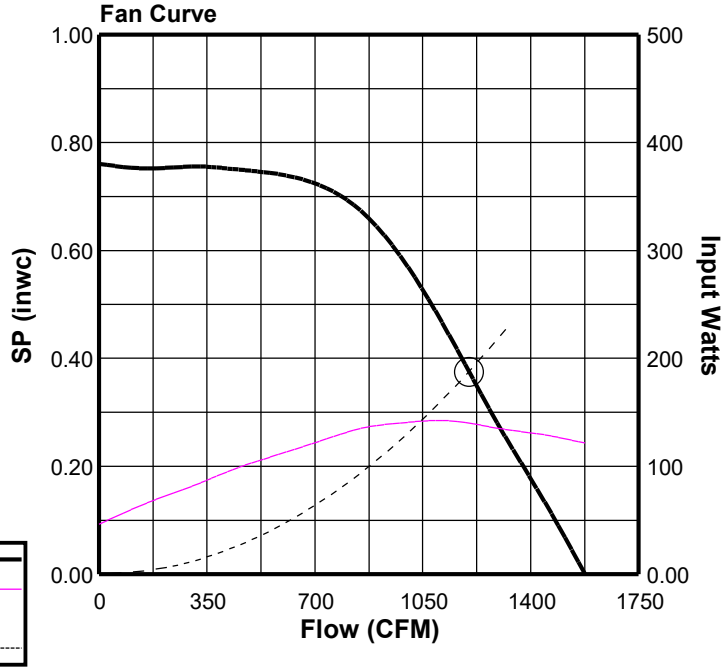
A	10-5/16	L	12-1/16	Z	6
B	14-3/4	M	10-1/16		
C	17-5/8	N	22-1/16		
D	18	P	31-7/8		
E	27-5/16	R	3/4		
F	11-1/16	S	7/16		
G	10-1/4	T	1/2		
H	23-1/2	U	1-5/8		
J	13-1/2	X	17-15/16		
K	8-1/2	Y	9-3/4		

NOTE: Accessories may affect dimensions shown.

Weight(lbs)***	Shipping	314	Unit	233

***Includes fan, motor & accessories.

Fan Curve



Fan Curve Legend

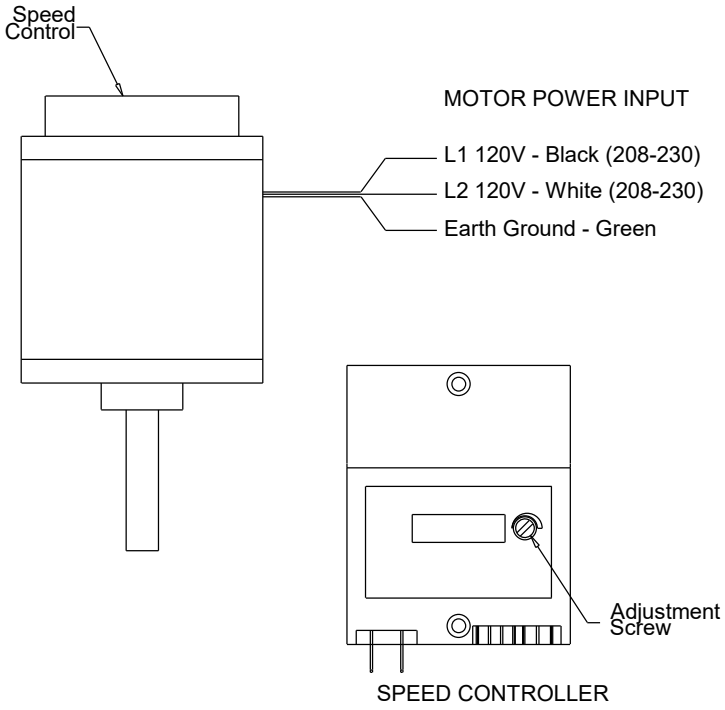
CFM vs SP	———
CFM vs Watts	———
Point of Operation	◯
System Curve	- - - - -

Speed Control

Internal Speed Control Electronically Commutated (EC) Motor Type N

STANDARD CONSTRUCTION FEATURES:

Vari-Flow EC Motors are available in 1/8 to 1 HP for 120V or 208-230V -Single phase applications have a adjustable speed range of 500 to 1725 or 500 to 2800 - Some motors come with a factory programmed maximum RPM for specific applicaitons - Integral potentiometer for adjusting motor speed - Slotted adjustment bolt for screwdriver adjustment of speed.

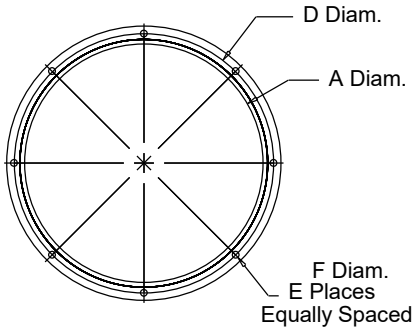


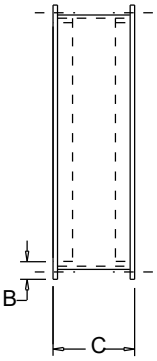
Dimensions (inches)

Mark	Qty	Description
EF-C36, EF-C37	1	OPEN -3/4HP - 115V/1

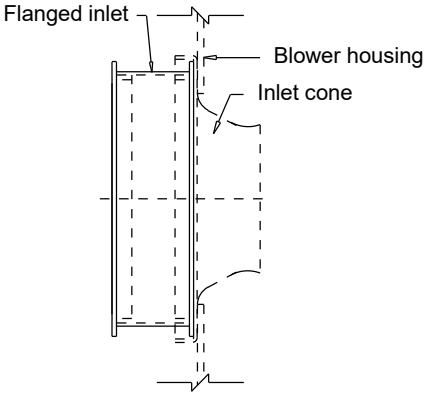
Flanged Inlet

Steel





FLANGED INLET



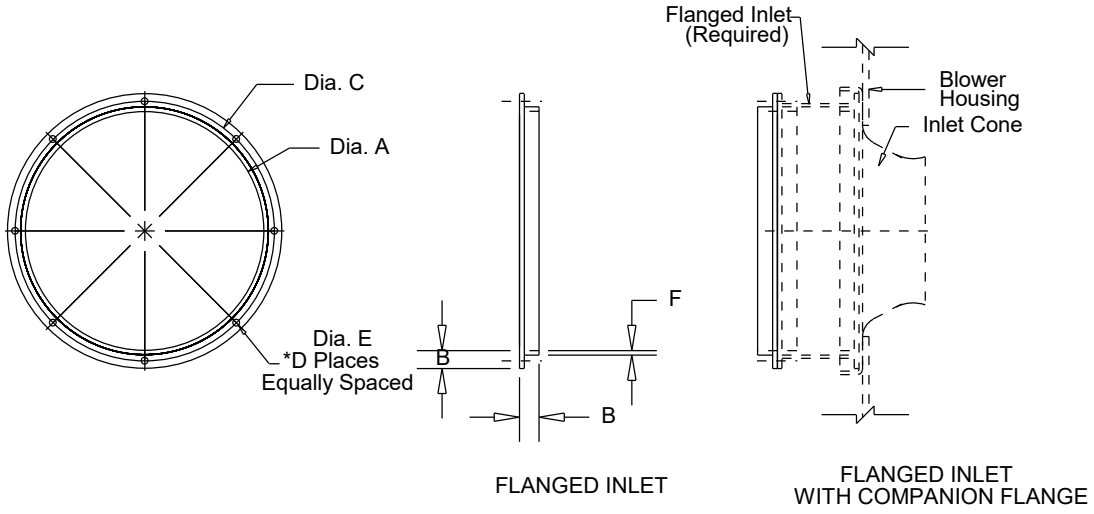
FLANGED INLET

Dimensions (inches)

Mark	Qty	Description	A	B	C	D	E	F
EF-C36, EF-C37	1	STEEL FLANGED INLET	14-1/8	1-1/2	6	16	8	1/2

Inlet Companion Flange

Steel



FLANGED INLET

FLANGED INLET
WITH COMPANION FLANGE

Dimensions (inches)

Mark	Qty	Description	A	B	C	# D Std.	# D UL762	E	F
EF-C36, EF-C37	1	STL INLET COMP FLNGE	14-1/8	1-1/2	16	8	14	1/2	1/8

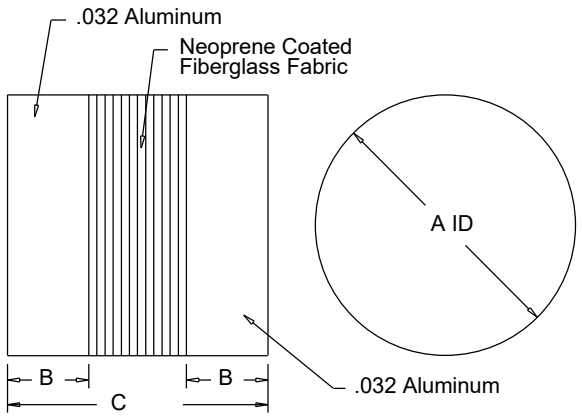
Flexible Inlet Connector

STANDARD CONSTRUCTION FEATURES:

Neoprene Coated Fibergalss fabric - 3" aluminum strips.

Note:

Consult factory for use of Hypalon Coated Fiberglass fabric for additional UV and chemical resistance.
All Lab Exhauster fans ordered with flex duct connectors will be the Hypalon type flex duct.



Dimensions (inches)

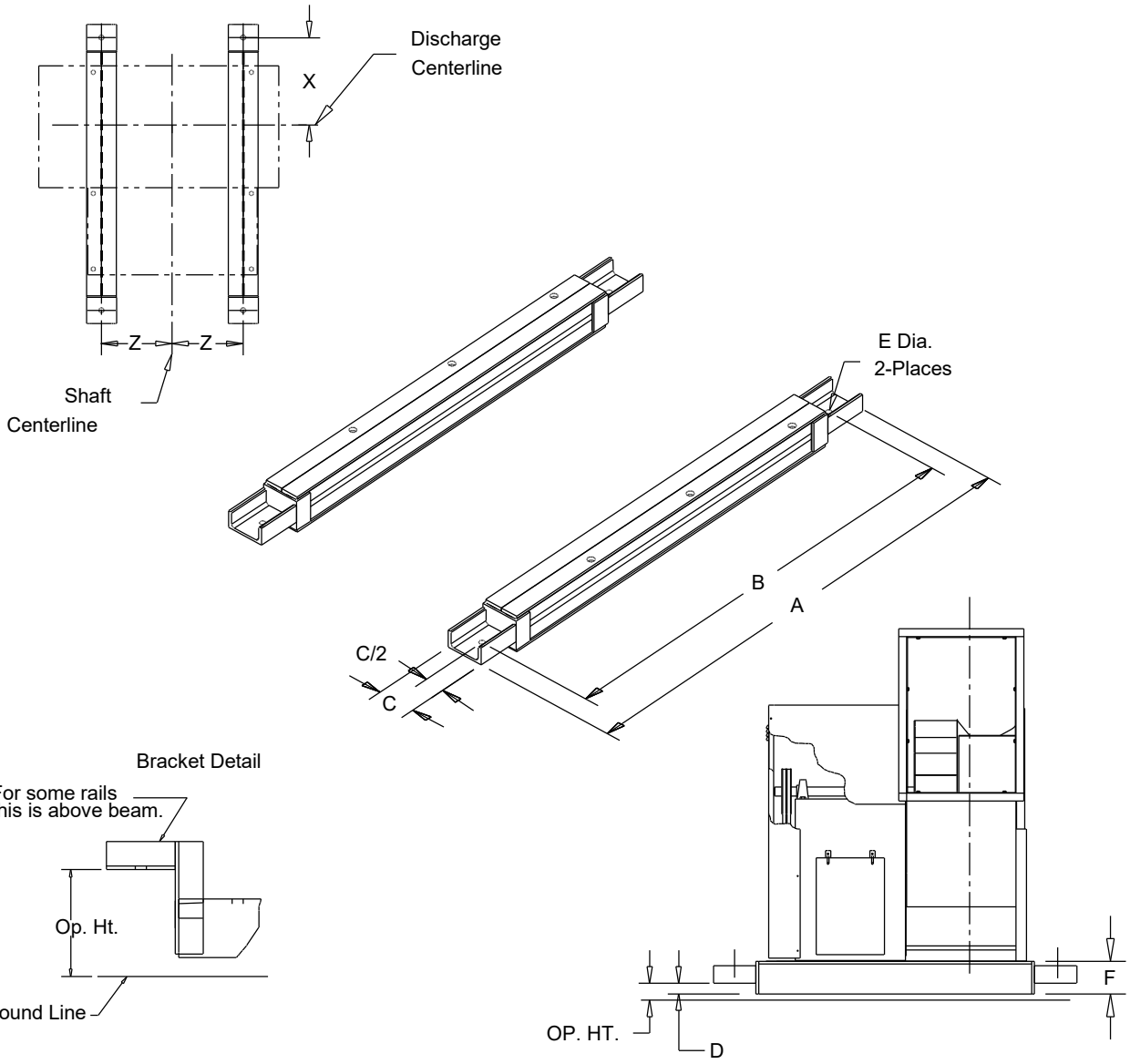
Mark	Qty	Description	A I.D.	B	C Max.
EF-C36, EF-C37	1	INLET FLEX DUCT CONN	17-3/4	3	9

MARK: EF-C36, EF-C37
PROJECT: CHANNEL ISLAND FAN SELECTION
DATE: 5/7/2020

Isolation Rail

STANDARD CONSTRUCTION FEATURES:

Minimum 4" structural steel channel (ASTM A36)-All connections fully welded-Mounting holes provided-Lorenized powder coat finish



Dimensions (inches)

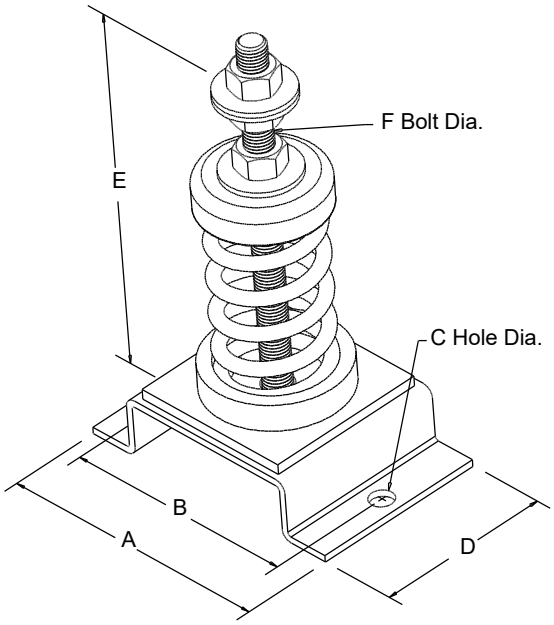
Mark	Qty	A	B	C	D	E	F	X**	Z*	OP. HT.
EF-C36, EF-C37	1	35 7/8	30 7/8	3	10 1/2	11/16	3	11 3/16	8 13/16	11

*locates center line of shaft/inlet
**locates center of discharge

RESTRAINED SPRING FLOOR

Restrained Spring Isolator Floor Mounted

NOTE:
All isolators listed are designed to provide a minimum of 50% overload capacity.



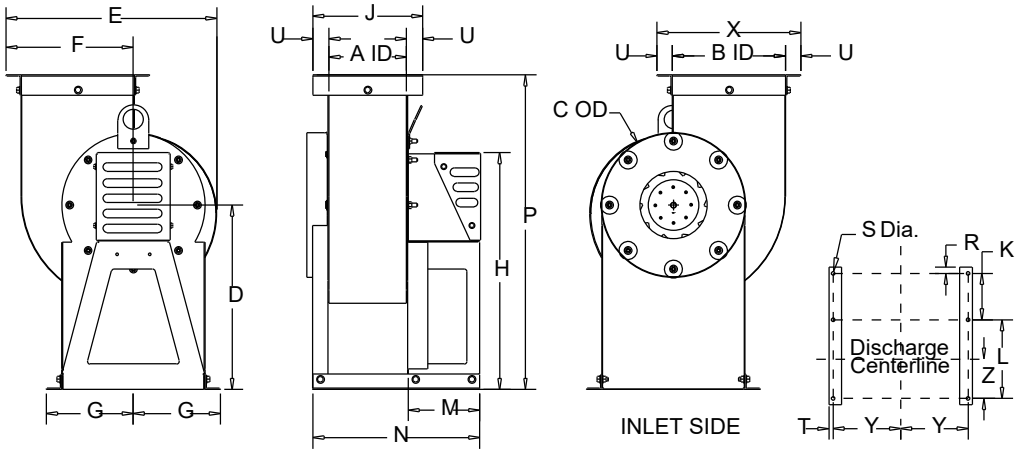
Dimensions (inches)

Mark	Qty	Description	A	B	C Dia.	D	E	F	Deflection
EF-C36, EF-C37	1	RS2-100 SET(4)	8	6-1/2	11/16	4-1/2	11	5/8	2

MARK: EF-C39
PROJECT: CHANNEL ISLAND FAN SELECTION
DATE: 5/7/2020

CPV-EC

Centrifugal Blower
Clockwise Upblast
Electronically Commutated
Vari-Flow® Motor
Arrangement 4



Performance

Qty	Catalog Number	Flow (CFM)	SP (inwc)	Fan RPM	Input Watts	FEG	Speed Control
1	120CPV-EC	1200	.375	1464	165	n/a(<1HP)	EC

Altitude (ft): 0 Temperature (F): 70

Motor Information

HP	RPM	Volts/Ph/Hz	Enclosure
1/2	1725	115/1/60	OPEN -EC

Fan Information

Class	OVel(mph)	Rotation	Discharge	Access
I	16.2	CW	Upblast	3:00

Sound Data Sound Power by Octave Band

	1	2	3	4	5	6	7	8	LwA	dBA
Inlet	69	75	74	70	64	63	58	52	72	60
Outlet	81	81	74	70	66	65	59	53	73	62

Accessories:

FAN MOUNTED SPEED CONTROL
STEEL FLANGED INLET
STL INLET COMP FLNGE
INLET FLEX DUCT CONN
ISOLATION RAILS
RS2-100 SET(4) - ISOLATORS

Dimensions (inches)

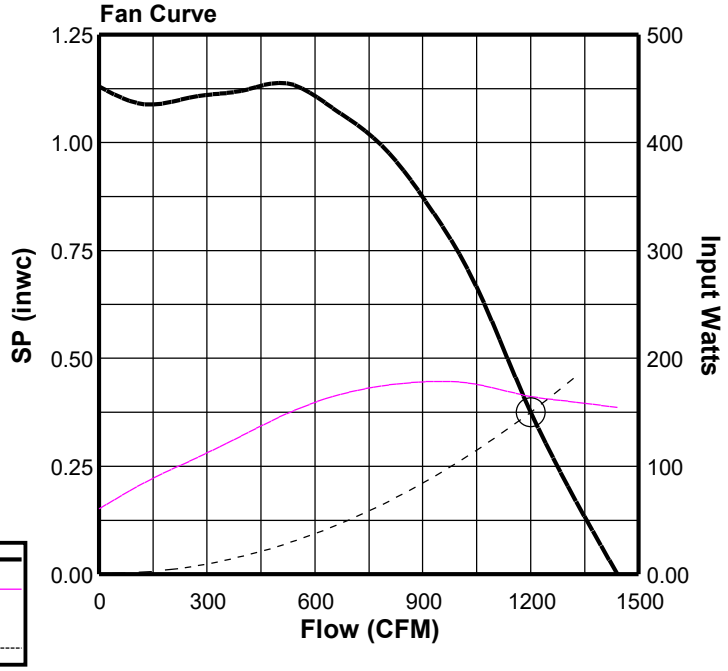
A	9-3/16	L	10-15/16	Z	5-7/16
B	13-1/8	M	9-9/16		
C	16-1/8	N	20-7/16		
D	18	P	31-3/8		
E	24-7/16	R	3/4		
F	9-3/16	S	7/16		
G	9-1/2	T	1/2		
H	23	U	1-5/8		
J	12-3/8	X	16-5/16		
K	8	Y	9		

NOTE: Accessories may affect dimensions shown.

Weight(lbs)***	Shipping	281	Unit	203

***Includes fan, motor & accessories.

Fan Curve



Fan Curve Legend

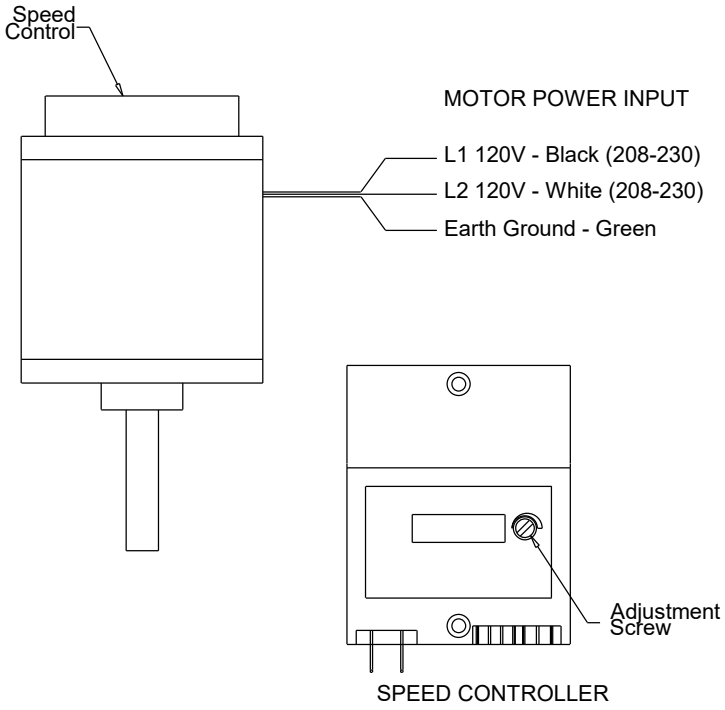
CFM vs SP	———
CFM vs Watts	———
Point of Operation	◯
System Curve	- - - - -

Speed Control

Internal Speed Control Electronically Commutated (EC) Motor Type N

STANDARD CONSTRUCTION FEATURES:

Vari-Flow EC Motors are available in 1/8 to 1 HP for 120V or 208-230V -Single phase applications have a adjustable speed range of 500 to 1725 or 500 to 2800 - Some motors come with a factory programmed maximum RPM for specific applicaitons - Integral potentiometer for adjusting motor speed - Slotted adjustment bolt for screwdriver adjustment of speed.

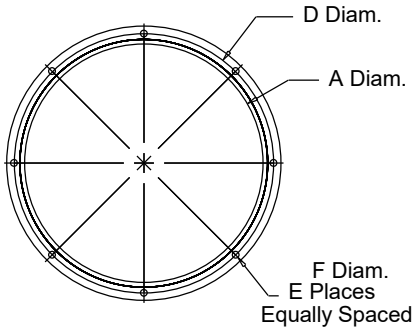


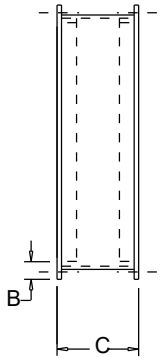
Dimensions (inches)

Mark	Qty	Description
EF-C39	1	OPEN -1/2HP - 115V/1

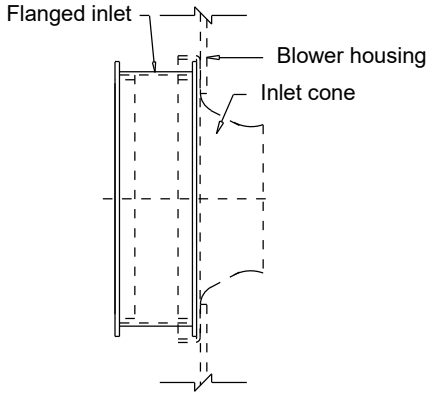
Flanged Inlet

Steel





FLANGED INLET



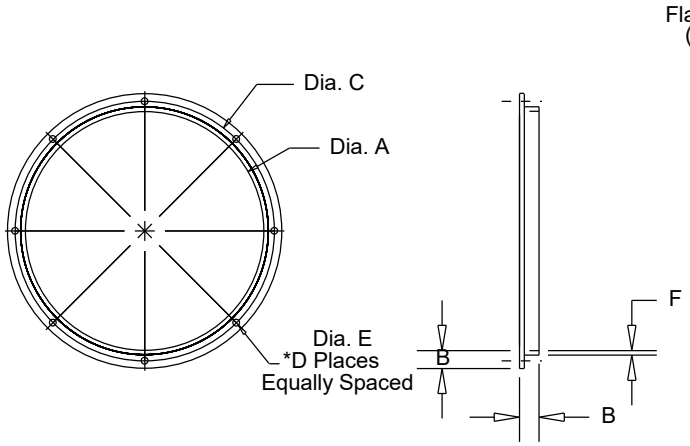
FLANGED INLET

Dimensions (inches)

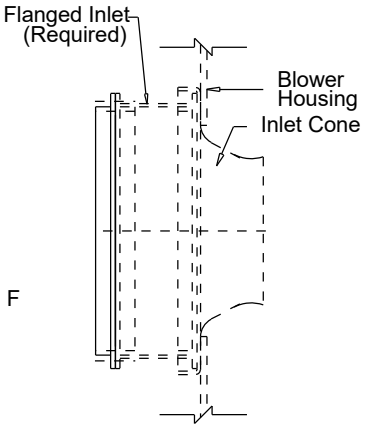
Mark	Qty	Description	A	B	C	D	E	F
EF-C39	1	STEEL FLANGED INLET	12-5/8	1-1/2	6	14-1/2	8	1/2

Inlet Companion Flange

Steel



FLANGED INLET



FLANGED INLET
WITH COMPANION FLANGE

Dimensions (inches)

Mark	Qty	Description	A	B	C	# D Std.	# D UL762	E	F
EF-C39	1	STL INLET COMP FLNGE	12-5/8	1-1/2	14-1/2	8	12	1/2	1/8

PROJECT: CHANNEL ISLAND FAN SELECTION
DATE: 5/7/2020

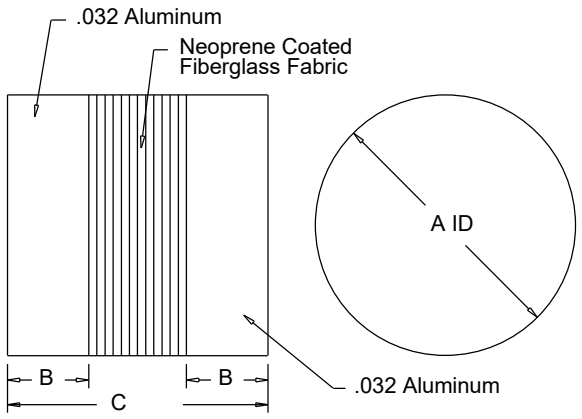
Flexible Inlet Connector

STANDARD CONSTRUCTION FEATURES:

Neoprene Coated Fibergalss fabric - 3" aluminum strips.

Note:

Consult factory for use of Hypalon Coated Fiberglass fabric for additional UV and chemical resistance.
All Lab Exhauster fans ordered with flex duct connectors will be the Hypalon type flex duct.



Dimensions (inches)

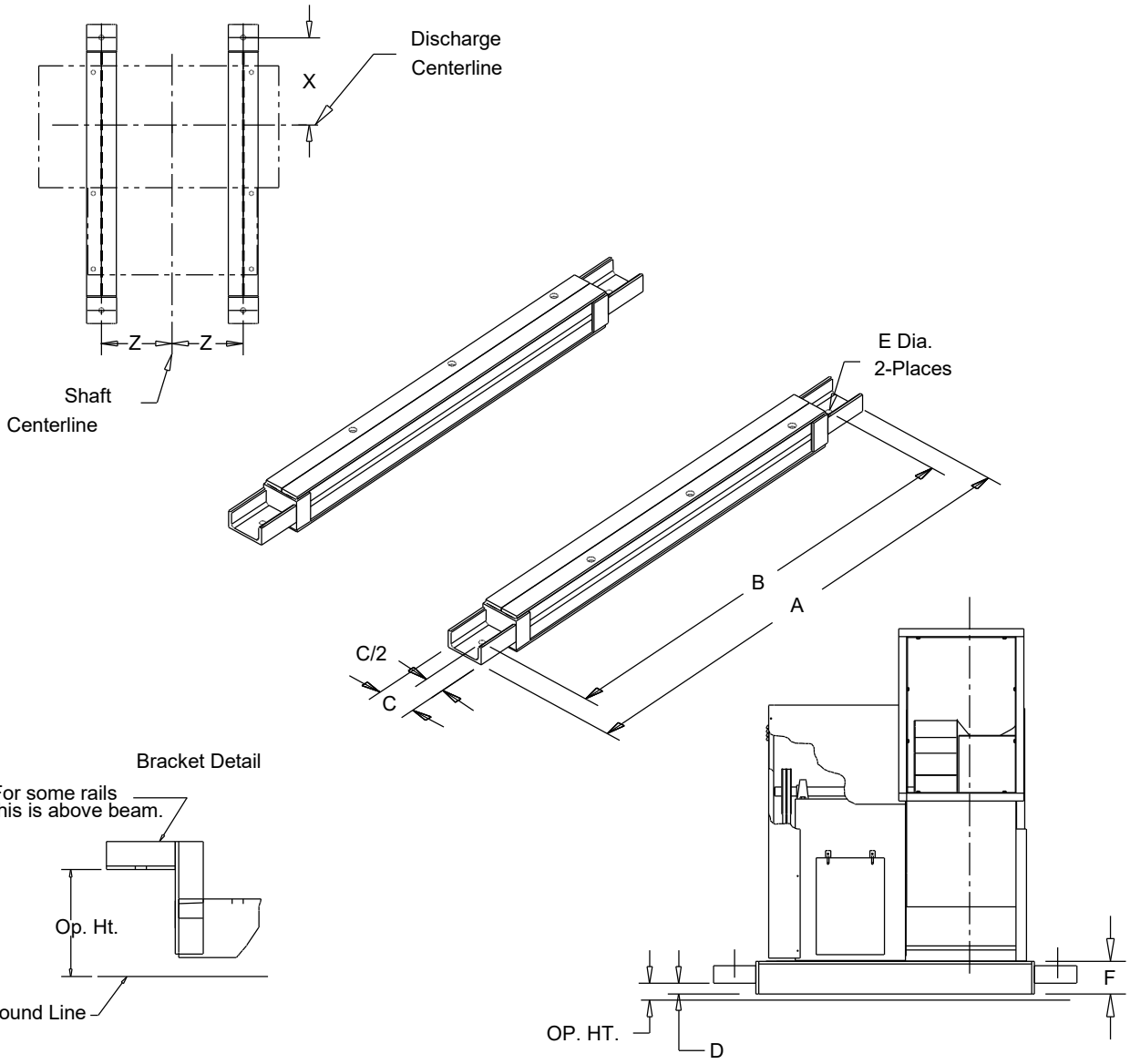
Mark	Qty	Description	A I.D.	B	C Max.
EF-C39	1	INLET FLEX DUCT CONN	16-1/4	3	9

MARK: EF-C39
PROJECT: CHANNEL ISLAND FAN SELECTION
DATE: 5/7/2020

Isolation Rail

STANDARD CONSTRUCTION FEATURES:

Minimum 4" structural steel channel (ASTM A36)-All connections fully welded-Mounting holes provided-Lorenized powder coat finish



Dimensions (inches)

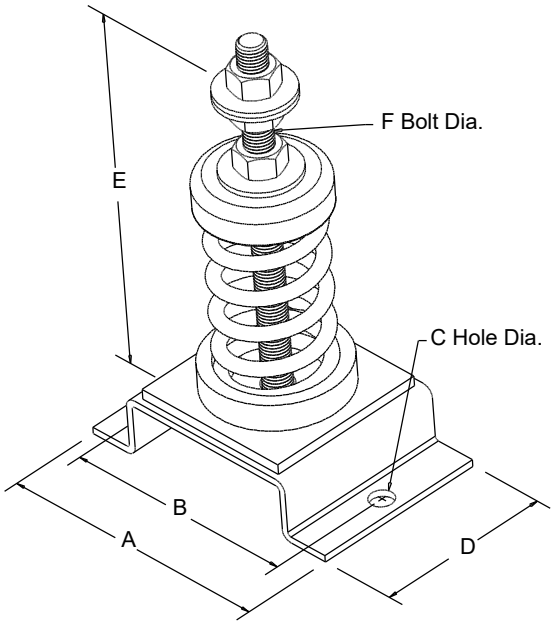
Mark	Qty	A	B	C	D	E	F	X**	Z*	OP. HT.
EF-C39	1	34 1/4	29 1/4	3	10 1/2	11/16	3	10 5/8	8 1/16	11

*locates center line of shaft/inlet
**locates center of discharge

RESTRAINED SPRING FLOOR

Restrained Spring Isolator Floor Mounted

NOTE:
All isolators listed are designed to provide a minimum of 50% overload capacity.



Dimensions (inches)

Mark	Qty	Description	A	B	C Dia.	D	E	F	Deflection
EF-C39	1	RS2-100 SET(4)	8	6-1/2	11/16	4-1/2	11	5/8	2

COOK

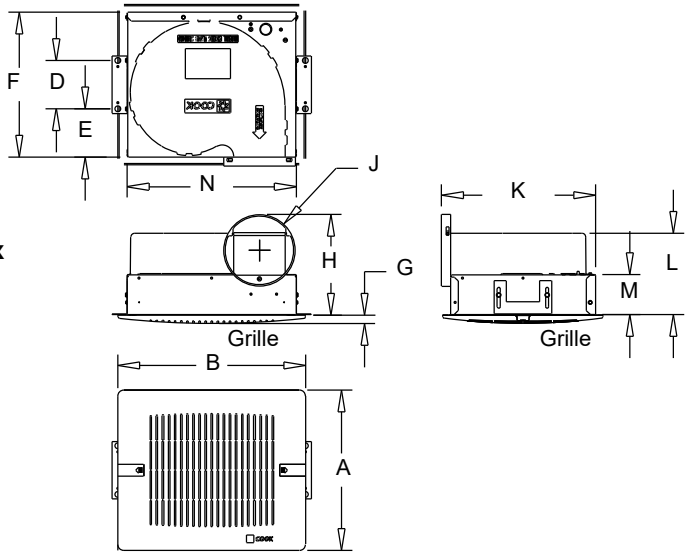
MARK: EF-34D
PROJECT: CHANNEL ISLAND FAN SELECTION
DATE: 5/8/2020

GEMINI

Ceiling Fans
100 Series

STANDARD CONSTRUCTION FEATURES:

Forward curved injection molded polypropylene fan wheel - Injection molded flame resistant fan housing with round outlet duct - 22 ga. galvanized steel inlet box - Isolation mounted motor, mounted to one piece galvanized stamped steel integral motor mount/inlet - Permanently lubricated 2-speed motor with built-in thermal overload protection and disconnect plug - Field wiring compartment with receptacle - Adjustable prepunched mounting bracket - White, high impact styrene injection molded grille - Shipped in ISTA certified transit tested packaging.



Performance

Qty	Catalog Number	Flow (CFM)	SP (inwc)	Nominal RPM	Input Watts	Speed Control
1	GC-148	100	.375	966	41	FSC

Altitude (ft): 105 Temperature (F): 70

Motor Information

Volts/Ph/Hz	Nameplate Amps
115/1/60	.417

Sound Data Inlet Sound Power by Octave Band

1	2	3	4	5	6	7	8	LwA	dBA	Sones
51	52	55	52	48	42	38	32	53	39	2.0

Accessories:

WHITE PLASTIC GRILLE
FAN SPEED CONTROLLER 5A 120V PREWIRED
OCCUPANT SENSOR-CEIL
INTEGRAL BD DAMPER
GEMINI ISOLATOR KIT - ISOLATORS

Dimensions (inches)

A Plastic	13-1/4
B Plastic	15-1/2
D	4
E	4
F	12
G	5/8
H	8-3/8
J O.D.	5-15/16
K	12-3/4
L	6-11/16

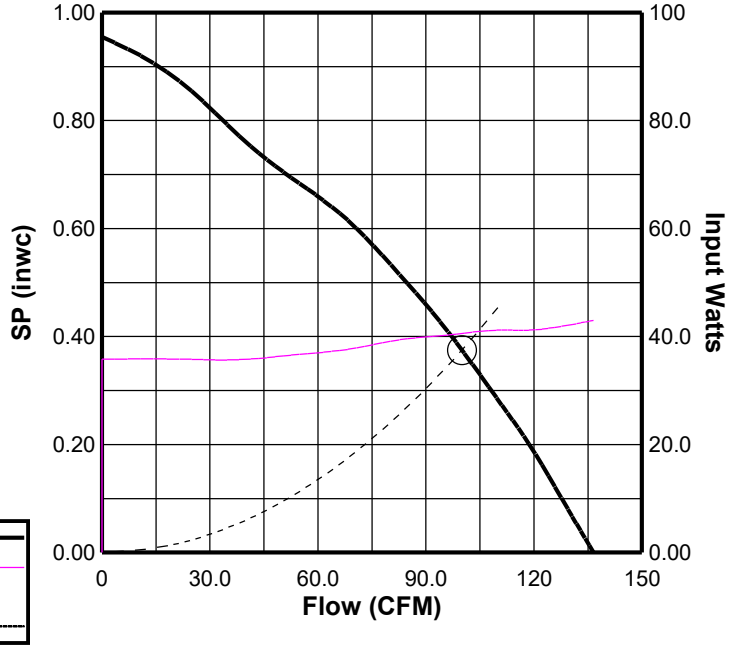
M	3-1/4
N	14

NOTE: Accessories may affect dimensions shown.

Weight(lbs)***	Shipping	19	Unit	16

***Includes fan, motor & accessories.

Fan Curve



Fan Curve Legend

CFM vs SP	———
CFM vs Watts	———
Point of Operation	◯
System Curve	- - - - -

COOK

GEMINI

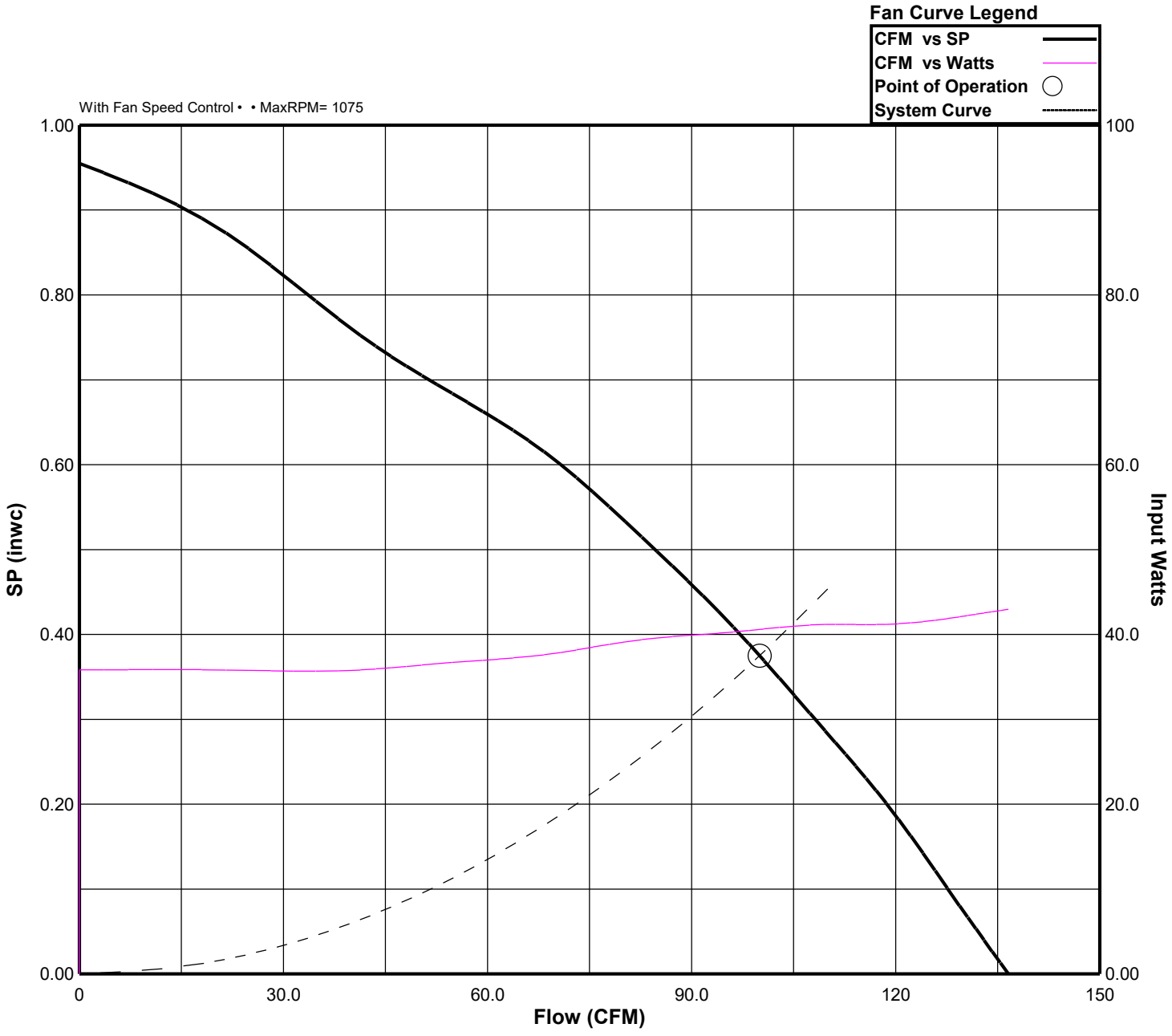
MARK: EF-34D
PROJECT: CHANNEL ISLAND FAN SELECTION
DATE: 5/8/2020

Performance

Catalog Number	Flow (CFM)	SP (inwc)	Nominal RPM	Input Watts	OVEL (mph)	TSPD (mph)	SE	TEMP (°F)	ALT (ft)
GC-148	100	.375	966	41	6	22	36%	70	105

Sound Data Inlet Sound Power by Octave Band

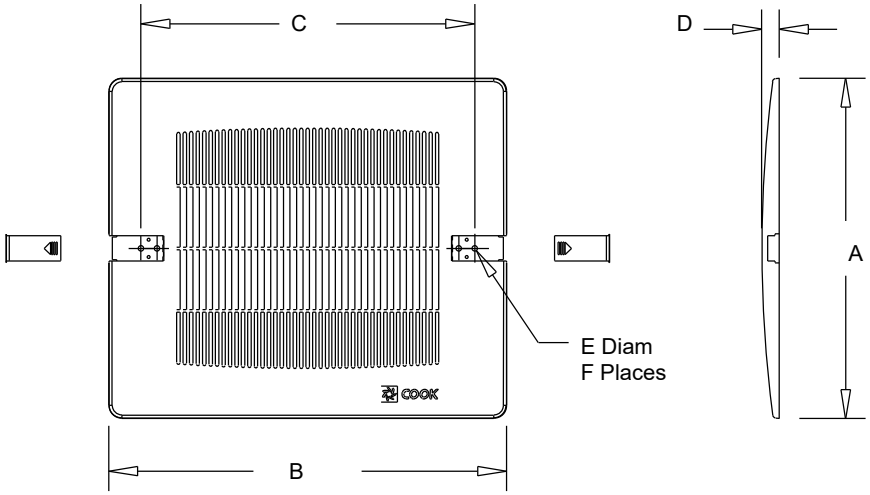
1	2	3	4	5	6	7	8	LwA	dBA	Sones
51	52	55	52	48	42	38	32	53	39	2.0



PROJECT: CHANNEL ISLAND FAN SELECTION
DATE: 5/8/2020

GEMINI

PLASTIC GRILLE



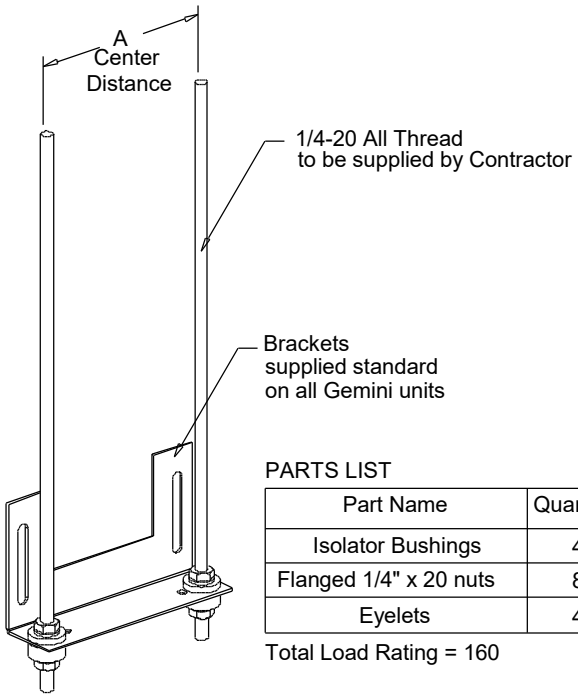
Dimensions (inches)

Mark	Qty	Description	A	B	C	D	E Diam	F Places
EF-34D	1	WHITE PLASTIC GRILLE	13-1/4	15-1/2	13	1/4	1/4	4

PROJECT: CHANNEL ISLAND FAN SELECTION
DATE: 5/8/2020

GEMINI

Gemini Isolator Kit
GIK
Rubber In Shear



PARTS LIST

Part Name	Quantity
Isolator Bushings	4
Flanged 1/4" x 20 nuts	8
Eyelets	4

Total Load Rating = 160

Dimensions (inches)

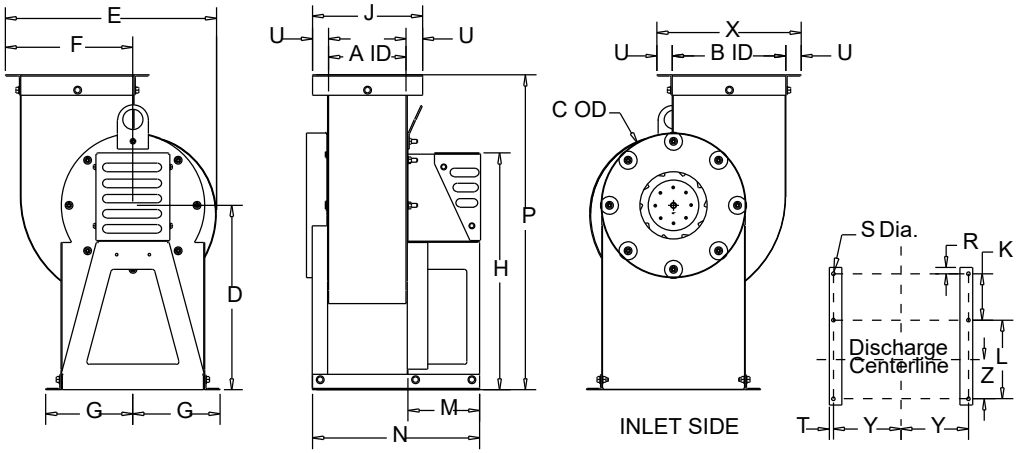
Mark	Qty	Description	Part #	A
EF-34D	1	GEMINI ISOLATO	GIK	4

COOK

MARK: EF-C36, EF-C37	
PROJECT: CHANNEL ISLAND FAN SELECTION	
DATE: 5/7/2020	

CPV-EC

Centrifugal Blower
Clockwise Upblast
Electronically Commutated
Vari-Flow® Motor
Arrangement 4



Performance

Qty	Catalog Number	Flow (CFM)	SP (inwc)	Fan RPM	Input Watts	FEG	Speed Control
1	135CPV-EC	1200	.375	1060	140	n/a(<1HP)	EC

Altitude (ft): 0 Temperature (F): 70

Motor Information

HP	RPM	Volts/Ph/Hz	Enclosure
3/4	1725	115/1/60	OPEN -EC

Vari-Flow

Fan Information

Class	OVel(mph)	Rotation	Discharge	Access
I	12.9	CW	Upblast	3:00

Sound Data Sound Power by Octave Band

	1	2	3	4	5	6	7	8	LwA	dBA
Inlet	67	71	70	63	59	58	51	44	66	55
Outlet	79	76	69	64	61	59	51	45	68	56

Accessories:

FAN MOUNTED SPEED CONTROL
STEEL FLANGED INLET
STL INLET COMP FLNGE
INLET FLEX DUCT CONN
ISOLATION RAILS
RS2-100 SET(4) - ISOLATORS

Dimensions (inches)

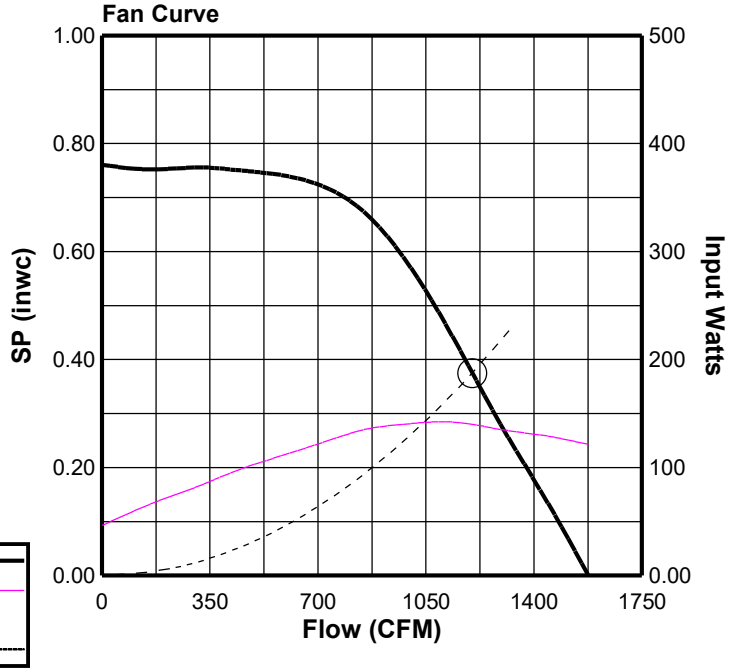
A	10-5/16	L	12-1/16	Z	6
B	14-3/4	M	10-1/16		
C	17-5/8	N	22-1/16		
D	18	P	31-7/8		
E	27-5/16	R	3/4		
F	11-1/16	S	7/16		
G	10-1/4	T	1/2		
H	23-1/2	U	1-5/8		
J	13-1/2	X	17-15/16		
K	8-1/2	Y	9-3/4		

NOTE: Accessories may affect dimensions shown.

Weight(lbs)***	Shipping	314	Unit	233

***Includes fan, motor & accessories.

Fan Curve



Fan Curve Legend

CFM vs SP	———
CFM vs Watts	———
Point of Operation	◯
System Curve	- - - - -

COOK

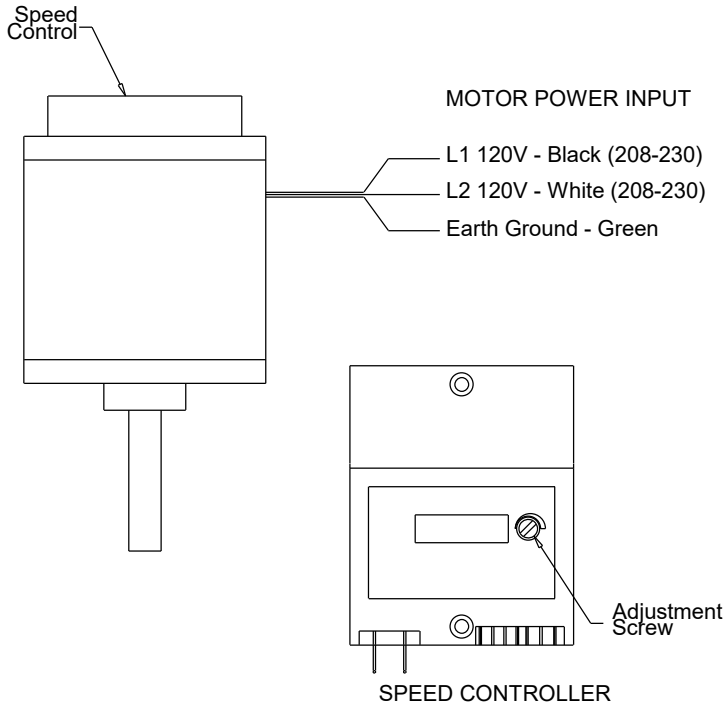
PROJECT: CHANNEL ISLAND FAN SELECTION
DATE: 5/7/2020

Speed Control

Internal Speed Control Electronically Commutated (EC) Motor Type N

STANDARD CONSTRUCTION FEATURES:

Vari-Flow EC Motors are available in 1/8 to 1 HP for 120V or 208-230V -Single phase applications have a adjustable speed range of 500 to 1725 or 500 to 2800 - Some motors come with a factory programmed maximum RPM for specific applicaitons - Integral potentiometer for adjusting motor speed - Slotted adjustment bolt for screwdriver adjustment of speed.

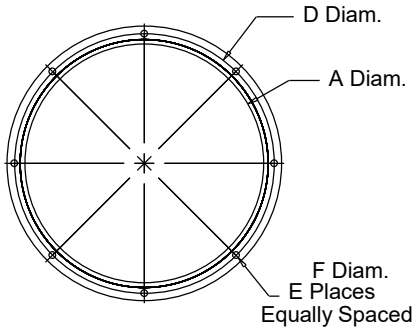


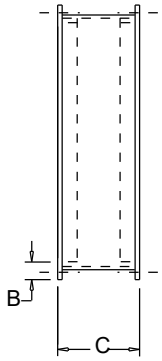
Dimensions (inches)

Mark	Qty	Description
EF-C36, EF-C37	1	OPEN -3/4HP - 115V/1

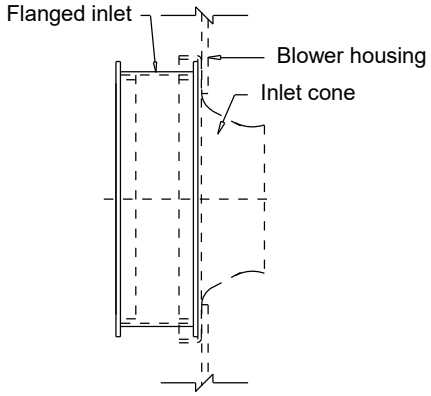
Flanged Inlet

Steel





FLANGED INLET



FLANGED INLET

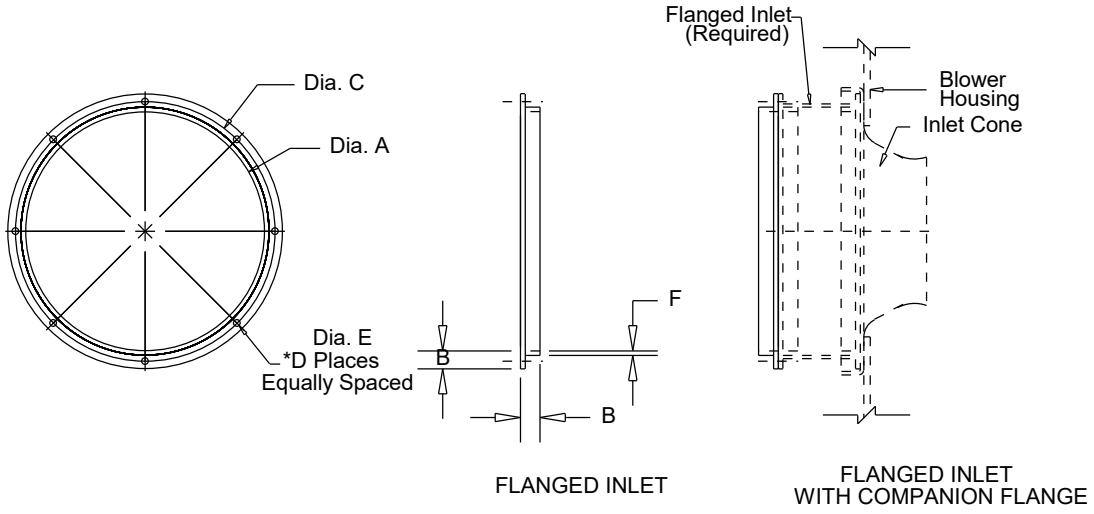
Dimensions (inches)

Mark	Qty	Description	A	B	C	D	E	F
EF-C36, EF-C37	1	STEEL FLANGED INLET	14-1/8	1-1/2	6	16	8	1/2

PROJECT: CHANNEL ISLAND FAN SELECTION
DATE: 5/7/2020

Inlet Companion Flange

Steel



Dimensions (inches)

Mark	Qty	Description	A	B	C	# D Std.	# D UL762	E	F
EF-C36, EF-C37	1	STL INLET COMP FLNGE	14-1/8	1-1/2	16	8	14	1/2	1/8

PROJECT: CHANNEL ISLAND FAN SELECTION
DATE: 5/7/2020

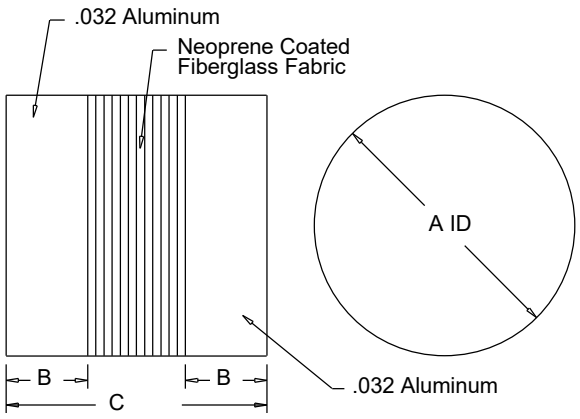
Flexible Inlet Connector

STANDARD CONSTRUCTION FEATURES:

Neoprene Coated Fibergalss fabric - 3" aluminum strips.

Note:

Consult factory for use of Hypalon Coated Fiberglass fabric for additional UV and chemical resistance.
All Lab Exhauster fans ordered with flex duct connectors will be the Hypalon type flex duct.



Dimensions (inches)

Mark	Qty	Description	A I.D.	B	C Max.
EF-C36, EF-C37	1	INLET FLEX DUCT CONN	17-3/4	3	9

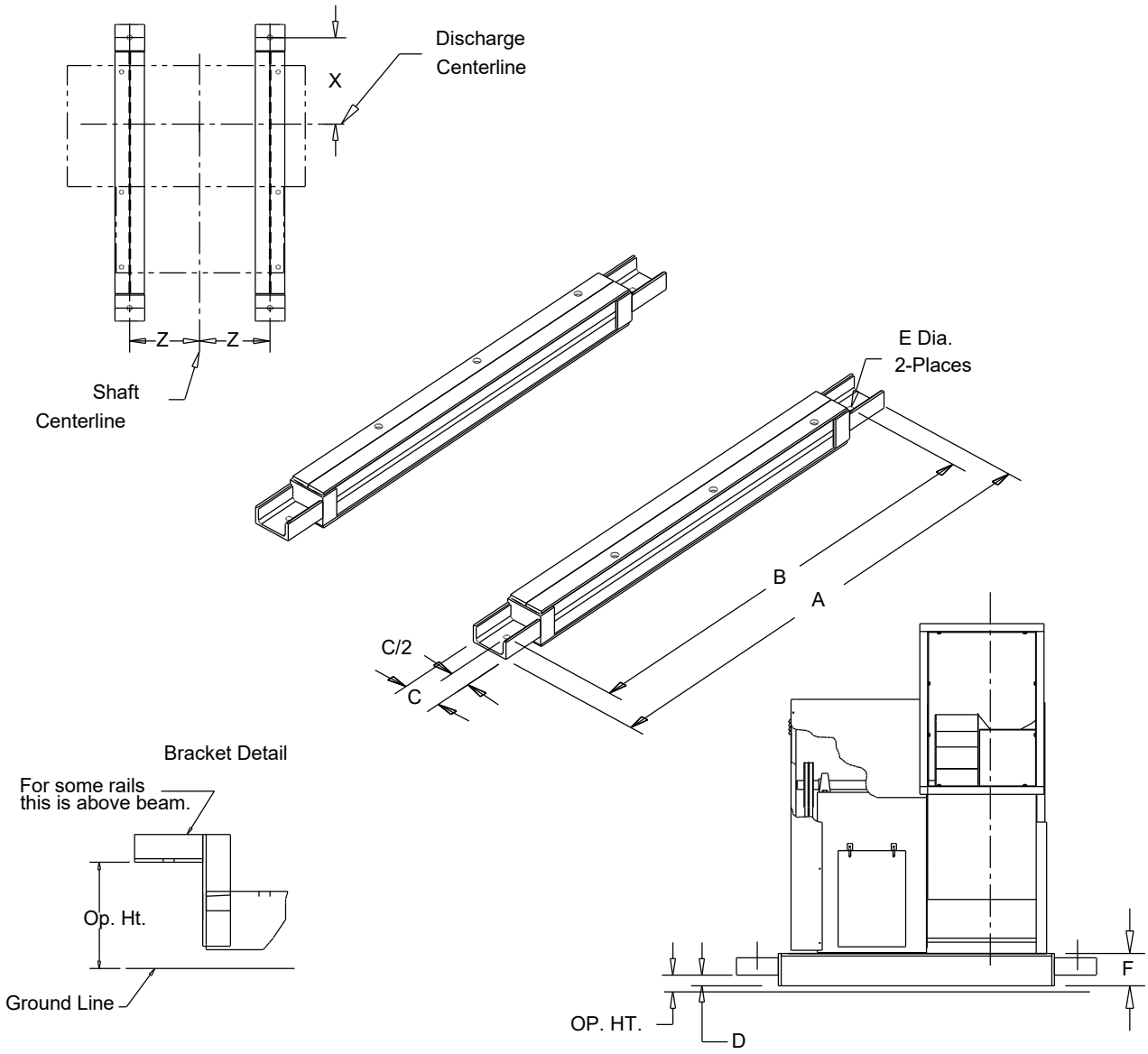
COOK

Isolation Rail

MARK: EF-C36, EF-C37
PROJECT: CHANNEL ISLAND FAN SELECTION
DATE: 5/7/2020

STANDARD CONSTRUCTION FEATURES:

Minimum 4" structural steel channel (ASTM A36)-All connections fully welded-Mounting holes provided-Lorenized powder coat finish



Dimensions (inches)

Mark	Qty	A	B	C	D	E	F	X**	Z*	OP. HT.
EF-C36, EF-C37	1	35 7/8	30 7/8	3	10 1/2	11/16	3	11 3/16	8 13/16	11

*locates center line of shaft/inlet
**locates center of discharge

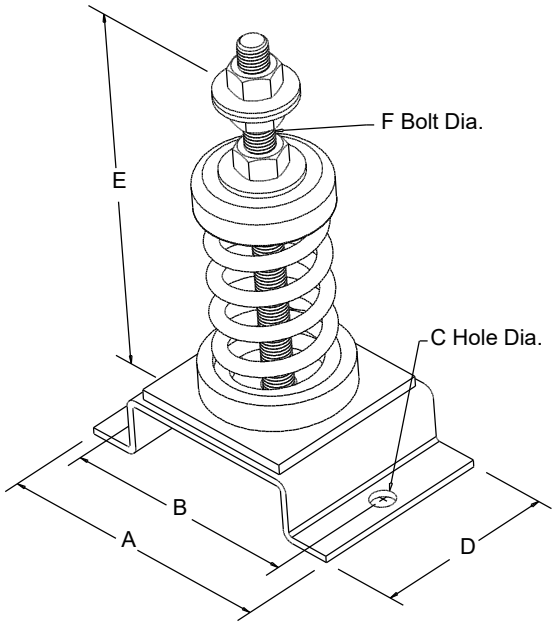
COOK

PROJECT: CHANNEL ISLAND FAN SELECTION
DATE: 5/7/2020

RESTRAINED SPRING FLOOR

Restrained Spring Isolator Floor Mounted

NOTE:
All isolators listed are designed to provide a minimum of 50% overload capacity.



Dimensions (inches)

Mark	Qty	Description	A	B	C Dia.	D	E	F	Deflection
EF-C36, EF-C37	1	RS2-100 SET(4)	8	6-1/2	11/16	4-1/2	11	5/8	2

COOK

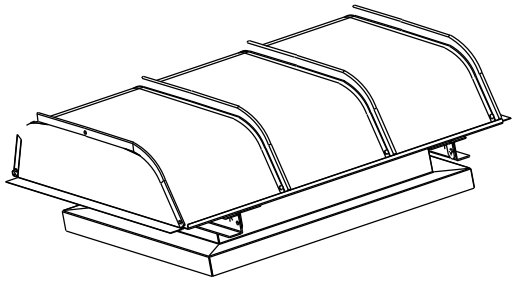
MARK: GV/?-??? 600CFM
PROJECT: CHANNEL ISLAND FAN SELECTION
DATE: 5/13/2020

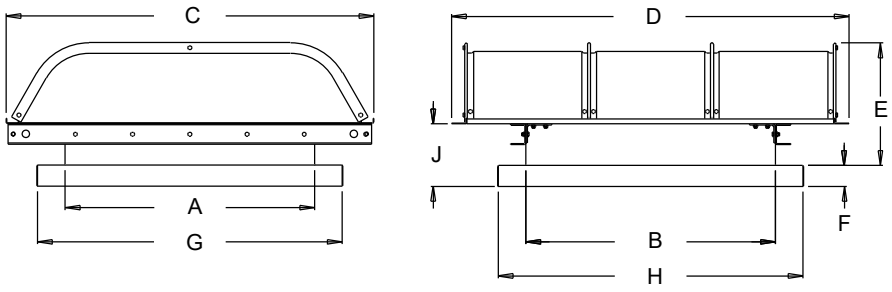
GR

Gravity Relief Ventilator

STANDARD CONSTRUCTION FEATURES:

Heavy gauge aluminum construction - Birdscreen - Radius throat - Rain gutter to prevent rain infiltration - Welded curb cap corners - Integral lifting lugs/tie down points - Hinged hood standard on throat lengths less than 73" - Five year warranty.





Performance

Qty	Catalog Number	Flow (CFM)	SP (inwc)	Face Velocity (mph)	Throat Velocity (mph)	Installation
1	12X12GR	600	.021	2	7	Non-Ducted

Altitude (ft): 0 Temperature (F): 70

Dimensions (inches)

A	12
B	12
C	31
D	27
E	12
F	2
G	17.5
H	17.5
J	6

NOTE: Accessories may affect dimensions shown.

Weight(lbs)* **	**Shipping**	50	**Unit**	43

***Includes accessories.

Accessories:

ROOF CURB RCG 16X 16-13.5H
ALUM BIRDSCREEN

Notes:

GV/??? 600 CFM

COOK

PROJECT: CHANNEL ISLAND FAN SELECTION
DATE: 5/13/2020

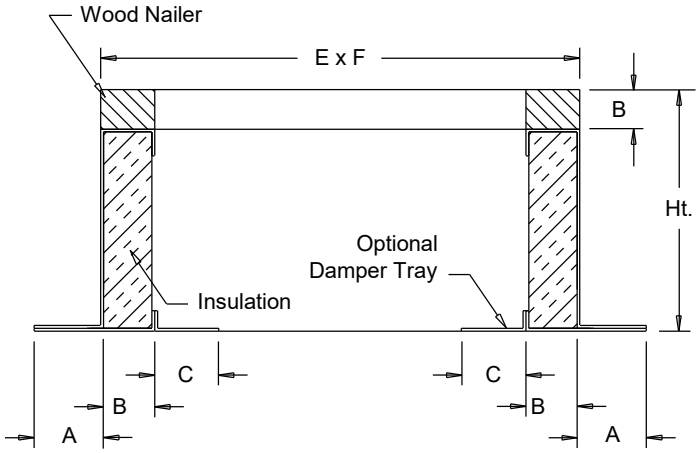
RCG

Galvanized Steel

STANDARD CONSTRUCTION FEATURES:

**18 ga. galvanized steel - 1-1/2"(3.81 cm),
3 lbs./cu.ft.(1.36 kg/cu. meter) density
thermal and accoustical insulation -
Continuously welded corners - Wood nailer.**

Options:(As noted below*)
1) No wood nailer
2) Damper tray



Note:

Roof Opening is (E - 3) X (F - 3)

Dimensions (inches)

Mark	Qty	Description	Ht	Options*	A	B	C	E	F	Roof Opening
GV/?-??? 600CFM	1	RCG 16X 16	13.5	-	2	1.5	1.875	16	16	13 X 13

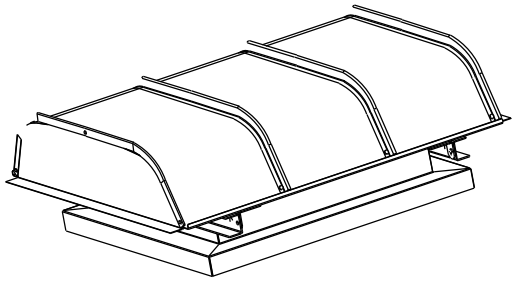
COOK

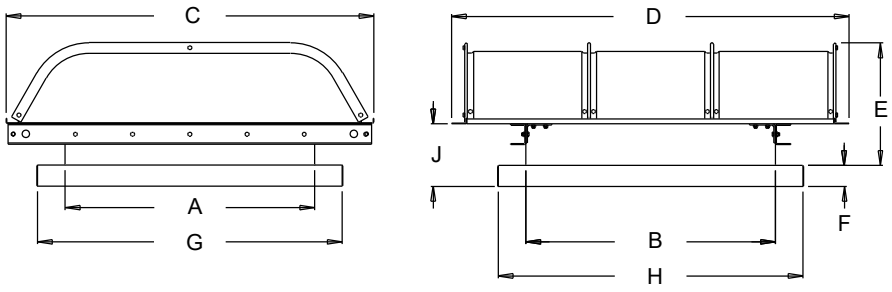
MARK: GV/?-??? 1200CFM
PROJECT: CHANNEL ISLAND FAN SELECTION
DATE: 5/13/2020

GR

Gravity Relief Ventilator

STANDARD CONSTRUCTION FEATURES:
Heavy gauge aluminum construction - Birdscreen - Radius throat - Rain gutter to prevent rain infiltration - Welded curb cap corners - Integral lifting lugs/tie down points - Hinged hood standard on throat lengths less than 73" - Five year warranty.





Performance

Qty	Catalog Number	Flow (CFM)	SP (inwc)	Face Velocity (mph)	Throat Velocity (mph)	Installation
1	12X18GR	1200	.021	3	9	Non-Ducted

Altitude (ft): 0 Temperature (F): 70

Accessories:
ROOF CURB RCG 16X 22-13.5H
ALUM BIRDSCREEN

Dimensions (inches)

A	12
B	18
C	31
D	39
E	12
F	2
G	17.5
H	23.5
J	6

NOTE: Accessories may affect dimensions shown.

Weight(lbs)* **	**Shipping**	63	**Unit**	52

***Includes accessories.

COOK

PROJECT: CHANNEL ISLAND FAN SELECTION
DATE: 5/13/2020

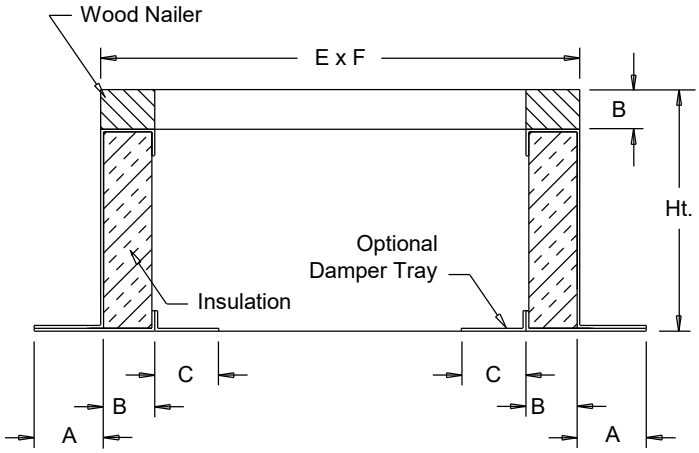
RCG

Galvanized Steel

STANDARD CONSTRUCTION FEATURES:

**18 ga. galvanized steel - 1-1/2"(3.81 cm),
3 lbs./cu.ft.(1.36 kg/cu. meter) density
thermal and accoustical insulation -
Continuously welded corners - Wood nailer.**

Options:(As noted below*)
1) No wood nailer
2) Damper tray



Note:

Roof Opening is (E - 3) X (F - 3)

Dimensions (inches)

Mark	Qty	Description	Ht	Options*	A	B	C	E	F	Roof Opening
GV/?-??? 1200CFM	1	RCG 16X 22	13.5	-	2	1.5	1.875	16	22	13 X 19

High Wall Heat Pump Ductless System

Indoor Model: **40MAQB09B--3**

Submittal Data

Job Data:		Location:	
Buyer:		Buyer P.O. #:	
Carrier #:		Unit Number:	
Model Number:		Performance Data Certified By:	
Date:			





Performance SERIES

STANDARD FEATURES
- Modes: Cool, Heat, Dry, Fan, Auto
- Turbo Mode
- Four fan speeds
- Sleep Mode
- Up-Down Louver control (fixed or swing)
- Follow Me (senses temperature at handheld remote)
- Heating Setback (46° F Heating Mode)
- Quiet indoor operation
- Aluminum Golden Hydrophilic pre-coated fins

CONTROLS:
- Wireless Remote Controller included with indoor unit
- Wired Remote Controller KSACN0401AAA (7 Day programmable) (Optional)

LIMITED WARRANTY*
- 10 year limited to original purchaser on compressor and parts upon timely registration, otherwise 5 years

*For residential applications. See warranty for full details.

System	Size		9
	Indoor Model		40MAQB09B--3
Electrical	Voltage, Phase, Cycle	V/Ph/Hz	208/230-1-60
	Power Supply	Indoor unit powered by outdoor unit	
	MCA	A.	0.2
Controls	Wireless Remote Controller (°F/°C Convertible)		Standard
	Wired Remote Controller (°F/°C Convertible)		Optional
Operating Range	Cooling Indoor DB Min -Max	°F(°C)	63~86 (17~30)
	Heating Indoor DB Min -Max	°F(°C)	32~86 (0~30)
Piping	Pipe Connection Size - Liquid	in (mm)	1/4 (6.35)
	Pipe Connection Size - Suction	in (mm)	3/8 (9.52)

Indoor Coil	Face Area	Sq. Ft.	2.19
	No. Rows		2
	Fins per inch		20
	Circuits		3
Indoor	Unit Width	in (mm)	32.87 (835)
	Unit Height	in (mm)	11.02 (280)
	Unit Depth	in (mm)	7.80 (198)
	Net Weight	lbs (kg)	19.18 (8.7)
	Number of Fan Speeds		4
	Airflow (lowest to highest)	CFM	210/290/360/380
	Sound Pressure (lowest to highest)	dB(A)	27/34/42
	Air throw Data	ft (m)	23 (7)
	Moisture removal	Pint/h (L/h	1.1 (0.5)
	Field Drain Pipe Size O.D	in (mm)	0.625 (16)

Performance may vary based on the outdoor unit matched to. See compatible outdoor units pages for Performance Data.
For Compatibility See Product Data

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Edition Date: 03/2018
Catalog No: SUB40MAQ-09-3-02

Accessories

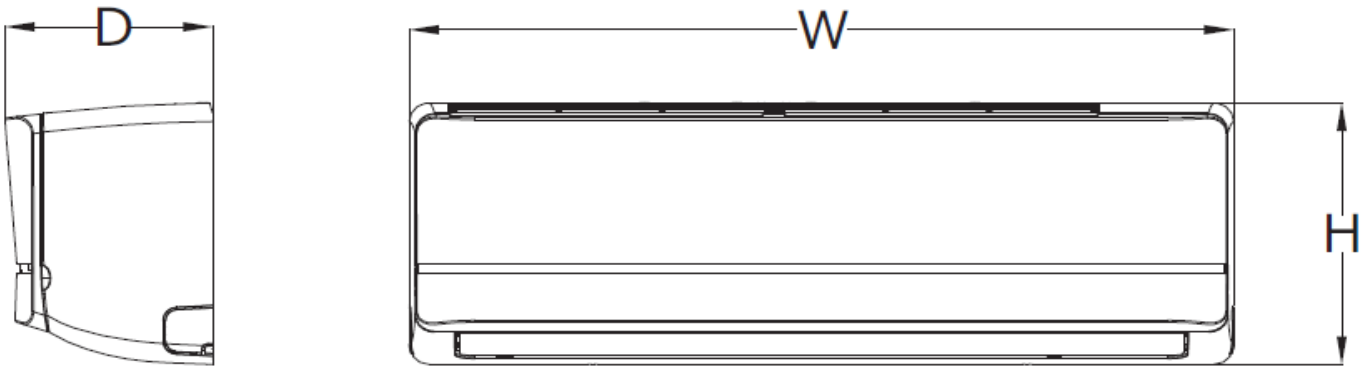
53DS-900---118	Condensate Pump (208/230V)
KSACN0101AAA	Wired Remote Control with Timer Function
KSACN0401AAA	Wired Remote Control 7 day Programmable*
KSAIF0301AAA	Wi-Fi™ Kit High Wall Mid-Tier
KSAIC0101230	24V Interface Kit 230V
53DS-900---089	Insulated 25’ Line Set - 1/4” x 3/8”
53DS-900---090	Wireless Remote Control Locking Mount Kit

**Note: ***KSACN0401AAA Wired Remote Control 7 Day programmable compatible with High Walls Units starting with Serial Number 0216V10001.

**24V Interface compatible with High Walls Units starting with Serial Number 4316V10001.

Construction View

Indoor Model: 40MAQB09B--3



Unit Width	in (mm)	32.87 (835)
Unit Height	in (mm)	11.02 (280)
Unit Depth	in (mm)	7.80 (198)
Net Weight	lbs (kg)	19.18 (8.7)

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Edition Date: 03/2018

Catalog No: SUB40MAQ-09-3-02

High Wall Heat Pump Ductless System

Indoor Model: **40MAQB12B--3**

Submittal Data

Job Data:		Location:	
Buyer:		Buyer P.O. #:	
Carrier #:			
Unit Number:		Model Number:	
Performance Data Certified By:		Date:	





Performance SERIES

STANDARD FEATURES
- Modes: Cool, Heat, Dry, Fan, Auto
- Turbo Mode
- Four fan speeds
- Sleep Mode
- Up-Down Louver control (fixed or swing)
- Follow Me (senses temperature at handheld remote)
- Heating Setback (46° F Heating Mode)
- Quiet indoor operation
- Aluminum Golden Hydrophilic pre-coated fins

CONTROLS:
- Wireless Remote Controller included with indoor unit
- Wired Remote Controller KSACN0401AAA (7 Day programmable) (Optional)

LIMITED WARRANTY*
- 10 year limited to original purchaser on compressor and parts upon timely registration, otherwise 5 years

*For residential applications. See warranty for full details.

System	Size		12
	Indoor Model		40MAQB12B--3
Electrical	Voltage, Phase, Cycle	V/Ph/Hz	208/230-1-60
	Power Supply	Indoor unit powered by outdoor unit	
	MCA	A.	0.2
Controls	Wireless Remote Controller (°F/°C Convertible)		Standard
	Wired Remote Controller (°F/°C Convertible)		Optional
Operating Range	Cooling Indoor DB Min -Max	°F(°C)	63~86 (17~30)
	Heating Indoor DB Min -Max	°F(°C)	32~86 (0~30)
Piping	Pipe Connection Size - Liquid	in (mm)	1/4 (6.35)
	Pipe Connection Size - Suction	in (mm)	1/2 (12.7)

Indoor Coil	Face Area	Sq. Ft.	2.19
	No. Rows		2
	Fins per inch		20
	Circuits		3
Indoor	Unit Width	in (mm)	32.87 (835)
	Unit Height	in (mm)	11.02 (280)
	Unit Depth	in (mm)	7.80 (198)
	Net Weight	lbs (kg)	19.18 (8.7)
	Number of Fan Speeds		4
	Airflow (lowest to highest)	CFM	210/300/360/380
	Sound Pressure (lowest to highest)	dB(A)	27/34/42
	Air throw Data	ft (m)	23 (7)
	Moisture removal	Pint/h (L/h	2.3 (1.1)
	Field Drain Pipe Size O.D	in (mm)	0.625 (16)

Performance may vary based on the outdoor unit matched to. See compatible outdoor units pages for Performance Data.
For Compatibility See Product Data

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Catalog No: SUB40MAQ-12-3-02

Accessories

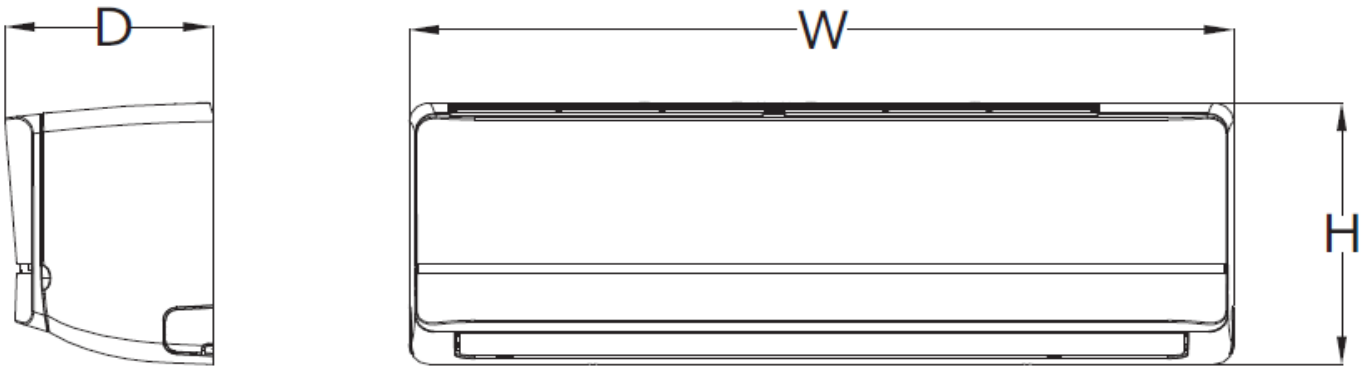
53DS-900---118	Condensate Pump (208/230V)
KSACN0101AAA	Wired Remote Control with Timer Function
KSACN0401AAA	Wired Remote Control 7 day Programmable*
KSAIF0301AAA	Wi-Fi™ Kit High Wall Mid-Tier
KSAIC0101230	24V Interface Kit 230V
53DS-900---008	Insulated 25' Line Set - 1/4" x 1/2"
53DS-900---090	Wireless Remote Control Locking Mount Kit

**Note: ***KSACN0401AAA Wired Remote Control 7 Day programmable compatible with High Walls Units starting with Serial Number 0216V10001.

**24V Interface compatible with High Walls Units starting with Serial Number 4316V10001.

Construction View

Indoor Model: 40MAQB12B--3



Unit Width	in (mm)	32.87 (835)
Unit Height	in (mm)	11.02 (280)
Unit Depth	in (mm)	7.80 (198)
Net Weight	lbs (kg)	19.18 (8.7)

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Edition Date: 03/2018

Catalog No: SUB40MAQ-12-3-02

High Wall Heat Pump Ductless System

Indoor Model: **40MAQB18B--3**

Submittal Data

Job Data:		Location:	
Buyer:		Buyer P.O. #:	
Carrier #:			
Unit Number:		Model Number:	
Performance Data Certified By:		Date:	





Performance SERIES

STANDARD FEATURES
- Modes: Cool, Heat, Dry, Fan, Auto
- Turbo Mode
- Four fan speeds
- Sleep Mode
- Up-Down Louver control (fixed or swing)
- Follow Me (senses temperature at handheld remote)
- Heating Setback (46° F Heating Mode)
- Quiet indoor operation
- Aluminum Golden Hydrophilic pre-coated fins

CONTROLS:
- Wireless Remote Controller included with indoor unit
- Wired Remote Controller KSACN0401AAA (7 Day programmable) (Optional)

LIMITED WARRANTY*
- 10 year limited to original purchaser on compressor and parts upon timely registration, otherwise 5 years

*For residential applications. See warranty for full details.

System	Size		18
	Indoor Model		40MAQB18B--3
Electrical	Voltage, Phase, Cycle	V/Ph/Hz	208/230-1-60
	Power Supply	Indoor unit powered by outdoor unit	
	MCA	A.	0.3
Controls	Wireless Remote Controller (°F/°C Convertible)		Standard
	Wired Remote Controller (°F/°C Convertible)		Optional
Operating Range	Cooling Indoor DB Min -Max	°F(°C)	63~86 (17~30)
	Heating Indoor DB Min -Max	°F(°C)	32~86 (0~30)
Piping	Pipe Connection Size - Liquid	in (mm)	1/4 (6.35)
	Pipe Connection Size - Suction	in (mm)	1/2 (12.7)

Indoor Coil	Face Area	Sq. Ft.	2.58
	No. Rows		2
	Fins per inch		20
	Circuits		4
Indoor	Unit Width	in (mm)	38.98 (990)
	Unit Height	in (mm)	12.40 (315)
	Unit Depth	in (mm)	8.58 (218)
	Net Weight	lbs (kg)	26.46 (12.0)
	Number of Fan Speeds		4
	Airflow (lowest to highest)	CFM	310/450/650/680
	Sound Pressure (lowest to highest)	dB(A)	33/40/46
	Air throw Data	ft (m)	30 (9)
	Moisture removal	Pint/h (L/h	3.8 (1.8)
	Field Drain Pipe Size O.D	in (mm)	0.625 (16)

Performance may vary based on the outdoor unit matched to. See compatible outdoor units pages for Performance Data.
For Compatibility See Product Data

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Accessories

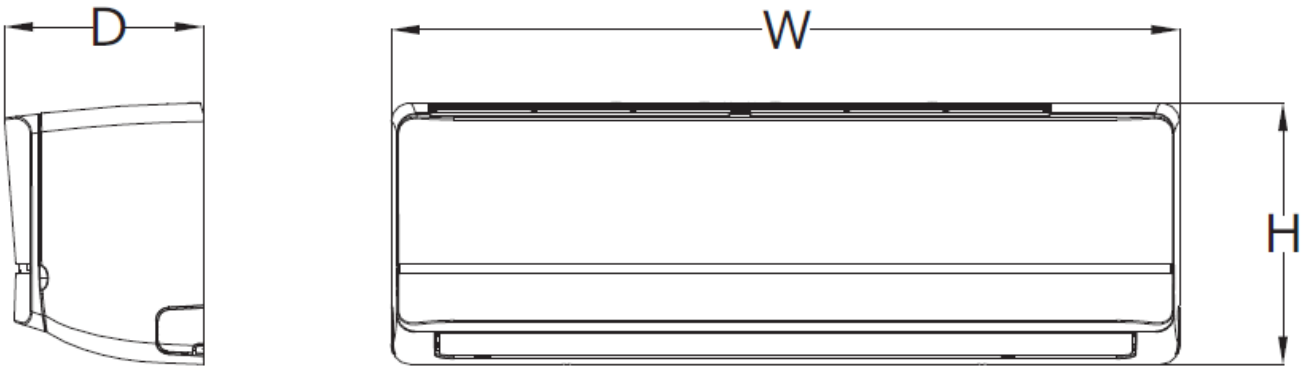
53DS-900---118	Condensate Pump (208/230V)
KSACN0101AAA	Wired Remote Control with Timer Function
KSACN0401AAA	Wired Remote Control 7 day Programmable*
KSAIF0301AAA	Wi-Fi™ Kit High Wall Mid-Tier
KSAIC0101230	24V Interface Kit 230V
53DS-900---008	Insulated 25' Line Set - 1/4" x 1/2"
53DS-900---090	Wireless Remote Control Locking Mount Kit

**Note: ***KSACN0401AAA Wired Remote Control 7 Day programmable compatible with High Walls Units starting with Serial Number 0216V10001.

**24V Interface compatible with High Walls Units starting with Serial Number 4316V10001.

Construction View

Indoor Model: 40MAQB18B--3



Unit Width	in (mm)	38.98 (990)
Unit Height	in (mm)	12.40 (315)
Unit Depth	in (mm)	8.58 (218)
Net Weight	lbs (kg)	26.46 (12.0)

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Edition Date: 03/2018

Catalog No: SUB40MAQ-18-3-02

High Wall Heat Pump Ductless System

Indoor Model: **40MAQB24B--3**

Submittal Data

Job Data:		Location:	
Buyer:		Buyer P.O. #:	
Carrier #:		Unit Number:	
Model Number:		Performance Data Certified By:	
Date:			





Performance SERIES

STANDARD FEATURES
- Modes: Cool, Heat, Dry, Fan, Auto
- Turbo Mode
- Four fan speeds
- Sleep Mode
- Up-Down Louver control (fixed or swing)
- Follow Me (senses temperature at handheld remote)
- Heating Setback (46° F Heating Mode)
- Quiet indoor operation
- Aluminum Golden Hydrophilic pre-coated fins

CONTROLS:
- Wireless Remote Controller included with indoor unit
- Wired Remote Controller KSACN0401AAA (7 Day programmable) (Optional)

LIMITED WARRANTY*
- 10 year limited to original purchaser on compressor and parts upon timely registration, otherwise 5 years

*For residential applications. See warranty for full details.

System	Size		24
	Indoor Model		40MAQB24B--3
Electrical	Voltage, Phase, Cycle	V/Ph/Hz	208/230-1-60
	Power Supply	Indoor unit powered by outdoor unit	
	MCA	A.	0.4
Controls	Wireless Remote Controller (°F/°C Convertible)		Standard
	Wired Remote Controller (°F/°C Convertible)		Optional
Operating Range	Cooling Indoor DB Min -Max	°F(°C)	63~86 (17~30)
	Heating Indoor DB Min -Max	°F(°C)	32~86 (0~30)
Piping	Pipe Connection Size - Liquid	in (mm)	3/8 (9.52)
	Pipe Connection Size - Suction	in (mm)	5/8 (16)

Indoor Coil	Face Area	Sq. Ft.	3.68
	No. Rows		3
	Fins per inch		18
	Circuits		7
Indoor	Unit Width	in (mm)	46.69 (1186)
	Unit Height	in (mm)	13.39 (343)
	Unit Depth	in (mm)	10.16 (258)
	Net Weight	lbs (kg)	40.12 (18.2)
	Number of Fan Speeds		4
	Airflow (lowest to highest)	CFM	520/620/780/870
	Sound Pressure (lowest to highest)	dB(A)	39/45/50
	Air throw Data	ft (m)	36 (11)
	Moisture removal	Pint/h (L/h	5.4 (2.6)
	Field Drain Pipe Size O.D	in (mm)	0.625 (16)

Performance may vary based on the outdoor unit matched to. See compatible outdoor units pages for Performance Data.
For Compatibility See Product Data

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Accessories

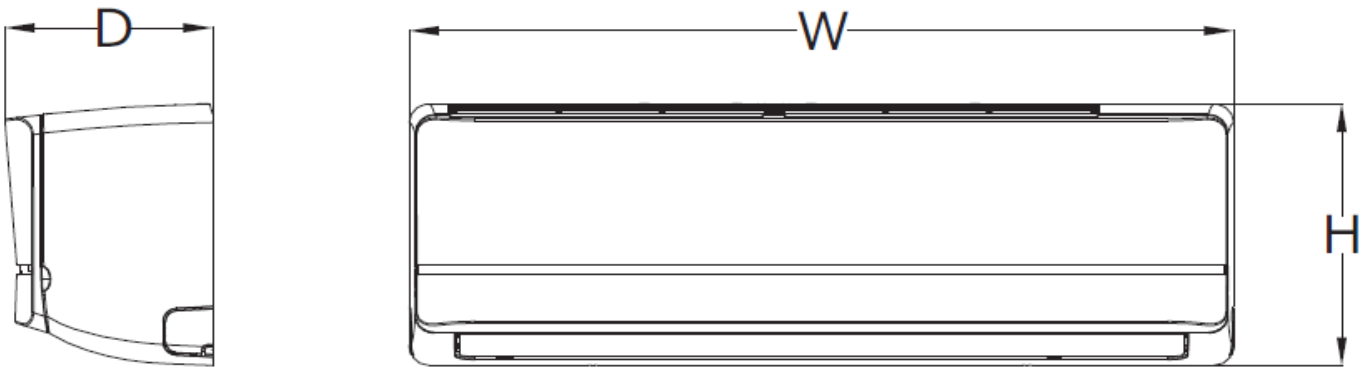
53DS-900---118	Condensate Pump (208/230V)
KSACN0101AAA	Wired Remote Control with Timer Function
KSACN0401AAA	Wired Remote Control 7 day Programmable*
KSAIF0301AAA	Wi-Fi™ Kit High Wall Mid-Tier
KSAIC0101230	24V Interface Kit 230V
53DS-900---090	Wireless Remote Control Locking Mount Kit

**Note: ***KSACN0401AAA Wired Remote Control 7 Day programmable compatible with High Walls Units starting with Serial Number 0216V10001.

**24V Interface compatible with High Walls Units starting with Serial Number 4316V10001.

Construction View

Indoor Model: 40MAQB24B--3



Unit Width	in (mm)	46.69 (1186)
Unit Height	in (mm)	13.39 (343)
Unit Depth	in (mm)	10.16 (258)
Net Weight	lbs (kg)	40.12 (18.2)

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Edition Date: 03/2018

Catalog No: SUB40MAQ-24-3-02

High Wall Heat Pump Ductless System

Indoor Model: **40MAQB30B--3**

Submittal Data

Job Data:		Location:	
Buyer:		Buyer P.O. #:	
Carrier #:		Unit Number:	
Model Number:		Performance Data Certified By:	
Date:			





Performance SERIES

STANDARD FEATURES
- Modes: Cool, Heat, Dry, Fan, Auto
- Turbo Mode
- Four fan speeds
- Sleep Mode
- Up-Down Louver control (fixed or swing)
- Follow Me (senses temperature at handheld remote)
- Heating Setback (46° F Heating Mode)
- Quiet indoor operation
- Aluminum Golden Hydrophilic pre-coated fins

CONTROLS:
- Wireless Remote Controller included with indoor unit
- Wired Remote Controller KSACN0401AAA (7 Day programmable) (Optional)

LIMITED WARRANTY*
- 10 year limited to original purchaser on compressor and parts upon timely registration, otherwise 5 years

*For residential applications. See warranty for full details.

System	Size		30
	Indoor Model		40MAQB30B--3
Electrical	Voltage, Phase, Cycle	V/Ph/Hz	208/230-1-60
	Power Supply	Indoor unit powered by outdoor unit	
	MCA	A.	0.4
Controls	Wireless Remote Controller (°F/°C Convertible)		Standard
	Wired Remote Controller (°F/°C Convertible)		Optional
Operating Range	Cooling Indoor DB Min -Max	°F(°C)	63~86 (17~30)
	Heating Indoor DB Min -Max	°F(°C)	32~86 (0~30)
Piping	Pipe Connection Size - Liquid	in (mm)	3/8 (9.52)
	Pipe Connection Size - Suction	in (mm)	5/8 (16)

Indoor Coil	Face Area	Sq. Ft.	3.68
	No. Rows		3
	Fins per inch		18
	Circuits		7
Indoor	Unit Width	in (mm)	46.69 (1186)
	Unit Height	in (mm)	13.39 (343)
	Unit Depth	in (mm)	10.16 (258)
	Net Weight	lbs (kg)	40.12 (18.2)
	Number of Fan Speeds		4
	Airflow (lowest to highest)	CFM	520/620/780/870
	Sound Pressure (lowest to highest)	dB(A)	39/45/50
	Air throw Data	ft (m)	36 (11)
	Moisture removal	Pint/h (L/h	8.1 (3.9)
	Field Drain Pipe Size O.D	in (mm)	0.625 (16)

Performance may vary based on the outdoor unit matched to. See compatible outdoor units pages for Performance Data.
For Compatibility See Product Data

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Catalog No: SUB40MAQ-30-3-02

Accessories

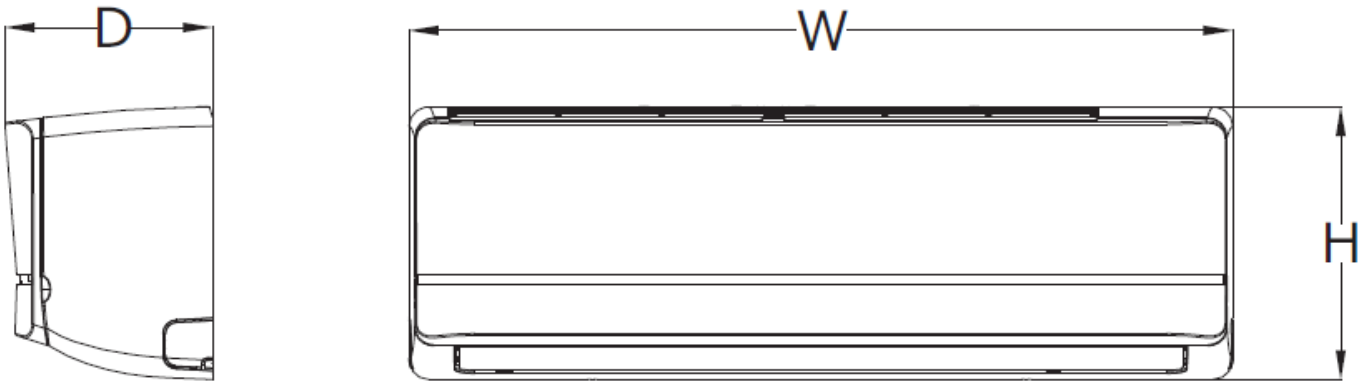
53DS-900---118	Condensate Pump (208/230V)
KSACN0101AAA	Wired Remote Control with Timer Function
KSACN0401AAA	Wired Remote Control 7 day Programmable*
KSAIF0301AAA	Wi-Fi™ Kit High Wall Mid-Tier
KSAIC0101230	24V Interface Kit 230V
53DS-900---090	Wireless Remote Control Locking Mount Kit

**Note: ***KSACN0401AAA Wired Remote Control 7 Day programmable compatible with High Walls Units starting with Serial Number 0216V10001.

**24V Interface compatible with High Walls Units starting with Serial Number 4316V10001.

Construction View

Indoor Model: 40MAQB30B--3



Unit Width	in (mm)	46.69 (1186)
Unit Height	in (mm)	13.39 (343)
Unit Depth	in (mm)	10.16 (258)
Net Weight	lbs (kg)	40.12 (18.2)

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Edition Date: 03/2018

Catalog No: SUB40MAQ-30-3-02

High Wall Heat Pump Ductless System

Indoor Model: **40MAQB36B--3**

Submittal Data

Job Data:		Location:	
Buyer:		Buyer P.O. #:	
Carrier #:		Unit Number:	
Model Number:		Performance Data Certified By:	
Date:			





Performance SERIES

STANDARD FEATURES
- Modes: Cool, Heat, Dry, Fan, Auto
- Turbo Mode
- Four fan speeds
- Sleep Mode
- Up-Down Louver control (fixed or swing)
- Follow Me (senses temperature at handheld remote)
- Heating Setback (46° F Heating Mode)
- Quiet indoor operation
- Aluminum Golden Hydrophilic pre-coated fins

CONTROLS:
- Wireless Remote Controller included with indoor unit
- Wired Remote Controller KSACN0401AAA (7 Day programmable) (Optional)

LIMITED WARRANTY*
- 10 year limited to original purchaser on compressor and parts upon timely registration, otherwise 5 years

*For residential applications. See warranty for full details.

System	Size		36
	Indoor Model		40MAQB36B--3
Electrical	Voltage, Phase, Cycle	V/Ph/Hz	208/230-1-60
	Power Supply	Indoor unit powered by outdoor unit	
	MCA	A.	0.4
Controls	Wireless Remote Controller (°F/°C Convertible)		Standard
	Wired Remote Controller (°F/°C Convertible)		Optional
Operating Range	Cooling Indoor DB Min -Max	°F(°C)	63~86 (17~30)
	Heating Indoor DB Min -Max	°F(°C)	32~86 (0~30)
Piping	Pipe Connection Size - Liquid	in (mm)	3/8 (9.52)
	Pipe Connection Size - Suction	in (mm)	5/8 (16)

Indoor Coil	Face Area	Sq. Ft.	3.68
	No. Rows		3
	Fins per inch		18
	Circuits		7
Indoor	Unit Width	in (mm)	46.69 (1186)
	Unit Height	in (mm)	13.39 (343)
	Unit Depth	in (mm)	10.16 (258)
	Net Weight	lbs (kg)	40.12 (18.2)
	Number of Fan Speeds		4
	Airflow (lowest to highest)	CFM	520/620/780/870
	Sound Pressure (lowest to highest)	dB(A)	39/45/50
	Air throw Data	ft (m)	36 (11)
	Moisture removal	Pint/h (L/h	11.7 (5.6)
	Field Drain Pipe Size O.D	in (mm)	0.625 (16)

Performance may vary based on the outdoor unit matched to. See compatible outdoor units pages for Performance Data.
For Compatibility See Product Data

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Edition Date: 03/2018
Catalog No: SUB40MAQ-36-3-02

Accessories

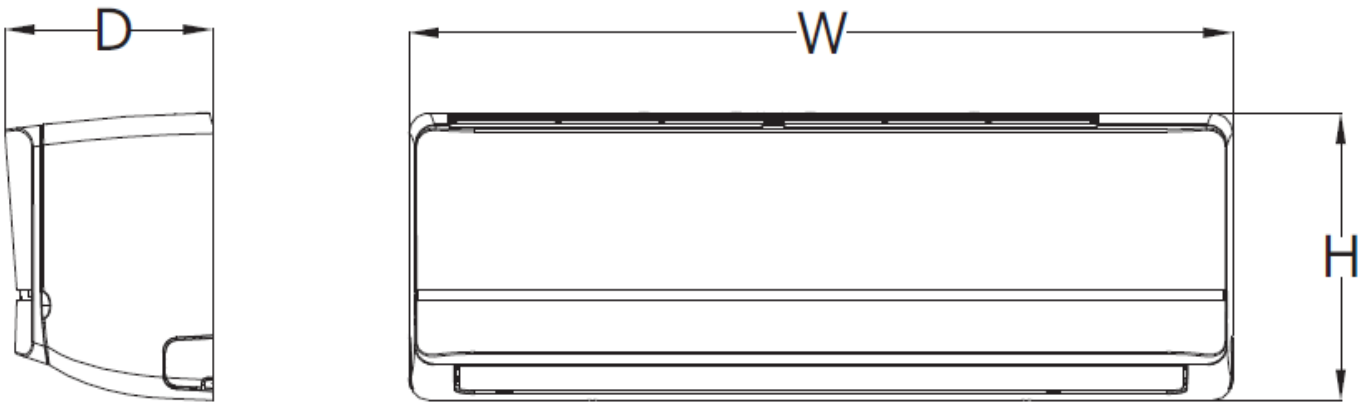
53DS-900---118	Condensate Pump (208/230V)
KSACN0101AAA	Wired Remote Control with Timer Function
KSACN0401AAA	Wired Remote Control 7 day Programmable*
KSAIF0301AAA	Wi-Fi™ Kit High Wall Mid-Tier
KSAIC0101230	24V Interface Kit 230V
53DS-900---090	Wireless Remote Control Locking Mount Kit

**Note: ***KSACN0401AAA Wired Remote Control 7 Day programmable compatible with High Walls Units starting with Serial Number 0216V10001.

**24V Interface compatible with High Walls Units starting with Serial Number 4316V10001.

Construction View

Indoor Model: 40MAQB36B--3



Unit Width	in (mm)	46.69 (1186)
Unit Height	in (mm)	13.39 (343)
Unit Depth	in (mm)	10.16 (258)
Net Weight	lbs (kg)	40.12 (18.2)

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Edition Date: 03/2018

Catalog No: SUB40MAQ-36-3-02

MUA FAN INFORMATION – Job#4373127

FAN UNIT NO	TAG	FAN UNIT MODEL #	BLOWER	HOUSING	MIN CFM	DESIGN CFM	ESP	RPM	MOTOR ENCL	HP	BHP	ø	VOLT	FLA	MCA	MOCP	EVAP FLOW RATE (Gal/Hr)	EVAP COOLER ENTERING DB TEMP	EVAP COOLER ENTERING WB TEMP	EVAP COOLER LEAVING DB TEMP	EVAP COOLER LEAVING WB TEMP	WEIGHT (LBS)	SONES
1	MAU-F1	A4-IBT-800-400-400-28Z	28Z-4-MDD	A4-IBT-800-400-400	5000	8000	0.500	1323	□DP-ECM	6.700	4.9400	3	460	6.6	9.7A	15A	4.93	90.0°F	64.0°F	71.0°F	64.0°F	2943	26
2	MAU-G1	A4-IBT-800-400-400-28Z	28Z-4-MDD	A4-IBT-800-400-400	5000	8100	0.500	1338	□DP-ECM	6.700	5.1050	3	460	6.6	9.7A	15A	5.01	90.0°F	64.0°F	71.0°F	64.0°F	2943	27

*Evap Flow Rate is variable based on water pressure.

GAS FIRED MAKE-UP AIR UNIT(S)

FAN UNIT NO	TAG	INPUT BTUs	□UTPUT BTUs	TEMP RISE	REQUIRED INPUT GAS PRESSURE	GAS TYPE	BURNER EFFICIENCY(%)
1	MAU-F1	507600	406080	44 deg F	7 in. w.c. - 14 in. w.c.	Natural	80
2	MAU-G1	513945	411156	44 deg F	7 in. w.c. - 14 in. w.c.	Natural	80

FAN OPTIONS

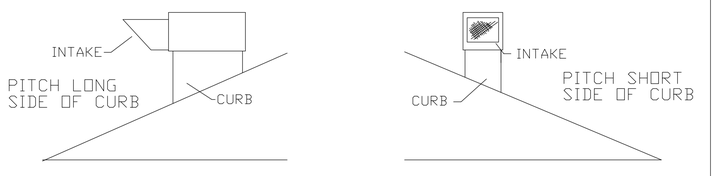
FAN UNIT NO	TAG	□PTION (Qty - Descr)
1	MAU-F1	1 - Motorized Backdraft Damper for A4-I Housing
		1 - Inlet Pressure Gauge, 0-35"
		1 - Manifold Pressure Gauge, 0 to 10" wc, 2 Furnaces
		1 - Commercial Smoke Detector/Alarm Interlock (Supplied by □thers)
		1 - ECM Wiring Package-Supply - Manual or 0-10VDC Reference Speed Control (3 Phase Ziehl Motor)
		1 - Clogged Filter Switch with notification on HMI
		1 - Insulated Blower Section Size 4 Commercial Modular
		1 - Insulation □ption for VBank filter section
		1 - IBT/MUA Evap Interlock
		1 - Single Point Electrical Connection Single Module. If a Non-DCV Prewire is used on the IBT Heater, the #28, #47, 'NS', 'MA', or 'E2' □ption Prewire must be selected. Do not provide supply starter in prewire.
		1 - DDC IP BACNet remote unit monitoring. Allows for remote DDC occupied override and set point changes.
2	MAU-G1	1 - Motorized Backdraft Damper for A4-I Housing
		1 - Inlet Pressure Gauge, 0-35"
		1 - Manifold Pressure Gauge, 0 to 10" wc, 2 Furnaces
		1 - Commercial Smoke Detector/Alarm Interlock (Supplied by □thers)
		1 - ECM Wiring Package-Supply - Manual or 0-10VDC Reference Speed Control (3 - Phase Ziehl Motor)
		1 - Clogged Filter Switch with notification on HMI
		1 - Insulated Blower Section Size 4 Commercial Modular
		1 - Insulation □ption for VBank filter section
		1 - IBT/MUA Evap Interlock
		1 - Single Point Electrical Connection Single Module. If a Non-DCV Prewire is used on the IBT Heater, the #28, #47, 'NS', 'MA', or 'E2' □ption Prewire must be selected. Do not provide supply starter in prewire.
		1 - DDC IP BACNet remote unit monitoring. Allows for remote DDC occupied override and set point changes.

CURB ASSEMBLIES

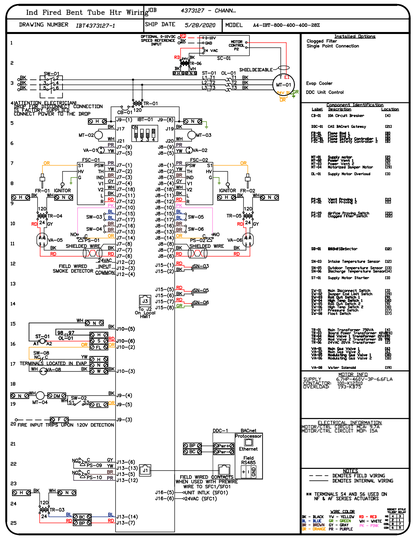
NO	ON FAN	TAG	WEIGHT	ITEM	SIZE
1	# 1	MAU-F1	129 LBS	Curb	42.000"W x 121.250"L x 20.000"H 1.000:12.000 Pitch Along Width, Right Insulated
	# 1			Rail	4.000"W x 4.000"L x 36.000"H 1.000:12.000 Pitch Along Length, Right
	# 1			Rail	4.000"W x 4.000"L x 36.000"H 1.000:12.000 Pitch Along Length, Right
2	# 2	MAU-G1	129 LBS	Curb	42.000"W x 121.250"L x 20.000"H 1.000:12.000 Pitch Along Width, Right Insulated
	# 2			Rail	4.000"W x 4.000"L x 36.000"H 1.000:12.000 Pitch Along Length, Right
	# 2			Rail	4.000"W x 4.000"L x 36.000"H 1.000:12.000 Pitch Along Length, Right

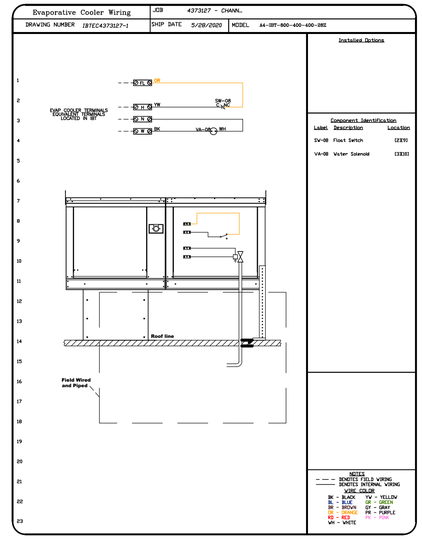
RECTANGULAR PITCHED ROOF CURB

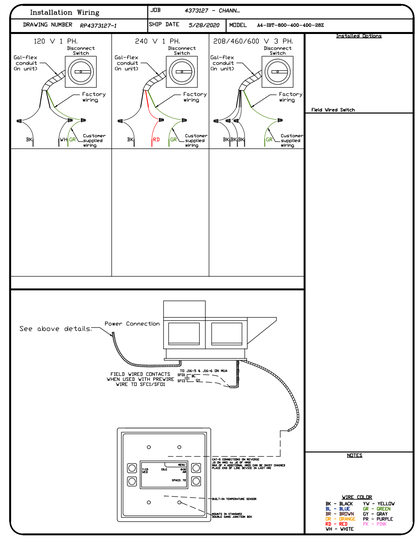
SPECIFY ROOF PITCH ____/12" AND PITCH ORIENTATION

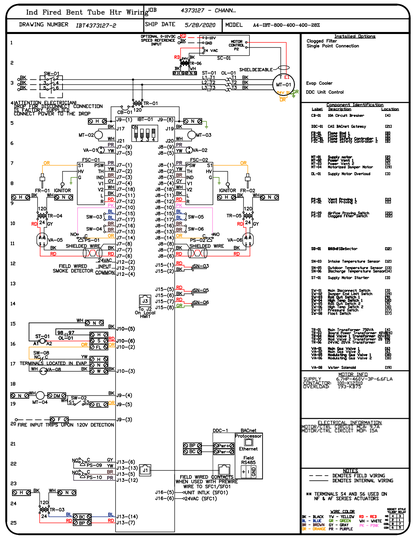


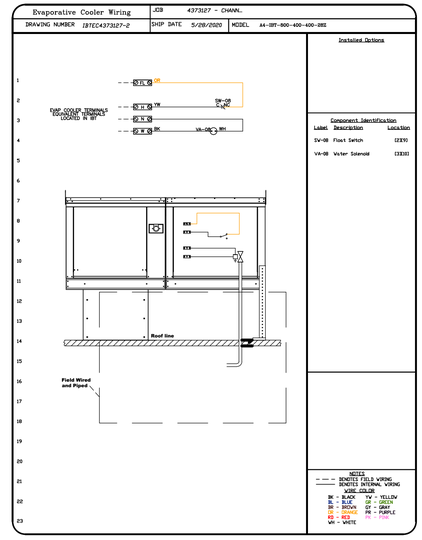
CONTRACTOR TO CONFIRM PITCH AND DIRECTION PRIOR TO FABRICATION

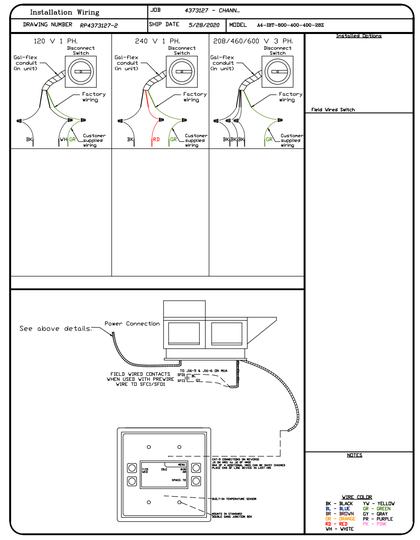












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REVISIONS

	DESCRIPTION	DATE:
△		
△		
△		
△		

CHANNEL ISLANDS HS
1400 Raiders Way,
Oxnard, CA, 93033

DATE: 5/28/2020

DWG.#: 4373127

DRAWN BY: BDN-81

SCALE: 3/4" = 1'-0"

MASTER DRAWING

SHEET NO. 1

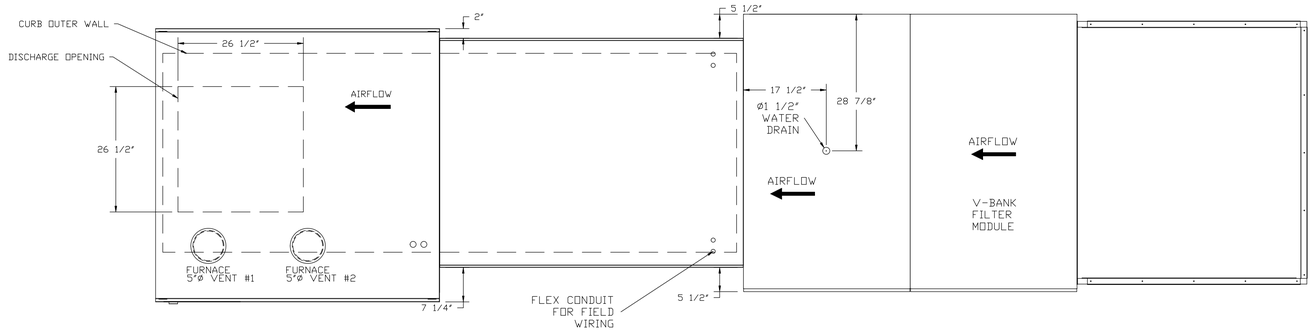
FAN #1 A4-IBT-800-400-400-28Z - HEATER (MAU-F1)
1. INDIRECT BENT TUBE GAS FIRED HEATER WITH 28" DIRECT DRIVE FAN, 2 FURNACES, ELECTRONIC FULL MODULATION, CONSTANT 80% EFFICIENCY, AND 12:1 MAX TURNDOWN FOR NG, (10:1 MAX TURNDOWN FOR LP). STAINLESS STEEL BURNERS AND HEAT EXCHANGERS.
2. EVAP COOLER (LPD) & V-BANK WITH 2" TA-13 FILTERS-OUTDOOR
3. DOWN DISCHARGE - AIR FLOW RIGHT -> LEFT
4. MOTORIZED BACK DRAFT DAMPER 34" X 36" FOR SIZE 4 STANDARD & MODULAR HEATER UNITS W/EXTENDED SHAFT, STANDARD GALVANIZED CONSTRUCTION, 3/4" REAR FLANGE, LOW LEAKAGE, NFBUP-S ACTUATOR INCLUDED
5. GAS PRESSURE GAUGE, 0-35", 2.5" DIAMETER, 1/4" THREAD SIZE
6. GAS PRESSURE GAUGE, 0 TO +10 INCHES WC., 2.5" DIAMETER, 1/8" THREAD SIZE, REAR THREAD, FOR 2 FURNACES
7. COMMERCIAL SMOKE DETECTOR INTERLOCK (DETECTOR BY OTHERS)
8. ECM WIRING PACKAGE AND MANUAL OR 0-10 VDC CONTROL FOR SUPPLY EC ZIEHL FANS. RTC CONTROLLER
9. CLOGGED FILTER SWITCH WITH NOTIFICATION ON HMI
10. INSULATED BLOWER HOUSING SIZE 4 COMMERCIAL MODULAR
11. "INSULATION" FOR V-BANK INTAKE OPTION.
12. LAYER CONTROL FOR IBT EVAP
13. SINGLE POINT ELECTRICAL CONNECTION FOR ALL IBT HEATERS WITH 1 MODULE. QNTY 1 750VA TRANSFORMER USED. IF A NON-DCV PREWIRE IS USED ON THE IBT HEATER, THE #28, #47, "MA", OR "E2" OPTION PREWIRE MUST BE SELECTED. DO NOT PROVIDE SUPPLY STARTER IN PREWIRE.
14. REMOTE IP BACNET MONITORING FOR SUPPLY FANS.
15. HINGED DOUBLE WALL INSULATED DOOR ASSEMBLY (BURNER/BLOWER/EVAP SECTION)
IBT - US Patent 877119 B2

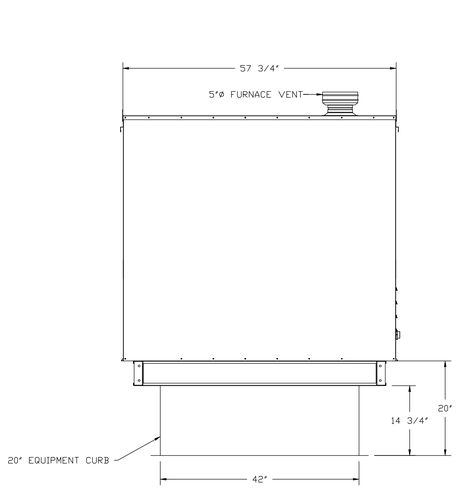
*NOTE: SUPPLY DUCT MUST BE INSTALLED TO MEET SMACNA STANDARDS. A MINIMUM STRAIGHT DUCT LENGTH MUST BE MAINTAINED DOWNSTREAM OF UNIT DISCHARGE AS OUTLINED IN AMCA PUBLICATION 201. DO NOT RELY ON UNIT TO SUPPORT DUCT IN ANY WAY. FAILURE TO PROPERLY SIZE DUCTWORK MAY CAUSE SYSTEM EFFECTS AND REDUCE PERFORMANCE OF THE EQUIPMENT.
SUGGESTED STRAIGHT DUCT SIZE IS 26" x 26"

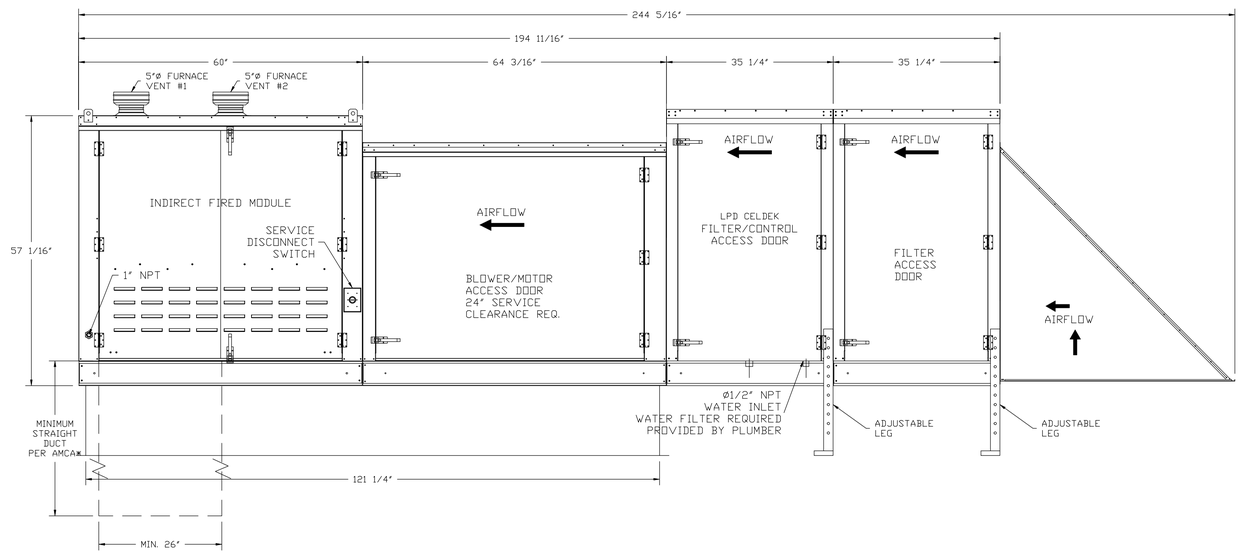
SUPPLY SIDE HEATER INFORMATION:

WINTER TEMPERATURE = 39°F. TEMP. RISE = 44°F.
BTUs CALCULATED OFF ACTUAL AIR DENSITY
OUTPUT BTUs AT ALTITUDE OF 0.0 ft. = 403204
INPUT BTUs AT ALTITUDE OF 0.0 ft. = 504005
OUTPUT BTUs AT ALTITUDE OF 68 ft. = 402214
INPUT BTUs AT ALTITUDE OF 68 ft. = 502768









CONTRACTOR TO CONFIRM ROOF PITCH AND DIRECTION PRIOR TO FABRICATION

REVISIONS

	DESCRIPTION	DATE:
1		
2		
3		
4		

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CHANNEL ISLANDS HS
1400 Raiders Way,
Oxnard, CA, 93033

DATE: 5/28/2020

DWG.#: 4373127

DRAWN BY: BDN-81

SCALE: 3/4" = 1'-0"

MASTER DRAWING

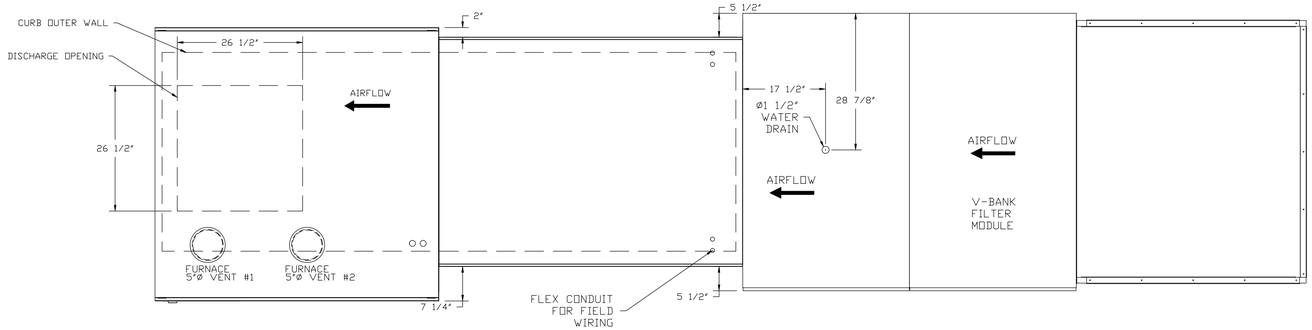
SHEET NO. 2

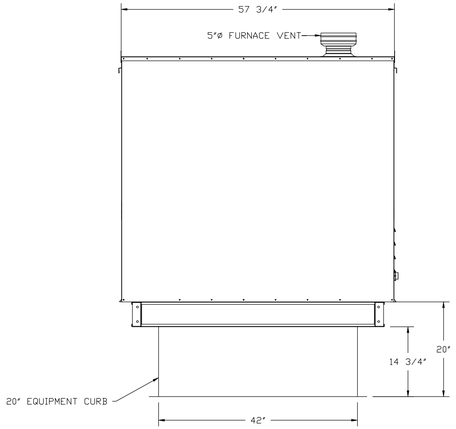
FAN #2 A4-IBT-800-400-400-28Z - HEATER (MAU-G1)
1. INDIRECT BENT TUBE GAS FIRED HEATER WITH 28" DIRECT DRIVE FAN, 2 FURNACES, ELECTRONIC FULL MODULATION, CONSTANT 80% EFFICIENCY, AND 12:1 MAX TURNDOWN FOR NG, (10:1 MAX TURNDOWN FOR LP). STAINLESS STEEL BURNERS AND HEAT EXCHANGERS.
2. EVAP COOLER (LPD) & V-BANK WITH 2" TA-13 FILTERS-OUTDOOR
3. DOWN DISCHARGE - AIR FLOW RIGHT -> LEFT
4. MOTORIZED BACK DRAFT DAMPER 34" X 36" FOR SIZE 4 STANDARD & MODULAR HEATER UNITS W/EXTENDED SHAFT, STANDARD GALVANIZED CONSTRUCTION, 3/4" REAR FLANGE, LOW LEAKAGE, NFBUP-S ACTUATOR INCLUDED
5. GAS PRESSURE GAUGE, 0-35", 2.5" DIAMETER, 1/4" THREAD SIZE
6. GAS PRESSURE GAUGE, 0 TO +10 INCHES WC, 2.5" DIAMETER, 1/8" THREAD SIZE, REAR THREAD, FOR 2 FURNACES
7. COMMERCIAL SMOKE DETECTOR INTERLOCK <DETECTOR BY OTHERS>
8. ECM WIRING PACKAGE AND MANUAL OR 0-10 VDC CONTROL FOR SUPPLY EC ZIEHL FANS. RTC CONTROLLER
9. CLOGGED FILTER SWITCH WITH NOTIFICATION ON HMI
10. INSULATED BLOWER HOUSING SIZE 4 COMMERCIAL MODULAR
11. "INSULATION" FOR V-BANK INTAKE OPTION.
12. LAYER CONTROL FOR IBT EVAP
13. SINGLE POINT ELECTRICAL CONNECTION FOR ALL IBT HEATERS WITH 1 MODULE. QNTY 1 750VA TRANSFORMER USED. IF A NON-DCV PREWIRE IS USED ON THE IBT HEATER, THE #28, #47, "MA", OR "E2" OPTION PREWIRE MUST BE SELECTED. DO NOT PROVIDE SUPPLY STARTER IN PREWIRE.
14. REMOTE IP BACNET MONITORING FOR SUPPLY FANS.
15. HINGED DOUBLE WALL INSULATED DOOR ASSEMBLY (BURNER/BLOWER/EVAP SECTION)
IBT - US Patent 877119 B2

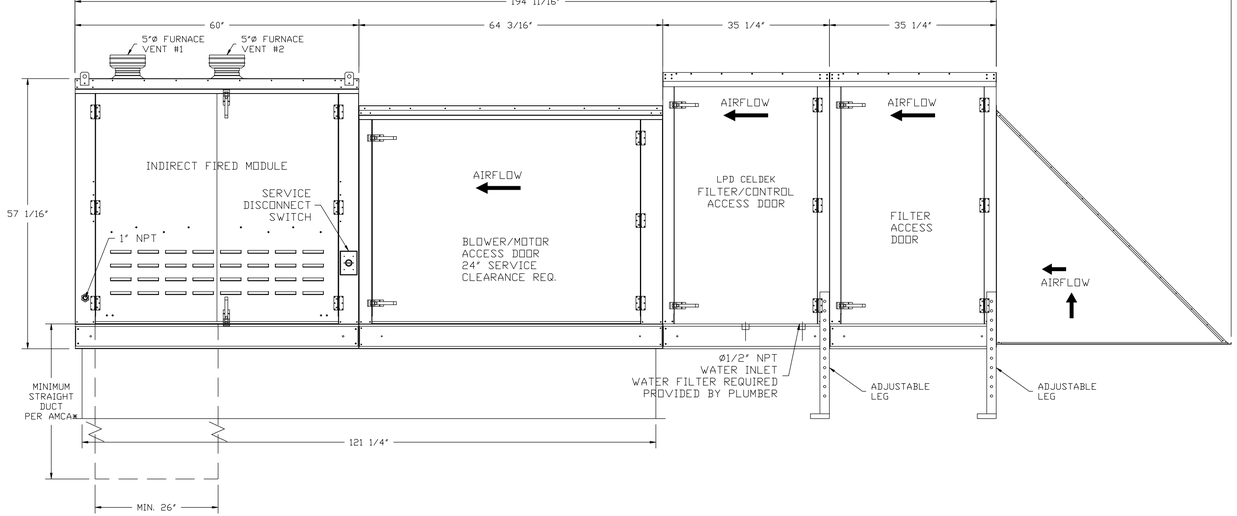
*NOTE: SUPPLY DUCT MUST BE INSTALLED TO MEET SMACNA STANDARDS. A MINIMUM STRAIGHT DUCT LENGTH MUST BE MAINTAINED DOWNSTREAM OF UNIT DISCHARGE AS OUTLINED IN AMCA PUBLICATION 201. DO NOT RELY ON UNIT TO SUPPORT DUCT IN ANY WAY. FAILURE TO PROPERLY SIZE DUCTWORK MAY CAUSE SYSTEM EFFECTS AND REDUCE PERFORMANCE OF THE EQUIPMENT. SUGGESTED STRAIGHT DUCT SIZE IS 26" x 26"

SUPPLY SIDE HEATER INFORMATION:

WINTER TEMPERATURE = 39°F. TEMP. RISE = 44°F.
BTUs CALCULATED OFF ACTUAL AIR DENSITY
OUTPUT BTUs AT ALTITUDE OF 0.0 ft. = 408244
INPUT BTUs AT ALTITUDE OF 0.0 ft. = 510305
OUTPUT BTUs AT ALTITUDE OF 68 ft. = 407242
INPUT BTUs AT ALTITUDE OF 68 ft. = 509052







CONTRACTOR TO CONFIRM ROOF PITCH AND DIRECTION PRIOR TO FABRICATION

REVISIONS

	DESCRIPTION	DATE:
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CHANNEL ISLANDS HS
1400 Raiders Way,
Oxnard, CA, 93033

DATE: 5/28/2020

DWG.#: 4373127

DRAWN BY: BDN-81

SCALE: 3/4" = 1'-0"

MASTER DRAWING

SHEET NO. 3

Order # 4373127 - CHANNEL ISLANDS HS - Oxnard, Ca

Fan #1 A4-IBT-800-400-400-28Z (2945 lbs./129 curb)
Tag: MAU-F1

Indirect Bent Tube Gas Fired Heater with 28" Direct Drive Fan, 2 Furnaces, Electronic Full Modulation, Constant 80% Efficiency, and 12:1 Max Turndown for NG, (10:1 Max Turndown for LP). Stainless Steel Burners and Heat Exchangers.

Supply Motor:
Model 115386-ECM-60-480-28, 6.700 HP, 3 Phase, 460 V, 60Hz, 6.6 FLA, ODP-ECM (Open Drip Proof Electronically Commutated Motor)

Burner:
Min Output BTU: 53,333 BTU/Hr
Max Output BTU: 640,001 BTU/Hr
Max Input BTU: 800,000 BTU/Hr
Gas Type: Natural

Supply Performance:
Volume: 8000 cfm
RPM: 1323
TS: 9698 ft/min
SP: 1.020" w.g.
0.500" Ext. + 0.493" Int. + 0.027" Opt.
BHP: 4.94

Heating Schedule:
Altitude: 68'
Winter Entering Air Dry Bulb Temp: 39°F
Temp Rise: 44°F
Output BTU: 406080
Input BTU: 507600
BTUs BASED OFF ACTUAL AIR DENSITY

Cooling Schedule:
Intake Entering Dry Bulb Temperature: 90°F
Intake Entering Wet Bulb Temperature: 64°F
Intake Entering Relative Humidity: 23%
Intake Leaving Dry Bulb Temperature: 71°F
Intake Leaving Wet Bulb Temperature: 64°F
Temperature drop calculations are based on tested data.

Supply Installation Information:
Gas Inlet Pressure: 7 in. w.c. - 14 in. w.c.
Insurance: No Insurance Requirement (ANSI)
Unit Main Input: 9.7 Amps MCA, 15 Amps MOP, 460 V, 14 AWG Wire Min.
Supply Unit Voltage: 3 phs 460 V 60Hz
SCCR: 10 kAmp

Blower:
28 Inch Plenum Fan for size 4 MOD. Motor integral to Wheel. Max RPM = 1300.

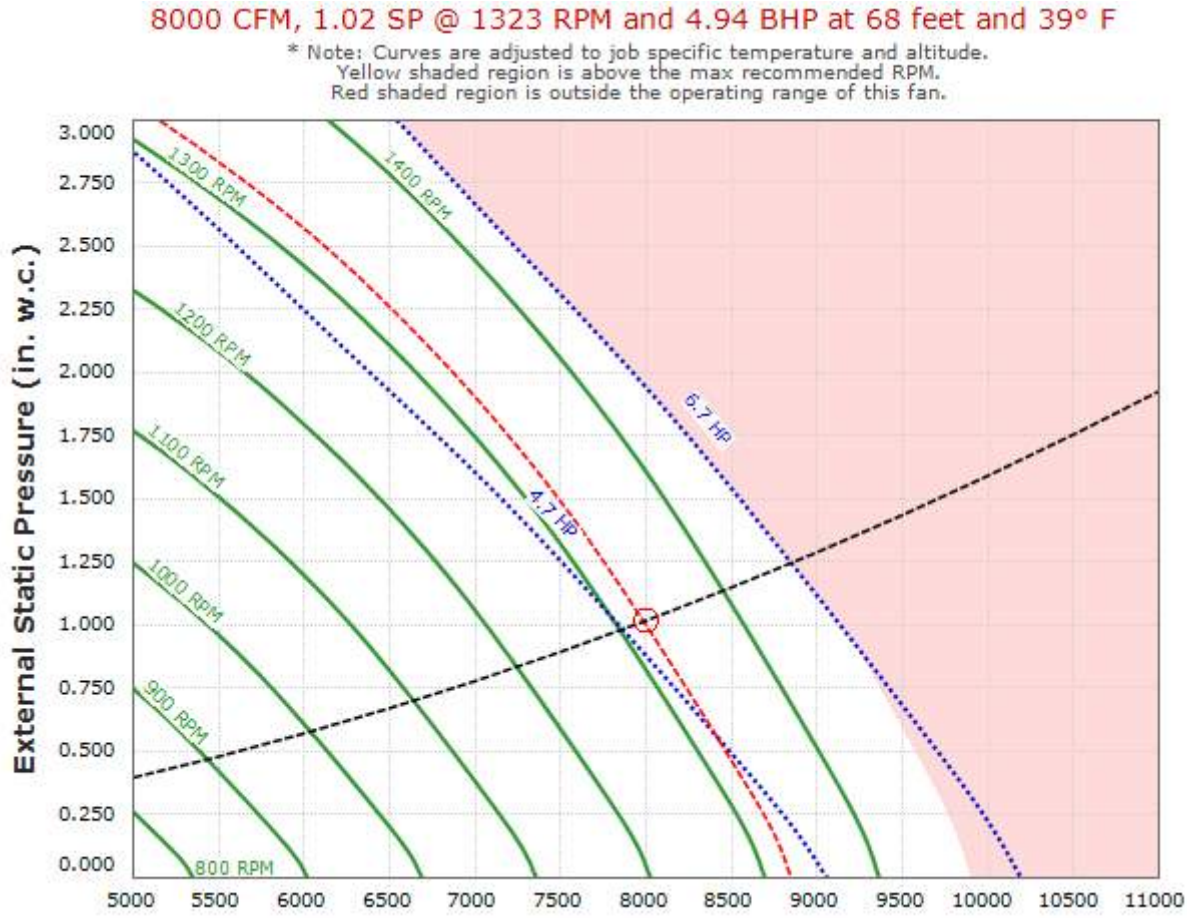
Temp Control:
50-90°F Space Temp Control • Field Wired On/Off Switch Control • Heating Activation Based On Either Intake or Space Set Point

Intake:
LPD Celdek and V-Bank for Size # 4 Modular Make Up Air unit. For outdoor installation. Includes Screened Intake

Filters:
12x Throw away filter 20w x 25h x 2d, MERV13 rating, 1750 max cfm. 12 per box

Curb & Supports:
ROOF CURB - 42" x 121.25" X 20" Supply Height, Insulated
Adjustable Equipment Legs, 36 in. high, set of 2
Adjustable Equipment Legs, 36 in. high, set of 2

Selected Options:
- CASLink building monitoring system communications module. Requires internet & field wired ethernet connection or 3G cellular service. Includes Rev 3 Comm Module, RJ45 to modbus converter, 3 FT cat5 cable, and 1 FT of shielded twisted pair.
- Motorized Back Draft Damper 34" X 36" for Size 4 Standard & Modular Heater Units w/Extended Shaft, Standard Galvanized Construction, 3/4" Rear Flange, Low Leakage, NFBUP-S Actuator Included
- Gas Pressure Gauge, 0-35", 2.5" Diameter, 1/4" Thread Size
- Gas Pressure Gauge, 0 to +10 Inches Wc., 2.5" Diameter, 1/8" Thread Size, Rear Thread, For 2 Furnaces
- Commercial Smoke Detector Interlock (Detector By Others)
- ECM Wiring Package and Manual or 0-10 VDC Control for Supply EC Ziehl Fans. RTC Controller
- Clogged Filter Switch with Notification on HMI
- Insulated Blower Housing Size 4 Commercial Modular
- "Insulation" for V-bank Intake Option.
- Layer Control for IBT Evap
- Single Point Electrical Connection for all IBT Heaters with 1 module. QNTY 1 750va Transformer Used. If a Non-DCV Prewire is used on the IBT Heater, the #28, #47, "MA", or "E2" Option Prewire must be selected. Do not provide supply starter in prewire.



A4-IBT-800-400-400-28Z supply sound data @ 1323 RPM:

LWA: 85.7 Sones at 5 ft.: 26 DBA at 5 ft.: 74.2

Frequency	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz
Sound Power (dB)	88.3	95.4	86.1	79.1	79.8	74.4	72.6	68.4

Order # 4373127 - CHANNEL ISLANDS HS - Oxnard, Ca

Fan #2 A4-IBT-800-400-400-28Z (2945 lbs./129 curb)
Tag: MAU-G1

Indirect Bent Tube Gas Fired Heater with 28" Direct Drive Fan, 2 Furnaces, Electronic Full Modulation, Constant 80% Efficiency, and 12:1 Max Turndown for NG, (10:1 Max Turndown for LP). Stainless Steel Burners and Heat Exchangers.

Supply Motor:
Model 115386-ECM-60-480-28, 6.700 HP, 3 Phase, 460 V, 60Hz, 6.6 FLA, ODP-ECM (Open Drip Proof Electronically Commutated Motor)

Burner:
Min Output BTU: 53,333 BTU/Hr
Max Output BTU: 640,001 BTU/Hr
Max Input BTU: 800,000 BTU/Hr
Gas Type: Natural

Supply Performance:
Volume: 8100 cfm
RPM: 1338
TS: 9808 ft/min
SP: 1.033" w.g.
0.500" Ext. + 0.505" Int. + 0.028" Opt.
BHP: 5.105

Heating Schedule:
Altitude: 68'
Winter Entering Air Dry Bulb Temp: 39°F
Temp Rise: 44°F
Output BTU: 411156
Input BTU: 513945
BTUs BASED OFF ACTUAL AIR DENSITY

Cooling Schedule:
Intake Entering Dry Bulb Temperature: 90°F
Intake Entering Wet Bulb Temperature: 64°F
Intake Entering Relative Humidity: 23%
Intake Leaving Dry Bulb Temperature: 71°F
Intake Leaving Wet Bulb Temperature: 64°F
Temperature drop calculations are based on tested data.

Supply Installation Information:
Gas Inlet Pressure: 7 in. w.c. - 14 in. w.c.
Insurance: No Insurance Requirement (ANSI)
Unit Main Input: 9.7 Amps MCA, 15 Amps MOP, 460 V, 14 AWG Wire Min.
Supply Unit Voltage: 3 phs 460 V 60Hz
SCCR: 10 kAmp

Blower:
28 Inch Plenum Fan for size 4 MOD. Motor integral to Wheel. Max RPM = 1300.

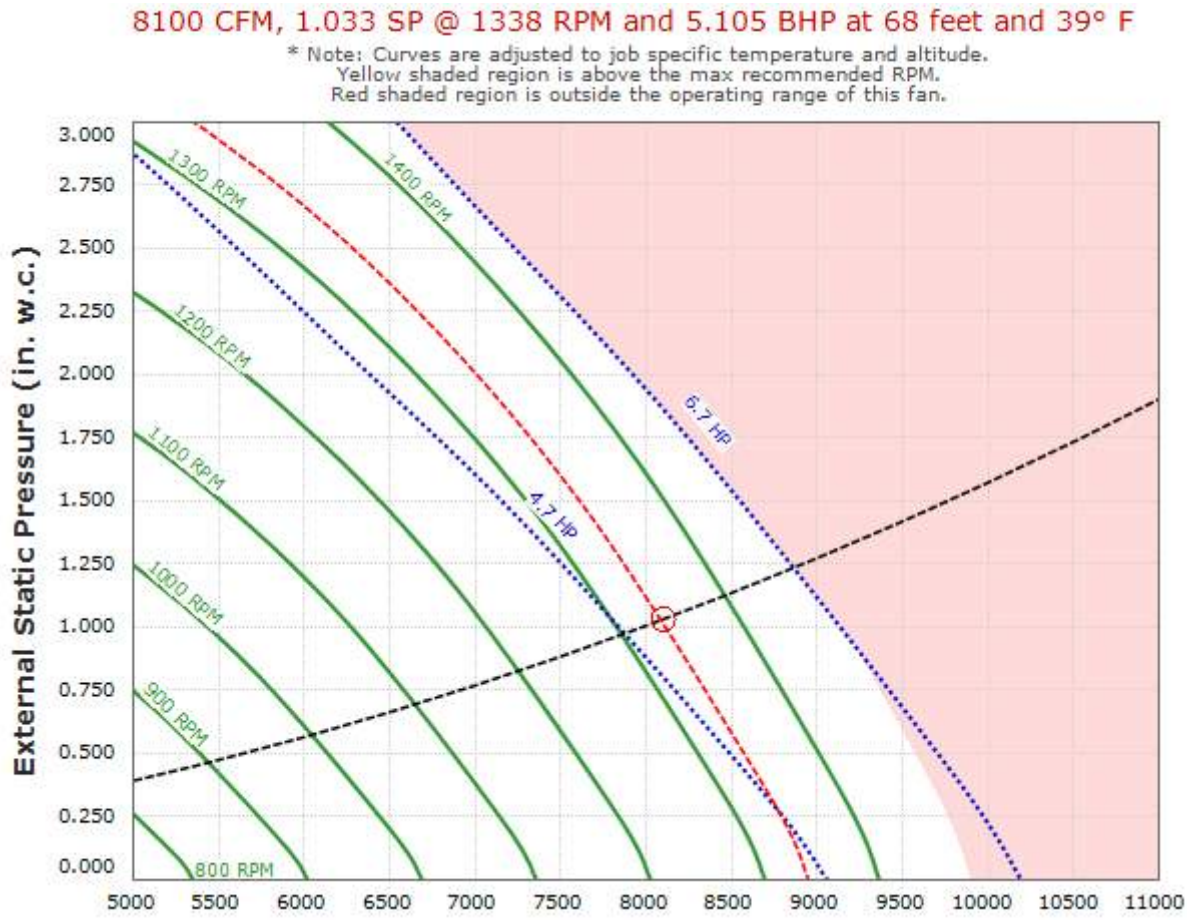
Temp Control:
50-90°F Space Temp Control • Field Wired On/Off Switch Control • Heating Activation Based On Either Intake or Space Set Point

Intake:
LPD Celdek and V-Bank for Size # 4 Modular Make Up Air unit. For outdoor installation. Includes Screened Intake

Filters:
12x Throw away filter 20w x 25h x 2d, MERV13 rating, 1750 max cfm. 12 per box

Curb & Supports:
ROOF CURB - 42" x 121.25" X 20" Supply Height, Insulated
Adjustable Equipment Legs, 36 in. high, set of 2
Adjustable Equipment Legs, 36 in. high, set of 2

Selected Options:
- CASLink building monitoring system communications module. Requires internet & field wired ethernet connection or 3G cellular service. Includes Rev 3 Comm Module, RJ45 to modbus converter, 3 FT cat5 cable, and 1 FT of shielded twisted pair.
- Motorized Back Draft Damper 34" X 36" for Size 4 Standard & Modular Heater Units w/Extended Shaft, Standard Galvanized Construction, 3/4" Rear Flange, Low Leakage, NFBUP-S Actuator Included
- Gas Pressure Gauge, 0-35", 2.5" Diameter, 1/4" Thread Size
- Gas Pressure Gauge, 0 to +10 Inches Wc., 2.5" Diameter, 1/8" Thread Size, Rear Thread, For 2 Furnaces
- Commercial Smoke Detector Interlock (Detector By Others)
- ECM Wiring Package and Manual or 0-10 VDC Control for Supply EC Ziehl Fans. RTC Controller
- Clogged Filter Switch with Notification on HMI
- Insulated Blower Housing Size 4 Commercial Modular
- "Insulation" for V-bank Intake Option.
- Layer Control for IBT Evap
- Single Point Electrical Connection for all IBT Heaters with 1 module. QNTY 1 750va Transformer Used. If a Non-DCV Prewire is used on the IBT Heater, the #28, #47, "MA", or "E2" Option Prewire must be selected. Do not provide supply starter in prewire.



A4-IBT-800-400-400-28Z supply sound data @ 1338 RPM:

LWA: 86 Sones at 5 ft.: 27 DBA at 5 ft.: 74.5

Frequency	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz
Sound Power (dB)	88.5	95.6	86.5	79.4	80.2	74.6	72.9	68.7

MUA FAN INFORMATION – Job#4377953

FAN UNIT NO	TAG	FAN UNIT MODEL #	BLOWER	HOUSING	MIN CFM	DESIGN CFM	ESP	RPM	MOTOR ENCL	HP	BHP	ø	VOLT	FLA	MCA	MOCP	EVAP FLOW RATE (Gal/Hr)	EVAP COOLER ENTERING DB TEMP	EVAP COOLER ENTERING WB TEMP	EVAP COOLER LEAVING DB TEMP	EVAP COOLER LEAVING WB TEMP	WEIGHT (LBS)	SONES
1	MUA-P1	A1-IBT-150-15D	15MF-1-MOD	A1-IBT-150	800	1500	0.750	1956	ODP,PREMIUM	2.000	1.2230	3	460	2.7	4.5A	15A	2.95	90.0°F	64.0°F	71.0°F	64.0°F	1147	19.1
2	MAU-P2	A3-IBT-400-24D	24MF-3-MOD	A3-IBT-400	2500	5800	0.750	1491	ODP,PREMIUM	10.000	6.9760	3	460	12.2	16.4A	25A	7.72	90.0°F	64.0°F	73.0°F	64.0°F	2021	15.3

*Evap Flow Rate is variable based on water pressure.

GAS FIRED MAKE-UP AIR UNIT(S)

FAN UNIT NO	TAG	INPUT BTUs	OUTPUT BTUs	TEMP RISE	REQUIRED INPUT GAS PRESSURE	GAS TYPE	BURNER EFFICIENCY(%)
1	MUA-P1	100000	80000	46 deg F	7 in. w.c. - 14 in. w.c.	Natural	80
2	MAU-P2	400000	320000	47 deg F	7 in. w.c. - 14 in. w.c.	Natural	80

FAN OPTIONS

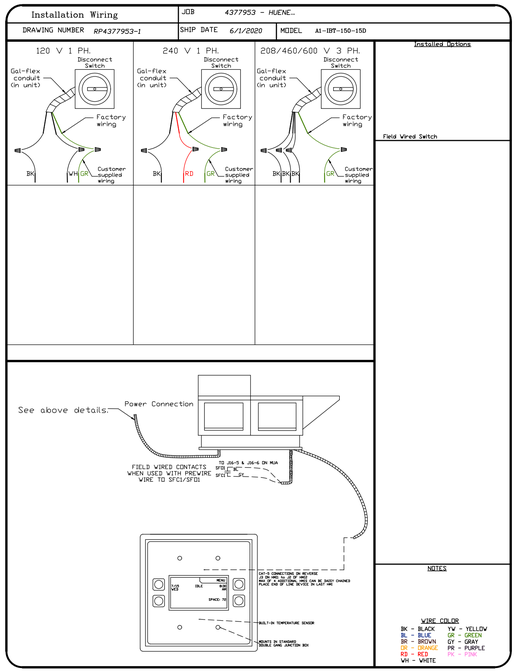
FAN UNIT NO	TAG	OPTION (Qty - Descr)
1	MUA-P1	1 - Motorized Backdraft Damper for A1-I Housing
		1 - Inlet Pressure Gauge, 0-35"
		1 - Manifold Pressure Gauge, 0 to 10" wc, 1 Furnace
		1 - Commercial Smoke Detector/Alarm Interlock (Supplied by Others)
		1 - Clogged Filter Switch with notification on HMI
		1 - Insulated Blower Section Size 1-2 Commercial
		1 - Insulation Option for VBank filter section
		1 - VAV Package w/ Manual/DDC Control (571 VFD Included)
		1 - VFD factory mounted and wired in commercial control vestibule for IBT
		1 - Load Reactor Mounted in Fan
		1 - IBT/MUA Evap Interlock
		1 - Single Point Electrical Connection Single Module. If a Non-DCV Prewire is used on the IBT Heater, the #28, #47, "NS", "MA", or "E2" Option Prewire must be selected. Do not provide supply starter in prewire.
		1 - DDC IP BACNet remote unit monitoring. Allows for remote DDC occupied override and set point changes.
2	MAU-P2	1 - Motorized Backdraft Damper for A3-I Housing
		1 - Inlet Pressure Gauge, 0-35"
		1 - Manifold Pressure Gauge, 0 to 10" wc, 1 Furnace
		1 - IBT/MUA Evap Interlock
		1 - Commercial Smoke Detector/Alarm Interlock (Supplied by Others)
		1 - Single Point Electrical Connection Single Module. If a Non-DCV Prewire is used on the IBT Heater, the #28, #47, "NS", "MA", or "E2" Option Prewire must be selected. Do not provide supply starter in prewire.
		1 - Clogged Filter Switch with notification on HMI
		1 - Curb Duct Hanger
		1 - Insulated Blower Section Size 3 Commercial Modular
		1 - Insulation Option for VBank filter section
		1 - VAV Package w/ 0-10VDC Input Control (571 VFD Included)
		1 - Load Reactor Mounted in Fan
		1 - VFD factory mounted and wired in commercial control vestibule for IBT
		1 - DDC IP BACNet remote unit monitoring. Allows for remote DDC occupied override and set point changes.

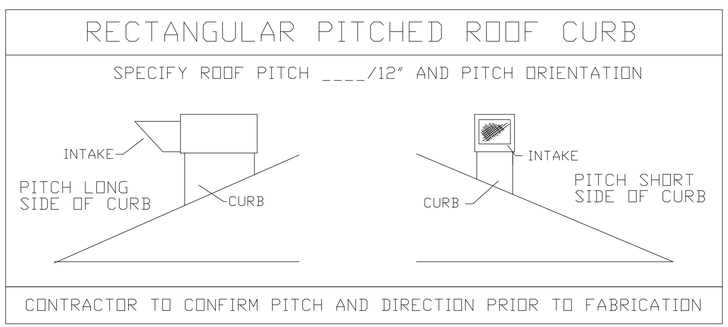
FAN ACCESSORIES

FAN UNIT NO	TAG	EXHAUST			SUPPLY			
		GREASE CUP	GRAVITY DAMPER	WALL MOUNT	SIDE DISCHARGE	GRAVITY DAMPER	MOTORIZED DAMPER	WALL MOUNT
1	MUA-P1						YES	
2	MAU-P2						YES	

CURB ASSEMBLIES

NO	ON FAN	TAG	WEIGHT	ITEM	SIZE
1	# 1	MUA-P1	63 LBS	Curb	21.000"W x 153.188"L x 14.000"H Right Insulated
2	# 2	MAU-P2	160 LBS	Curb	35.000"W x 178.188"L x 14.000"H Right Insulated





REVISIONS

	DESCRIPTION	DATE:
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CAPTIVE-AIRE
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1810 14th St Suite 214, Santa Monica, CA, 90404 PHONE: (310) 876-8505 FAX: (919) 747-5639 EMAIL: reg81@captiveaire.com

CHANNEL ISLAND HS (Kitchen)
OXNARD, CA, 93036

DATE: 6/1/2020

DWG.#: 4377953

DRAWN BY: BDN-81

SCALE: 3/4" = 1'-0"

MASTER DRAWING

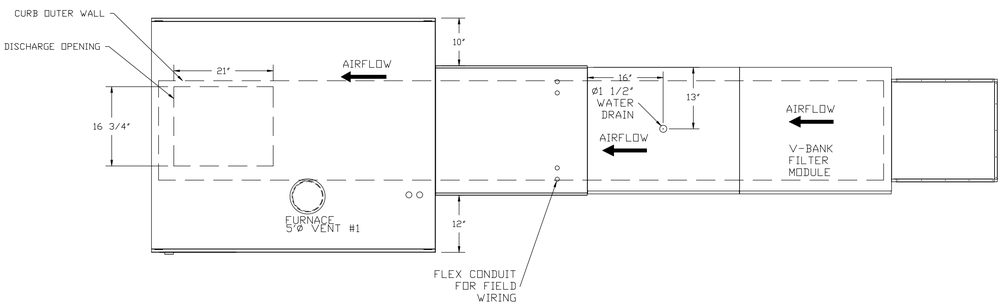
SHEET NO. 1

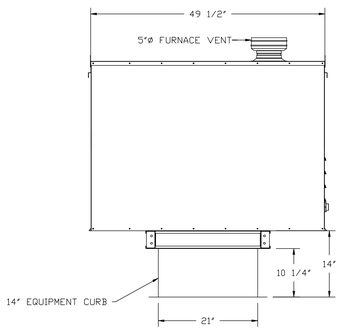
FAN #1 AI-IBT-150-15D - HEATER (MUA-P1)
1. INDIRECT BENT TUBE GAS FIRED HEATER WITH 15" DIRECT DRIVE FAN, 1 FURNACE, ELECTRONIC FULL MODULATION, CONSTANT 80% EFFICIENCY, AND 6:1 MAX TURNDOWN FOR NG, (5:1 MAX TURNDOWN FOR LP). STAINLESS STEEL BURNER AND HEAT EXCHANGER.
2. EVAP COOLER (CELDEK) & V-BANK WITH 2" TA-13 FILTERS - OUTDOOR
3. DOWN DISCHARGE - AIR FLOW RIGHT -> LEFT
4. MOTORIZED BACK DRAFT DAMPER 16" X 18" FOR SIZE 1 STANDARD & MODULAR HEATER UNITS W/EXTENDED SHAFT, STANDARD GALVANIZED CONSTRUCTION, 3/4" REAR FLANGE, LOW LEAKAGE, TFB120S ACTUATOR INCLUDED
5. GAS PRESSURE GAUGE, 0-35", 2.5" DIAMETER, 1/4" THREAD SIZE
6. GAS PRESSURE GAUGE, 0 TO +10 INCHES WC, 2.5" DIAMETER, 1/8" THREAD SIZE, REAR THREAD
7. COMMERCIAL SMOKE DETECTOR INTERLOCK (DETECTOR BY OTHERS)
8. CLOGGED FILTER SWITCH WITH NOTIFICATION ON HMI
9. INSULATED BLOWER HOUSING SIZES 1-2 COMMERCIAL MODULAR
10. "INSULATION" FOR V-BANK INTAKE OPTION.
11. VAV (VARIABLE-AIR-VOLUME) WIRING PACKAGE FOR COMMERCIAL FANS. MANUAL SPEED CONTROL VARIABLE FREQUENCY DRIVE INCLUDED
12. VFD FACTORY MOUNTED AND WIRED IN UNIT CONTROL VESTIBULE.
13. MOUNT LOAD REACTOR IN FAN.
14. LAYER CONTROL FOR IBT EVAP
15. SINGLE POINT ELECTRICAL CONNECTION FOR ALL IBT HEATERS WITH 1 MODULE. QNTY 1 750VA TRANSFORMER USED. IF A NON-DCV PREWIRE IS USED ON THE IBT HEATER, THE #28, #47, "MA", OR "E2" OPTION PREWIRE MUST BE SELECTED. DO NOT PROVIDE SUPPLY STARTER IN PREWIRE.
16. REMOTE IP BACNET MONITORING FOR SUPPLY FANS.
17. HINGED DOUBLE WALL INSULATED DOOR ASSEMBLY (BURNER/BLOWER/EVAP SECTION)
IBT - US Patent 877119 B2

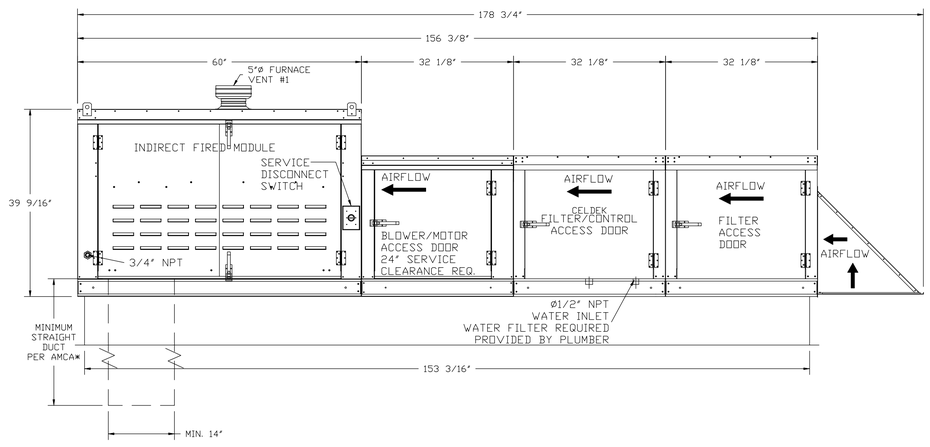
*NOTE: SUPPLY DUCT MUST BE INSTALLED TO MEET SMACNA STANDARDS. A MINIMUM STRAIGHT DUCT LENGTH MUST BE MAINTAINED DOWNSTREAM OF UNIT DISCHARGE AS OUTLINED IN AMCA PUBLICATION 201. DO NOT RELY ON UNIT TO SUPPORT DUCT IN ANY WAY. FAILURE TO PROPERLY SIZE DUCTWORK MAY CAUSE SYSTEM EFFECTS AND REDUCE PERFORMANCE OF THE EQUIPMENT. SUGGESTED STRAIGHT DUCT SIZE IS 14" x 14"

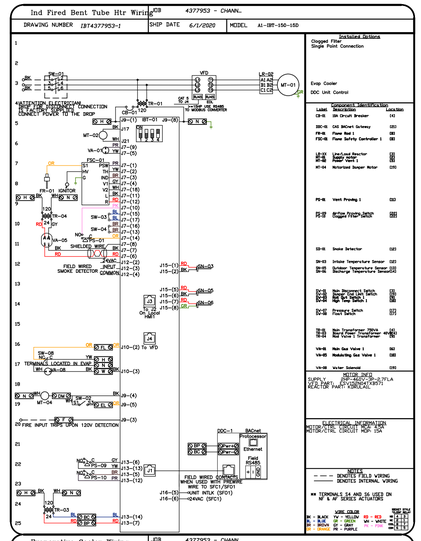
SUPPLY SIDE HEATER INFORMATION:

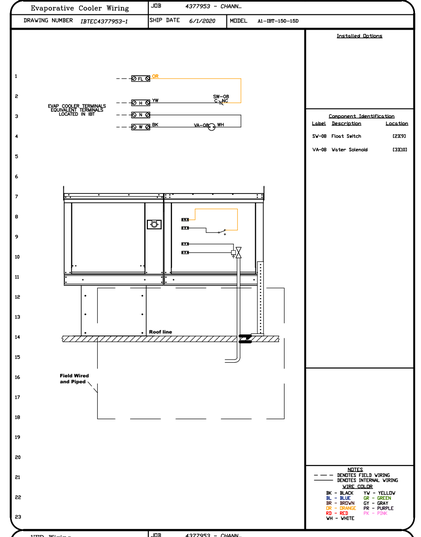
WINTER TEMPERATURE = 30°F. TEMP. RISE = 46°F.
BTUs CALCULATED OFF ACTUAL AIR DENSITY
OUTPUT BTUs AT ALTITUDE OF 0.0 ft. = 80490
INPUT BTUs AT ALTITUDE OF 0.0 ft. = 100612
OUTPUT BTUs AT ALTITUDE OF 68 ft. = 80292
INPUT BTUs AT ALTITUDe OF 68 ft. = 100365

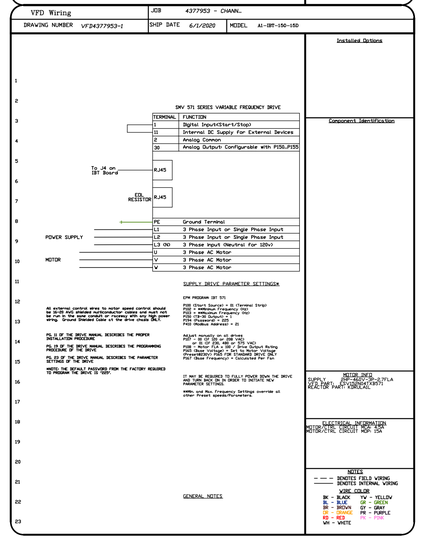












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REVISIONS

	DESCRIPTION	DATE:
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CHANNEL ISLAND HS (Kitchen)
OXNARD, CA, 93036

DATE: 6/1/2020

DWG.#: 4377953

DRAWN BY: BDN-81

SCALE: 3/4" = 1'-0"

MASTER DRAWING

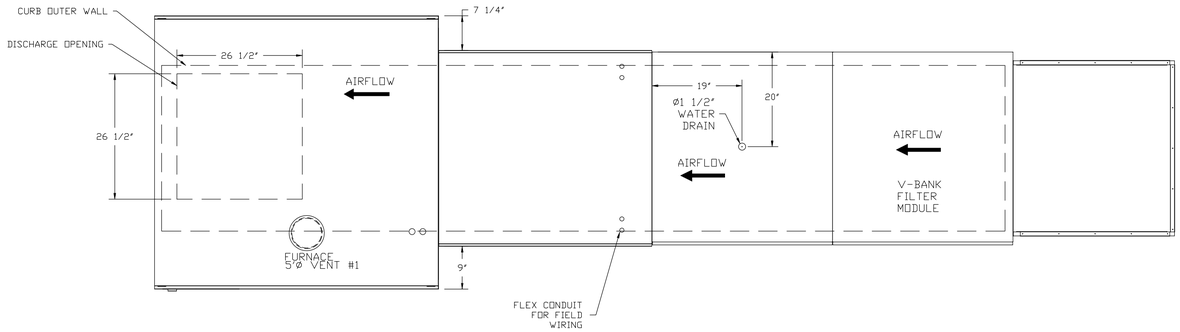
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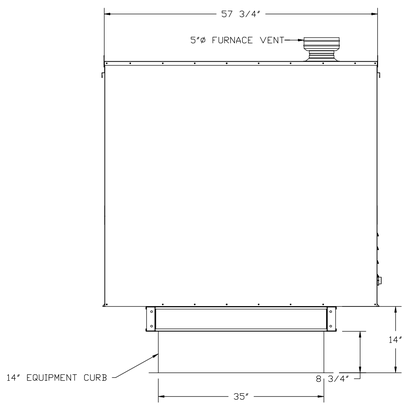
FAN #2 A3-IBT-400-24D - HEATER (MAU-P2)
1. INDIRECT BENT TUBE GAS FIRED HEATER WITH 24" DIRECT DRIVE FAN, 1 FURNACE, ELECTRONIC FULL MODULATION, CONSTANT 80% EFFICIENCY, AND 6:1 MAX TURNDOWN FOR NG, (5:1 MAX TURNDOWN FOR LP). STAINLESS STEEL BURNER AND HEAT EXCHANGER.
2. EVAP COOLER (CELDEK) & V-BANK WITH 2" TA-13 FILTERS - OUTDOOR
3. DOWN DISCHARGE - AIR FLOW RIGHT -> LEFT
4. MOTORIZED BACK DRAFT DAMPER 30" X 30" FOR SIZE 3 STANDARD & MODULAR HEATER UNITS W/EXTENDED SHAFT, STANDARD GALVANIZED CONSTRUCTION, 3/4" REAR FLANGE, LOW LEAKAGE, NFBUP-S ACTUATOR INCLUDED
5. GAS PRESSURE GAUGE, 0-35", 2.5" DIAMETER, 1/4" THREAD SIZE
6. GAS PRESSURE GAUGE, 0 TO +10 INCHES W.C., 2.5" DIAMETER, 1/8" THREAD SIZE, REAR THREAD
7. LAYER CONTROL FOR IBT EVAP
8. COMMERCIAL SMOKE DETECTOR INTERLOCK (DETECTOR BY OTHERS)
9. SINGLE POINT ELECTRICAL CONNECTION FOR ALL IBT HEATERS WITH 1 MODULE. QNTY 1 750VA TRANSFORMER USED. IF A NON-DCV PREWIRE IS USED ON THE IBT HEATER, THE #28, #47, "MA", OR "E2" OPTION PREWIRE MUST BE SELECTED. DO NOT PROVIDE SUPPLY STARTER IN PREWIRE.
10. CLOGGED FILTER SWITCH WITH NOTIFICATION ON HMI
11. CURB DUCT HANGER - 1-1/4" ANGLE IRON FRAME WELDED TO CURB TO SUPPORT STANDARD SIZE DUCTWORK. PRICED PER CURB. ONLY AVAILABLE WHEN CURB ASSEMBLY IS ORDERED.
12. INSULATED BLOWER HOUSING SIZE 3 COMMERCIAL MODULAR
13. "INSULATION" FOR V-BANK INTAKE OPTION
14. VAV (VARIABLE-AIR-VOLUME) WIRING PACKAGE FOR COMMERCIAL FANS. 0-10VDC SPEED CONTROL VARIABLE FREQUENCY DRIVE INCLUDED
15. MOUNT LOAD REACTOR IN FAN.
16. VFD FACTORY MOUNTED AND WIRED IN UNIT CONTROL VESTIBULE.
17. REMOTE IP BACNET MONITORING FOR SUPPLY FANS.
18. HINGED DOUBLE WALL INSULATED DOOR ASSEMBLY (BURNER/BLOWER/EVAP SECTION)
IBT - US Patent 877119 B2

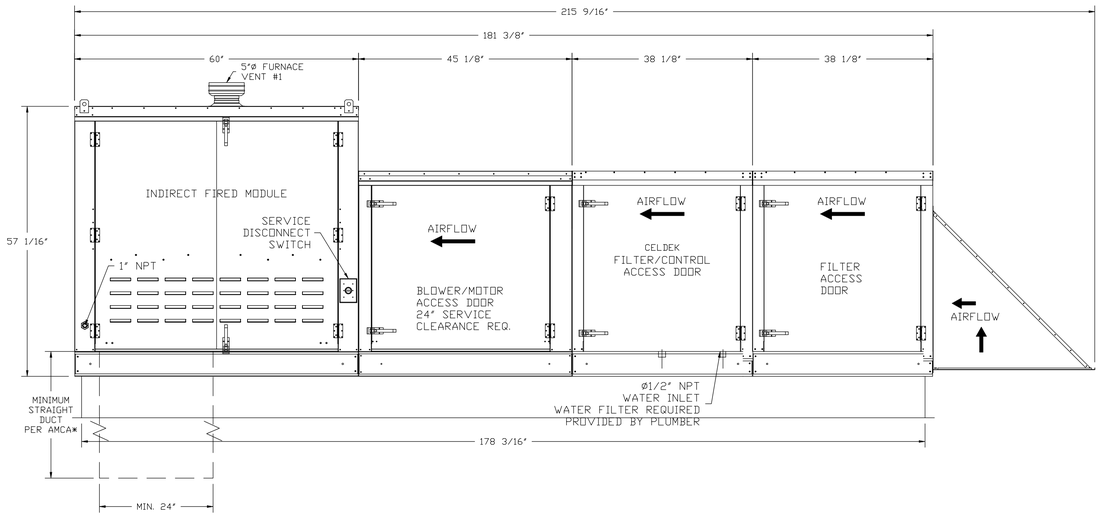
*NOTE: SUPPLY DUCT MUST BE INSTALLED TO MEET SMACNA STANDARDS. A MINIMUM STRAIGHT DUCT LENGTH MUST BE MAINTAINED DOWNSTREAM OF UNIT DISCHARGE AS OUTLINED IN AMCA PUBLICATION 201. DO NOT RELY ON UNIT TO SUPPORT DUCT IN ANY WAY. FAILURE TO PROPERLY SIZE DUCTWORK MAY CAUSE SYSTEM EFFECTS AND REDUCE PERFORMANCE OF THE EQUIPMENT.
SUGGESTED STRAIGHT DUCT SIZE IS 24" x 24"

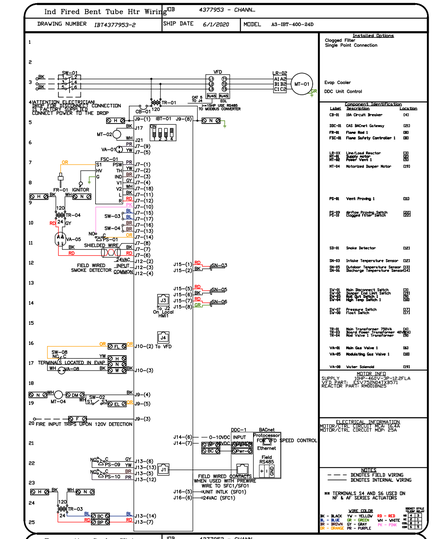
SUPPLY SIDE HEATER INFORMATION:

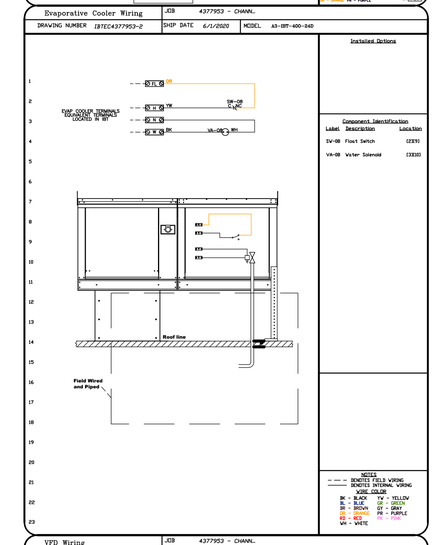
WINTER TEMPERATURE = 30°F. TEMP. RISE = 47°F.
BTUs CALCULATED OFF ACTUAL AIR DENSITY
OUTPUT BTUs AT ALTITUDE OF 0.0 ft. = 317993
INPUT BTUs AT ALTITUDE OF 0.0 ft. = 397491
OUTPUT BTUs AT ALTITUDE OF 68 ft. = 317212
INPUT BTUs AT ALTITUDe OF 68 ft. = 396516

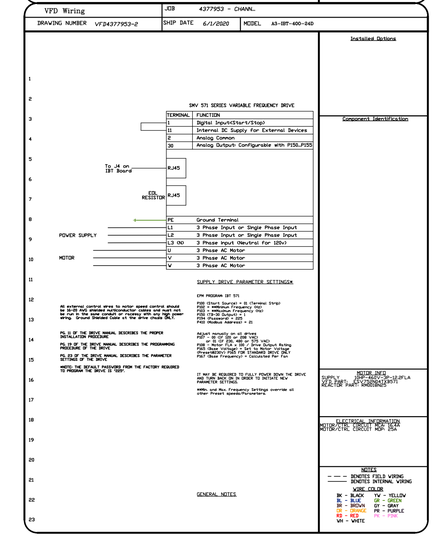












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www.captiveaire.com

REVISIONS

	DESCRIPTION	DATE:
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CHANNEL ISLAND HS (Kitchen)
OXNARD, CA, 93036

DATE: 6/1/2020

DWG.#: 4377953

DRAWN BY: BDN-81

SCALE: 3/4" = 1'-0"

MASTER DRAWING

SHEET NO. 3

Order # 4377953 - CHANNEL ISLAND HS (Kitchen) - Oxnard, Ca

Fan #1 A1-IBT-150-15D (1147 lbs./63 curb)
Tag: MUA-P1

Indirect Bent Tube Gas Fired Heater with 15" Direct Drive Fan, 1 Furnace, Electronic Full Modulation, Constant 80% Efficiency, and 6:1 Max Turndown for NG, (5:1 Max Turndown for LP). Stainless Steel Burner and Heat Exchanger.

Supply Motor:
Model DTP0024, 2.000 HP, 3 Phase, 460 V, 60Hz, 2.7 FLA, ODP, Premium (E-Plus3) Eff.

Burner:
Min Output BTU: 20,000 BTU/Hr
Max Output BTU: 120,001 BTU/Hr
Max Input BTU: 150,000 BTU/Hr
Gas Type: Natural

Supply Performance:
Volume: 1500 cfm
RPM: 1956
TS: 7681 ft/min
SP: 1.323" w.g.
0.750" Ext. + 0.555" Int. + 0.018" Opt.
BHP: 1.223

Heating Schedule:
Altitude: 68'
Winter Entering Air Dry Bulb Temp: 30°F
Temp Rise: 46°F
Output BTU: 80000
Input BTU: 100000
BTUs BASED OFF ACTUAL AIR DENSITY

Cooling Schedule:
Intake Entering Dry Bulb Temperature: 90°F
Intake Entering Wet Bulb Temperature: 64°F
Intake Entering Relative Humidity: 23%
Intake Leaving Dry Bulb Temperature: 71°F
Intake Leaving Wet Bulb Temperature: 64°F
Temperature drop calculations are based on tested data.

Supply Installation Information:
Gas Inlet Pressure: 7 in. w.c. - 14 in. w.c.
Insurance: No Insurance Requirement (ANSI)
Unit Main Input: 4.5 Amps MCA, 15 Amps MOP, 460 V, 14 AWG Wire Min.
Supply Unit Voltage: 3 phs 460 V 60Hz
SCCR: 10 kAmp

Blower:
15 Inch Mixed Flow Plenum Fan for size 1 MOD. Hub specified to match motor shaft.

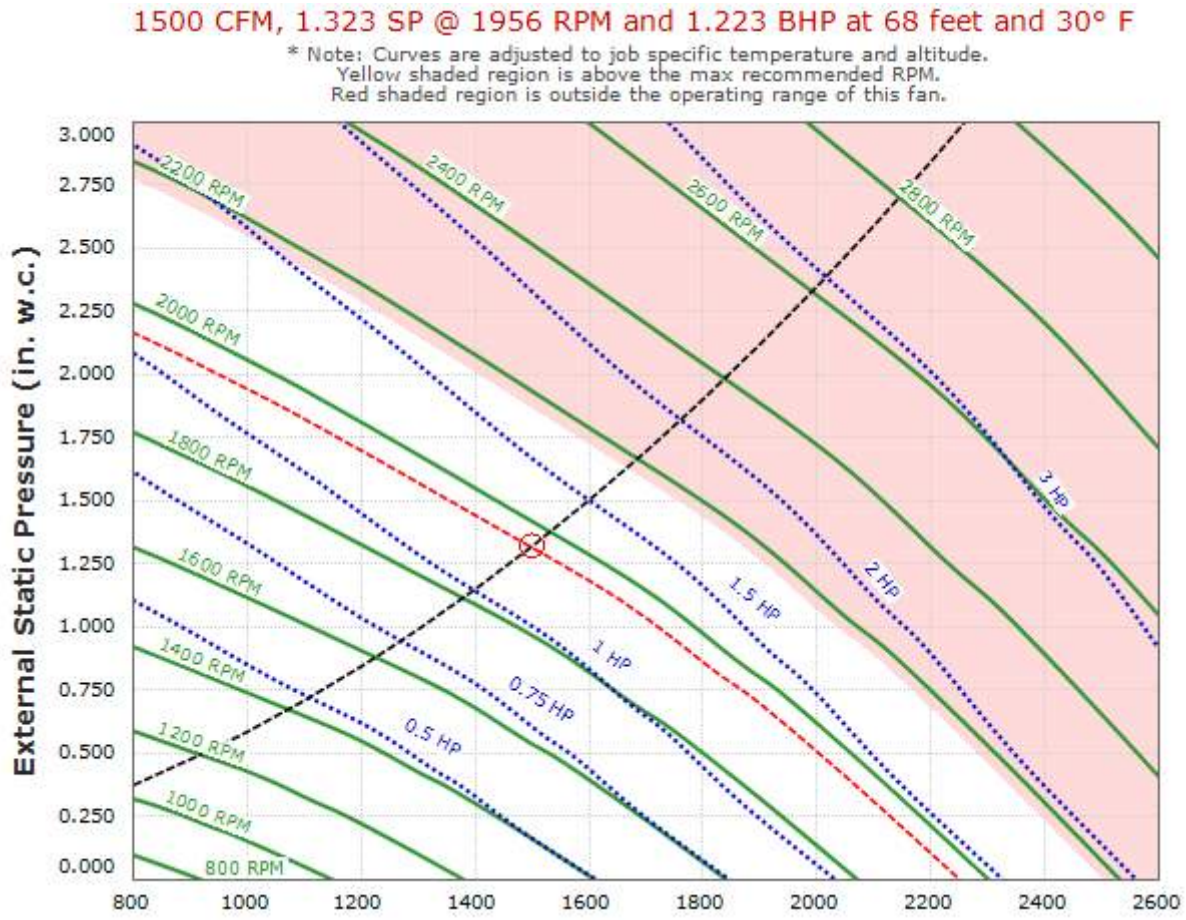
Temp Control:
50-90°F Space Temp Control • Field Wired On/Off Switch Control • Heating Activation Based On Either Intake or Space Set Point

Intake:
Celdek and V-Bank for Size # 1 Modular Supply unit with TA filters. For outdoor installation. MERV 13 V-Bank Filters. Includes Screened Intake

Filters:
3x Throw away filter 20w x 25h x 2d, MERV13 rating, 1750 max cfm. 12 per box

Curb & Supports:
ROOF CURB - 21" Width, 153.188" Length, 14" Supply Height, Insulated. Braced in one place.

Selected Options:
- Motorized Back Draft Damper 16" X 18" for Size 1 Standard & Modular Heater Units w/Extended Shaft, Standard Galvanized Construction, 3/4" Rear Flange, Low Leakage, TFB120S Actuator Included
- Gas Pressure Gauge, 0-35", 2.5" Diameter, 1/4" Thread Size
- Gas Pressure Gauge, 0 to +10 Inches Wc., 2.5" Diameter, 1/8" Thread Size, Rear Thread
- Commercial Smoke Detector Interlock (Detector By Others)
- Clogged Filter Switch with Notification on HMI
- Insulated Blower Housing Sizes 1-2 Commercial Modular
- "Insulation" for V-bank Intake Option.
- VAV (Variable-Air-Volume) Wiring Package for Commercial Fans. Manual Speed Control Variable Frequency Drive Included
- Supply Variable Frequency Drive - 2 HP Max., 400/480 V, Three Phase, 4.0/3.5 A Max., NEMA 1 Enclosure, with 2RJ-45 FOR MODBUS
- VFD factory mounted and wired in unit control vestibule.
- Mount Load Reactor in Fan.
- Layer Control for IBT Evap
- Single Point Electrical Connection for all IBT Heaters with 1 module. QNTY 1 750va Transformer Used. If a Non-DCV Prewire is used on the IBT Heater, the #28, #47, "MA", or "E2" Option Prewire must be selected. Do not provide supply starter in prewire.
- Remote IP BACnet monitoring for supply fans.



A1-IBT-150-15D supply sound data @ 1956 RPM:

LWA: 81.5 Sones at 5 ft.: 19.1 DBA at 5 ft.: 70

Frequency	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz
Sound Power (dB)	76.6	84.2	81.2	78.5	74.3	72.5	72.1	67.8

Order # 4377953 - CHANNEL ISLAND HS (Kitchen) - Oxnard, Ca

Fan #2 A3-IBT-400-24D (2021 lbs./160 curb)
Tag: MAU-P2

Indirect Bent Tube Gas Fired Heater with 24" Direct Drive Fan, 1 Furnace, Electronic Full Modulation, Constant 80% Efficiency, and 6:1 Max Turndown for NG, (5:1 Max Turndown for LP). Stainless Steel Burner and Heat Exchanger.

Supply Motor:
Model DTP0104, 10.000 HP, 3 Phase, 460 V, 60Hz, 12.2 FLA, ODP, Premium (E-Plus3) Eff.

Burner:
Min Output BTU: 53,333 BTU/Hr
Max Output BTU: 320,001 BTU/Hr
Max Input BTU: 400,000 BTU/Hr
Gas Type: Natural

Supply Performance:
Volume: 5800 cfm
RPM: 1491
TS: 9368 ft/min
SP: 1.959" w.g.
0.750" Ext. + 1.182" Int. + 0.027" Opt.
BHP: 6.976

Heating Schedule:
Altitude: 68'
Winter Entering Air Dry Bulb Temp: 30°F
Temp Rise: 47°F
Output BTU: 320000
Input BTU: 400000
BTUs BASED OFF ACTUAL AIR DENSITY

Cooling Schedule:
Intake Entering Dry Bulb Temperature: 90°F
Intake Entering Wet Bulb Temperature: 64°F
Intake Entering Relative Humidity: 23%
Intake Leaving Dry Bulb Temperature: 73°F
Intake Leaving Wet Bulb Temperature: 64°F
Temperature drop calculations are based on tested data.

Supply Installation Information:
Gas Inlet Pressure: 7 in. w.c. - 14 in. w.c.
Insurance: No Insurance Requirement (ANSI)
Unit Main Input: 16.4 Amps MCA, 25 Amps MOP, 460 V, 12 AWG Wire Min.
Supply Unit Voltage: 3 phs 460 V 60Hz
SCCR: 10 kAmp

Blower:
24 Inch Mixed Flow Plenum Fan for size 3 MOD. Hub specified to match motor shaft.

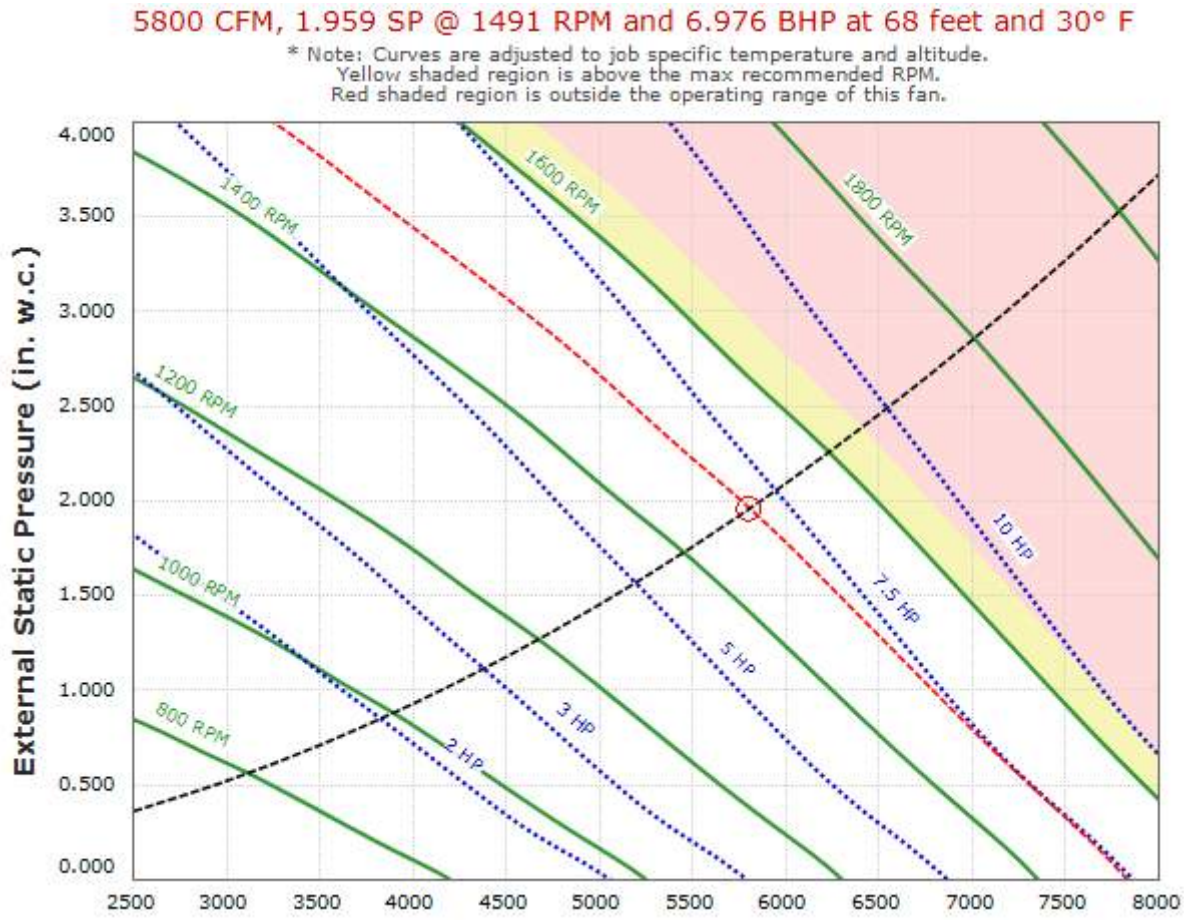
Temp Control:
50-90°F Space Temp Control • Field Wired On/Off Switch Control • Heating Activation Based On Either Intake or Space Set Point

Intake:
Celdek and V-Bank for Size # 3 Modular Supply unit with TA filters.For outdoor installation. MERV 13 V-Bank Filters. Includes Screened Intake

Filters:
8x Throw away filter 20w x 25h x 2d, MERV13 rating, 1750 max cfm. 12 per box

Curb & Supports:
ROOF CURB - 35" Width X 178.188" Length X 14" Supply Height, Insulated. Braced 2 places along length of curb.

Selected Options:
- Motorized Back Draft Damper 30" X 30" for Size 3 Standard & Modular Heater Units w/Extended Shaft, Standard Galvanized Construction, 3/4" Rear Flange, Low Leakage, NFBUP-S Actuator Included
- Gas Pressure Gauge, 0-35", 2.5" Diameter, 1/4" Thread Size
- Gas Pressure Gauge, 0 to +10 Inches Wc., 2.5" Diameter, 1/8" Thread Size, Rear Thread
- Layer Control for IBT Evap
- Commercial Smoke Detector Interlock (Detector By Others)
- Single Point Electrical Connection for all IBT Heaters with 1 module. QNTY 1 750va Transformer Used. If a Non-DCV Prewire is used on the IBT Heater, the #28, #47, "MA", or "E2" Option Prewire must be selected. Do not provide supply starter in prewire.
- Clogged Filter Switch with Notification on HMI
- Curb Duct Hanger - 1-1/4" Angle Iron Frame Welded to Curb to support standard size ductwork. Priced per curb. Only available when curb assembly is ordered.
- Insulated Blower Housing Size 3 Commercial Modular
- "Insulation" for V-bank Intake Option.
- VAV (Variable-Air-Volume) Wiring Package for Commercial Fans. 0-10VDC Speed Control Variable Frequency Drive Included
- Supply Variable Frequency Drive - 10 HP Max., 400/480 V, Three Phase, 16.1/14.0 A Max., NEMA 1 Enclosure, with 2RJ-45 FOR MODBUS
- Mount Load Reactor in Fan.
- VFD factory mounted and wired in unit control vestibule.
- Remote IP BACnet monitoring for supply fans.



A3-IBT-400-24D supply sound data @ 1491 RPM:

LWA: 78.2 Sones at 5 ft.: 15.3 DBA at 5 ft.: 66.7

Frequency	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz
Sound Power (dB)	74.2	81.7	78.1	74.7	72.1	69.4	67.2	64.6

CARRIER 3 - 5 TONS:
48/50FC 04-06, 48/50GC 04, 48HC 04, 48KC 04 & 05, 48LC 04, 50HCQ04, 50KCQ 04 & 05

1118-PE/MPE**-****

POWER EXHAUST/ECONOMIZER
VERTICAL OR HORIZONTAL APPLICATIONS

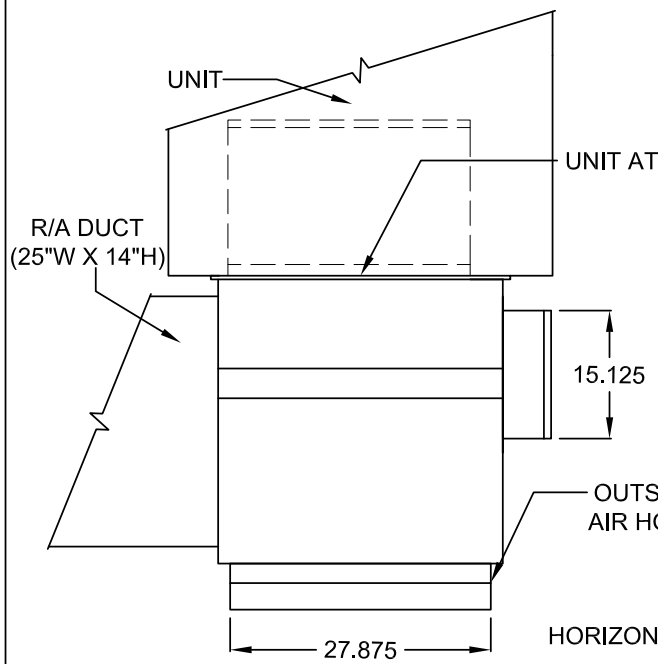
FEATURES

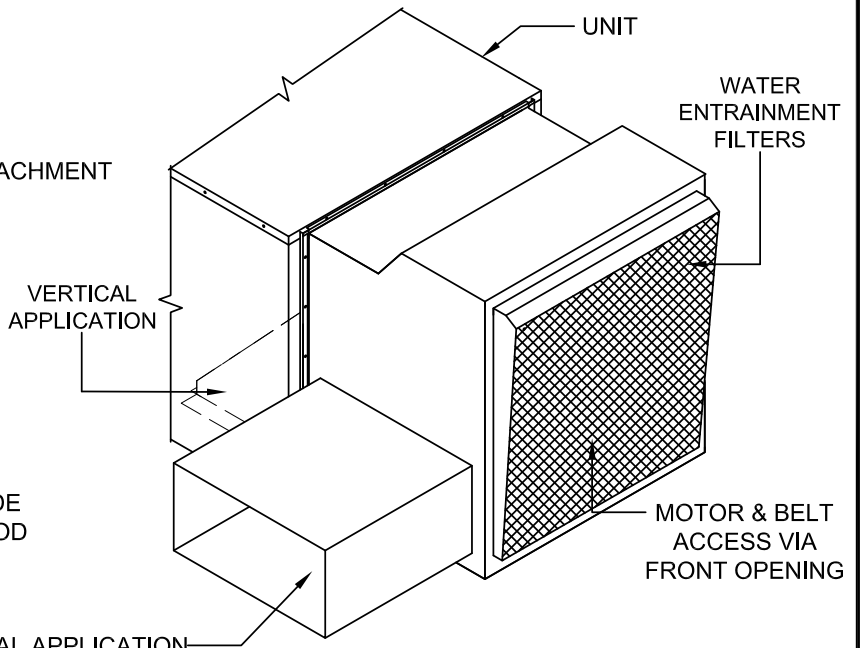
1) CONVERTIBLE FOR BOTH HORIZONTAL & VERTICAL APPLICATIONS.
2) COLOR KEYED CHASSIS.
3) DWDI FORWARD CURVE CENTRIFUGAL FAN.
4) THERMAL OVERLOAD PROTECTED MOTORS.
5) HINGED CONTROL ACCESS DOOR.
6) VARIABLE FREQUENCY DRIVE (MODULATING OPTION)
7) LOGIC MODULE.
8) OAT SENSOR.
9) MAT SENSOR.
10) COMMUNICATING ACTUATOR.
11) CLASS 1A OUTSIDE AIR & RETURN AIR DAMPERS.
12) COMMERCIAL BACKDRAFT DAMPERS WITH BLADE EDGE SEALS MECHANICALLY LOCKED INTO BLADE EDGE.

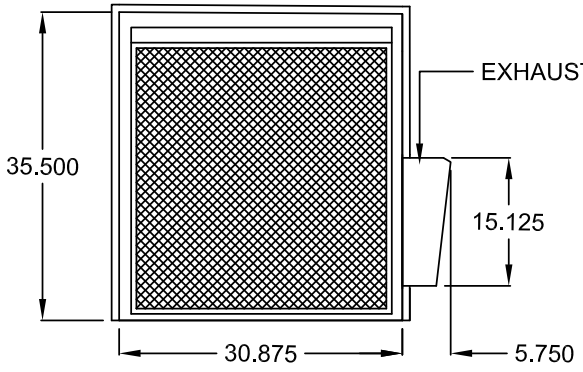
AMCA RATED CLASS 1A LEAKAGE RATED HIGH PERFORMANCE DAMPER ONE-PIECE AIRFOIL BLADE FOR LOW PRESSURE DROP

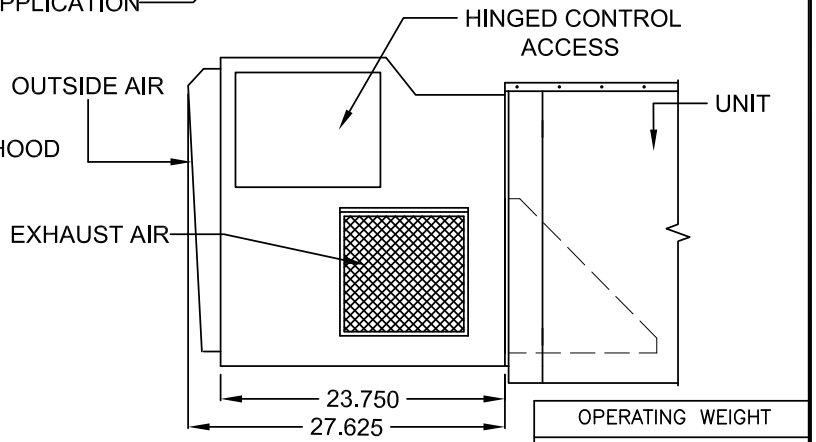
OPTIONS

1) DRY BULB SENSOR (OAT)
2) ENTHALPY SENSOR (OAT)
3) DUAL DRY BULB (OAT/RAT)
4) DUAL ENTHALPY (OAT/RAT)
5) BACNET VARIABLE FREQUENCY DRIVE
6) ACTUATORS ONLY
7) NO CONTROLS









OPERATING WEIGHT
222 LBS

CanFab
CANNON FABRICATION INC
182 GRANITE STREET, SUITE 101, CORONA, CA 92879
PHONE: (951)278-1830 FAX: (951)278-8444 www.canfab.com canfab@canfab.com

FOR: 3 tons		
PART NO:	PROJECT:	
ENGINEER:	DISTRIBUTOR:	
DRAWING NO:	Rev: 00	DATE:
APPROVED BY:		DATE: / /

MOTOR / ELECTRICAL DATA

MODEL:	1118			115 VOLT/1 PH			208 VOLT/ 1PH			230 VOLT/ 1PH			208 VOLT/3 PH			230 VOLT/ 3PH			460 VOLT/ 3PH		
			MOTOR	MOTOR			MOTOR			MOTOR			MOTOR			MOTOR			MOTOR		
TONS	CFM	RPM	HP	FLA	MCA	MOCP	FLA	MCA	MOCP	FLA	MCA	MOCP	FLA	MCA	MOCP	FLA	MCA	MOCP	FLA	MCA	MOCP
3	1200	838	0.5	6.2	7.75	13.95	3	3.75	6.75	3.1	3.875	6.975	2.2	2.75	4.95	2.4	3	5.4	1.2	1.5	2.7
3	1600	889	0.5	6.2	7.75	13.95	3	3.75	6.75	3.1	3.875	6.975	2.2	2.75	4.95	2.4	3	5.4	1.2	1.5	2.7
5	2000	959	0.75	10	12.5	22.5	5.2	6.5	11.7	5	6.25	11.25	2.4	3.625	6.525	3	3.75	6.75	1.5	1.875	3.375

POWER EXHAUST IS DESIGNED FOR A ESP OF .50 WC
FAN PERFORMANCE LAB TESTED BY FAN MANUFACTURER

SHEAVE ADJUSTMENT

SHEAVE TURNS TO ACHIEVE CFM/RPM		
CFM	SHEAVE TURNS	ACTUAL RPM
1200	5	838
1600	4	889
2000	3	959

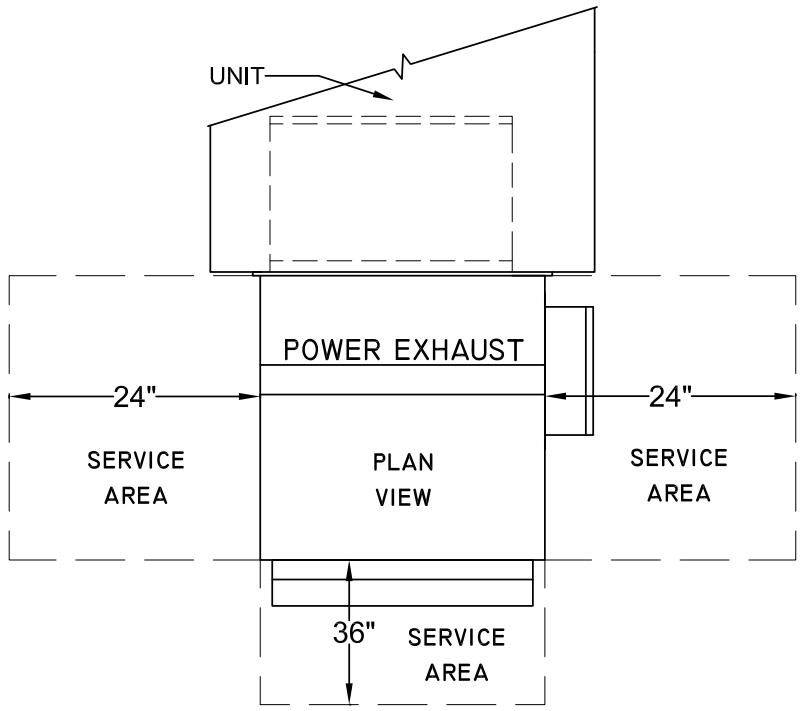
NOTE: TURNS OPEN ARE DETERMINED FROM FULLY CLOSED POSITION
FAN DATA ACQUIRED BY 3RD PARTY TESTING

DAMPER PRESSURE DROP

DAMPER PRESSURE DROP		
CFM	O/A PD (INW.G.)	R/A PD (INW.G.)
1200	0.0137	0.0137
1600	0.0244	0.0244
2000	0.0382	0.0382

SERVICE CLEARANCES

SERVICE AREA NOT DRAWN TO SCALE.



CARRIER 4 - 6-1/2 TONS:
48/50FC 07, 48/50GC 05 & 06, 48HC 05 & 06, 48KC 06, 48LC 05 & 06, 48TC 07, 50HCQ 05 & 06, 50KCQ 06, 50TCQ 07

1120-PE/MPE**-****

POWER EXHAUST/ECONOMIZER
VERTICAL OR HORIZONTAL APPLICATIONS

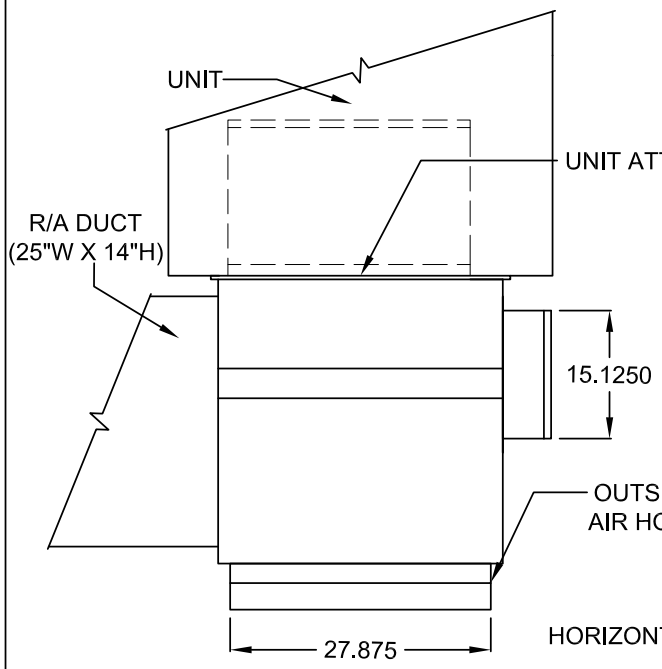
FEATURES

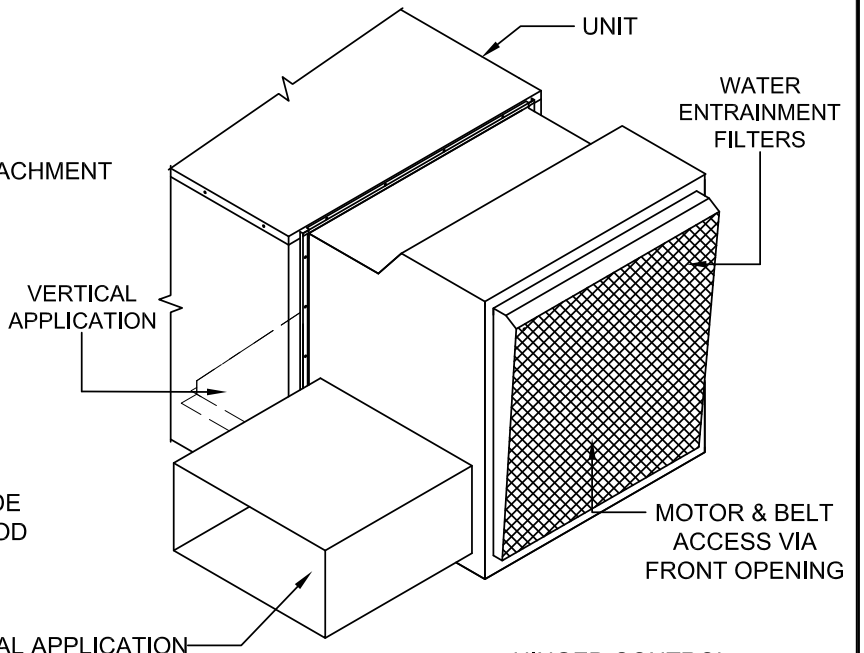
1) CONVERTIBLE FOR BOTH HORIZONTAL & VERTICAL APPLICATIONS.
2) COLOR KEYED CHASSIS.
3) DWDI FORWARD CURVE CENTRIFUGAL FAN.
4) THERMAL OVERLOAD PROTECTED MOTORS.
5) HINGED CONTROL ACCESS DOOR.
6) VARIABLE FREQUENCY DRIVE (MODULATING OPTION)
7) LOGIC MODULE.
8) OAT SENSOR.
9) MAT SENSOR.
10) COMMUNICATING ACTUATOR.
11) CLASS 1A OUTSIDE AIR & RETURN AIR DAMPERS.
12) COMMERCIAL BACKDRAFT DAMPER WITH BLADE EDGE SEALS MECHANICALLY LOCKED INTO BLADE EDGE.

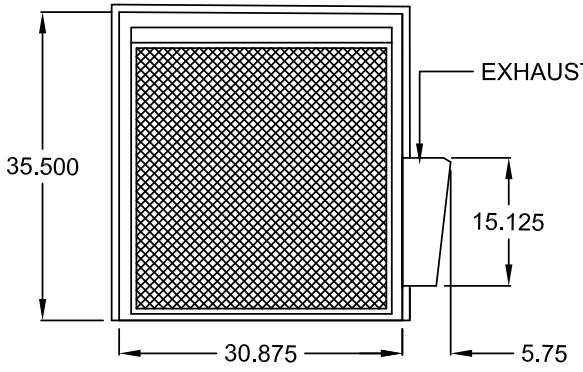
AMCA RATED CLASS 1A LEAKAGE RATED HIGH PERFORMANCE DAMPER ONE-PIECE AIRFOIL BLADE FOR LOW PRESSURE DROP

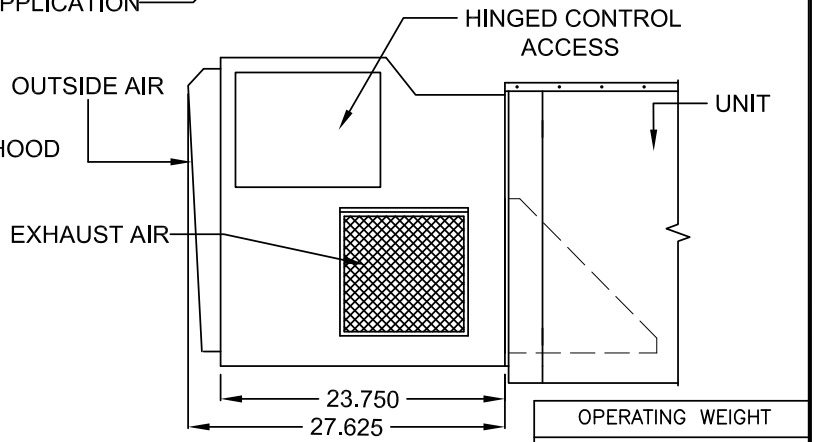
OPTIONS

1) DRY BULB SENSOR (OAT)
2) ENTHALPY SENSOR (OAT)
3) DUAL DRY BULB (OAT/RAT)
4) DUAL ENTHALPY (OAT/RAT)
5) BACNET VARIABLE FREQUENCY DRIVE
6) ACTUATOR ONLY
7) NO CONTROLS









OPERATING WEIGHT
222 LBS

CANNON FABRICATION INC
182 GRANITE STREET, SUITE 101, CORONA, CA 92879
PHONE: (951)278-1830 FAX: (951)278-8444 www.canfab.com canfab@canfab.com

FOR:	4 & 5 tons		
PART NO:		PROJECT:	
ENGINEER:		DISTRIBUTOR:	
DRAWING NO:	Rev: 00	DATE:	
APPROVED BY:		DATE:	/ /

MOTOR / ELECTRICAL DATA

MODEL:	1120			115 VOLT/1 PH			208 VOLT/ 1PH			230 VOLT/ 1PH			208 VOLT/3 PH			230 VOLT/ 3PH			460 VOLT/ 3PH		
			MOTOR	MOTOR			MOTOR			MOTOR			MOTOR			MOTOR			MOTOR		
TONS	CFM	RPM	HP	FLA	MCA	MOCP	FLA	MCA	MOCP	FLA	MCA	MOCP	FLA	MCA	MOCP	FLA	MCA	MOCP	FLA	MCA	MOCP
3	1600	889	1.5	6.2	7.75	13.95	3	3.75	6.75	3.1	3.875	6.975	1.2	2.75	4.95	2.4	3	5.4	1.2	1.5	2.7
5	2000	959	1.75	10	12.5	22.5	5.2	6.5	11.7	5	6.25	11.25	2.9	3.625	6.525	3	3.75	6.75	1.5	1.875	3.375
6	2400	1041	1.5	16.4	20.5	36.9	8.4	10.5	18.9	8.2	10.25	18.45	5	6.25	11.25	4.8	6	10.8	2.4	3	5.4

POWER EXHAUST IS DESIGNED FOR A ESP OF .50 WC
FAN PERFORMANCE LAB TESTED BY FAN MANUFACTURER

SHEAVE ADJUSTMENT

SHEAVE TURNS TO ACHIEVE CFM/RPM		
CFM	SHEAVE TURNS	ACTUAL RPM
1600	3	889
2000	3	959
2400	2	1041

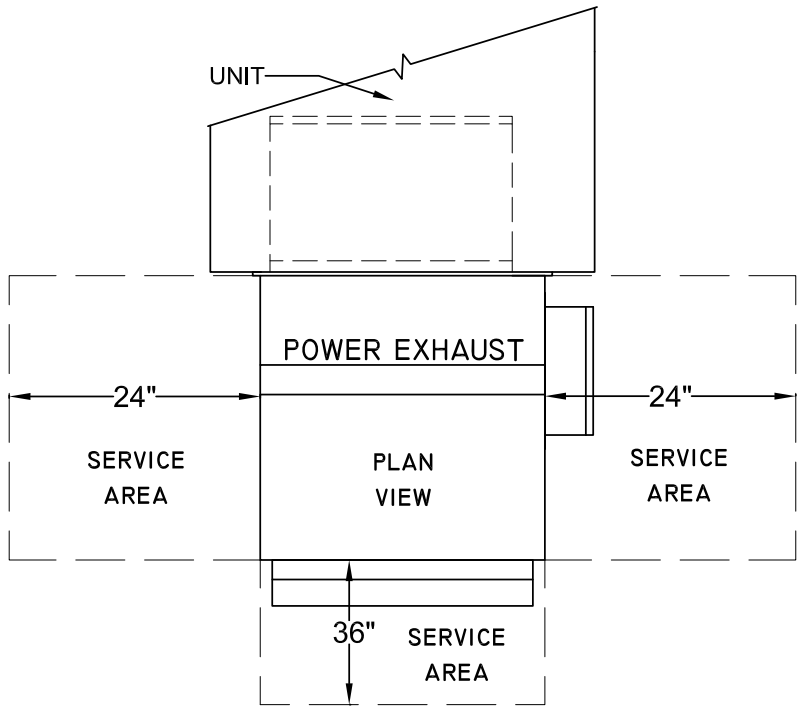
NOTE: TURNS OPEN ARE DETERMINED FROM FULLY CLOSED POSITION
FAN DATA ACQUIRED BY 3RD PARTY TESTING

DAMPER PRESSURE DROP

DAMPER PRESSURE DROP		
CFM	O/A PD (INW.G.)	R/A PD (INW.G.)
1600	0.0244	0.0244
2000	0.0382	0.0382
2400	0.0458	0.0458

SERVICE CLEARANCES

SERVICE AREA NOT DRAWN TO SCALE.



CARRIER 7-1/2 - 12-1/2 TON:
48HC 08 - 12, 48LC 07, 48TC 09 - 14, 50HCQ 08 & 09, 50TCQ 08 - 12

1124-PE/MPE**-****

POWER EXHAUST/ECONOMIZER
VERTICAL OR HORIZONTAL APPLICATIONS

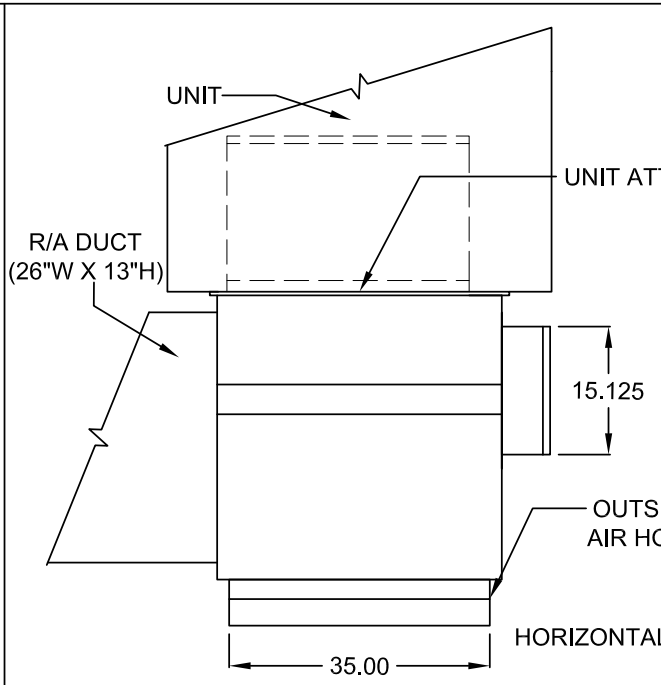
FEATURES

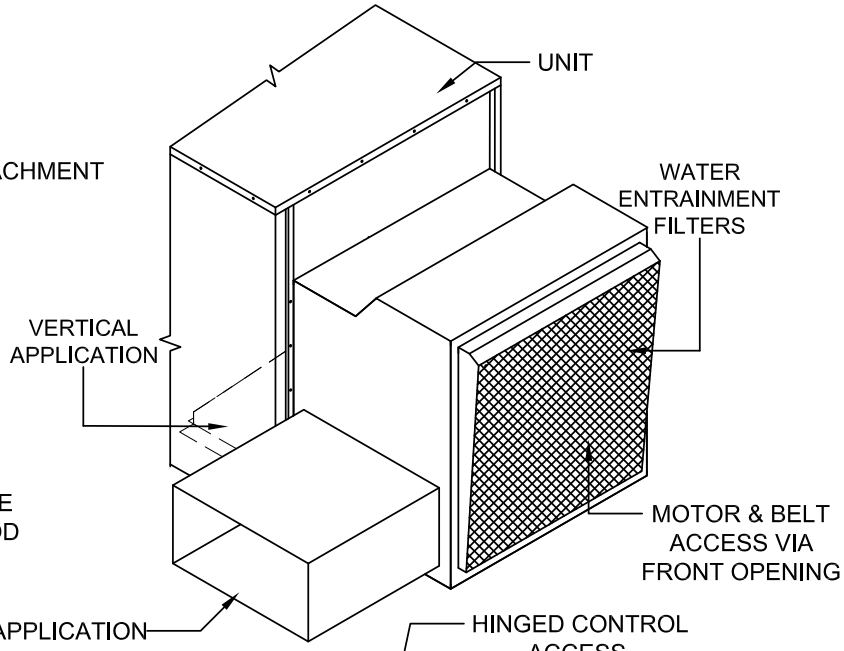
1) CONVERTIBLE FOR BOTH HORIZONTAL & VERTICAL APPLICATIONS.
2) COLOR KEYED CHASSIS.
3) DWDI FORWARD CURVE CENTRIFUGAL FAN.
4) THERMAL OVERLOAD PROTECTED MOTORS.
5) HINGED CONTROL ACCESS DOOR.
6) VARIABLE FREQUENCY DRIVE (MODULATING OPTION)
7) LOGIC MODULE.
8) OAT SENSOR.
9) MAT SENSOR.
10) COMMUNICATING ACTUATOR.
11) CLASS 1A OUTSIDE AIR & RETURN AIR DAMPERS.
12) COMMERCIAL BACKDRAFT DAMPER WITH BLADE EDGE SEALS MECHANICALLY LOCKED INTO BLADE EDGE.

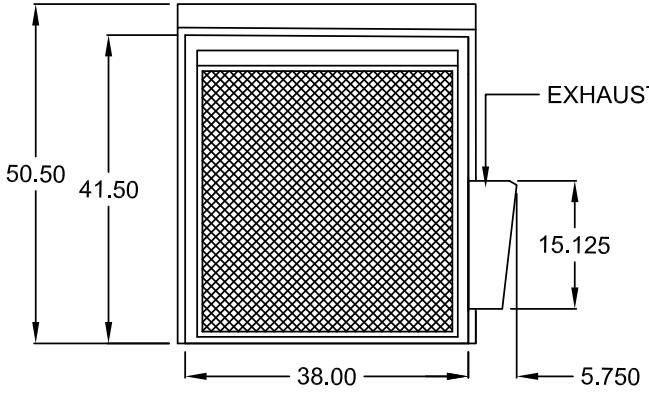
AMCA RATED CLASS 1A LEAKAGE RATED HIGH PERFORMANCE DAMPER ONE-PIECE AIRFOIL BLADE FOR LOW PRESSURE DROP

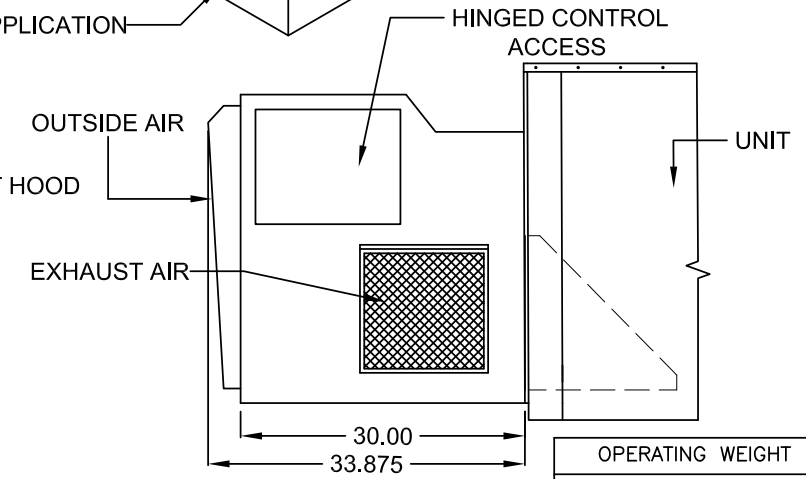
OPTIONS

1) DRY BULB SENSOR (OAT)
2) ENTHALPY SENSOR (OAT)
3) DUAL DRY BULB (OAT/RAT)
4) DUAL ENTHALPY (OAT/RAT)
5) BACNET VARIABLE FREQUENCY DRIVE
6) ACTUATOR ONLY
7) NO CONTROLS









OPERATING WEIGHT
331 LBS

CanFab
CANNON FABRICATION INC
182 GRANITE STREET, SUITE 101, CORONA, CA 92879
PHONE: (951)278-1830 FAX: (951)278-8444 www.canfab.com canfab@canfab.com

6 Ton

FOR:		
PART NO:	PROJECT:	
ENGINEER:	DISTRIBUTOR:	
DRAWING NO:	Rev: 00	DATE:
APPROVED BY:		DATE: / /

MOTOR / ELECTRICAL DATA

MODEL:	1124			115 VOLT/1 PH MOTOR			230 VOLT/ 1PH MOTOR			230 VOLT/ 1PH MOTOR			208 VOLT/3 PH MOTOR			230 VOLT/ 3PH MOTOR			460 VOLT/ 3PH MOTOR		
TONS	CFM	RPM	MOTOR HP	FLA	MCA	MOCP	FLA	MCA	MOCP	FLA	MCA	MOCP	FLA	MCA	MOCP	FLA	MCA	MOCP	FLA	MCA	MOCP
6	2400	806	0.75	10	12.5	22.5	8.2	6.5	11.7	5	6.25	11.25	2.4	3.625	6.525	3	3.75	6.75	7.5	1.875	3.375
7.5	3000	860	1.5	16.4	20.5	36.9	2.4	10.5	18.9	8.2	10.25	18.45	5	6.25	11.25	4.8	6	10.8	2.4	3	5.4
7.5	3000	904	1.5	16.4	20.5	36.9	2.4	10.5	18.9	8.2	10.25	18.45	5	6.25	11.25	4.8	6	10.8	2.4	3	5.4
10	3000	978	2	21	26.25	47.25	11.3	14.125	25.425	10.5	14.125	23.625	6.2	7.75	13.95	6.2	7.75	13.95	3.1	3.875	6.975
12.5	5000	1117	5													12.5	15.75	28.35	6.3	7.875	14.175

POWER EXHAUST IS DESIGNED FOR A ESP OF .50 WC
FAN PERFORMANCE LAB TESTED BY FAN MANUFACTURER

SHEAVE ADJUSTMENT

SHEAVE TURNS TO ACHIEVE CFM/RPM		
CFM	SHEAVE TURNS	ACTUAL RPM
2400	4.5	806
3000	4.5	860
3400	4.5	904
4000	1	978
5000	0	1117

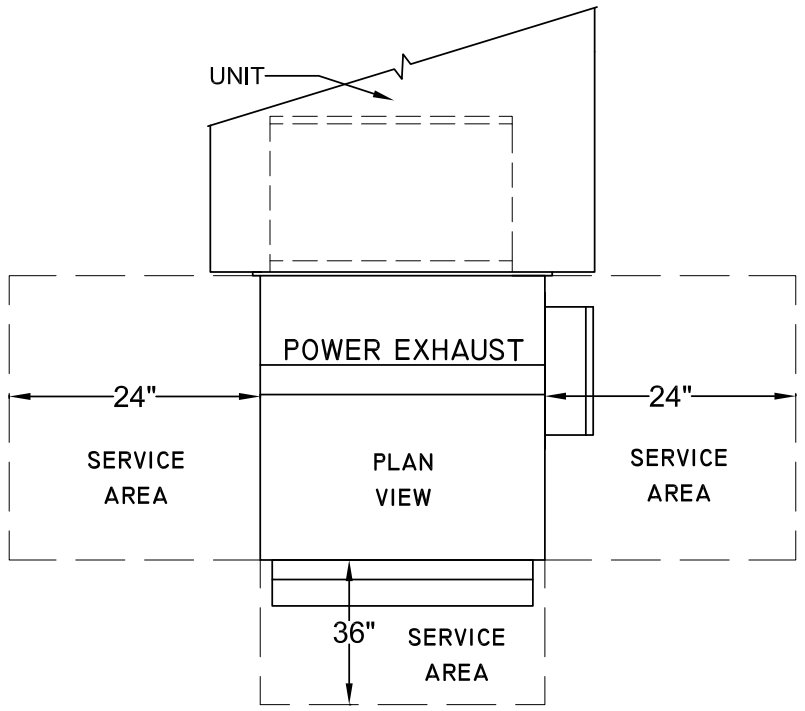
NOTE: TURNS OPEN ARE DETERMINED FROM FULLY CLOSED POSITION
FAN DATA ACQUIRED BY 3RD PARTY TESTING

DAMPER PRESSURE DROP

DAMPER PRESSURE DROP		
CFM	O/A PD (INW.G.)	R/A PD (INW.G.)
2400	0.0097	0.0097
3000	0.0152	0.0152
3400	0.0195	0.0195
4000	0.027	0.027
5000	0.0286	0.0286

SERVICE CLEARANCES

SERVICE AREA NOT DRAWN TO SCALE.



CARRIER 7.5 - 15 TON UNITS:
48HC 14, 48LC 08 - 12, 48TC 16, 50HCQ 12, 50TCQ14

1178-PE/MPE**-****

POWER EXHAUST/ECONOMIZER
VERTICAL OR HORIZONTAL APPLICATIONS

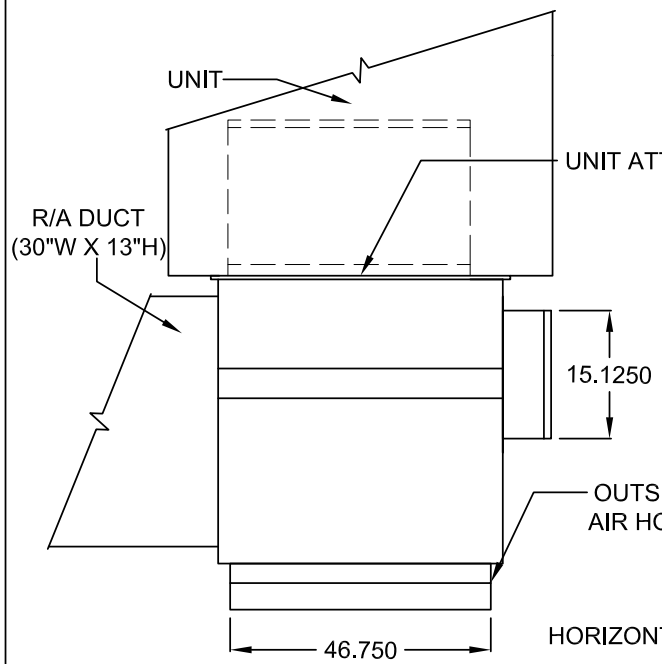
FEATURES

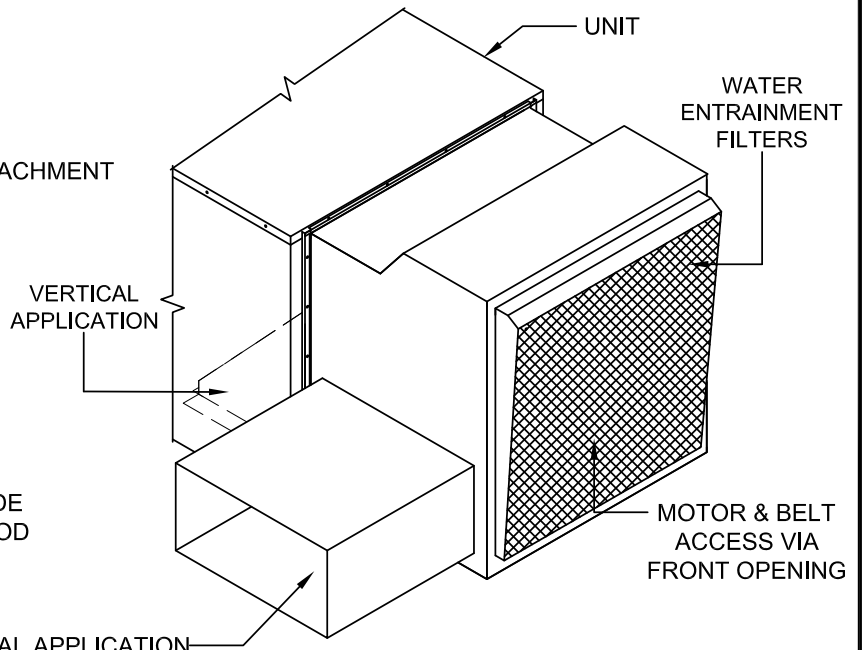
1) CONVERTIBLE FOR BOTH HORIZONTAL & VERTICAL APPLICATIONS.
2) COLOR KEYED CHASSIS.
3) DWDI FORWARD CURVE CENTRIFUGAL FAN.
4) THERMAL OVERLOAD PROTECTED MOTORS.
5) HINGED CONTROL ACCESS DOOR.
6) VARIABLE FREQUENCY DRIVE (MODULATING OPTION)
7) LOGIC MODULE.
8) OAT SENSOR.
9) MAT SENSOR.
10) COMMUNICATING ACTUATOR.
11) CLASS 1A OUTSIDE AIR & RETURN AIR DAMPERS.
12) COMMERCIAL BACKDRAFT DAMPERS WITH BLADE EDGE SEALS MECHANICALLY LOCKED INTO BLADE EDGE.

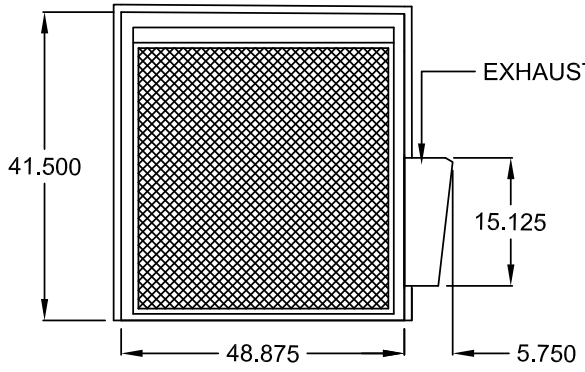
AMCA RATED CLASS 1A LEAKAGE RATED HIGH PERFORMANCE DAMPER ONE-PIECE AIRFOIL BLADE FOR LOW PRESSURE DROP

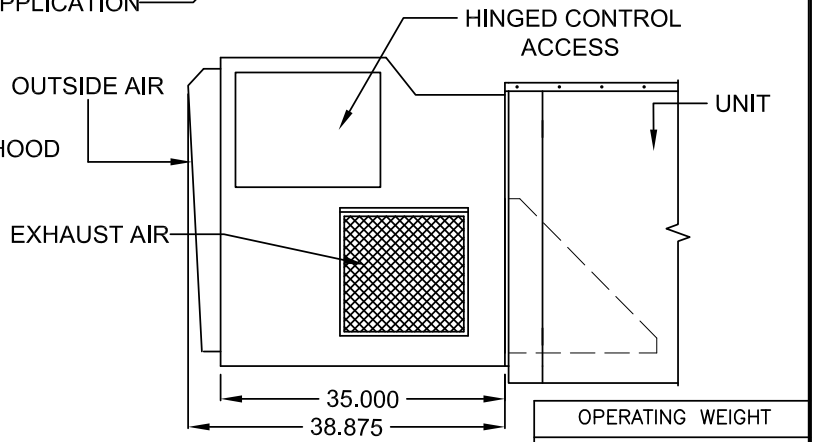
OPTIONS

1) DRY BULB SENSOR (OAT)
2) ENTHALPY SENSOR (OAT)
3) DUAL DRY BULB (OAT/RAT)
4) DUAL ENTHALPY (OAT/RAT)
5) BACNET VARIABLE FREQUENCY DRIVE
6) ACTUATORS ONLY
7) NO CONTROLS









OPERATING WEIGHT
360 LBS

CanFab
CANNON FABRICATION INC
182 GRANITE STREET, SUITE 101, CORONA, CA 92879
PHONE: (951)278-1830 FAX: (951)278-8444 www.canfab.com canfab@canfab.com

7.5 Ton

FOR:		
PART NO:	PROJECT:	
ENGINEER:	DISTRIBUTOR:	
DRAWING NO:	Rev: 00	DATE:
APPROVED BY:		DATE: / /

MOTOR / ELECTRICAL DATA

MODEL:	1178			115 VOLT/1 PH			208 VOLT/ 1PH			230 VOLT/ 1PH			208 VOLT/3 PH			230 VOLT/ 3PH			460 VOLT/ 3PH		
			MOTOR	MOTOR			MOTOR			MOTOR			MOTOR			MOTOR			MOTOR		
TONS	CFM	RPM	HP	FLA	MCA	MOCP	FLA	MCA	MOCP	FLA	MCA	MOCP	FLA	MCA	MOCP	FLA	MCA	MOCP	FLA	MCA	MOCP
8.5	3000	654	1	14.7	18.375	33.075	7.2	9	16.2	7.4	9.25	16.65	3.4	4.25	7.65	4.5	4.5	8.1	1.8	2.25	4.05
8.5	3000	669	1	14.7	18.375	33.075	7.2	9	16.2	7.4	9.25	16.65	3.4	4.25	7.65	4.5	4.5	8.1	1.8	2.25	4.05
10	4000	699	1.5	16.4	20.5	36.9	8.4	10.5	18.9	8.2	10.25	18.45	5	6.25	11.25	3.4	6	10.8	2.4	3	5.4
12.5	5000	759	3										9.2	11.5	20.7	8.5	10.75	19.35	4.3	5.375	9.675
15	6000	830	5													12.5	15.75	28.35	6.3	7.875	14.175

POWER EXHAUST IS DESIGNED FOR A ESP OF .50 WC
FAN PERFORMANCE LAB TESTED BY FAN MANUFACTURER

SHEAVE ADJUSTMENT

SHEAVE TURNS TO ACHIEVE CFM/RPM		
CFM	SHEAVE TURNS	ACTUAL RPM
4000	5.5	654
3400	5	669
4000	4.5	669
5000	3	759
6000	1.5	830

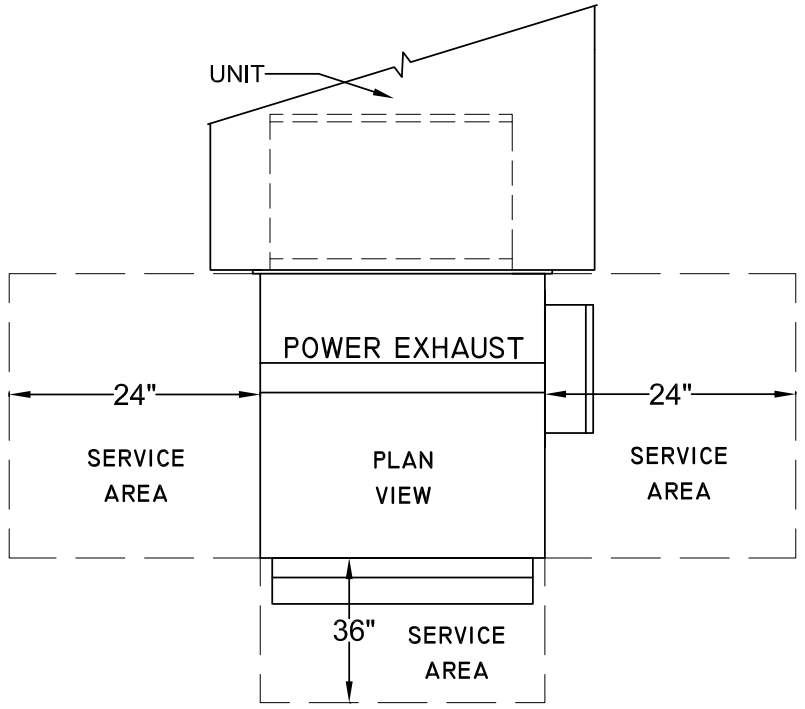
NOTE: TURNS OPEN ARE DETERMINED FROM FULLY CLOSED POSITION
FAN DATA ACQUIRED BY 3RD PARTY TESTING

DAMPER PRESSURE DROP

DAMPER PRESSURE DROP		
CFM	O/A PD (INW.G.)	R/A PD (INW.G.)
3000	0.0112	0.0112
3400	0.0127	0.0127
4000	0.015	0.015
6000	0.0235	0.0235
6000	0.0338	0.0338

SERVICE CLEARANCES

SERVICE AREA NOT DRAWN TO SCALE.



CARRIER 17-1/2 - 20 TONS:
48HC 17 & 20, 48LCI4, 48TC 17 - 24, 50TCQ 17 & 24

1180-PE/MPE**-****

POWER EXHAUST/ECONOMIZER
VERTICAL OR HORIZONTAL APPLICATIONS

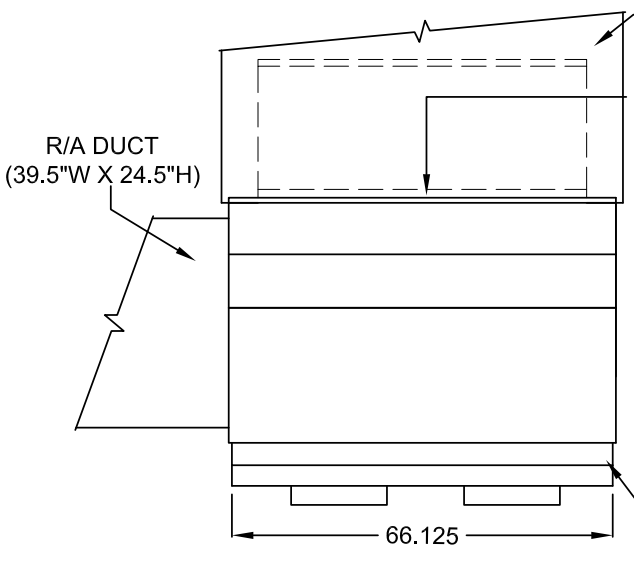
FEATURES

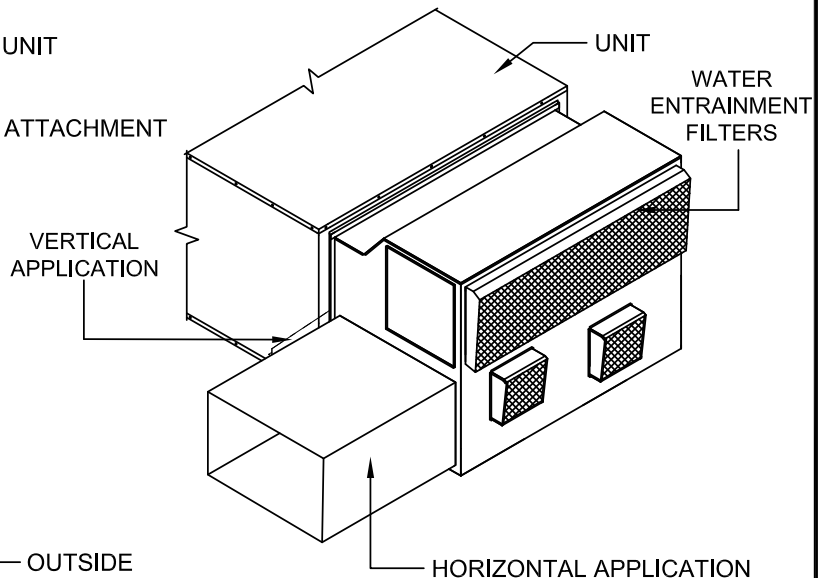
1) CONVERTIBLE FOR BOTH HORIZONTAL & VERTICAL APPLICATIONS.
2) COLOR KEYED CHASSIS.
3) DWDI FORWARD CURVE CENTRIFUGAL FAN.
4) THERMAL OVERLOAD PROTECTED MOTORS.
5) HINGED CONTROL ACCESS DOOR.
6) VARIABLE FREQUENCY DRIVE (MODULATING OPTION)
7) LOGIC MODULE.
8) OAT SENSOR.
9) MAT SENSOR.
10) COMMUNICATING ACTUATOR.
11) CLASS 1A OUTSIDE AIR & RETURN AIR DAMPERS.
12) COMMERCIAL BACKDRAFT DAMPERS WITH BLADE EDGE SEALS MECHANICALLY LOCKED INTO BLADE EDGE.

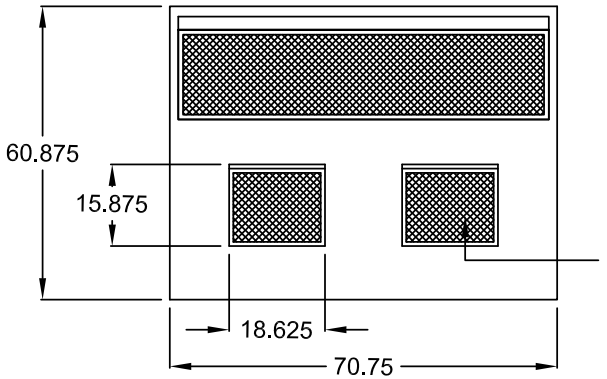
AMCA RATED CLASS 1A LEAKAGE RATED HIGH PERFORMANCE DAMPER ONE-PIECE AIRFOIL BLADE FOR LOW PRESSURE DROP

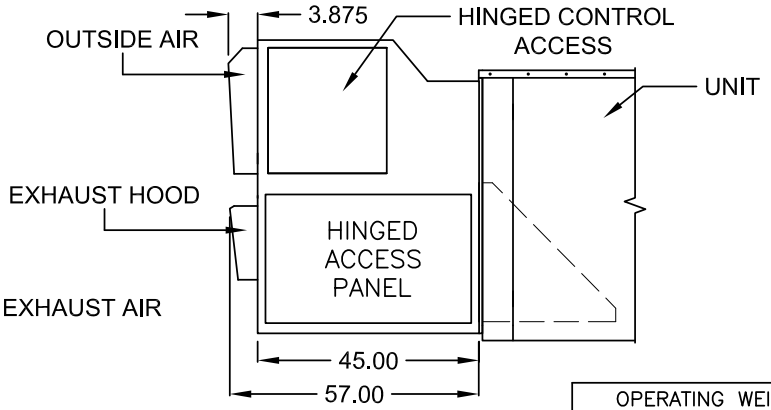
OPTIONS

1) DRY BULB SENSOR (OAT)
2) ENTHALPY SENSOR (OAT)
3) DUAL DRY BULB (OAT/RAT)
4) DUAL ENTHALPY (OAT/RAT)
5) BACNET VARIABLE FREQUENCY DRIVE
6) ACTUATOR ONLY
7) NO CONTROLS









OPERATING WEIGHT
736 LBS

CanFab
CANNON FABRICATION INC
182 GRANITE STREET, SUITE 101, CORONA, CA 92879
PHONE: (951)278-1830 FAX: (951)278-8444 www.canfab.com canfab@canfab.com

12.5 Ton

FOR:		
PART NO:	PROJECT:	
ENGINEER:	DISTRIBUTOR:	
DRAWING NO:	Rev: 00	DATE:
APPROVED BY:		DATE: / /

MOTOR / ELECTRICAL DATA

MODEL: 1180				115 VOLT/1 PH MOTOR			208 VOLT/ 1PH MOTOR			230 VOLT/ 1PH MOTOR			208 VOLT/3 PH MOTOR			230 VOLT/ 3PH MOTOR			460 VOLT/ 3PH MOTOR		
TONS	CFM	RPM	MOTOR HP	FLA	MCA	MOCP	FLA	MCA	MOCP	FLA	MCA	MOCP	FLA	MCA	MOCP	FLA	MCA	MOCP	FLA	MCA	MOCP
12.5	5000	641	1.5	16.4	20.5	36.9	8.4	12.5	18.8	8.2	10.25	18.45	6	6.25	11.25	3.4	6	10.8	3.4	3	5.4
15	6000	654	2	21	26.25	47.25	11.3	14.125	25.425	10.5	14.125	23.625	6.2	7.75	13.95	6.2	7.75	13.95	3.1	3.875	6.975
17.5	7000	673	2	21	26.25	47.25	11.3	14.125	25.425	10.5	14.125	23.625	6.2	7.75	13.95	6.2	7.75	13.95	3.1	3.875	6.975
15	8000	697	3										9.2	11.5	20.7	8.6	10.75	15.95	4.3	5.375	9.675

POWER EXHAUST IS DESIGNED FOR A ESP OF .50 WC
FAN PERFORMANCE LAB TESTED BY FAN MANUFACTURER

SHEAVE ADJUSTMENT

SHEAVE TURNS TO ACHIEVE CFM/RPM		
CFM	SHEAVE TURNS	ACTUAL RPM
5000	5.5	641
6000	5	654
7000	4.5	673
8000	3.5	697

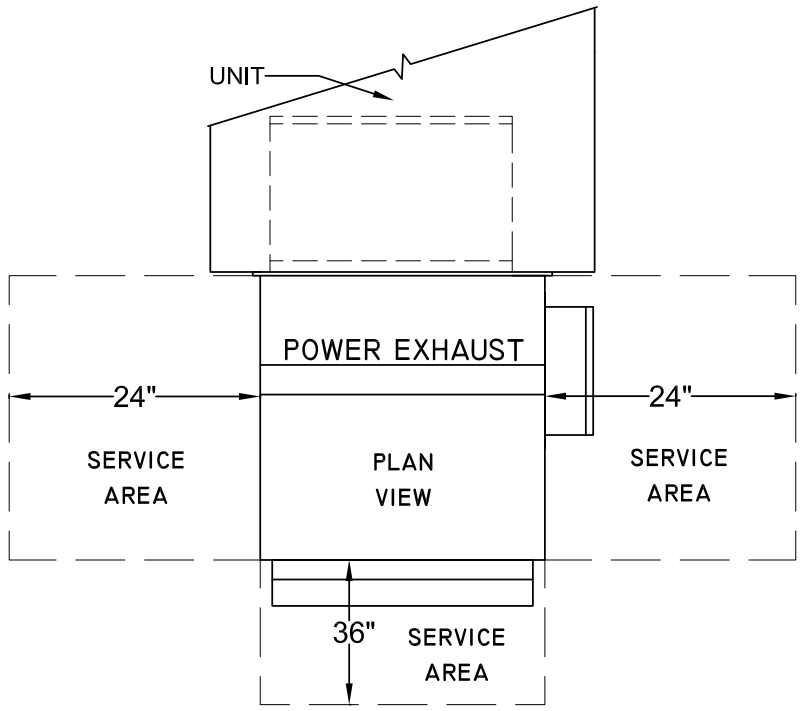
NOTE: TURNS OPEN ARE DETERMINED FROM FULLY CLOSED POSITION
FAN DATA ACQUIRED BY 3RD PARTY TESTING

DAMPER PRESSURE DROP

DAMPER PRESSURE DROP		
CFM	O/A PD (INW.G.)	R/A PD (INW.G.)
5000	0.005	0.005
6000	0.007	0.007
7000	0.01	0.01
8000	0.012	0.012

SERVICE CLEARANCES

SERVICE AREA NOT DRAWN TO SCALE.



H-95

Tag Cover Sheet
Unit Report
Certified Drawing
Performance Report

Unit Parameters

Unit Model: **48GCLM04A3Q6-3A0A0**
Unit Size: **04 (3 Tons)**
Volts-Phase-Hertz: **460-3-60**
Heating Type: **Gas**
Duct Cfg: **Vertical Supply / Vertical Return**
Low Nox, Low Heat
Two Stage Cooling Models

Dimensions (ft. in.) & Weight (lb.) ***

Unit Length: **6' 2.375"**
Unit Width: **3' 10.625"**
Unit Height: **2' 9.375"**
*** Total Operating Weight: **531** lb

*** Weights and Dimensions are approximate. Weight does not include unit packaging. Approximate dimensions are provided primarily for shipping purposes. For exact dimensions and weights, refer to appropriate product data catalog.

Unit Configuration

Direct Drive - EcoBlue - High Static
E-coat Al/Cu - E-coat Al/Cu - Louvered Hail Guards
SystemVu Controls
Standard Packaging

Warranty Information

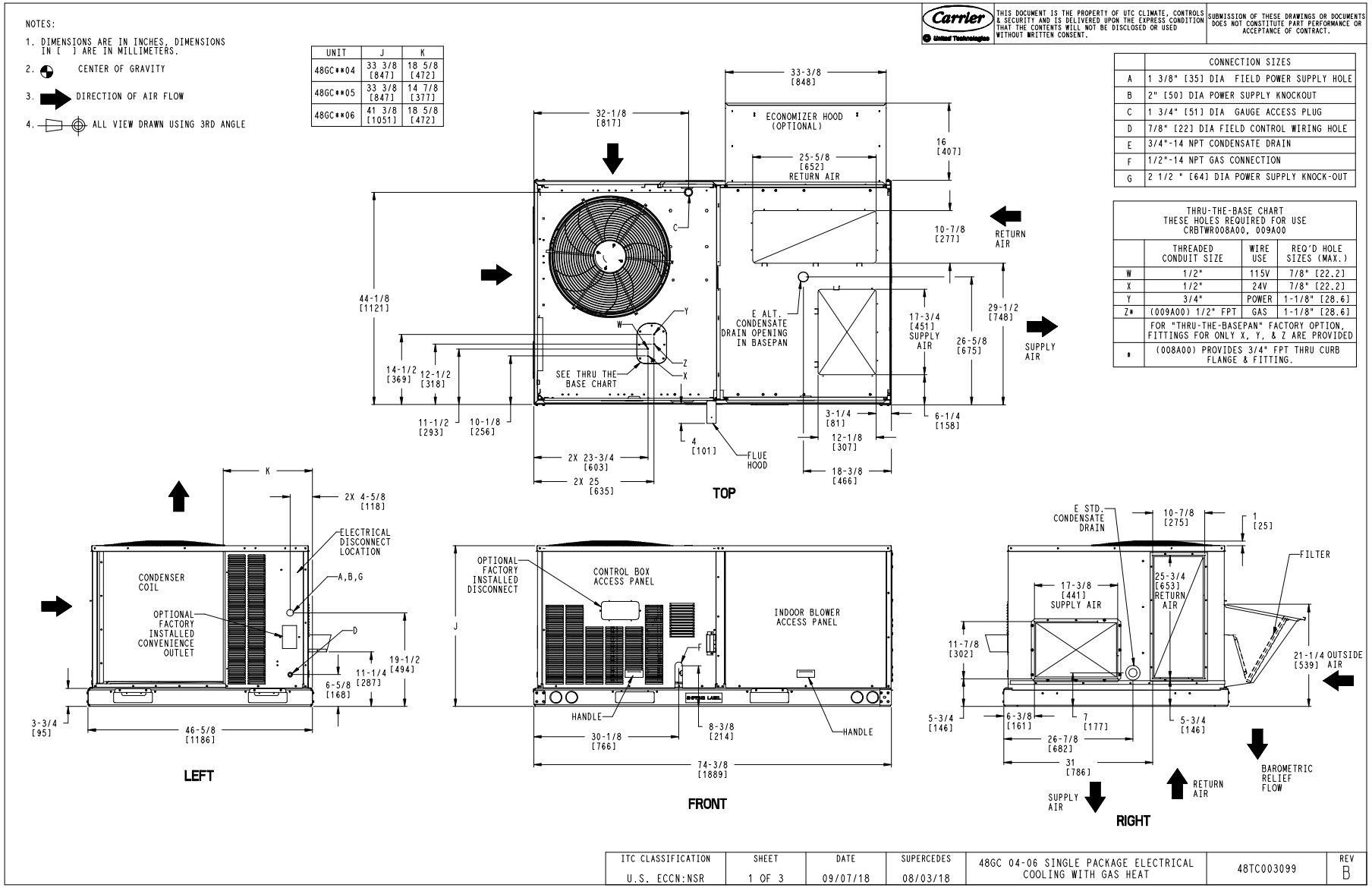
1-Year parts(std.)
5-Year compressor parts(std.)

No optional warranties were selected.

NOTE: Please see Warranty Catalog 500-089 for explanation of policies and ordering methods.

Ordering Information

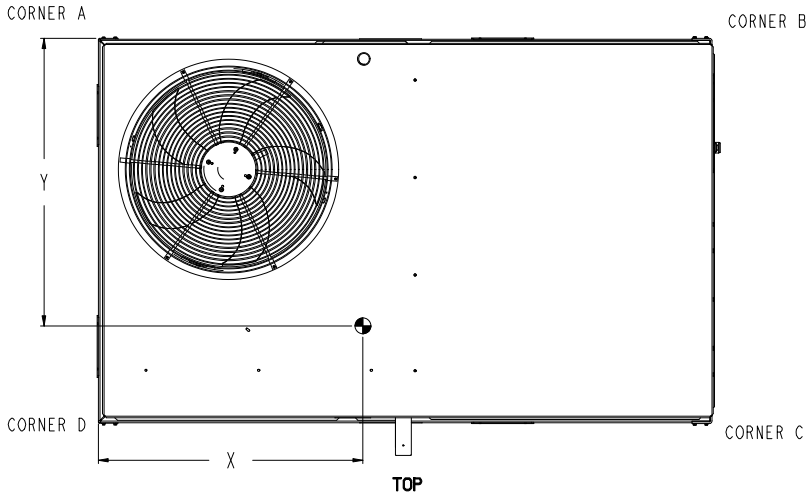
Part Number	Description	Quantity
48GCLM04A3Q6-3A0A0	Rooftop Unit	1
	Base Unit	
	Direct Drive - EcoBlue - High Static	
	E-coat Al/Cu - E-coat Al/Cu - Louvered Hail Guards	
	SystemVu controller, No intake or exhaust option. SystemVu controller meets California Title 24 Sect	


NOTES:
1. DIMENSIONS ARE IN INCHES, DIMENSIONS IN [ ] ARE IN MILLIMETERS.
2. CENTER OF GRAVITY
3. DIRECTION OF AIR FLOW
4. ALL VIEW DRAWN USING 3RD ANGLE
Carrier
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SUBMISSION OF THESE DRAWINGS OR DOCUMENTS DOES NOT CONSTITUTE PART PERFORMANCE OR ACCEPTANCE OF CONTRACT.
UNIT | J | K
48GC**04 | 33 3/8 [847] | 18 5/8 [472]
48GC**05 | 33 3/8 [847] | 14 7/8 [377]
48GC**06 | 41 3/8 [1051] | 18 5/8 [472]
CONNECTION SIZES
A 1 3/8" [35] DIA FIELD POWER SUPPLY HOLE
B 2" [50] DIA POWER SUPPLY KNOCKOUT
C 1 3/4" [51] DIA GAUGE ACCESS PLUG
D 7/8" [22] DIA FIELD CONTROL WIRING HOLE
E 3/4"-14 NPT CONDENSATE DRAIN
F 1/2"-14 NPT GAS CONNECTION
G 2 1/2 " [64] DIA POWER SUPPLY KNOCK-OUT
THRU-THE-BASE CHART
THESE HOLES REQUIRED FOR USE CRBTWR008A00, 009A00
THREADED CONDUIT SIZE | WIRE USE | REQ'D HOLE SIZES (MAX.)
W 1/2" | 115V | 7/8" [22.2]
X 1/2" | 24V | 7/8" [22.2]
Y 3/4" | POWER | 1-1/8" [28.6]
Z* (009A00) 1/2" FPT | GAS | 1-1/8" [28.6]
FOR "THRU-THE-BASEPAN" FACTORY OPTION, FITTINGS FOR ONLY X, Y, & Z ARE PROVIDED
* (008A00) PROVIDES 3/4" FPT THRU CURB FLANGE & FITTING.
33-3/8 [848]
32-1/8 [817]
ECONOMIZER HOOD (OPTIONAL)
25-5/8 [652] RETURN AIR
16 [407]
10-7/8 [277]
RETURN AIR
SUPPLY AIR
29-1/2 [748]
26-5/8 [675]
17-3/4 [451] SUPPLY AIR
E ALT. CONDENSATE DRAIN OPENING IN BASEPAN
SEE THRU THE BASE CHART
44-1/8 [1121]
14-1/2 [369]
12-1/2 [318]
11-1/2 [293]
10-1/8 [256]
2X 23-3/4 [603]
2X 25 [635]
4 [101]
FLUE HOOD
3-1/4 [81]
12-1/8 [307]
6-1/4 [158]
18-3/8 [466]
TOP
K
2X 4-5/8 [118]
ELECTRICAL DISCONNECT LOCATION
A,B,G
CONDENSER COIL
OPTIONAL FACTORY INSTALLED CONVENIENCE OUTLET
D
19-1/2 [494]
11-1/4 [287]
6-5/8 [168]
3-3/4 [95]
46-5/8 [1186]
LEFT
OPTIONAL FACTORY INSTALLED DISCONNECT
CONTROL BOX ACCESS PANEL
INDOOR BLOWER ACCESS PANEL
J
F
HANDLE
HANDLE
30-1/8 [766]
8-3/8 [214]
74-3/8 [1889]
FRONT
E STD. CONDENSATE DRAIN
10-7/8 [275]
1 [25]
FILTER
17-3/8 [441] SUPPLY AIR
25-3/4 [653] RETURN AIR
11-7/8 [302]
21-1/4 OUTSIDE [539] AIR
5-3/4 [146]
6-3/8 [161]
7 [177]
5-3/4 [146]
26-7/8 [682]
31 [786]
RETURN AIR
BAROMETRIC RELIEF FLOW
SUPPLY AIR
RIGHT
ITC CLASSIFICATION: U.S. ECCN:NSR
SHEET: 1 OF 3
DATE: 09/07/18
SUPERCEDES: 08/03/18
48GC 04-06 SINGLE PACKAGE ELECTRICAL COOLING WITH GAS HEAT
48TC003099
REV: B

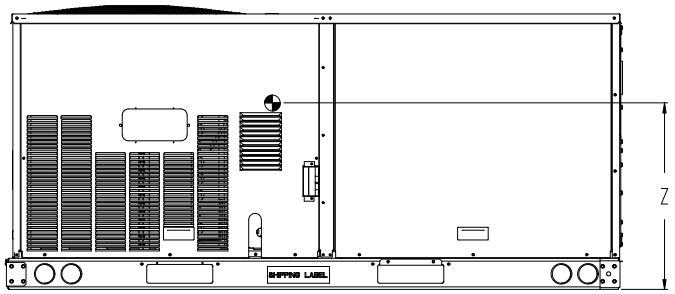
UNIT	STD. UNIT WEIGHT *		CORNER WEIGHT (A)		CORNER WEIGHT (B)		CORNER WEIGHT (C)		CORNER WEIGHT (D)		C.G.		HEIGHT
	LBS.	KG.	LBS.	KG.	LBS.	KG.	LBS.	KG.	LBS.	KG.	X	Y	Z
48GC**04	513	233	131	59	127	58	125	57	130	59	36 1/2 [927]	23 1/4 [591]	18 1/4 [464]
48GC**05	555	252	142	64	137	62	135	61	141	64	36 1/2 [927]	23 1/4 [591]	18 [457]
48GC**06	600	272	161	73	151	68	140	64	149	68	36 [914]	22 1/2 [572]	19 3/8 [492]

*- STANDARD UNIT WEIGHT IS WITH LOW GAS HEAT AND WITHOUT PACKAGING.
FOR OTHER OPTINS AND ACCESSORIES REFER TO THE PRODUCT DATA CATALOG.

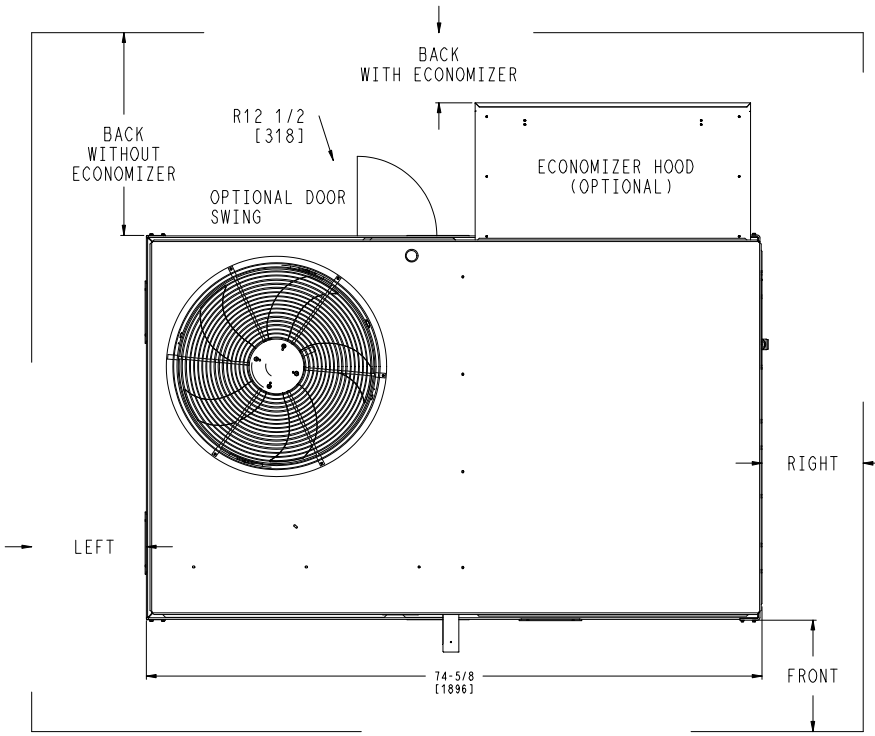
Carrier
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TOP



FRONT



NOTES:

1. FOR ALL MINIMUM CLEARANCES LOCAL CODES OR JURISDICTIONS MAY PREVAIL.

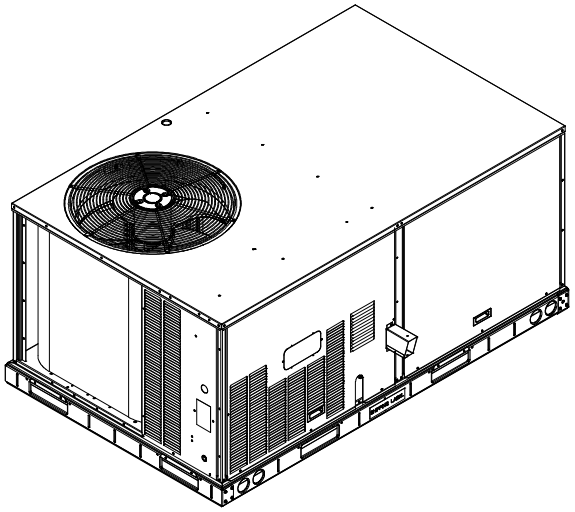
	CLEARANCE		
	SERVICE WITH:	SERVICE WITH:	OPERATING
SURFACE	CONDUCTIVE BARRIER	NONCONDUCTIVE BARRIER	CLEARANCE
FRONT	48 [1219mm]	36 [914mm]	18 [457mm]
LEFT	48 [1219mm]	42 [1067mm]	18 [457mm]
BACK	48 [1219mm]	42 [1067mm]	18 [457mm]
BACK W/HOOD	36 [914mm]	36 [914mm]	18 [457mm]
RIGHT	36 [914mm]	36 [914mm]	18 [457mm]
TOP	72 [1829mm]	72 [1829mm]	72 [1829mm]

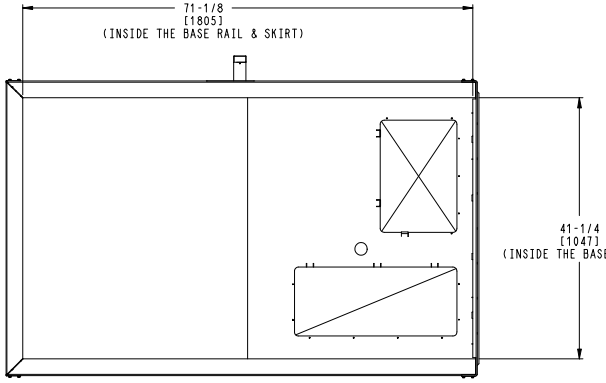
ITC CLASSIFICATION	SHEET	DATE	SUPERCEDES			REV
U.S. ECCN:NSR	2 OF 3	09/07/18	08/03/18	48GC 04-06 SINGLE PACKAGE ELECTRICAL COOLING WITH GAS HEAT	48TC003099	B

Carrier
United Technologies

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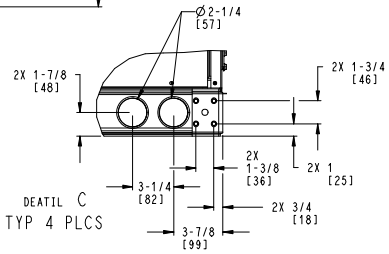
SUBMISSION OF THESE DRAWINGS OR DOCUMENTS DOES NOT CONSTITUTE PART PERFORMANCE OR ACCEPTANCE OF CONTRACT.

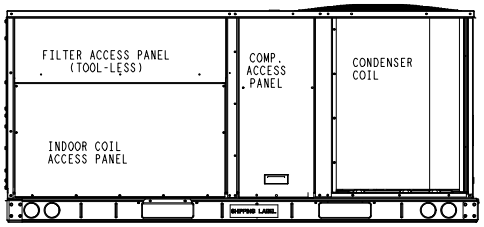




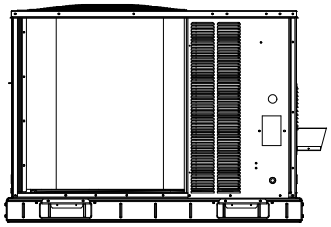
INSIDE BASERAIL DIMENSIONS

BOTTOM

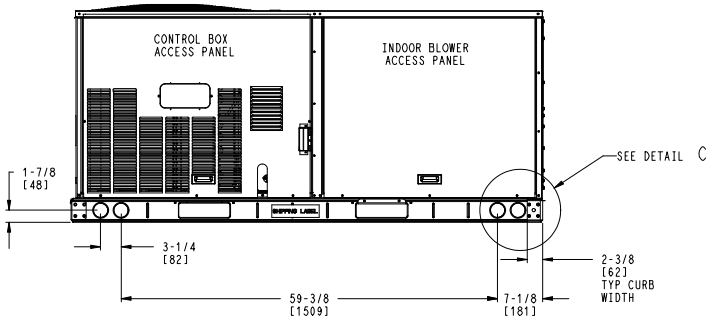




BACK



LEFT



FRONT

ITC CLASSIFICATION	SHEET	DATE	SUPERCEDES			REV
U.S. ECCN:NSR	3 OF 3	09/07/18	08/03/18	48GC 04-06 SINGLE PACKAGE ELECTRICAL COOLING WITH GAS HEAT	48TC003099	B

Part Number:48GCLM04A3Q6-3A0A0

ARI SEER:	**16.00**	
Base Unit Dimensions		
Unit Length:	**74.4**	in
Unit Width:	**46.6**	in
Unit Height:	**33.4**	in
Operating Weight		
Base Unit Weight:	**513**	lb
Direct Drive - EcoBlue - High Static:	**3**	lb
E-coat Al/Cu - E-coat Al/Cu - Louvered Hail Guards:	**13**	lb
SystemVu Controls:	**2**	lb
Total Operating Weight:	**531**	lb
Unit		
Unit Voltage-Phase-Hertz:	**460-3-60**	
Air Discharge:	**Vertical**	
Fan Drive Type:	**Direct**	
Actual Airflow:	**900**	CFM
Site Altitude:	**0**	ft
Cooling Performance		
Condenser Entering Air DB:	**95.0**	F
Evaporator Entering Air DB:	**80.0**	F
Evaporator Entering Air WB:	**67.0**	F
Entering Air Enthalpy:	**31.44**	BTU/lb
Evaporator Leaving Air DB:	**57.8**	F
Evaporator Leaving Air WB:	**55.2**	F
Evaporator Leaving Air Enthalpy:	**23.30**	BTU/lb
Gross Cooling Capacity:	**32.97**	MBH
Gross Sensible Capacity:	**21.62**	MBH
Compressor Power Input:	**2.45**	kW
Coil Bypass Factor:	**0.095**	
Heating Performance		
Heating Airflow:	**900**	CFM
Entering Air Temp:	**70.0**	F
Leaving Air Temp:	**120.4**	F
Gas Heating Input Capacity:	**60.0**	MBH
Gas Heating Output Capacity:	**49.0**	MBH
Temperature Rise:	**50.4**	F
Thermal Efficiency (%):	**81.0**	
Supply Fan		
External Static Pressure:	**1.50**	in wg
Fan RPM:	**2126**	
Fan Power:	**0.77**	BHP
NOTE:	**Selected IFM RPM Range: 249 - 2490**	
Electrical Data		
Voltage Range:	**414 - 506**	
Compressor #1 RLA:	**5.7**	
Compressor #1 LRA:	**38**	
Indoor Fan Motor Type:	**HIGH**	
Indoor Fan Motor FLA:	**1.5**	
Combustion Fan Motor FLA (ea):	**0.25**	
Power Supply MCA:	**10**	
Power Supply MOCP (Fuse or HACR):	**15**	

Disconnect Size FLA: **9**
Disconnect Size LRA: **42**
Electrical Convenience Outlet: **None**
Outdoor Fan [Qty / FLA (ea)]: **1 / 0.8**

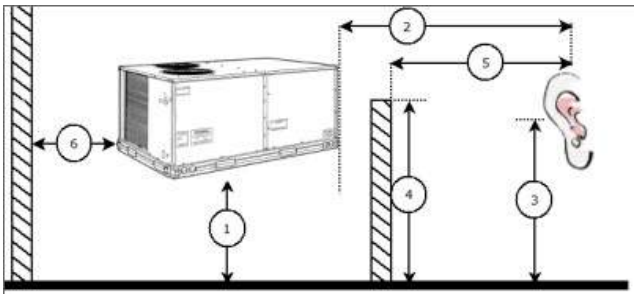
Control Panel SCCR: 5kA RMS at Rated Symmetrical Voltage

Acoustics

Sound Power Levels, db re 10E-12 Watts

	Discharge	Inlet	Outdoor
63 Hz	97.5	89.0	85.6
125 Hz	87.2	83.2	84.7
250 Hz	74.7	73.3	80.5
500 Hz	72.2	66.1	76.0
1000 Hz	69.5	63.4	72.4
2000 Hz	65.0	56.6	68.0
4000 Hz	62.7	52.5	62.8
8000 Hz	58.1	43.0	59.3
A-Weighted	77.3	71.7	79.0

Advanced Acoustics



Advanced Accoustics Parameters

1. Unit height above ground: **30.0** ft
2. Horizontal distance from unit to receiver: **50.0** ft
3. Receiver height above ground: **5.7** ft
4. Height of obstruction: **0.0** ft
5. Horizontal distance from obstruction to receiver: **0.0** ft
6. Horizontal distance from unit to obstruction: **0.0** ft

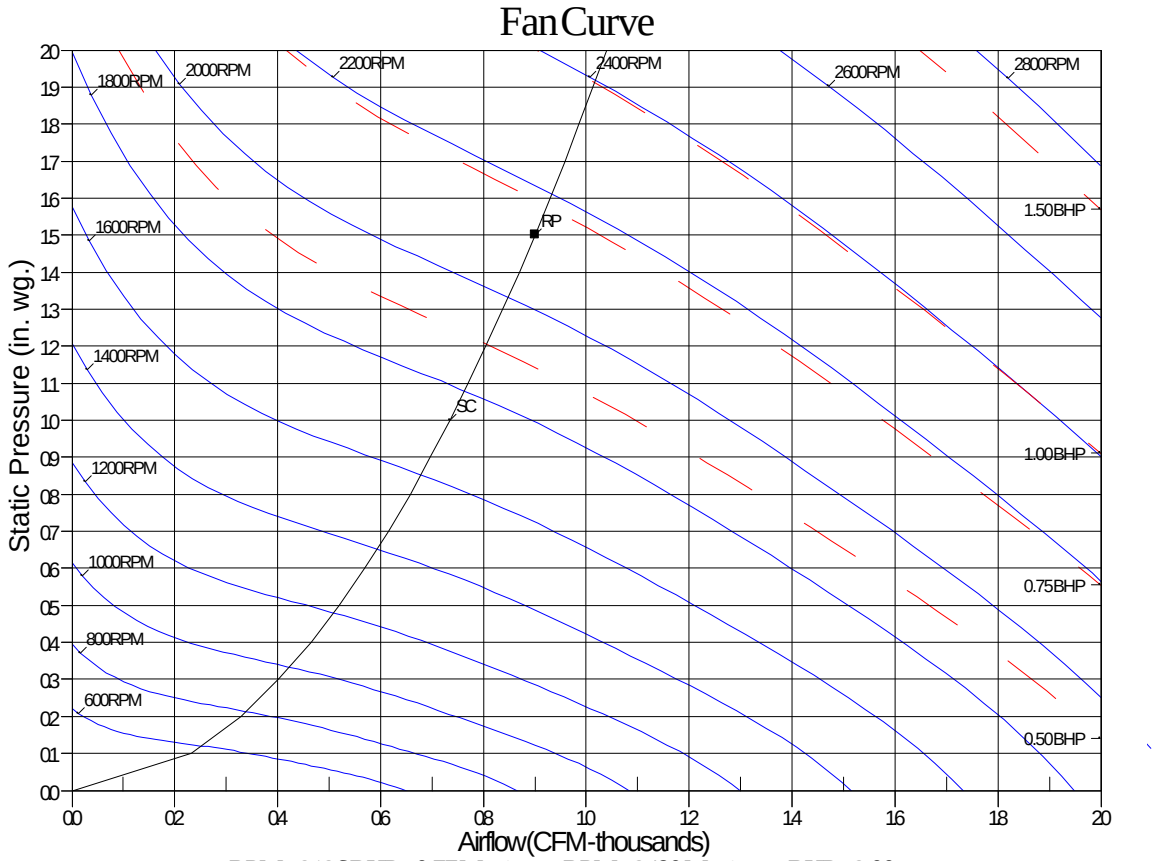
Detailed Acoustics Information

Octave Band Center Freq. Hz	63	125	250	500	1k	2k	4k	8k	Overall
A	85.6	84.7	80.5	76.0	72.4	68.0	62.8	59.3	89.2 Lw
B	59.4	68.6	71.9	72.8	72.4	69.2	63.8	58.2	78.5 LwA
C	53.2	52.3	48.1	43.6	40.0	35.6	30.4	26.9	56.8 Lp
D	27.0	36.2	39.5	40.4	40.0	36.8	31.4	25.8	46.1 LpA

Legend
A Sound Power Levels at Unit's Acoustic Center, Lw
B A-Weighted Sound Power Levels at Unit's Acoustic Center, LwA
C Sound Pressure Levels at Specific Distance from Unit, Lp

D A-Weighted Sound Pressure Levels at Specific Distance from Unit, LpA

Calculation methods used in this program are patterned after the ASHRAE Guide; other ASHRAE Publications and the AHRI Acoustical Standards. While a very significant effort has been made to insure the technical accuracy of this program, it is assumed that the user is knowledgeable in the art of system sound estimation and is aware of the tolerances involved in real world acoustical estimation. This program makes certain assumptions as to the dominant sound sources and sound paths which may not always be appropriate to the real system being estimated. Because of this, no assurances can be offered that this software will always generate an accurate sound prediction from user supplied input data. If in doubt about the estimation of expected sound levels in a space, an Acoustical Engineer or a person with sound prediction expertise should be consulted.



H-91

Tag Cover Sheet
Unit Report
Certified Drawing
Performance Report

Unit Report For H-91

Project: 19-248 Channel Island HVAC Upgrade Building H 02/05/2020
Prepared By: 06:33PM

Unit Parameters

Unit Model: **48GCLM05A3Q6-3A0A0**
Unit Size: **05 (4 Tons)**
Volts-Phase-Hertz: **460-3-60**
Heating Type: **Gas**
Duct Cfg: **Vertical Supply / Vertical Return**
Low Nox, Low Heat
Two Stage Cooling Models

Dimensions (ft. in.) & Weight (lb.) ***

Unit Length: **6' 2.375"**
Unit Width: **3' 10.625"**
Unit Height: **2' 9.375"**
*** Total Operating Weight: **575** lb

*** Weights and Dimensions are approximate. Weight does not include unit packaging. Approximate dimensions are provided primarily for shipping purposes. For exact dimensions and weights, refer to appropriate product data catalog.

Unit Configuration

Direct Drive - EcoBlue - High Static
E-coat Al/Cu - E-coat Al/Cu - Louvered Hail Guards
SystemVu Controls
Standard Packaging

Warranty Information

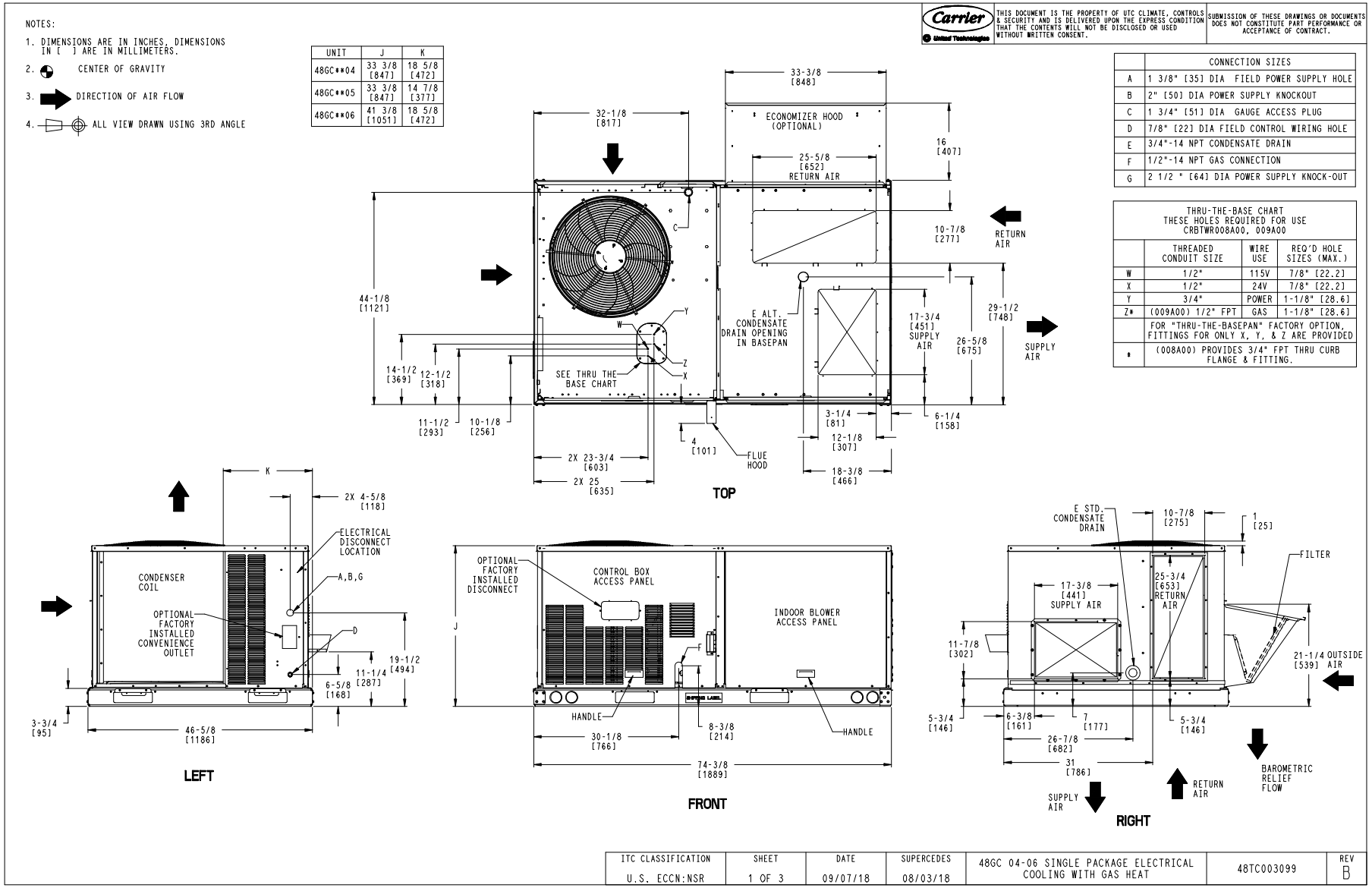
1-Year parts(std.)
5-Year compressor parts(std.)

No optional warranties were selected.

NOTE: Please see Warranty Catalog 500-089 for explanation of policies and ordering methods.

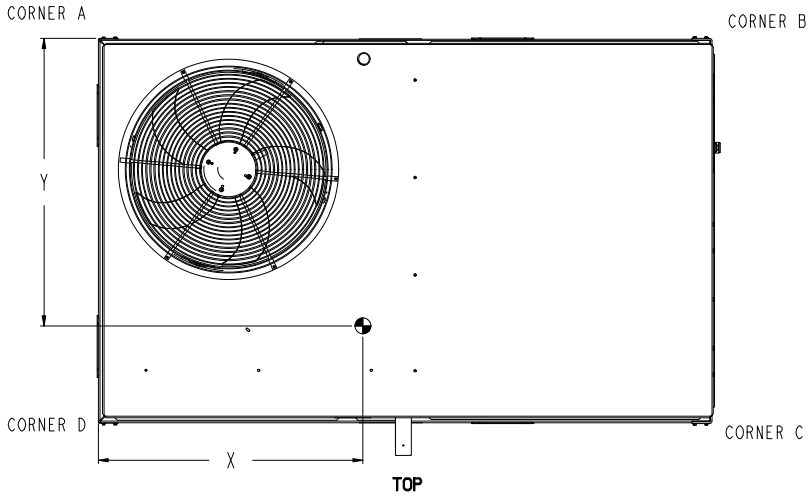
Ordering Information

Part Number	Description	Quantity
48GCLM05A3Q6-3A0A0	Rooftop Unit	1
	Base Unit	
	Direct Drive - EcoBlue - High Static	
	E-coat Al/Cu - E-coat Al/Cu - Louvered Hail Guards	
	SystemVu controller, No intake or exhaust option. SystemVu controller meets California Title 24 Sect	

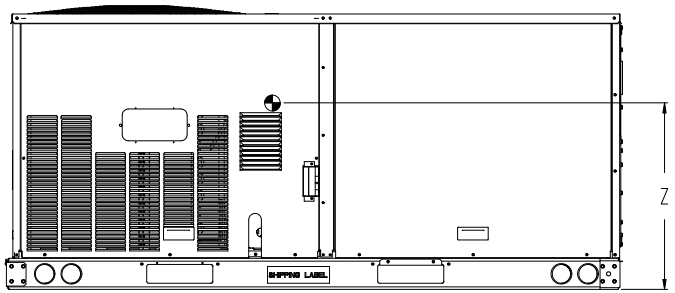

NOTES:
1. DIMENSIONS ARE IN INCHES, DIMENSIONS IN [ ] ARE IN MILLIMETERS.
2. CENTER OF GRAVITY
3. DIRECTION OF AIR FLOW
4. ALL VIEW DRAWN USING 3RD ANGLE
Carrier
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48GC**04 | 33 3/8 [847] | 18 5/8 [472]
48GC**05 | 33 3/8 [847] | 14 7/8 [377]
48GC**06 | 41 3/8 [1051] | 18 5/8 [472]
CONNECTION SIZES
A 1 3/8" [35] DIA FIELD POWER SUPPLY HOLE
B 2" [50] DIA POWER SUPPLY KNOCKOUT
C 1 3/4" [51] DIA GAUGE ACCESS PLUG
D 7/8" [22] DIA FIELD CONTROL WIRING HOLE
E 3/4"-14 NPT CONDENSATE DRAIN
F 1/2"-14 NPT GAS CONNECTION
G 2 1/2 " [64] DIA POWER SUPPLY KNOCK-OUT
THRU-THE-BASE CHART
THESE HOLES REQUIRED FOR USE CRBTWR008A00, 009A00
THREADED CONDUIT SIZE | WIRE USE | REQ'D HOLE SIZES (MAX.)
W 1/2" | 115V | 7/8" [22.2]
X 1/2" | 24V | 7/8" [22.2]
Y 3/4" | POWER | 1-1/8" [28.6]
Z* (009A00) 1/2" FPT | GAS | 1-1/8" [28.6]
FOR "THRU-THE-BASEPAN" FACTORY OPTION, FITTINGS FOR ONLY X, Y, & Z ARE PROVIDED
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SUPPLY AIR
44-1/8 [1121]
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17-3/4 [451] SUPPLY AIR
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SEE THRU THE BASE CHART
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FLUE HOOD
2X 23-3/4 [603]
2X 25 [635]
18-3/8 [466]
TOP
K
2X 4-5/8 [118]
ELECTRICAL DISCONNECT LOCATION
A,B,G
CONDENSER COIL
OPTIONAL FACTORY INSTALLED CONVENIENCE OUTLET
D
19-1/2 [494]
11-1/4 [287]
6-5/8 [168]
3-3/4 [95]
46-5/8 [1186]
LEFT
OPTIONAL FACTORY INSTALLED DISCONNECT
CONTROL BOX ACCESS PANEL
INDOOR BLOWER ACCESS PANEL
J
F
HANDLE
30-1/8 [766]
8-3/8 [214]
HANDLE
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FRONT
E STD. CONDENSATE DRAIN
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17-3/8 [441] SUPPLY AIR
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31 [786]
BAROMETRIC RELIEF FLOW
SUPPLY AIR
RETURN AIR
RIGHT
ITC CLASSIFICATION: U.S. ECCN:NSR
SHEET: 1 OF 3
DATE: 09/07/18
SUPERCEDES: 08/03/18
48GC 04-06 SINGLE PACKAGE ELECTRICAL COOLING WITH GAS HEAT
48TC003099
REV: B

UNIT	STD. UNIT WEIGHT *		CORNER WEIGHT (A)		CORNER WEIGHT (B)		CORNER WEIGHT (C)		CORNER WEIGHT (D)		C.G.		HEIGHT
	LBS.	KG.	LBS.	KG.	LBS.	KG.	LBS.	KG.	LBS.	KG.	X	Y	Z
48GC**04	513	233	131	59	127	58	125	57	130	59	36 1/2 [927]	23 1/4 [591]	18 1/4 [464]
48GC**05	555	252	142	64	137	62	135	61	141	64	36 1/2 [927]	23 1/4 [591]	18 [457]
48GC**06	600	272	161	73	151	68	140	64	149	68	36 [914]	22 1/2 [572]	19 3/8 [492]

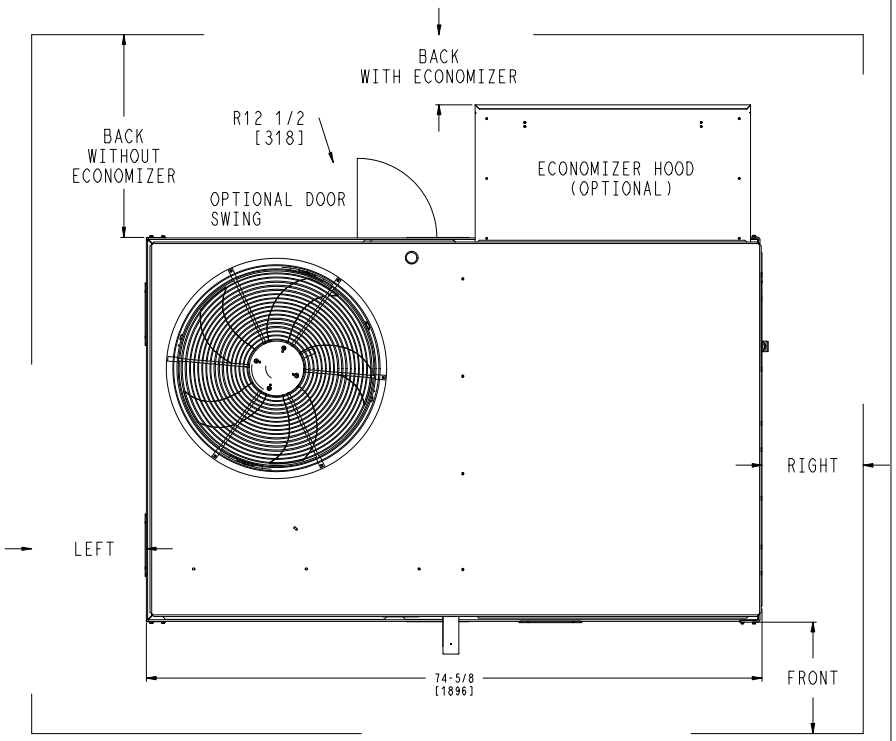
*- STANDARD UNIT WEIGHT IS WITH LOW GAS HEAT AND WITHOUT PACKAGING.
FOR OTHER OPTINS AND ACCESSORIES REFER TO THE PRODUCT DATA CATALOG.



TOP



FRONT



NOTES:

1. FOR ALL MINIMUM CLEARANCES LOCAL CODES OR JURISDICTIONS MAY PREVAIL.

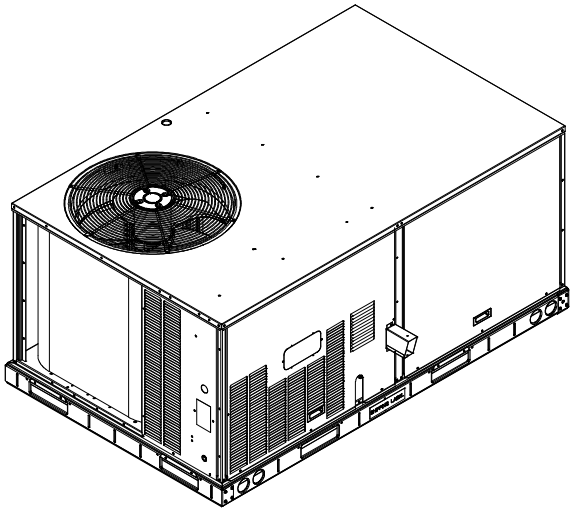
	CLEARANCE		
	SERVICE WITH:	SERVICE WITH:	OPERATING
SURFACE	CONDUCTIVE BARRIER	NONCONDUCTIVE BARRIER	CLEARANCE
FRONT	48 [1219mm]	36 [914mm]	18 [457mm]
LEFT	48 [1219mm]	42 [1067mm]	18 [457mm]
BACK	48 [1219mm]	42 [1067mm]	18 [457mm]
BACK W/HOOD	36 [914mm]	36 [914mm]	18 [457mm]
RIGHT	36 [914mm]	36 [914mm]	18 [457mm]
TOP	72 [1829mm]	72 [1829mm]	72 [1829mm]

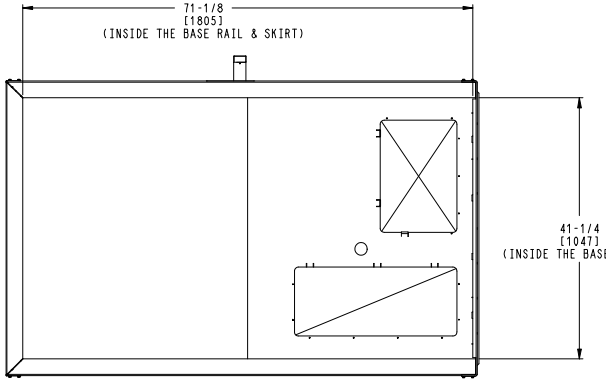
ITC CLASSIFICATION	SHEET	DATE	SUPERCEDES			REV
U.S. ECCN:NSR	2 OF 3	09/07/18	08/03/18	48GC 04-06 SINGLE PACKAGE ELECTRICAL COOLING WITH GAS HEAT	48TC003099	B

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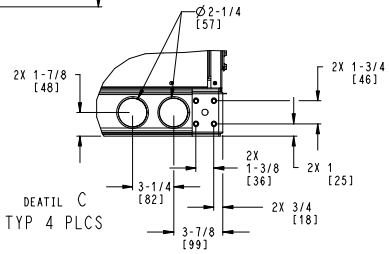
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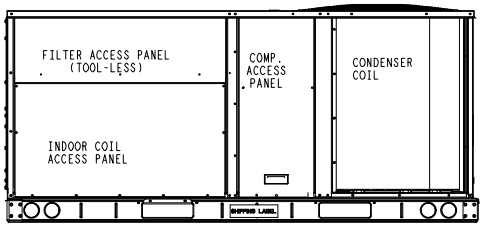




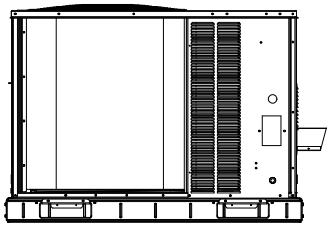
INSIDE BASERAIL DIMENSIONS

BOTTOM

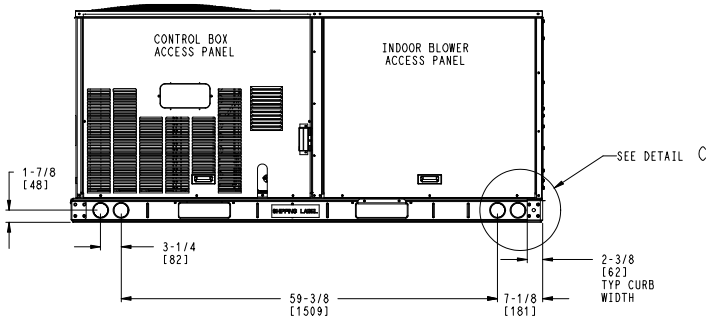




BACK



LEFT



FRONT

ITC CLASSIFICATION	SHEET	DATE	SUPERCEDES			REV
U.S. ECCN:NSR	3 OF 3	09/07/18	08/03/18	48GC 04-06 SINGLE PACKAGE ELECTRICAL COOLING WITH GAS HEAT	48TC003099	B

Part Number:48GCLM05A3Q6-3A0A0

ARI SEER:	**16.00**	
Base Unit Dimensions		
Unit Length:	**74.4**	in
Unit Width:	**46.6**	in
Unit Height:	**33.4**	in
Operating Weight		
Base Unit Weight:	**555**	lb
Direct Drive - EcoBlue - High Static:	**5**	lb
E-coat Al/Cu - E-coat Al/Cu - Louvered Hail Guards:	**13**	lb
SystemVu Controls:	**2**	lb
Total Operating Weight:	**575**	lb
Unit		
Unit Voltage-Phase-Hertz:	**460-3-60**	
Air Discharge:	**Vertical**	
Fan Drive Type:	**Direct**	
Actual Airflow:	**1470**	CFM
Site Altitude:	**0**	ft
Cooling Performance		
Condenser Entering Air DB:	**95.0**	F
Evaporator Entering Air DB:	**80.0**	F
Evaporator Entering Air WB:	**67.0**	F
Entering Air Enthalpy:	**31.44**	BTU/lb
Evaporator Leaving Air DB:	**57.7**	F
Evaporator Leaving Air WB:	**56.4**	F
Evaporator Leaving Air Enthalpy:	**24.00**	BTU/lb
Gross Cooling Capacity:	**49.23**	MBH
Gross Sensible Capacity:	**35.38**	MBH
Compressor Power Input:	**3.26**	kW
Coil Bypass Factor:	**0.075**	
Heating Performance		
Heating Airflow:	**1470**	CFM
Entering Air Temp:	**70.0**	F
Leaving Air Temp:	**100.9**	F
Gas Heating Input Capacity:	**60.0**	MBH
Gas Heating Output Capacity:	**49.0**	MBH
Temperature Rise:	**30.9**	F
Thermal Efficiency (%):	**81.0**	
Supply Fan		
External Static Pressure:	**1.50**	in wg
Fan RPM:	**2141**	
Fan Power:	**1.06**	BHP
NOTE:	**Selected IFM RPM Range: 266 - 2660**	
Electrical Data		
Voltage Range:	**414 - 506**	
Compressor #1 RLA:	**6.4**	
Compressor #1 LRA:	**41**	
Indoor Fan Motor Type:	**HIGH**	
Indoor Fan Motor FLA:	**2.4**	
Combustion Fan Motor FLA (ea):	**0.25**	
Power Supply MCA:	**12**	
Power Supply MOCP (Fuse or HACR):	**15**	

Disconnect Size FLA: **11**
Disconnect Size LRA: **46**
Electrical Convenience Outlet: **None**
Outdoor Fan [Qty / FLA (ea)]: **1 / 0.8**

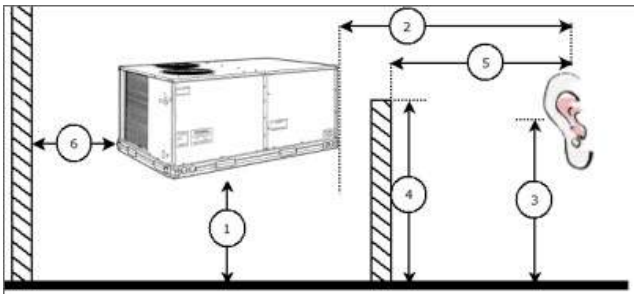
Control Panel SCCR: 5kA RMS at Rated Symmetrical Voltage

Acoustics

Sound Power Levels, db re 10E-12 Watts

	Discharge	Inlet	Outdoor
63 Hz	96.1	90.2	85.6
125 Hz	87.5	81.6	84.7
250 Hz	81.1	73.6	80.5
500 Hz	74.5	67.8	76.0
1000 Hz	71.7	69.2	72.4
2000 Hz	69.1	61.2	68.0
4000 Hz	64.8	54.4	62.8
8000 Hz	60.9	48.2	59.3
A-Weighted	79.3	73.5	79.0

Advanced Acoustics



Advanced Accoustics Parameters

1. Unit height above ground: **30.0** ft
2. Horizontal distance from unit to receiver: **50.0** ft
3. Receiver height above ground: **5.7** ft
4. Height of obstruction: **0.0** ft
5. Horizontal distance from obstruction to receiver: **0.0** ft
6. Horizontal distance from unit to obstruction: **0.0** ft

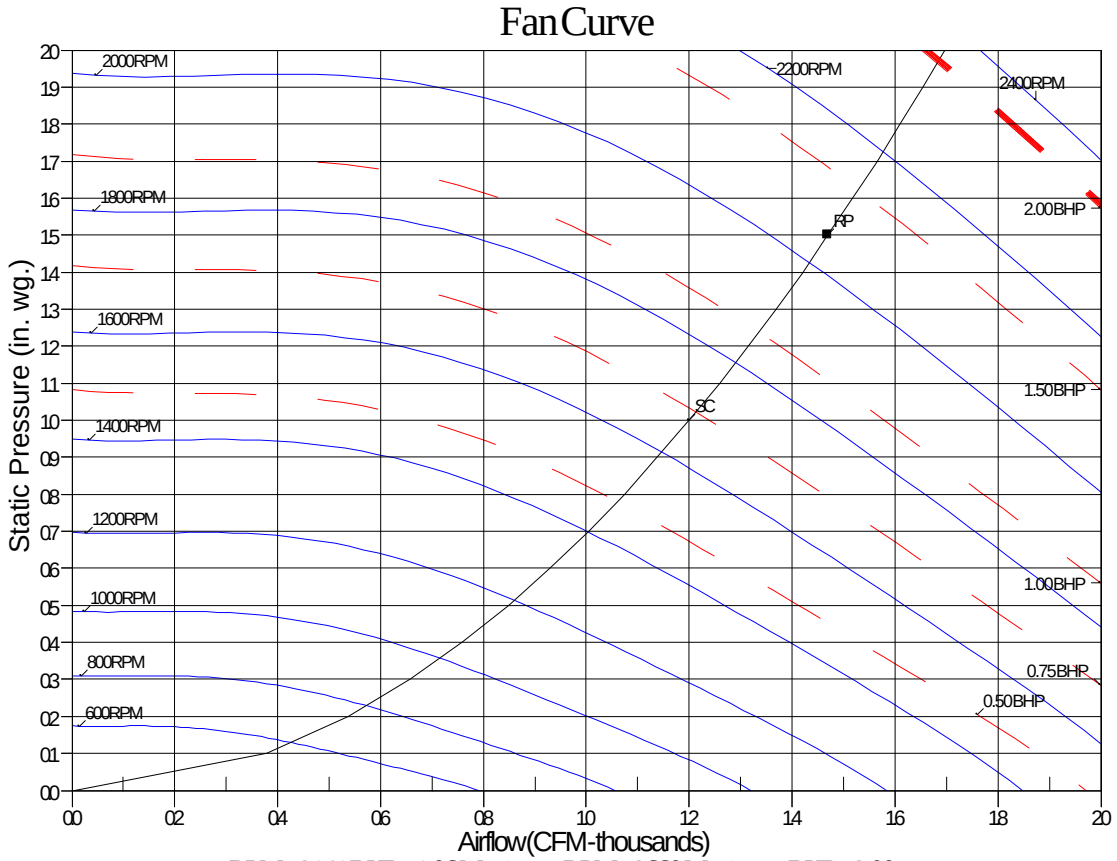
Detailed Acoustics Information

Octave Band Center Freq. Hz	63	125	250	500	1k	2k	4k	8k	Overall
A	85.6	84.7	80.5	76.0	72.4	68.0	62.8	59.3	89.2 Lw
B	59.4	68.6	71.9	72.8	72.4	69.2	63.8	58.2	78.5 LwA
C	53.2	52.3	48.1	43.6	40.0	35.6	30.4	26.9	56.8 Lp
D	27.0	36.2	39.5	40.4	40.0	36.8	31.4	25.8	46.1 LpA

Legend
A Sound Power Levels at Unit's Acoustic Center, Lw
B A-Weighted Sound Power Levels at Unit's Acoustic Center, LwA
C Sound Pressure Levels at Specific Distance from Unit, Lp

D A-Weighted Sound Pressure Levels at Specific Distance from Unit, LpA

Calculation methods used in this program are patterned after the ASHRAE Guide; other ASHRAE Publications and the AHRI Acoustical Standards. While a very significant effort has been made to insure the technical accuracy of this program, it is assumed that the user is knowledgeable in the art of system sound estimation and is aware of the tolerances involved in real world acoustical estimation. This program makes certain assumptions as to the dominant sound sources and sound paths which may not always be appropriate to the real system being estimated. Because of this, no assurances can be offered that this software will always generate an accurate sound prediction from user supplied input data. If in doubt about the estimation of expected sound levels in a space, an Acoustical Engineer or a person with sound prediction expertise should be consulted.



RPM=2141 BHP=1.06 Maximum RPM=2660 Maximum BHP=2.00
SC-System Curve RP-Rated Point

J-1

Tag Cover Sheet
Unit Report
Certified Drawing
Performance Report

Unit Report For J-1

Project: 19-248 Channel Island HVAC Upgrade BLDG J 02/05/2020
Prepared By: 06:37PM

Unit Parameters

Unit Model: **48GCLM06A2Q6-3A0A0**
Unit Size: **06 (5 Tons)**
Volts-Phase-Hertz: **460-3-60**
Heating Type: **Gas**
Duct Cfg: **Vertical Supply / Vertical Return**
Low Nox, Low Heat
Two Stage Cooling Models

Dimensions (ft. in.) & Weight (lb.) ***

Unit Length: **6' 2.375"**
Unit Width: **3' 10.625"**
Unit Height: **3' 5.375"**
*** Total Operating Weight: **619** lb

*** Weights and Dimensions are approximate. Weight does not include unit packaging. Approximate dimensions are provided primarily for shipping purposes. For exact dimensions and weights, refer to appropriate product data catalog.

Unit Configuration

Direct Drive - EcoBlue - Medium Static
E-coat Al/Cu - E-coat Al/Cu - Louvered Hail Guards
SystemVu Controls
Standard Packaging

Warranty Information

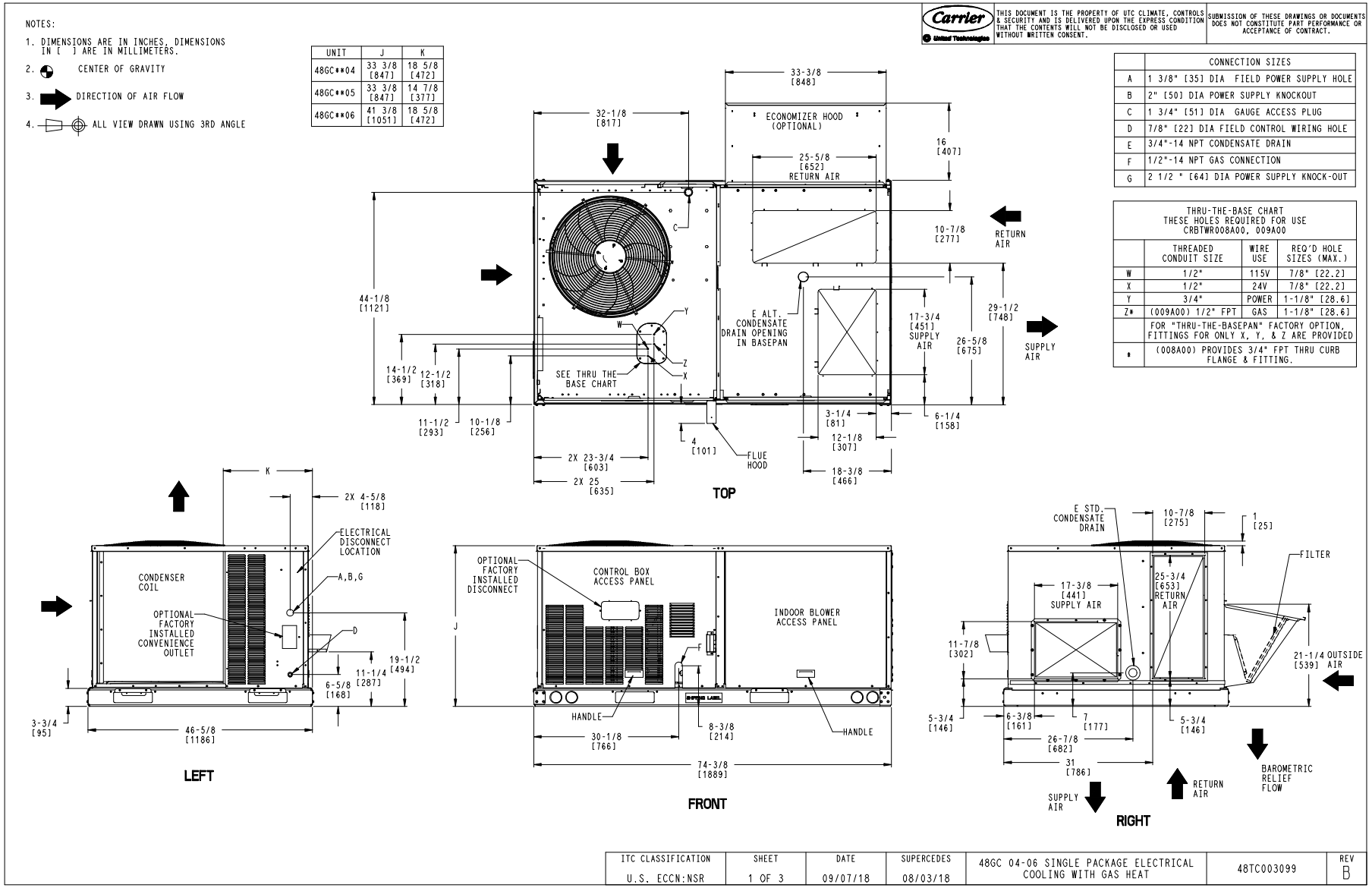
1-Year parts(std.)
5-Year compressor parts(std.)

No optional warranties were selected.

NOTE: Please see Warranty Catalog 500-089 for explanation of policies and ordering methods.

Ordering Information

Part Number	Description	Quantity
48GCLM06A2Q6-3A0A0	Rooftop Unit	1
	Base Unit	
	Direct Drive - EcoBlue - Medium Static	
	E-coat Al/Cu - E-coat Al/Cu - Louvered Hail Guards	
	SystemVu controller, No intake or exhaust option. SystemVu controller meets California Title 24 Sect	



UNIT	J	K
48GC**04	33 3/8 [847]	18 5/8 [472]
48GC**05	33 3/8 [847]	14 7/8 [377]
48GC**06	41 3/8 [1051]	18 5/8 [472]

	CONNECTION SIZES
A	1 3/8" [35] DIA FIELD POWER SUPPLY HOLE
B	2" [50] DIA POWER SUPPLY KNOCKOUT
C	1 3/4" [51] DIA GAUGE ACCESS PLUG
D	7/8" [22] DIA FIELD CONTROL WIRING HOLE
E	3/4"-14 NPT CONDENSATE DRAIN
F	1/2"-14 NPT GAS CONNECTION
G	2 1/2 " [64] DIA POWER SUPPLY KNOCK-OUT

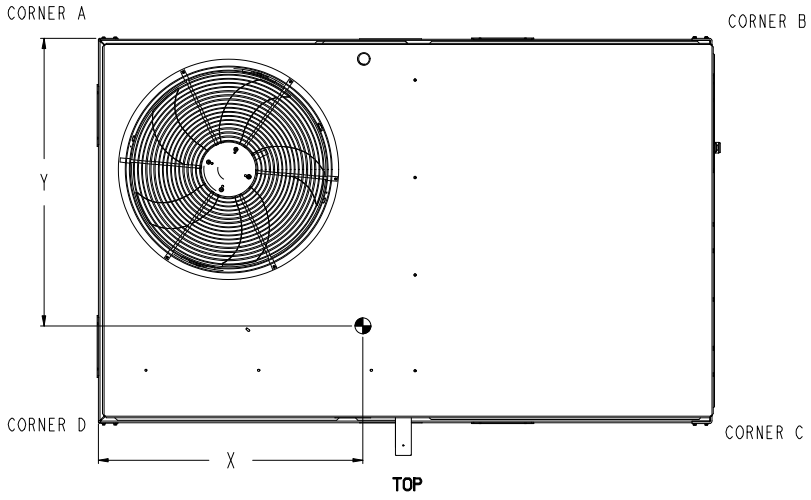
THRU-THE-BASE CHART
THESE HOLES REQUIRED FOR USE CRBTWR008A00, 009A00

	THREADED CONDUIT SIZE	WIRE USE	REQ'D HOLE SIZES (MAX.)
W	1/2"	115V	7/8" [22.2]
X	1/2"	24V	7/8" [22.2]
Y	3/4"	POWER	1-1/8" [28.6]
Z*	(009A00) 1/2" FPT	GAS	1-1/8" [28.6]
	FOR "THRU-THE-BASEPAN" FACTORY OPTION, FITTINGS FOR ONLY X, Y, & Z ARE PROVIDED		
*	(008A00) PROVIDES 3/4" FPT THRU CURB FLANGE & FITTING.		

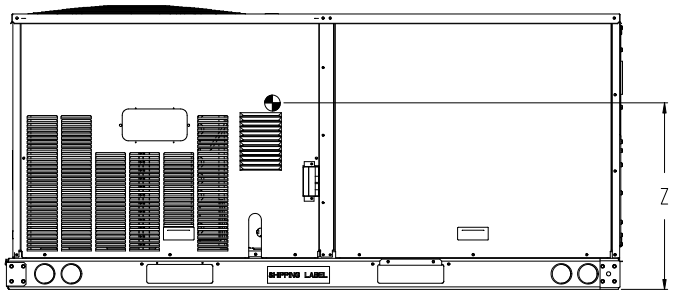
ITC CLASSIFICATION	SHEET	DATE	SUPERCEDES		REV
U.S. ECCN:NSR	1 OF 3	09/07/18	08/03/18	48GC 04-06 SINGLE PACKAGE ELECTRICAL COOLING WITH GAS HEAT	48TC003099	B

UNIT	STD. UNIT WEIGHT *		CORNER WEIGHT (A)		CORNER WEIGHT (B)		CORNER WEIGHT (C)		CORNER WEIGHT (D)		C.G.		HEIGHT
	LBS.	KG.	LBS.	KG.	LBS.	KG.	LBS.	KG.	LBS.	KG.	X	Y	Z
48GC**04	513	233	131	59	127	58	125	57	130	59	36 1/2 [927]	23 1/4 [591]	18 1/4 [464]
48GC**05	555	252	142	64	137	62	135	61	141	64	36 1/2 [927]	23 1/4 [591]	18 [457]
48GC**06	600	272	161	73	151	68	140	64	149	68	36 [914]	22 1/2 [572]	19 3/8 [492]

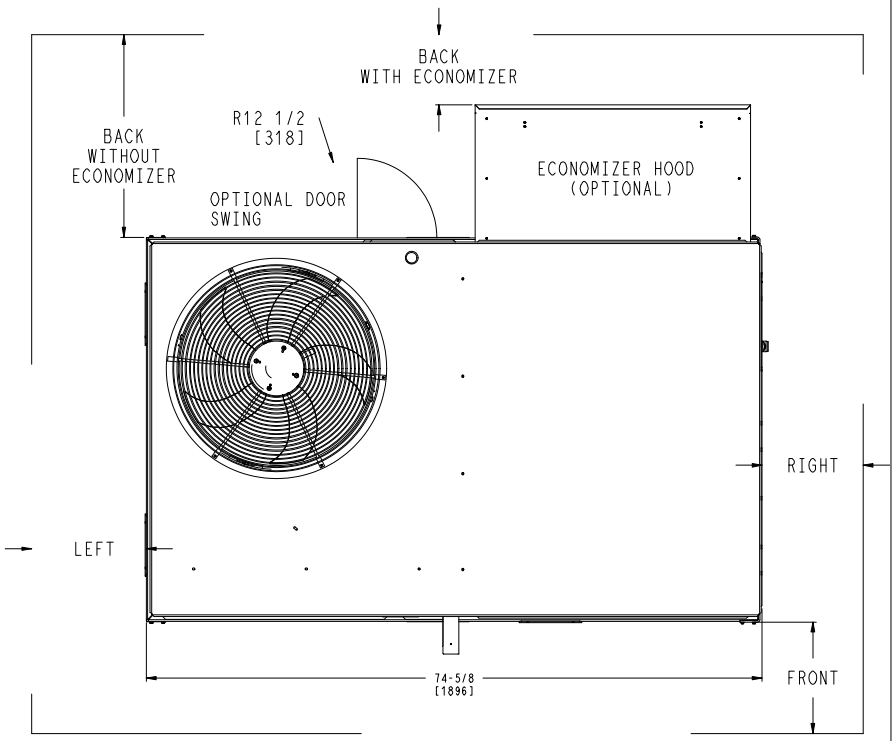
*- STANDARD UNIT WEIGHT IS WITH LOW GAS HEAT AND WITHOUT PACKAGING.
FOR OTHER OPTINS AND ACCESSORIES REFER TO THE PRODUCT DATA CATALOG.



TOP



FRONT



NOTES:

1. FOR ALL MINIMUM CLEARANCES LOCAL CODES OR JURISDICTIONS MAY PREVAIL.

	CLEARANCE		
	SERVICE WITH:	SERVICE WITH:	OPERATING
SURFACE	CONDUCTIVE BARRIER	NONCONDUCTIVE BARRIER	CLEARANCE
FRONT	48 [1219mm]	36 [914mm]	18 [457mm]
LEFT	48 [1219mm]	42 [1067mm]	18 [457mm]
BACK	48 [1219mm]	42 [1067mm]	18 [457mm]
BACK W/HOOD	36 [914mm]	36 [914mm]	18 [457mm]
RIGHT	36 [914mm]	36 [914mm]	18 [457mm]
TOP	72 [1829mm]	72 [1829mm]	72 [1829mm]

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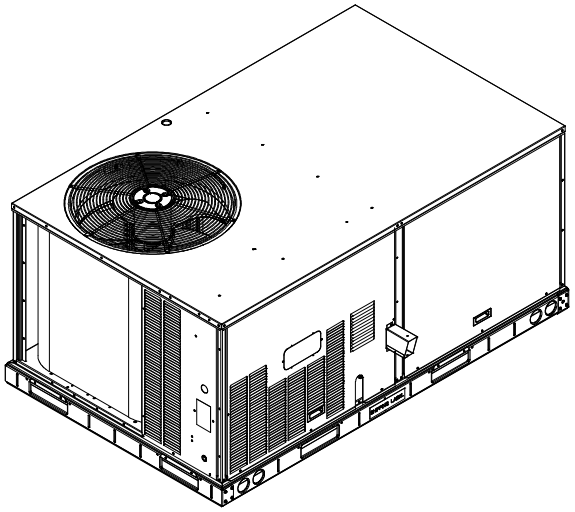
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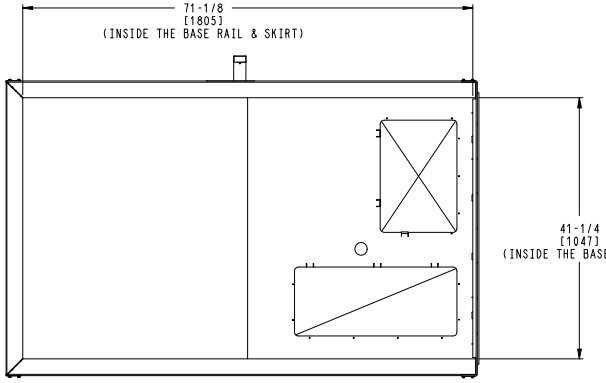
ITC CLASSIFICATION	SHEET	DATE	SUPERCEDES			REV
U.S. ECCN:NSR	2 OF 3	09/07/18	08/03/18	48GC 04-06 SINGLE PACKAGE ELECTRICAL COOLING WITH GAS HEAT	48TC003099	B

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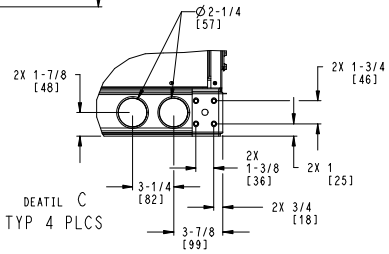
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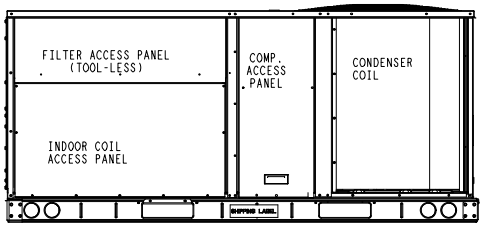




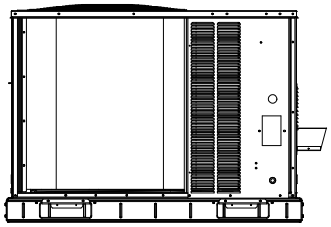
INSIDE BASERAIL DIMENSIONS

BOTTOM

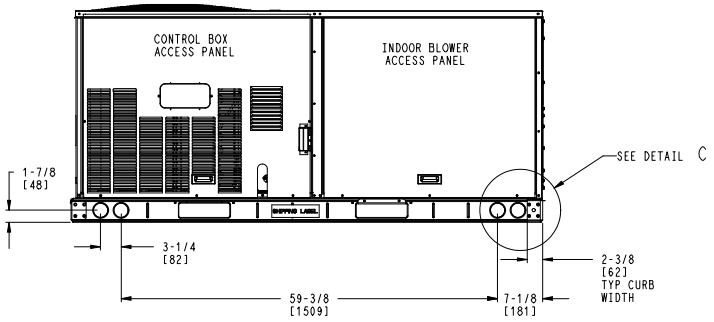




BACK



LEFT



FRONT

ITC CLASSIFICATION	SHEET	DATE	SUPERCEDES	48GC 04-06 SINGLE PACKAGE ELECTRICAL COOLING WITH GAS HEAT		REV
U.S. ECCN:NSR	3 OF 3	09/07/18	08/03/18		48TC003099	B

Part Number:48GCLM06A2Q6-3A0A0

ARI SEER:	**16.00**	
Base Unit Dimensions		
Unit Length:	**74.4**	in
Unit Width:	**46.6**	in
Unit Height:	**41.4**	in
Operating Weight		
Base Unit Weight:	**600**	lb
E-coat Al/Cu - E-coat Al/Cu - Louvered Hail Guards:	**17**	lb
SystemVu Controls:	**2**	lb
Total Operating Weight:	**619**	lb
Unit		
Unit Voltage-Phase-Hertz:	**460-3-60**	
Air Discharge:	**Vertical**	
Fan Drive Type:	**Direct**	
Actual Airflow:	**1560**	CFM
Site Altitude:	**0**	ft
Cooling Performance		
Condenser Entering Air DB:	**95.0**	F
Evaporator Entering Air DB:	**80.0**	F
Evaporator Entering Air WB:	**67.0**	F
Entering Air Enthalpy:	**31.44**	BTU/lb
Evaporator Leaving Air DB:	**55.0**	F
Evaporator Leaving Air WB:	**54.5**	F
Evaporator Leaving Air Enthalpy:	**22.85**	BTU/lb
Gross Cooling Capacity:	**60.29**	MBH
Gross Sensible Capacity:	**42.18**	MBH
Compressor Power Input:	**4.08**	kW
Coil Bypass Factor:	**0.033**	
Heating Performance		
Heating Airflow:	**1560**	CFM
Entering Air Temp:	**70.0**	F
Leaving Air Temp:	**99.1**	F
Gas Heating Input Capacity:	**60.0**	MBH
Gas Heating Output Capacity:	**49.0**	MBH
Temperature Rise:	**29.1**	F
Thermal Efficiency (%):	**81.0**	
Supply Fan		
External Static Pressure:	**1.50**	in wg
Fan RPM:	**2113**	
Fan Power:	**1.02**	BHP
NOTE:	**Selected IFM RPM Range: 239 - 2390**	
Electrical Data		
Voltage Range:	**414 - 506**	
Compressor #1 RLA:	**7.6**	
Compressor #1 LRA:	**52**	
Indoor Fan Motor Type:	**MED**	
Indoor Fan Motor FLA:	**1.9**	
Combustion Fan Motor FLA (ea):	**0.25**	
Power Supply MCA:	**13**	
Power Supply MOCP (Fuse or HACR):	**15**	
Disconnect Size FLA:	**12**	

Disconnect Size LRA: **57**
Electrical Convenience Outlet: **None**
Outdoor Fan [Qty / FLA (ea)]: **1 / 0.8**

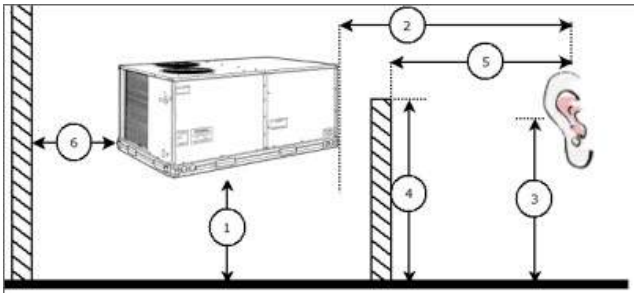
Control Panel SCCR: 5kA RMS at Rated Symmetrical Voltage

Acoustics

Sound Power Levels, db re 10E-12 Watts

	Discharge	Inlet	Outdoor
63 Hz	95.1	89.9	85.6
125 Hz	86.5	81.0	84.7
250 Hz	80.1	73.1	80.5
500 Hz	74.3	67.2	76.0
1000 Hz	71.3	68.8	72.4
2000 Hz	68.7	60.6	68.0
4000 Hz	64.6	53.9	62.8
8000 Hz	60.6	47.8	59.3
A-Weighted	78.7	73.1	79.0

Advanced Acoustics



Advanced Accoustics Parameters

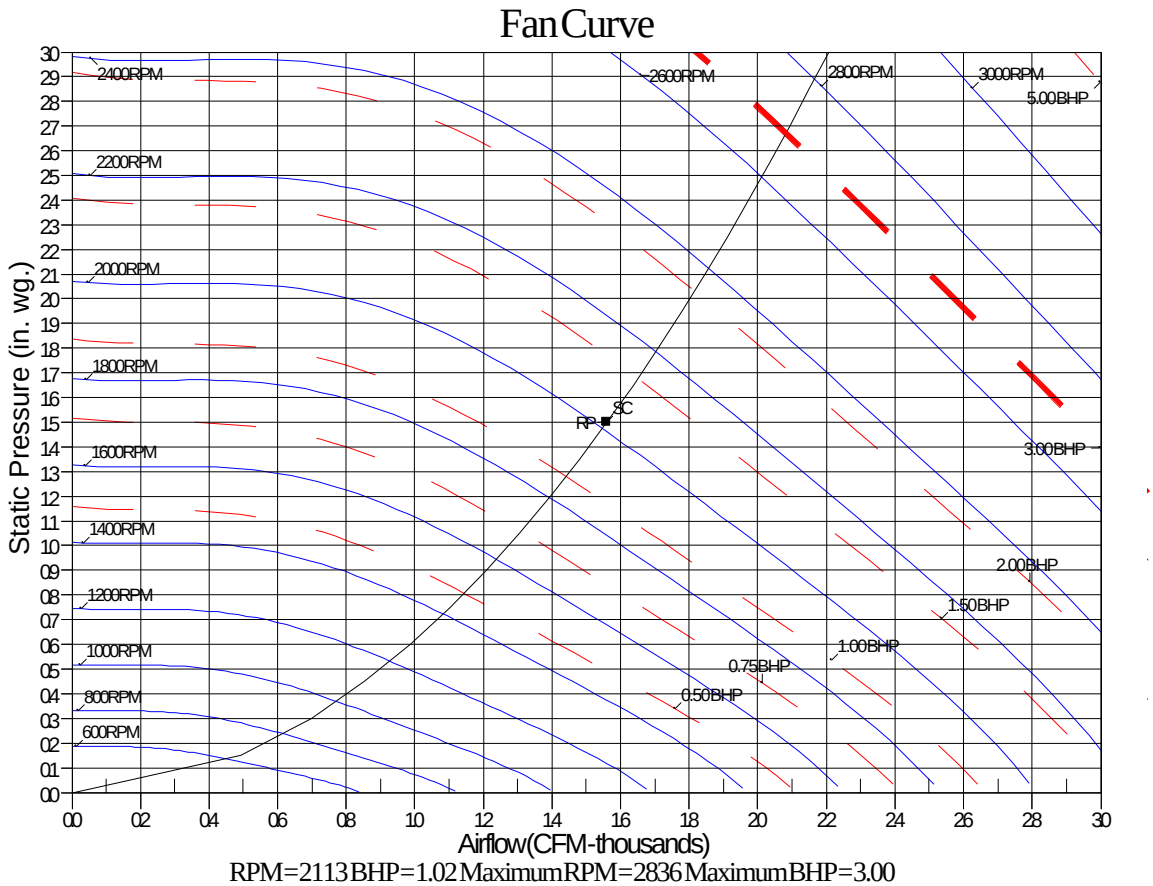
1. Unit height above ground: **30.0** ft
2. Horizontal distance from unit to receiver: **50.0** ft
3. Receiver height above ground: **5.7** ft
4. Height of obstruction: **0.0** ft
5. Horizontal distance from obstruction to receiver: **0.0** ft
6. Horizontal distance from unit to obstruction: **0.0** ft

Detailed Acoustics Information

Octave Band Center Freq. Hz	63	125	250	500	1k	2k	4k	8k	Overall
A	85.6	84.7	80.5	76.0	72.4	68.0	62.8	59.3	89.2 Lw
B	59.4	68.6	71.9	72.8	72.4	69.2	63.8	58.2	78.5 LwA
C	53.2	52.3	48.1	43.6	40.0	35.6	30.4	26.9	56.8 Lp
D	27.0	36.2	39.5	40.4	40.0	36.8	31.4	25.8	46.1 LpA

Legend
A Sound Power Levels at Unit's Acoustic Center, Lw
B A-Weighted Sound Power Levels at Unit's Acoustic Center, LwA
C Sound Pressure Levels at Specific Distance from Unit, Lp
D A-Weighted Sound Pressure Levels at Specific Distance from Unit, LpA

Calculation methods used in this program are patterned after the ASHRAE Guide; other ASHRAE Publications and the AHRI Acoustical Standards. While a very significant effort has been made to insure the technical accuracy of this program, it is assumed that the user is knowledgeable in the art of system sound estimation and is aware of the tolerances involved in real world acoustical estimation. This program makes certain assumptions as to the dominant sound sources and sound paths which may not always be appropriate to the real system being estimated. Because of this, no assurances can be offered that this software will always generate an accurate sound prediction from user supplied input data. If in doubt about the estimation of expected sound levels in a space, an Acoustical Engineer or a person with sound prediction expertise should be consulted.



RPM=2113 BHP=1.02 Maximum RPM=2836 Maximum BHP=3.00
SC-System Curve RP-Rated Point

H-93A

Tag Cover Sheet
Unit Report
Certified Drawing
Performance Report

Unit Report For H-93A

Project: 19-248 Channel Island HVAC Upgrade Building H 02/05/2020
Prepared By: 06:33PM

Unit Parameters

Unit Model: **48FCDM07A3Q6-3A0A0**
Unit Size: **07 (6 Tons)**
Volts-Phase-Hertz: **460-3-60**
Heating Type: **Gas**
Duct Cfg: **Vertical Supply / Vertical Return**
Low Heat
Single Circuit, Two Stage Cooling (07 only)

Dimensions (ft. in.) & Weight (lb.) ***

Unit Length: **6' 2.375"**
Unit Width: **3' 10.625"**
Unit Height: **3' 5.375"**
*** Total Operating Weight: **631** lb

*** Weights and Dimensions are approximate. Weight does not include unit packaging. Approximate dimensions are provided primarily for shipping purposes. For exact dimensions and weights, refer to appropriate product data catalog.

Lines and Filters

Return Air Filter Type: **Throwaway**
Return Air Filter Quantity: **4**
Return Air Filter Size: **16 x 16 x 2**

Unit Configuration

Direct Drive - EcoBlue - High Static
E-coat Al/Cu - E-coat Al/Cu - Louvered Hail Guards
SystemVu Controls
Standard Packaging

Warranty Information

1-Year parts(std.)
5-Year compressor parts(std.)
10-Year heat exchanger - Aluminized(std.)

No optional warranties were selected.

NOTE: Please see Warranty Catalog 500-089 for explanation of policies and ordering methods.

Ordering Information

Part Number	Description	Quantity
48FCDM07A3Q6-3A0A0	Rooftop Unit	1
	Base Unit	
	Direct Drive - EcoBlue - High Static	
	E-coat Al/Cu - E-coat Al/Cu - Louvered Hail Guards	
	SystemVu controller, No intake or exhaust option. SystemVu controller meets California Title 24 Sect	

NOTES:

1. DIMENSIONS ARE IN INCHES, DIMENSIONS IN [ ] ARE IN MILLIMETERS.
2. CENTER OF GRAVITY
3. DIRECTION OF AIR FLOW
4. ALL VIEW DRAWN USING 3RD ANGLE

UNIT	J	K
48FC**04	33 3/8 [847]	18 5/8 [472]
48FC**05	33 3/8 [847]	14 7/8 [377]
48FC**06	33 3/8 [847]	14 7/8 [377]
48FC**07	41 3/8 [1051]	18 5/8 [472]

Carrier United Technologies

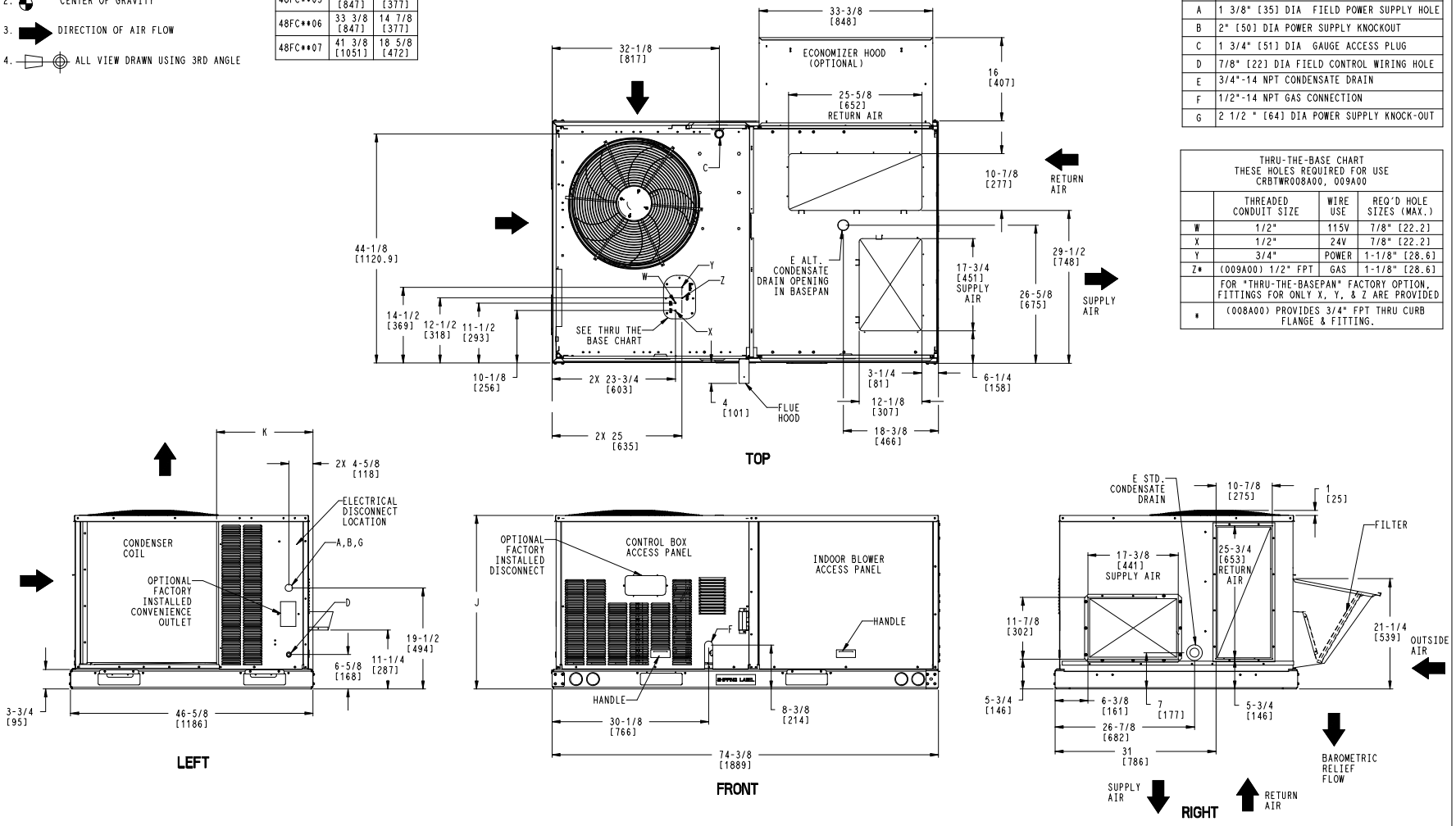
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SUBMISSION OF THESE DRAWINGS OR DOCUMENTS DOES NOT CONSTITUTE PART PERFORMANCE OR ACCEPTANCE OF CONTRACT.

	CONNECTION SIZES
A	1 3/8" [35] DIA FIELD POWER SUPPLY HOLE
B	2" [50] DIA POWER SUPPLY KNOCKOUT
C	1 3/4" [51] DIA GAUGE ACCESS PLUG
D	7/8" [22] DIA FIELD CONTROL WIRING HOLE
E	3/4"-14 NPT CONDENSATE DRAIN
F	1/2"-14 NPT GAS CONNECTION
G	2 1/2 " [64] DIA POWER SUPPLY KNOCK-OUT

THRU-THE-BASE CHART
THESE HOLES REQUIRED FOR USE CRBTWR008A00, 009A00

	THREADED CONDUIT SIZE	WIRE USE	REQ'D HOLE SIZES (MAX.)
W	1/2"	115V	7/8" [22.2]
X	1/2"	24V	7/8" [22.2]
Y	3/4"	POWER	1-1/8" [28.6]
Z*	(009A00) 1/2" FPT	GAS	1-1/8" [28.6]
	FOR "THRU-THE-BASEPAN" FACTORY OPTION, FITTINGS FOR ONLY X, Y, & Z ARE PROVIDED		
*	(008A00) PROVIDES 3/4" FPT THRU CURB FLANGE & FITTING.		



ITC CLASSIFICATION	SHEET	DATE	SUPERCEDES			REV
U.S. ECCN:NSR	1 OF 3	09/07/18	06/22/18	48FC 04-07 SINGLE PACKAGE ELECTRICAL COOLING WITH GAS HEAT	48TC003093	A

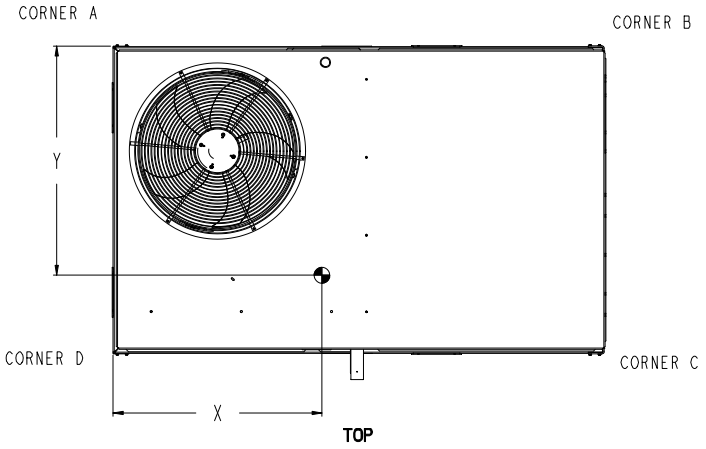
UNIT	STD. UNIT WEIGHT *		CORNER WEIGHT (A)		CORNER WEIGHT (B)		CORNER WEIGHT (C)		CORNER WEIGHT (D)		C.G.		HEIGHT
	LBS.	KG.	LBS.	KG.	LBS.	KG.	LBS.	KG.	LBS.	KG.	X	Y	Z
48FC**04	482	219	113	51	116	53	128	58	125	57	37 5/8 [956]	24 9/16 [624]	18 1/4 [464]
48FC**05	543	246	138	63	133	60	133	60	138	63	36 1/2 [927]	23 3/8 [594]	18 [457]
48FC**06	556	252	142	64	136	62	136	62	142	64	36 1/2 [927]	23 3/8 [594]	18 [457]
48FC**07	607	275	162	73	152	69	141	64	151	68	36 [914]	22 1/2 [572]	19 3/8 [492]

* STANDARD UNIT WEIGHT IS WITH LOW GAS HEAT AND WITHOUT PACKAGING.
FOR OTHER OPTIONS AND ACCESSORIES, REFER TO THE PRODUCT DATA CATALOG.

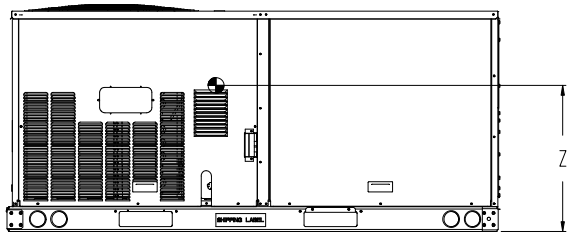
Carrier
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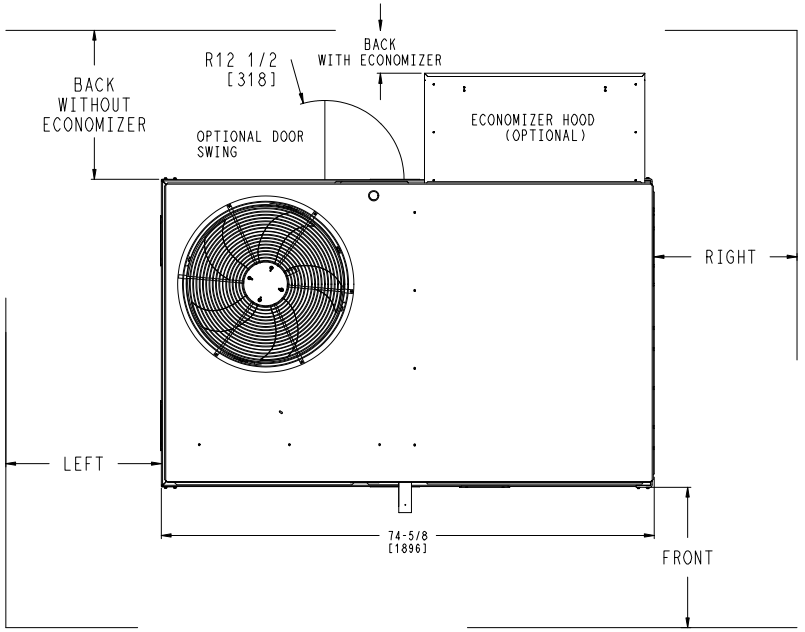
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TOP



FRONT



NOTES:

1. FOR ALL MINIMUM CLEARANCES LOCAL CODES OR JURISDICTIONS MAY PREVAIL.

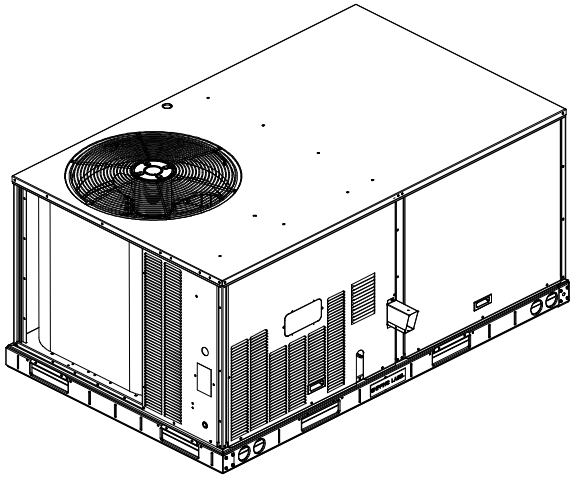
	CLEARANCE		
	SERVICE WITH:	SERVICE WITH:	OPERATING
SURFACE	CONDUCTIVE BARRIER	NONCONDUCTIVE BARRIER	CLEARANCE
FRONT	48 [1219mm]	36 [914mm]	18 [457mm]
LEFT	48 [1219mm]	42 [1067mm]	18 [457mm]
BACK	48 [1219mm]	42 [1067mm]	18 [457mm]
BACK W/HOOD	36 [914mm]	36 [914mm]	18 [457mm]
RIGHT	36 [914mm]	36 [914mm]	18 [457mm]
TOP	72 [1829mm]	72 [1829mm]	72 [1829mm]

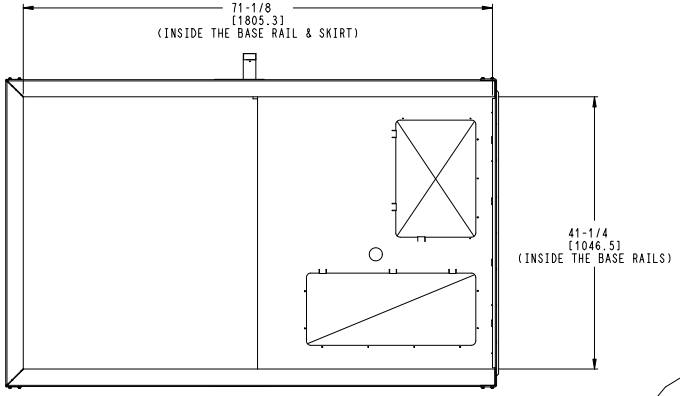
ITC CLASSIFICATION	SHEET	DATE	SUPERCEDES			REV
U.S. ECCN:NSR	2 OF 3	09/07/18	06/22/18	48FC 04-07 SINGLE PACKAGE ELECTRICAL COOLING WITH GAS HEAT	48TC003093	A

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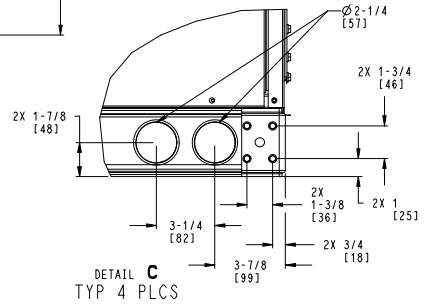
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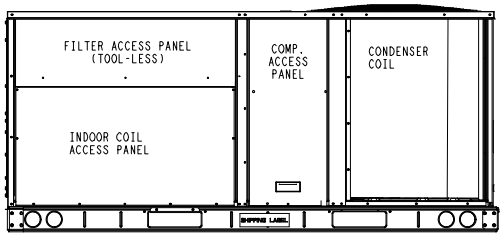


INSIDE BASERAIL DIMENSIONS

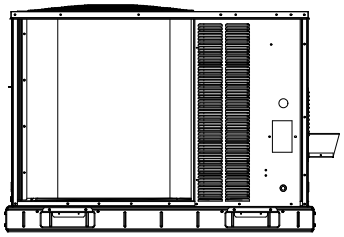
BOTTOM



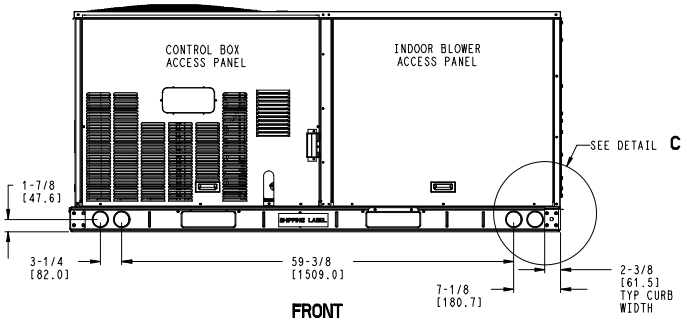
DETAIL **C**
TYP 4 PLCS



BACK



LEFT



FRONT

ITC CLASSIFICATION	SHEET	DATE	SUPERCEDES			REV
U.S. ECCN:NSR	3 OF 3	09/07/18	06/22/18	48FC 04-07 SINGLE PACKAGE ELECTRICAL COOLING WITH GAS HEAT	48TC003093	A

Part Number:48FCDM07A3Q6-3A0A0

ARI EER:	**11.00**	
IEER:	**15.0**	

Base Unit Dimensions

Unit Length:	**74.4**	in
Unit Width:	**46.6**	in
Unit Height:	**41.4**	in

Operating Weight

Base Unit Weight:	**607**	lb
Direct Drive - EcoBlue - High Static:	**5**	lb
E-coat Al/Cu - E-coat Al/Cu - Louvered Hail Guards:	**17**	lb
SystemVu Controls:	**2**	lb
Total Operating Weight:	**631**	lb

Unit

Unit Voltage-Phase-Hertz:	**460-3-60**	
Air Discharge:	**Vertical**	
Fan Drive Type:	**Direct**	
Actual Airflow:	**2720**	CFM
Site Altitude:	**0**	ft

Cooling Performance

Condenser Entering Air DB:	**95.0**	F
Evaporator Entering Air DB:	**80.0**	F
Evaporator Entering Air WB:	**67.0**	F
Entering Air Enthalpy:	**31.44**	BTU/lb
Evaporator Leaving Air DB:	**59.8**	F
Evaporator Leaving Air WB:	**58.6**	F
Evaporator Leaving Air Enthalpy:	**25.44**	BTU/lb
Gross Cooling Capacity:	**73.44**	MBH
Gross Sensible Capacity:	**59.33**	MBH
Compressor Power Input:	**5.30**	kW
Coil Bypass Factor:	**0.110**	

Heating Performance

Heating Airflow:	**2720**	CFM
Entering Air Temp:	**70.0**	F
Leaving Air Temp:	**88.4**	F
Gas Heating Input Capacity:	**67.0**	MBH
Gas Heating Output Capacity:	**54.0**	MBH
Temperature Rise:	**18.4**	F
Thermal Efficiency (%):	**81.0**	

Supply Fan

External Static Pressure:	**1.50**	in wg
Fan RPM:	**2787**	
Fan Power:	**2.30**	BHP
NOTE:	**Selected IFM RPM Range: 284 - 2836**	

Electrical Data

Voltage Range:	**414 - 506**
Compressor #1 RLA:	**8.4**
Compressor #1 LRA:	**66**
Indoor Fan Motor Type:	**HIGH**
Indoor Fan Motor FLA:	**2.9**
Combustion Fan Motor FLA (ea):	**0.25**
Power Supply MCA:	**15**

Power Supply MOCP (Fuse or HACR): **20**
Disconnect Size FLA: **14**
Disconnect Size LRA: **72**
Electrical Convenience Outlet: **None**
Outdoor Fan [Qty / FLA (ea)]: **1 / 0.8**

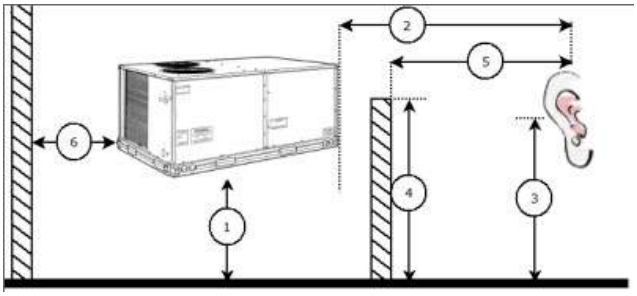
Control Panel SCCR: 5kA RMS at Rated Symmetrical Voltage

Acoustics

Sound Power Levels, db re 10E-12 Watts

	Discharge	Inlet	Outdoor
63 Hz	96.4	91.9	85.6
125 Hz	88.9	85.8	84.7
250 Hz	83.4	75.0	80.5
500 Hz	80.7	73.8	76.0
1000 Hz	78.6	74.8	72.4
2000 Hz	77.0	66.9	68.0
4000 Hz	70.4	59.0	62.8
8000 Hz	64.1	53.3	59.3
A-Weighted	84.3	78.2	79.0

Advanced Acoustics



Advanced Accoustics Parameters

1. Unit height above ground: **30.0** ft
2. Horizontal distance from unit to receiver: **50.0** ft
3. Receiver height above ground: **5.7** ft
4. Height of obstruction: **0.0** ft
5. Horizontal distance from obstruction to receiver: **0.0** ft
6. Horizontal distance from unit to obstruction: **0.0** ft

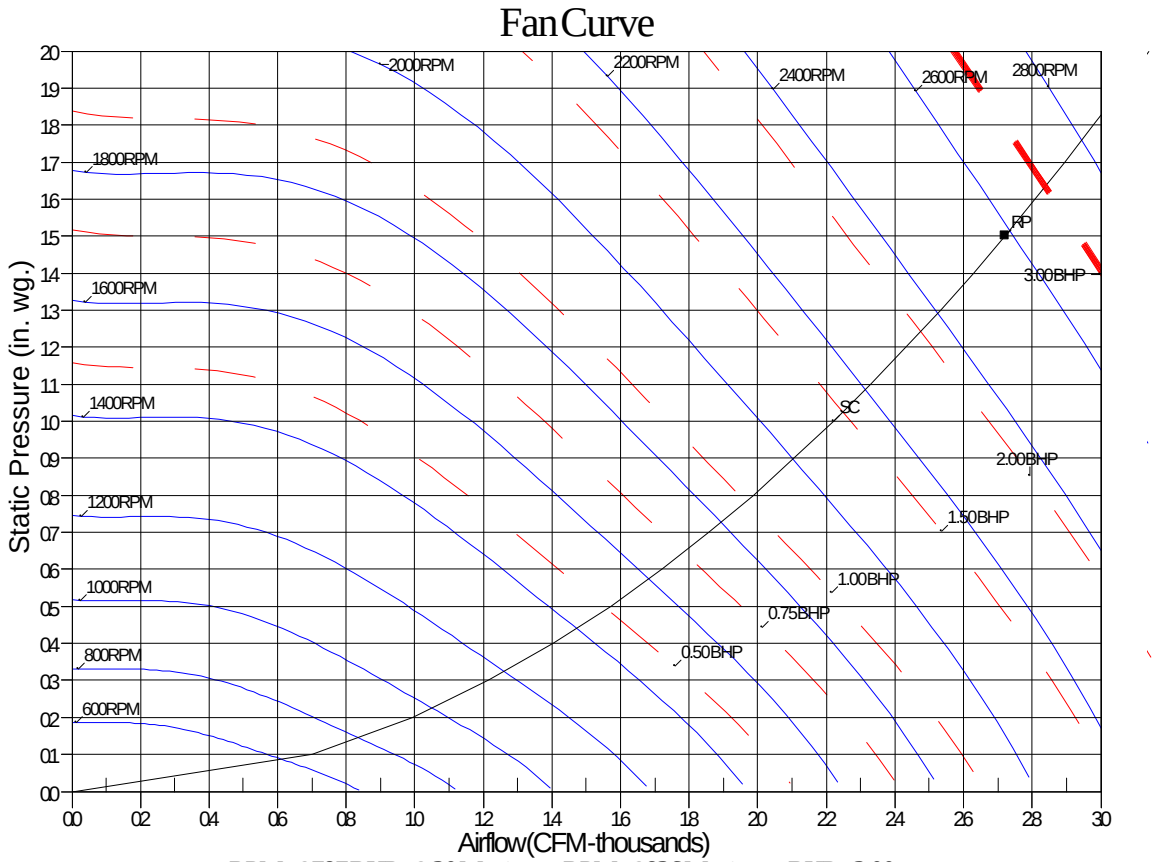
Detailed Acoustics Information

Octave Band Center Freq. Hz	63	125	250	500	1k	2k	4k	8k	Overall
A	85.6	84.7	80.5	76.0	72.4	68.0	62.8	59.3	89.2 Lw
B	59.4	68.6	71.9	72.8	72.4	69.2	63.8	58.2	78.5 LwA
C	53.2	52.3	48.1	43.6	40.0	35.6	30.4	26.9	56.8 Lp
D	27.0	36.2	39.5	40.4	40.0	36.8	31.4	25.8	46.1 LpA

Legend
A Sound Power Levels at Unit's Acoustic Center, Lw
B A-Weighted Sound Power Levels at Unit's Acoustic Center, LwA

C Sound Pressure Levels at Specific Distance from Unit, Lp
D A-Weighted Sound Pressure Levels at Specific Distance from Unit, LpA

Calculation methods used in this program are patterned after the ASHRAE Guide; other ASHRAE Publications and the AHRI Acoustical Standards. While a very significant effort has been made to insure the technical accuracy of this program, it is assumed that the user is knowledgeable in the art of system sound estimation and is aware of the tolerances involved in real world acoustical estimation. This program makes certain assumptions as to the dominant sound sources and sound paths which may not always be appropriate to the real system being estimated. Because of this, no assurances can be offered that this software will always generate an accurate sound prediction from user supplied input data. If in doubt about the estimation of expected sound levels in a space, an Acoustical Engineer or a person with sound prediction expertise should be consulted.



RPM=2787 BHP=2.30 Maximum RPM=2836 Maximum BHP=3.00
SC-System Curve RP-Rated Point

E-90

Tag Cover Sheet
Unit Report
Certified Drawing
Performance Report

Unit Report For E-90

Project: 19-248 Channel Island HVAC Upgrade Building E 02/05/2020
Prepared By: 05:51PM

Unit Parameters

Unit Model: **48LCD008A2Q6-4A0A0**
Unit Size: **08 (7.5 Tons)**
Volts-Phase-Hertz: **460-3-60**
Heating Type: **Gas**
Duct Cfg: **Vertical Supply / Vertical Return**
Low Gas Heat
Three stage cooling capacity control with TXV

Dimensions (ft. in.) & Weight (lb.) ***

Unit Length: **9' 7.875"**
Unit Width: **5' 3.375"**
Unit Height: **4' 10.75"**
*** Total Operating Weight: **1696** lb

*** Weights and Dimensions are approximate. Weight does not include unit packaging. Approximate dimensions are provided primarily for shipping purposes. For exact dimensions and weights, refer to appropriate product data catalog.

Unit Configuration

Medium Static Belt Drive with VFD Controller
E-coat Al/Cu - E-coat Al/Cu - Louvered Hail Guards
SystemVu Unit Controller and system building automation
Standard Packaging

Warranty Information

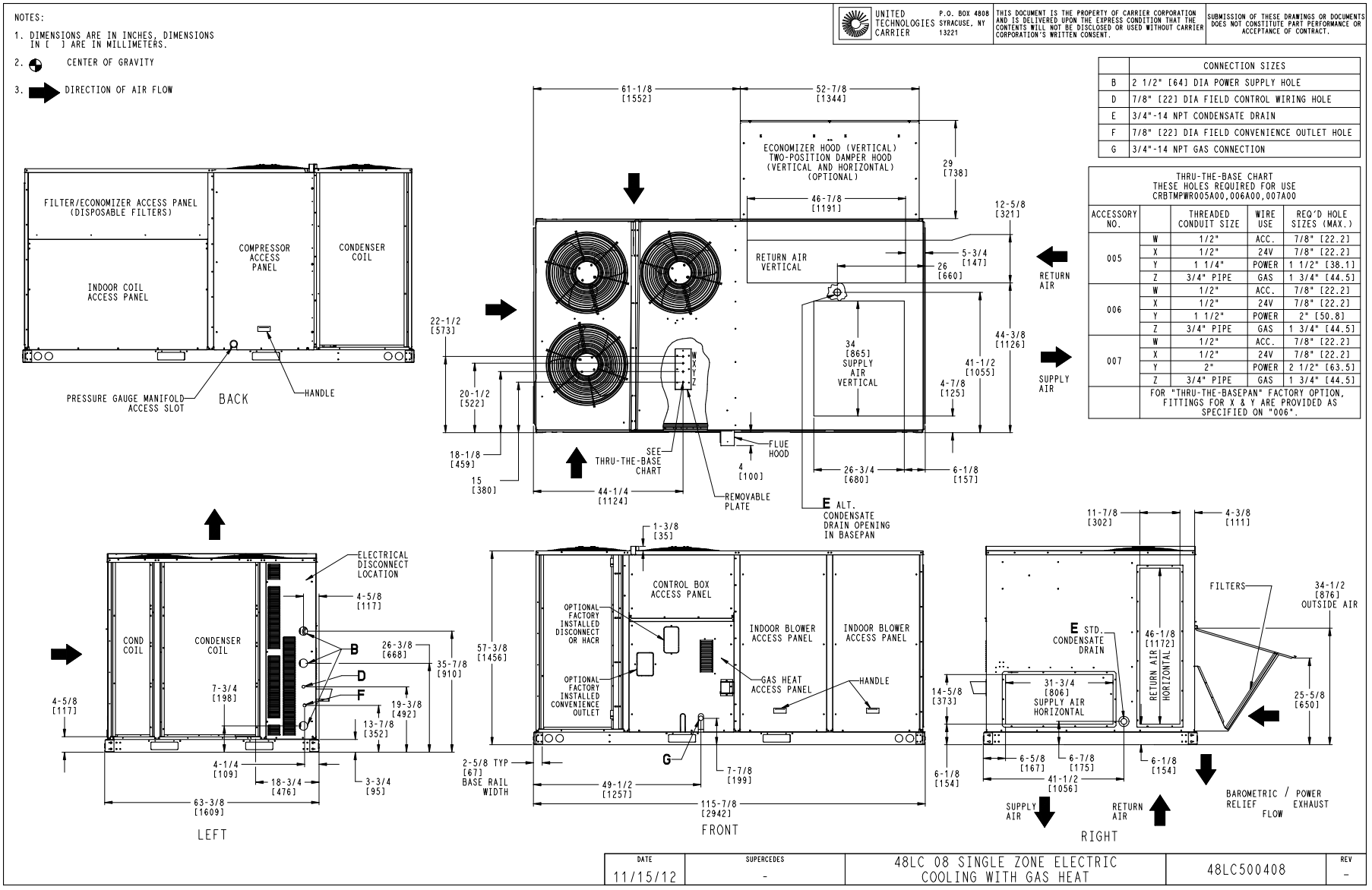
1-Year parts
5-Year compressor parts
10-Year heat exchanger - Aluminized

No optional warranties were selected.

NOTE: Please see Warranty Catalog 500-089 for explanation of policies and ordering methods.

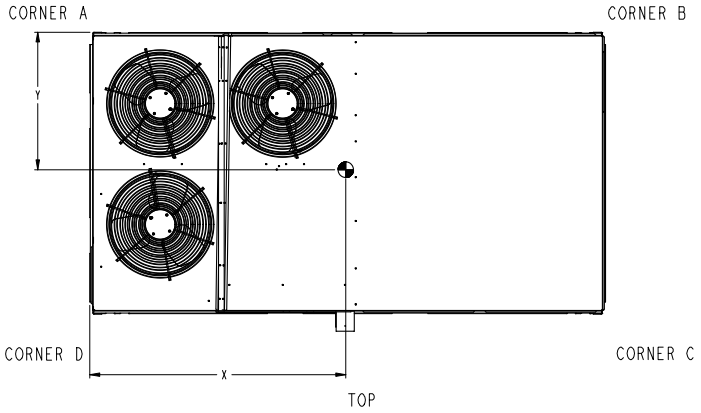
Ordering Information

Part Number	Description	Quantity
48LCD008A2Q6-4A0A0	Rooftop Unit	1
	Base Unit	
	Medium Static Belt Drive with VFD Controller	
	E-coat Al/Cu - E-coat Al/Cu - Louvered Hail Guards	
	SystemVu Controls. SystemVu meets Calf. Title 24 FDD	

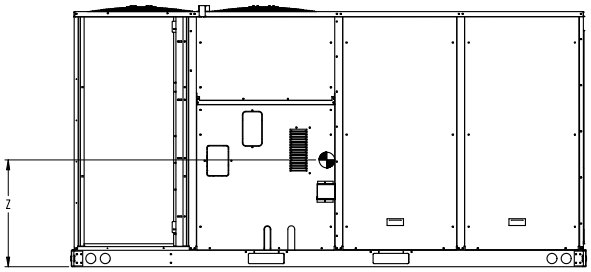

NOTES:
1. DIMENSIONS ARE IN INCHES, DIMENSIONS IN [ ] ARE IN MILLIMETERS.
2. CENTER OF GRAVITY
3. DIRECTION OF AIR FLOW
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CONNECTION SIZES
B 2 1/2" [64] DIA POWER SUPPLY HOLE
D 7/8" [22] DIA FIELD CONTROL WIRING HOLE
E 3/4"-14 NPT CONDENSATE DRAIN
F 7/8" [22] DIA FIELD CONVENIENCE OUTLET HOLE
G 3/4"-14 NPT GAS CONNECTION
THRU-THE-BASE CHART
THESE HOLES REQUIRED FOR USE CRBTMPWR005A00,006A00,007A00
ACCESSORY NO. | | THREADED CONDUIT SIZE | WIRE USE | REQ'D HOLE SIZES (MAX.)
005 W 1/2" ACC. 7/8" [22.2]
X 1/2" 24V 7/8" [22.2]
Y 1 1/4" POWER 1 1/2" [38.1]
Z 3/4" PIPE GAS 1 3/4" [44.5]
006 W 1/2" ACC. 7/8" [22.2]
X 1/2" 24V 7/8" [22.2]
Y 1 1/2" POWER 2" [50.8]
Z 3/4" PIPE GAS 1 3/4" [44.5]
007 W 1/2" ACC. 7/8" [22.2]
X 1/2" 24V 7/8" [22.2]
Y 2" POWER 2 1/2" [63.5]
Z 3/4" PIPE GAS 1 3/4" [44.5]
FOR "THRU-THE-BASEPAN" FACTORY OPTION, FITTINGS FOR X & Y ARE PROVIDED AS SPECIFIED ON "006".
FILTER/ECONOMIZER ACCESS PANEL (DISPOSABLE FILTERS)
INDOOR COIL ACCESS PANEL
COMPRESSOR ACCESS PANEL
CONDENSER COIL
PRESSURE GAUGE MANIFOLD ACCESS SLOT
HANDLE
BACK
61-1/8 [1552]
52-7/8 [1344]
ECONOMIZER HOOD (VERTICAL) TWO-POSITION DAMPER HOOD (VERTICAL AND HORIZONTAL) (OPTIONAL)
29 [738]
46-7/8 [1191]
12-5/8 [321]
RETURN AIR VERTICAL
5-3/4 [147]
26 [660]
RETURN AIR
22-1/2 [573]
34 [865] SUPPLY AIR VERTICAL
44-3/8 [1126]
41-1/2 [1055]
4-7/8 [125]
SUPPLY AIR
20-1/2 [522]
18-1/8 [459]
15 [380]
SEE THRU-THE-BASE CHART
FLUE HOOD
4 [100]
44-1/4 [1124]
REMOVABLE PLATE
26-3/4 [680]
6-1/8 [157]
E ALT. CONDENSATE DRAIN OPENING IN BASEPAN
ELECTRICAL DISCONNECT LOCATION
4-5/8 [117]
COND COIL
CONDENSER COIL
B
C
D
F
26-3/8 [668]
35-7/8 [910]
7-3/4 [198]
19-3/8 [492]
13-7/8 [352]
4-5/8 [117]
4-1/4 [109]
18-3/4 [476]
3-3/4 [95]
63-3/8 [1609]
LEFT
1-3/8 [35]
CONTROL BOX ACCESS PANEL
INDOOR BLOWER ACCESS PANEL
INDOOR BLOWER ACCESS PANEL
OPTIONAL FACTORY INSTALLED DISCONNECT OR HACR
OPTIONAL FACTORY INSTALLED CONVENIENCE OUTLET
GAS HEAT ACCESS PANEL
HANDLE
57-3/8 [1456]
G
2-5/8 TYP [67] BASE RAIL WIDTH
7-7/8 [199]
49-1/2 [1257]
115-7/8 [2942]
FRONT
11-7/8 [302]
4-3/8 [111]
FILTERS
34-1/2 [876] OUTSIDE AIR
E STD. CONDENSATE DRAIN
46-1/8 [1172]
RETURN AIR HORIZONTAL
14-5/8 [373]
31-3/4 [806] SUPPLY AIR HORIZONTAL
25-5/8 [650]
6-1/8 [154]
6-5/8 [167]
6-7/8 [175]
6-1/8 [154]
41-1/2 [1056]
SUPPLY AIR
RETURN AIR
BAROMETRIC RELIEF / POWER EXHAUST FLOW
RIGHT
DATE 11/15/12
SUPERCEDES -
48LC 08 SINGLE ZONE ELECTRIC COOLING WITH GAS HEAT
48LC500408
REV -

UNIT	STD UNIT WEIGHT		CORNER WEIGHT (A)		CORNER WEIGHT (B)		CORNER WEIGHT (C)		CORNER WEIGHT (D)		C.G.		
	LBS.	KG.	LBS.	KG.	LBS.	KG.	LBS.	KG.	LBS.	KG.	X	Y	Z
48LC 08	1606	728	426	193	415	188	377	171	387	176	57 [1448]	33 [838]	20 5/8 [525]

STANDARD UNIT WEIGHT IS WITH LOW GAS HEAT & WITHOUT PACKAGING.
FOR OPTIONS & ACCESSORIES, REFER TO THE PRODUCT DATA CATALOG.



TOP

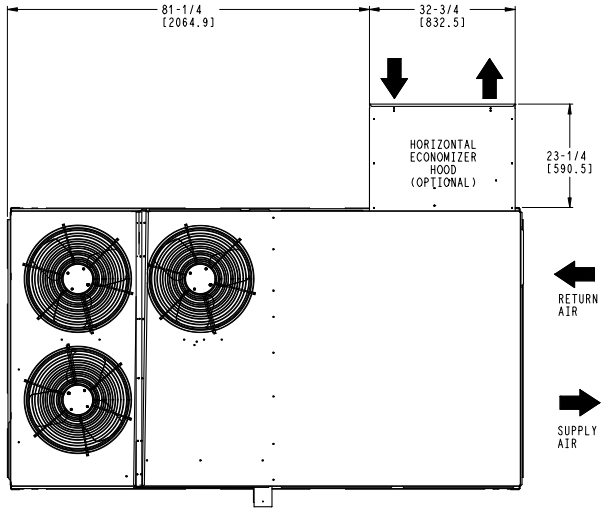


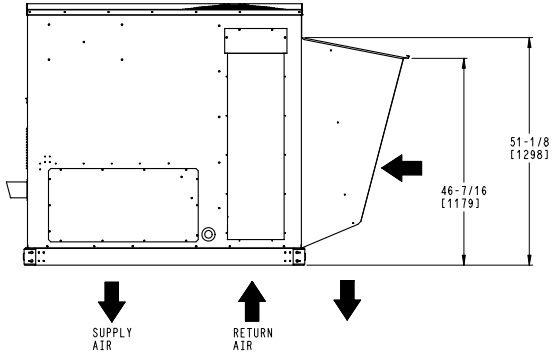
FRONT

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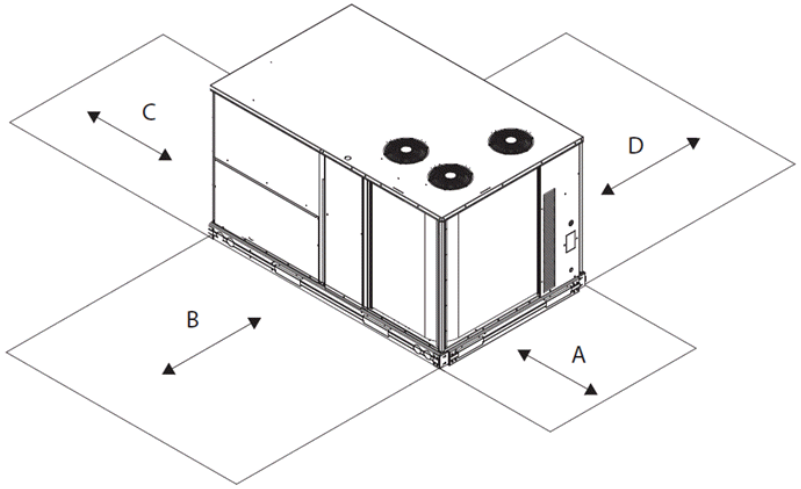


HORIZONTAL ECONOMIZER

DATE	SUPERCEDES		
11/15/12	-	48LC 08 SINGLE ZONE ELECTRIC COOLING WITH GAS HEAT	48LC500408

REV -

Service Clearance



C1057B

LOCATION	DIMENSION	CONDITION
A	48-in (1219 mm)	• Unit disconnect is mounted on panel
	18-in (457 mm)	• No disconnect, convenience outlet option • Recommended service clearance
	12-in (305 mm)	• Minimum clearance
B	42-in (1067 mm)	• Surface behind servicer is grounded (e.g., metal, masonry wall)
	36-in (914 mm)	• Surface behind servicer is electrically non-conductive (e.g., wood, fiberglass)
	Special	• Check for sources of flue products within 10-ft of unit fresh air intake hood
C	36-in (914 mm)	• Side condensate drain is used
	18-in (457 mm)	• Minimum clearance
D	48-in (1219 mm)	• No flue discharge accessory installed, surface is combustible material
	42-in (1067 mm)	• Surface behind servicer is grounded (e.g., metal, masonry wall, another unit)
	36-in (914 mm)	• Surface behind servicer is electrically non-conductive (e.g., wood, fiberglass)
	Special	• Check for adjacent units or building fresh air intakes within 10-ft of this unit's flue outlet

NOTE: Unit not designed to have overhead obstruction. Contact Application Engineering for guidance on any application planning overhead obstruction or vertical clearances.

Chassis 5

Part Number:48LCD008A2Q6-4A0A0

ARI EER:	**12.80**	
IEER:	**19.0**	

Base Unit Dimensions

Unit Length:	**115.9**	in
Unit Width:	**63.4**	in
Unit Height:	**58.8**	in

Operating Weight

Base Unit Weight:	**1606**	lb
Medium Static Belt Drive with VFD Controller:	**45**	lb
E-coat Al/Cu - E-coat Al/Cu - Louvered Hail Guards:	**45**	lb
Total Operating Weight:	**1696**	lb

Unit

Unit Voltage-Phase-Hertz:	**460-3-60**	
Air Discharge:	**Vertical**	
Fan Drive Type:	**Belt**	
Actual Airflow:	**2110**	CFM
Site Altitude:	**0**	ft

Cooling Performance

Condenser Entering Air DB:	**95.0**	F
Evaporator Entering Air DB:	**80.0**	F
Evaporator Entering Air WB:	**67.0**	F
Entering Air Enthalpy:	**31.44**	BTU/lb
Evaporator Leaving Air DB:	**55.3**	F
Evaporator Leaving Air WB:	**53.6**	F
Evaporator Leaving Air Enthalpy:	**22.34**	BTU/lb
Gross Cooling Capacity:	**86.42**	MBH
Gross Sensible Capacity:	**56.39**	MBH
Compressor Power Input:	**5.77**	kW
Coil Bypass Factor:	**0.003**	

Heating Performance

Heating Airflow:	**2110**	CFM
Entering Air Temp:	**70.0**	F
Leaving Air Temp:	**122.7**	F
Gas Heating Input Capacity:	**120.0 / 150.0**	MBH
Gas Heating Output Capacity:	**96.0 / 120.0**	MBH
Temperature Rise:	**52.7**	F
Thermal Efficiency (%):	**80.0**	

Supply Fan

External Static Pressure:	**1.50**	in wg
Fan RPM:	**812**	
Fan Power:	**2.18**	BHP
NOTE:	**The Selected Indoor Fan Motor requires a Field-Supplied Drive (RPM Range: 547 - 757).**	

Electrical Data

Voltage Range:	**414 - 506**
Compressor #1 RLA:	**6**
Compressor #1 LRA:	**44**
Compressor #2 RLA:	**6.2**
Compressor #2 LRA:	**41**
Indoor Fan Motor Type:	**MED**
Indoor Fan Motor FLA:	**3.8**
Combustion Fan Motor FLA (ea):	**0.25**

Power Supply MCA: **23**
Power Supply MOCP (Fuse or HACR): **25**
Disconnect Size FLA: **25**
Disconnect Size LRA: **104**
Electrical Convenience Outlet: **None**
Outdoor Fan [Qty / FLA (ea)]: **3 / 1.8**

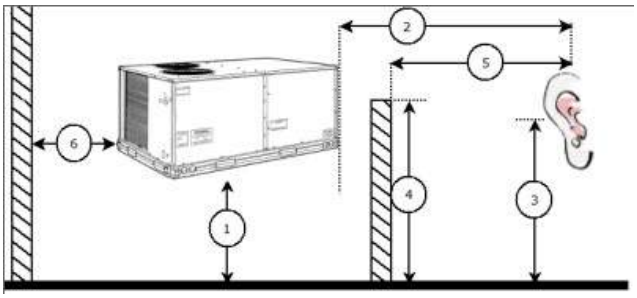
Control Panel SCCR: 5kA RMS at Rated Symmetrical Voltage

Acoustics

Sound Power Levels, db re 10E-12 Watts

	Discharge	Inlet	Outdoor
63 Hz	100.7	99.0	89.3
125 Hz	90.3	88.5	86.0
250 Hz	78.9	81.4	82.9
500 Hz	69.3	68.7	80.7
1000 Hz	68.0	65.8	78.5
2000 Hz	68.7	60.0	73.6
4000 Hz	67.3	59.4	69.6
8000 Hz	73.5	59.5	64.5
A-Weighted	80.4	78.2	83.0

Advanced Acoustics



Advanced Accoustics Parameters

1. Unit height above ground: **30.0** ft
2. Horizontal distance from unit to receiver: **50.0** ft
3. Receiver height above ground: **5.7** ft
4. Height of obstruction: **0.0** ft
5. Horizontal distance from obstruction to receiver: **0.0** ft
6. Horizontal distance from unit to obstruction: **0.0** ft

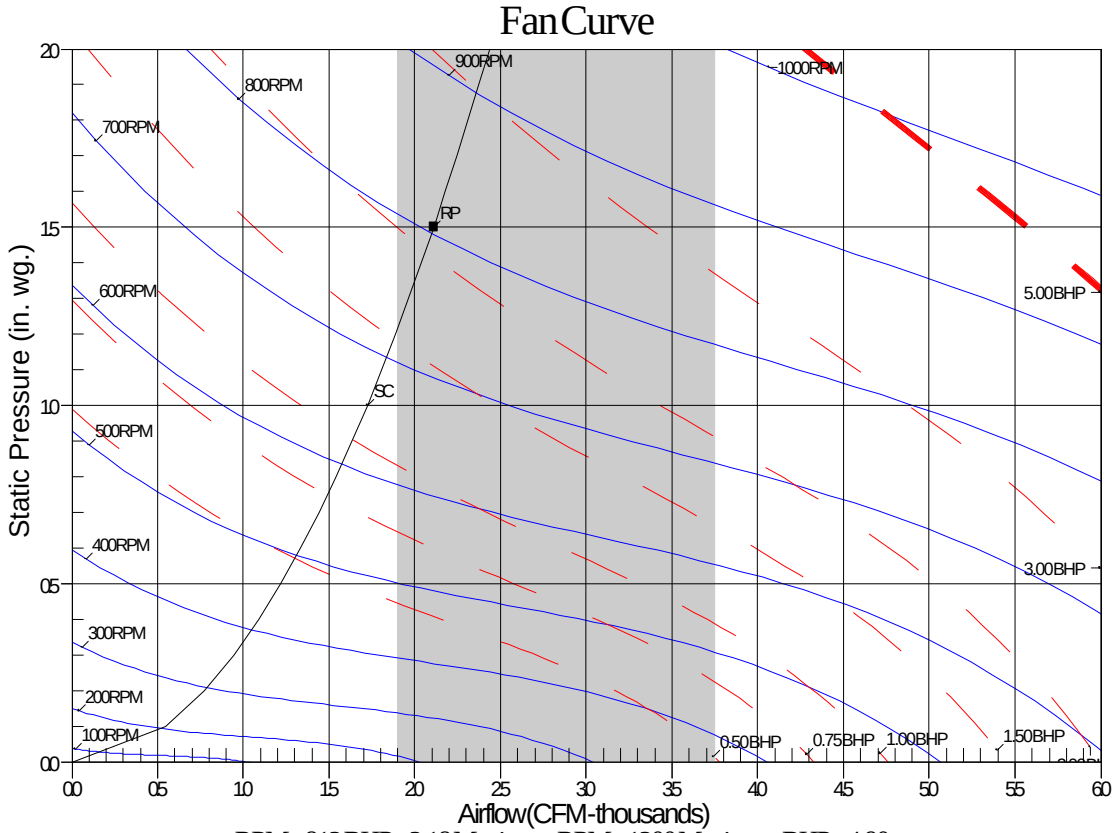
Detailed Acoustics Information

Octave Band Center Freq. Hz	63	125	250	500	1k	2k	4k	8k	Overall
A	89.3	86.0	82.9	80.7	78.5	73.6	69.6	64.5	92.2 Lw
B	63.1	69.9	74.3	77.5	78.5	74.8	70.6	63.4	83.2 LwA
C	56.9	53.6	50.5	48.3	46.1	41.2	37.2	32.1	59.8 Lp
D	30.7	37.5	41.9	45.1	46.1	42.4	38.2	31.0	50.8 LpA

Legend
A Sound Power Levels at Unit's Acoustic Center, Lw

B A-Weighted Sound Power Levels at Unit's Acoustic Center, LwA
C Sound Pressure Levels at Specific Distance from Unit, Lp
D A-Weighted Sound Pressure Levels at Specific Distance from Unit, LpA

Calculation methods used in this program are patterned after the ASHRAE Guide; other ASHRAE Publications and the AHRI Acoustical Standards. While a very significant effort has been made to insure the technical accuracy of this program, it is assumed that the user is knowledgeable in the art of system sound estimation and is aware of the tolerances involved in real world acoustical estimation. This program makes certain assumptions as to the dominant sound sources and sound paths which may not always be appropriate to the real system being estimated. Because of this, no assurances can be offered that this software will always generate an accurate sound prediction from user supplied input data. If in doubt about the estimation of expected sound levels in a space, an Acoustical Engineer or a person with sound prediction expertise should be consulted.



RPM=812 BHP=2.18 Maximum RPM=1200 Maximum BHP=4.90
Note: Please contact application engineering for selections outside the shaded region.
SC-System Curve RP-Rated Point

Unit Report For P-01A, 01B

Project: 19-248 Channel Island HVAC Upgrade BLDG N 02/05/2020
Prepared By: 07:06PM

Unit Parameters

Unit Model: **48LCD014A2Q6-4A0A0**
Unit Size: **14 (12.5 Tons)**
Volts-Phase-Hertz: **460-3-60**
Heating Type: **Gas**
Duct Cfg: **Vertical Supply / Vertical Return**
Low Gas Heat
Three stage cooling capacity control with TXV

Dimensions (ft. in.) & Weight (lb.) ***

Unit Length: **10' 7.875"**
Unit Width: **7' 2.375"**
Unit Height: **4' 2.5"**
*** Total Operating Weight: **1918** lb

*** Weights and Dimensions are approximate. Weight does not include unit packaging. Approximate dimensions are provided primarily for shipping purposes. For exact dimensions and weights, refer to appropriate product data catalog.

Unit Configuration

Medium Static Option - Vertical Models with VFD controller
E-coat Al/Cu - E-coat Al/Cu - Louvered Hail Guards
SystemVu Controller and system building automation
Standard Packaging

Warranty Information

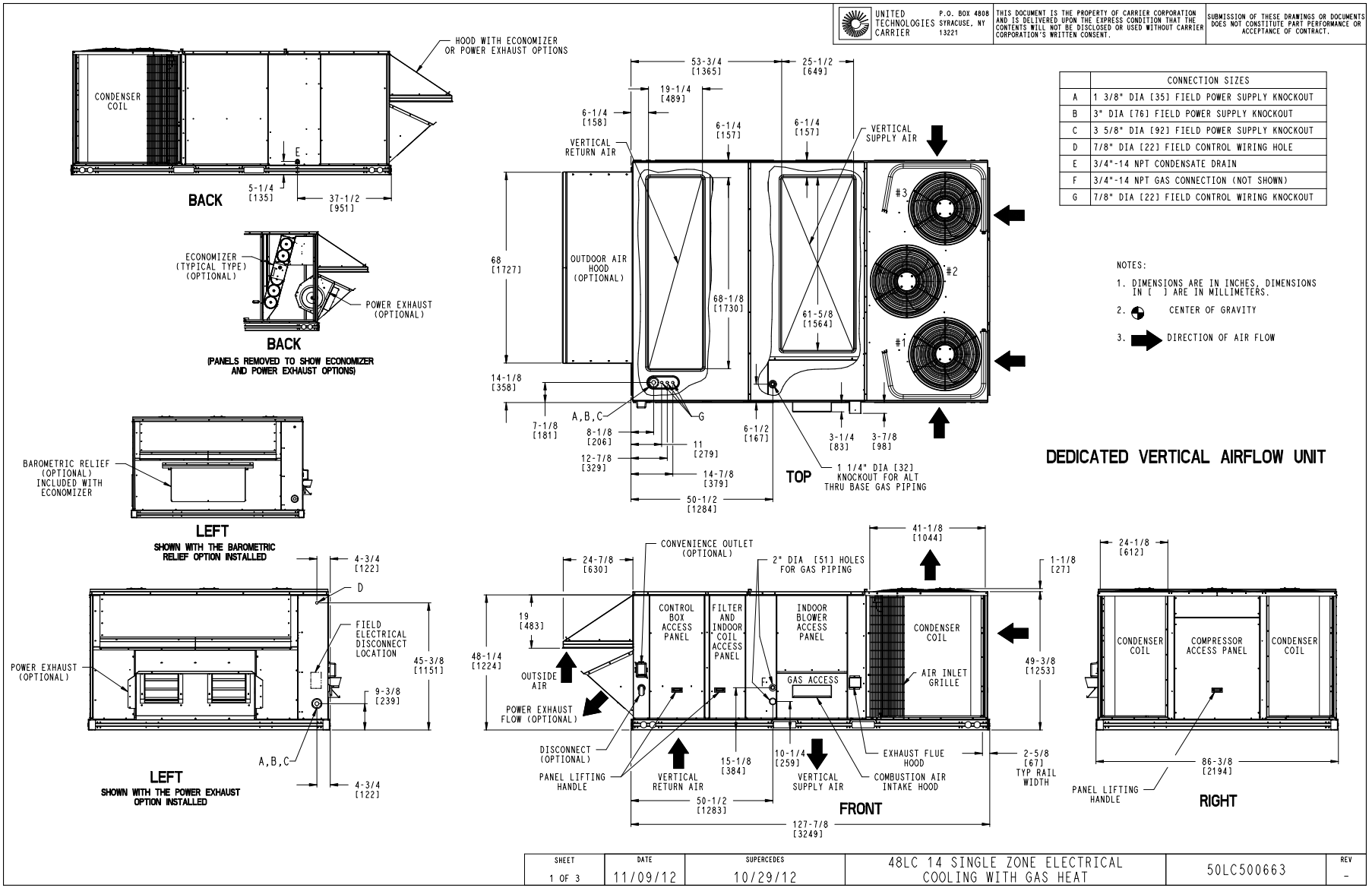
1-Year parts
5-Year compressor parts
10-Year heat exchanger - Aluminized

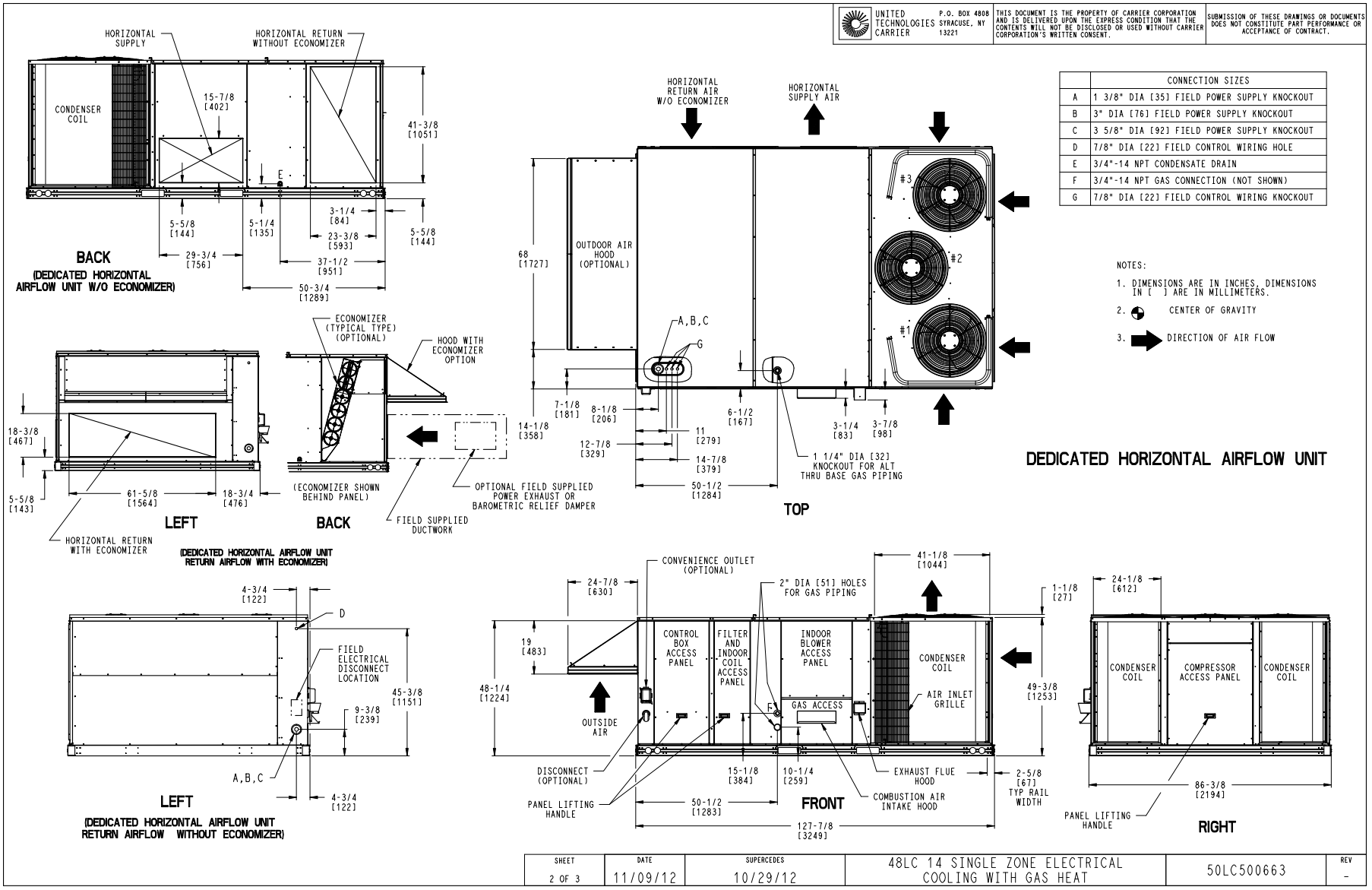
No optional warranties were selected.

NOTE: Please see Warranty Catalog 500-089 for explanation of policies and ordering methods.

Ordering Information

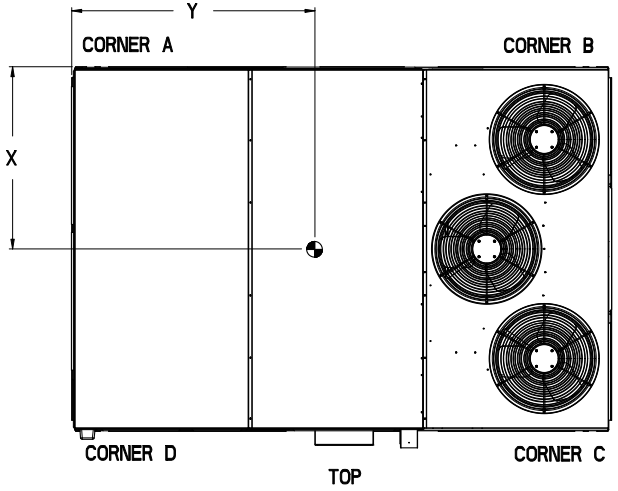
Part Number	Description	Quantity
48LCD014A2Q6-4A0A0	Rooftop Unit	2
	Base Unit	
	Medium Static Option - Vertical Models with VFD controller	
	E-coat Al/Cu - E-coat Al/Cu - Louvered Hail Guards	
	SystemVu Controls. SystemVu meets Calf. Title 24 FDD	


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HOOD WITH ECONOMIZER OR POWER EXHAUST OPTIONS
CONDENSER COIL
BACK
ECONOMIZER (TYPICAL TYPE) (OPTIONAL)
POWER EXHAUST (OPTIONAL)
BACK
(PANELS REMOVED TO SHOW ECONOMIZER AND POWER EXHAUST OPTIONS)
BAROMETRIC RELIEF (OPTIONAL) INCLUDED WITH ECONOMIZER
LEFT
SHOWN WITH THE BAROMETRIC RELIEF OPTION INSTALLED
POWER EXHAUST (OPTIONAL)
FIELD ELECTRICAL DISCONNECT LOCATION
A,B,C
LEFT
SHOWN WITH THE POWER EXHAUST OPTION INSTALLED
VERTICAL RETURN AIR
VERTICAL SUPPLY AIR
OUTDOOR AIR HOOD (OPTIONAL)
#1
#2
#3
A,B,C
G
1 1/4" DIA [32] KNOCKOUT FOR ALT THRU BASE GAS PIPING
TOP
DEDICATED VERTICAL AIRFLOW UNIT
CONNECTION SIZES
A 1 3/8" DIA [35] FIELD POWER SUPPLY KNOCKOUT
B 3" DIA [76] FIELD POWER SUPPLY KNOCKOUT
C 3 5/8" DIA [92] FIELD POWER SUPPLY KNOCKOUT
D 7/8" DIA [22] FIELD CONTROL WIRING HOLE
E 3/4"-14 NPT CONDENSATE DRAIN
F 3/4"-14 NPT GAS CONNECTION (NOT SHOWN)
G 7/8" DIA [22] FIELD CONTROL WIRING KNOCKOUT
NOTES:
1. DIMENSIONS ARE IN INCHES, DIMENSIONS IN [ ] ARE IN MILLIMETERS.
2. CENTER OF GRAVITY
3. DIRECTION OF AIR FLOW
CONVENIENCE OUTLET (OPTIONAL)
2" DIA [51] HOLES FOR GAS PIPING
CONTROL BOX ACCESS PANEL
FILTER AND INDOOR COIL ACCESS PANEL
INDOOR BLOWER ACCESS PANEL
CONDENSER COIL
AIR INLET GRILLE
GAS ACCESS
OUTSIDE AIR
POWER EXHAUST FLOW (OPTIONAL)
DISCONNECT (OPTIONAL)
PANEL LIFTING HANDLE
VERTICAL RETURN AIR
VERTICAL SUPPLY AIR
EXHAUST FLUE HOOD
COMBUSTION AIR INTAKE HOOD
FRONT
CONDENSER COIL
COMPRESSOR ACCESS PANEL
CONDENSER COIL
PANEL LIFTING HANDLE
RIGHT
SHEET 1 OF 3
DATE 11/09/12
SUPERCEDES 10/29/12
48LC 14 SINGLE ZONE ELECTRICAL COOLING WITH GAS HEAT
50LC500663
REV -


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HORIZONTAL SUPPLY
HORIZONTAL RETURN WITHOUT ECONOMIZER
CONDENSER COIL
BACK
(DEDICATED HORIZONTAL AIRFLOW UNIT W/O ECONOMIZER)
HORIZONTAL RETURN AIR W/O ECONOMIZER
HORIZONTAL SUPPLY AIR
OUTDOOR AIR HOOD (OPTIONAL)
A,B,C
G
#1
#2
#3
1 1/4" DIA [32] KNOCKOUT FOR ALT THRU BASE GAS PIPING
TOP
DEDICATED HORIZONTAL AIRFLOW UNIT
CONNECTION SIZES
A 1 3/8" DIA [35] FIELD POWER SUPPLY KNOCKOUT
B 3" DIA [76] FIELD POWER SUPPLY KNOCKOUT
C 3 5/8" DIA [92] FIELD POWER SUPPLY KNOCKOUT
D 7/8" DIA [22] FIELD CONTROL WIRING HOLE
E 3/4"-14 NPT CONDENSATE DRAIN
F 3/4"-14 NPT GAS CONNECTION (NOT SHOWN)
G 7/8" DIA [22] FIELD CONTROL WIRING KNOCKOUT
NOTES:
1. DIMENSIONS ARE IN INCHES, DIMENSIONS IN [ ] ARE IN MILLIMETERS.
2. CENTER OF GRAVITY
3. DIRECTION OF AIR FLOW
ECONOMIZER (TYPICAL TYPE) (OPTIONAL)
HOOD WITH ECONOMIZER OPTION
(ECONOMIZER SHOWN BEHIND PANEL)
OPTIONAL FIELD SUPPLIED POWER EXHAUST OR BAROMETRIC RELIEF DAMPER
FIELD SUPPLIED DUCTWORK
LEFT
BACK
HORIZONTAL RETURN WITH ECONOMIZER
(DEDICATED HORIZONTAL AIRFLOW UNIT RETURN AIRFLOW WITH ECONOMIZER)
FIELD ELECTRICAL DISCONNECT LOCATION
LEFT
(DEDICATED HORIZONTAL AIRFLOW UNIT RETURN AIRFLOW WITHOUT ECONOMIZER)
CONVENIENCE OUTLET (OPTIONAL)
2" DIA [51] HOLES FOR GAS PIPING
CONTROL BOX ACCESS PANEL
FILTER AND INDOOR COIL ACCESS PANEL
INDOOR BLOWER ACCESS PANEL
CONDENSER COIL
AIR INLET GRILLE
GAS ACCESS
OUTSIDE AIR
DISCONNECT (OPTIONAL)
PANEL LIFTING HANDLE
EXHAUST FLUE HOOD
COMBUSTION AIR INTAKE HOOD
FRONT
COMPRESSOR ACCESS PANEL
RIGHT
SHEET 2 OF 3
DATE 11/09/12
SUPERCEDES 10/29/12
48LC 14 SINGLE ZONE ELECTRICAL COOLING WITH GAS HEAT
50LC500663
REV -

UNIT	BASE UNIT OPERATING WEIGHT *		CORNER WEIGHT (A)		CORNER WEIGHT (B)		CORNER WEIGHT (C)		CORNER WEIGHT (D)		C.G.		
	LBS.	KG.	LBS.	KG.	LBS.	KG.	LBS.	KG.	LBS.	KG.	X	Y	Z
48LC14	1853	842.3	457.5	208.0	532.4	242.0	481.3	218.8	413.6	188.0	40 29/32 [1039.02]	68 21/32 [1743.87]	16 1/2 [419.1]

* BASE UNIT WEIGHT IS WITH LOW GAS HEAT, STD ID FAN MOTOR AND WITHOUT PACKAGING.
FOR OTHER OPTIONS AND ACCESSORIES REFER TO THE PRODUCT DATA CATALOG.



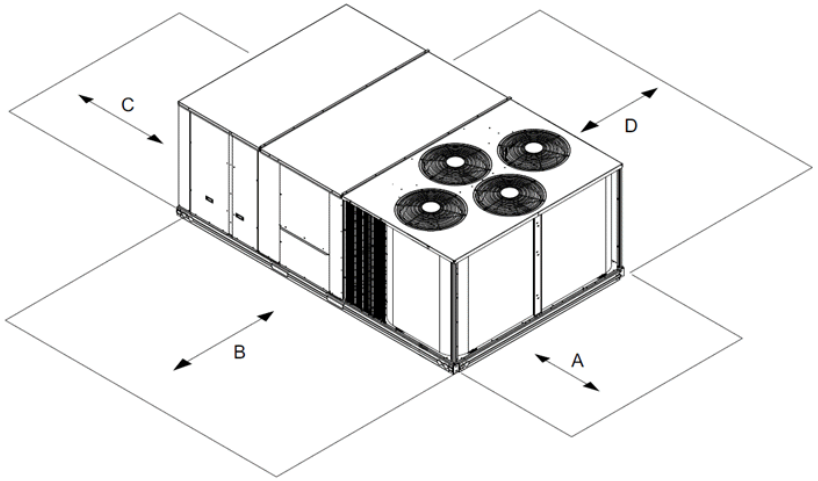
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SHEET	DATE	SUPERCEDES			REV
3 OF 3	11/09/12	10/29/12	48LC 14 SINGLE ZONE ELECTRICAL COOLING WITH GAS HEAT	50LC500663	-

Service Clearance



C12392

LOCATION	DIMENSION	CONDITION
A	36---in (914 mm)	• Recommended clearance for air flow and service
B	42---in (1067 mm)	• Recommended clearance for air flow and service
C	18---in (457 mm)	• No Convenience Outlet • No Economizer • No field installed disconnect on economizer hood side (Factory--- installed disconnect installed)
	36---in (914 mm)	• Convenience Outlet installed • Vertical surface behind servicer is electrically non---conductive (e.g.: wood, fiberglass)
	42---in (1067 mm)	• Convenience Outlet installed • Vertical surface behind servicer is electrically conductive (e.g.: metal, masonry)
	96---in (2438 mm)	• Economizer and/or Power Exhaust installed • Check for sources of flue products with 10 feet (3 meters) of economizer fresh air intake
D	42---in (1067 mm)	• Recommended clearance for service

NOTE: Unit not designed to have overhead obstruction. Contact Application Engineering for guidance on any application planning overhead obstruction or vertical clearances.

Chassis 6-9

Performance Summary For P-01A, 01B

Project: 19-248 Channel Island HVAC Upgrade BLDG N 02/05/2020
Prepared By: 07:06PM

Part Number:48LCD014A2Q6-4A0A0

ARI EER:	**12.40**	
IEER:	**19.1**	

Base Unit Dimensions

Unit Length:	**127.9**	in
Unit Width:	**86.4**	in
Unit Height:	**50.5**	in

Operating Weight

Base Unit Weight:	**1853**	lb
Medium Static Option - Vertical Models with VFD controller:	**5**	lb
E-coat Al/Cu - E-coat Al/Cu - Louvered Hail Guards:	**60**	lb
Total Operating Weight:	**1918**	lb

Unit

Unit Voltage-Phase-Hertz:	**460-3-60**	
Air Discharge:	**Vertical**	
Fan Drive Type:	**Belt**	
Actual Airflow:	**3880**	CFM
Site Altitude:	**0**	ft

Cooling Performance

Condenser Entering Air DB:	**95.0**	F
Evaporator Entering Air DB:	**80.0**	F
Evaporator Entering Air WB:	**67.0**	F
Entering Air Enthalpy:	**31.44**	BTU/lb
Evaporator Leaving Air DB:	**56.0**	F
Evaporator Leaving Air WB:	**55.1**	F
Evaporator Leaving Air Enthalpy:	**23.21**	BTU/lb
Gross Cooling Capacity:	**143.64**	MBH
Gross Sensible Capacity:	**100.58**	MBH
Compressor Power Input:	**10.47**	kW
Coil Bypass Factor:	**0.024**	

Heating Performance

Heating Airflow:	**3880**	CFM
Entering Air Temp:	**70.0**	F
Leaving Air Temp:	**104.1**	F
Gas Heating Input Capacity:	**141.0 / 176.0**	MBH
Gas Heating Output Capacity:	**114.0 / 143.0**	MBH
Temperature Rise:	**34.1**	F
Thermal Efficiency (%):	**81.0**	

Supply Fan

External Static Pressure:	**1.50**	in wg
Fan RPM:	**921**	
Fan Power:	**2.05**	BHP

NOTE: **The Selected Indoor Fan Motor requires a Field-Supplied Drive (RPM Range: 682 - 861).**

Electrical Data

Voltage Range:	**414 - 506**
Compressor #1 RLA:	**9.6**
Compressor #1 LRA:	**62**
Compressor #2 RLA:	**11.2**
Compressor #2 LRA:	**75**
Indoor Fan Motor Type:	**MED**
Indoor Fan Motor FLA:	**6.4**
Combustion Fan Motor FLA (ea):	**0.3**

Power Supply MCA: **33.9**
Power Supply MOCP (Fuse or HACR): **45**
Disconnect Size FLA: **36**
Disconnect Size LRA: **184**
Electrical Convenience Outlet: **None**
Outdoor Fan [Qty / FLA (ea)]: **3 / 1.3**

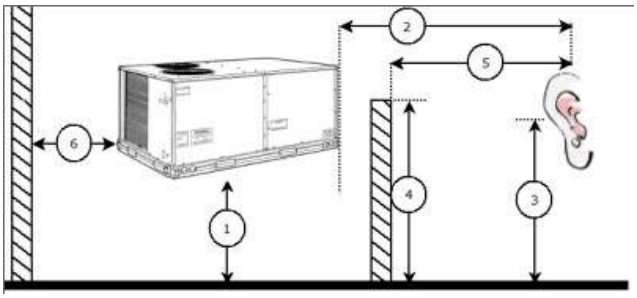
Control Panel SCCR: 5kA RMS at Rated Symmetrical Voltage

Acoustics

Sound Power Levels, db re 10E-12 Watts

	Discharge	Inlet	Outdoor
63 Hz	87.2	87.2	92.2
125 Hz	82.4	77.4	83.9
250 Hz	73.8	70.1	80.4
500 Hz	71.5	61.2	81.8
1000 Hz	66.2	56.6	78.7
2000 Hz	65.0	51.1	76.5
4000 Hz	65.9	47.7	72.2
8000 Hz	55.2	38.8	65.4
A-Weighted	74.6	67.3	84.0

Advanced Acoustics



Advanced Accoustics Parameters

1. Unit height above ground: **30.0** ft
2. Horizontal distance from unit to receiver: **50.0** ft
3. Receiver height above ground: **5.7** ft
4. Height of obstruction: **0.0** ft
5. Horizontal distance from obstruction to receiver: **0.0** ft
6. Horizontal distance from unit to obstruction: **0.0** ft

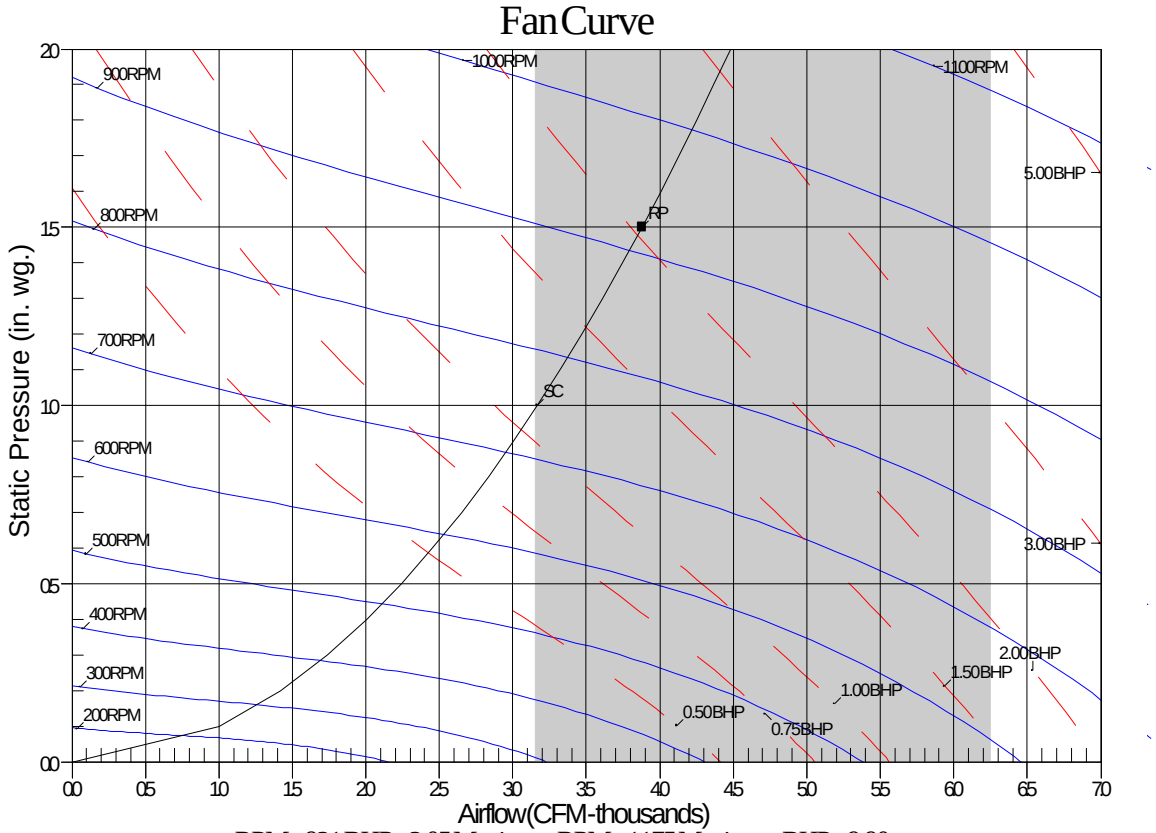
Detailed Acoustics Information

Octave Band Center Freq. Hz	63	125	250	500	1k	2k	4k	8k	Overall
A	92.2	83.9	80.4	81.8	78.7	76.5	72.2	65.4	93.6 Lw
B	66.0	67.8	71.8	78.6	78.7	77.7	73.2	64.3	84.1 LwA
C	59.8	51.5	48.0	49.4	46.3	44.1	39.8	33.0	61.2 Lp
D	33.6	35.4	39.4	46.2	46.3	45.3	40.8	31.9	51.7 LpA

Legend
A Sound Power Levels at Unit's Acoustic Center, Lw

B A-Weighted Sound Power Levels at Unit's Acoustic Center, LwA
C Sound Pressure Levels at Specific Distance from Unit, Lp
D A-Weighted Sound Pressure Levels at Specific Distance from Unit, LpA

Calculation methods used in this program are patterned after the ASHRAE Guide; other ASHRAE Publications and the AHRI Acoustical Standards. While a very significant effort has been made to insure the technical accuracy of this program, it is assumed that the user is knowledgeable in the art of system sound estimation and is aware of the tolerances involved in real world acoustical estimation. This program makes certain assumptions as to the dominant sound sources and sound paths which may not always be appropriate to the real system being estimated. Because of this, no assurances can be offered that this software will always generate an accurate sound prediction from user supplied input data. If in doubt about the estimation of expected sound levels in a space, an Acoustical Engineer or a person with sound prediction expertise should be consulted.



RPM=921 BHP=2.05 Maximum RPM=1175 Maximum BHP=9.90
Note: Please contact application engineering for selections outside the shaded region.
SC-System Curve RP-Rated Point

RTU-Q-1

Tag Cover Sheet
Unit Report
Certified Drawing
Performance Report
Corner Weight

Unit Report For RTU-Q-1

Project: Rio Mesa HS
Prepared By:

03/13/2020
07:05AM

Unit Parameters

Unit Size: **50 Tons**
Volts-Phase-Hertz: **460-3-60**
Supply / Return: **Horizontal/Horizontal**
Configuration: **VAV**
Evaporator Coil Type: **Std Evap**
Heating Capacity: **Low Gas Heat**
Filter Option: **2" MERV 5 Filters**

Shipping Dimensions

Unit Length: **27' 11"**
Unit Width: **7' 8"**
Unit Height: **5' 11"**

Unit Operating Weight: **7990** lb

***Weights and Dimensions are approximate. Weight does not include curbs and accessories. Approximate dimensions are provided primarily for shipping purposes. For exact dimensions refer to certified drawings.

** Shipping Weight does not include extended leadtime options' weight.

Controls

Application Type: **VAV**
Digital Compressor: **Selected**

Exhaust/Outdoor Air

Exhaust/Return: **Economizer with Modulating Power Exhaust**
P.E./ R.F. Motor HP: **6 Hp Exhaust/Return Fan**

Supply Fan

Supply Fan Type: **FC Supply Fan**
Supply Fan Motor HP: **20 Hp**

Condenser Coil

Cond. Coil Fin Coating: **Coated MCHX**

Mixed-Air and Outdoor Air Filters

Mixed-Air Filter Type: **2 in. MERV 5**
Mixed-Air Filter (Quantity) Size: **(8) 20x 25 x 2, (8) 20 x 20 x 2**
Outdoor Air Filter (Cleanable Mesh): **(5) 20 x 20 x 1, (2) 20 x 25 x 1**

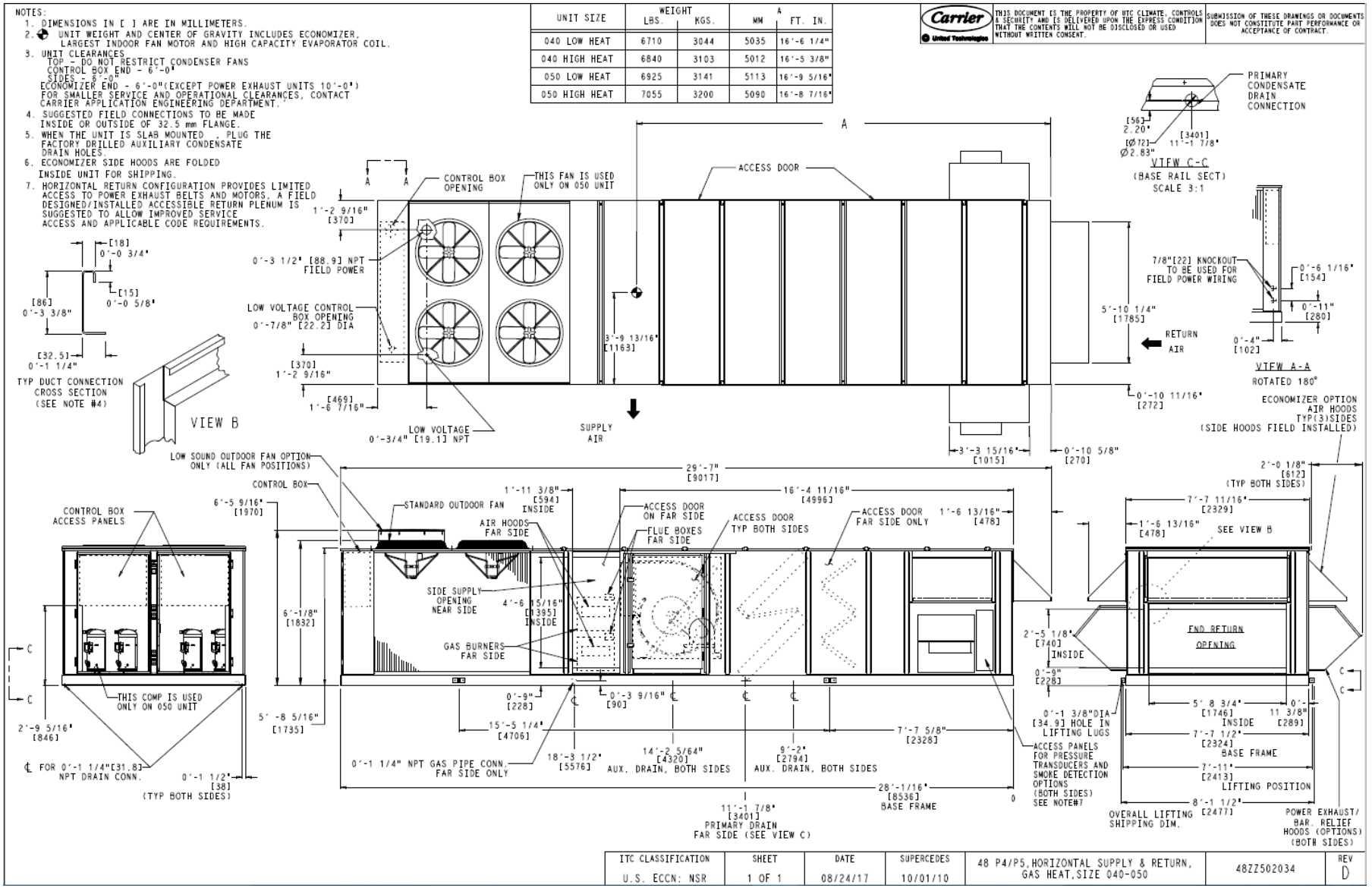
No Optional Warranty Specified

Ordering Information

Part Number	Description	Quantity
48P5D0506404K0Z3T6	Rooftop Unit	1
	Base Unit	
	Coated MCHX	
	Economizer with Modulating Power Exhaust	
	6 Hp Exhaust/Return Fan	
	Digital Compressor	
	Supply VFD w/ by-pass	
	20 Hp Supply Fan Motor	
	Low Leak Economizer Damper	

Accessories

Accessory Part #	Description	Quantity
CRFLTKTZ009A00	MERV 13 Filter Kit	1


NOTES:
1. DIMENSIONS IN [ ] ARE IN MILLIMETERS.
2. UNIT WEIGHT AND CENTER OF GRAVITY INCLUDES ECONOMIZER, LARGEST INDOOR FAN MOTOR AND HIGH CAPACITY EVAPORATOR COIL.
3. UNIT CLEARANCES
TOP - DO NOT RESTRICT CONDENSER FANS
CONTROL BOX END - 6'-0"
SIDES - 2'-0"
ECONOMIZER END - 6'-0"(EXCEPT POWER EXHAUST UNITS 10'-0")
FOR SMALLER SERVICE AND OPERATIONAL CLEARANCES, CONTACT CARRIER APPLICATION ENGINEERING DEPARTMENT.
4. SUGGESTED FIELD CONNECTIONS TO BE MADE INSIDE OR OUTSIDE OF 32.5 mm FLANGE.
5. WHEN THE UNIT IS SLAB MOUNTED , PLUG THE FACTORY DRILLED AUXILIARY CONDENSATE DRAIN HOLES.
6. ECONOMIZER SIDE HOODS ARE FOLDED INSIDE UNIT FOR SHIPPING.
7. HORIZONTAL RETURN CONFIGURATION PROVIDES LIMITED ACCESS TO POWER EXHAUST BELTS AND MOTORS. A FIELD DESIGNED/INSTALLED ACCESSIBLE RETURN PLENUM IS SUGGESTED TO ALLOW IMPROVED SERVICE ACCESS AND APPLICABLE CODE REQUIREMENTS.
UNIT SIZE
WEIGHT LBS.
WEIGHT KGS.
A MM
A FT. IN.
040 LOW HEAT 6710 3044 5035 16'-6 1/4"
040 HIGH HEAT 6840 3103 5012 16'-5 3/8"
050 LOW HEAT 6925 3141 5113 16'-9 5/16"
050 HIGH HEAT 7055 3200 5090 16'-8 7/16"
Carrier
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SUBMISSION OF THESE DRAWINGS OR DOCUMENTS DOES NOT CONSTITUTE PART PERFORMANCE OR ACCEPTANCE OF CONTRACT.
PRIMARY CONDENSATE DRAIN CONNECTION
VIEW C-C
(BASE RAIL SECT)
SCALE 3:1
ACCESS DOOR
CONTROL BOX OPENING
THIS FAN IS USED ONLY ON 050 UNIT
0'-3 1/2" [88.9] NPT FIELD POWER
LOW VOLTAGE CONTROL BOX OPENING
LOW VOLTAGE 0'-3/4" [19.1] NPT
SUPPLY AIR
RETURN AIR
7/8"[22] KNOCKOUT TO BE USED FOR FIELD POWER WIRING
VIEW A-A
ROTATED 180°
ECONOMIZER OPTION AIR HOODS TYP(3)SIDES (SIDE HOODS FIELD INSTALLED)
TYP DUCT CONNECTION CROSS SECTION (SEE NOTE #4)
VIEW B
LOW SOUND OUTDOOR FAN OPTION ONLY (ALL FAN POSITIONS)
CONTROL BOX
CONTROL BOX ACCESS PANELS
STANDARD OUTDOOR FAN
AIR HOODS FAR SIDE
FLUE BOXES FAR SIDE
ACCESS DOOR ON FAR SIDE
ACCESS DOOR TYP BOTH SIDES
ACCESS DOOR FAR SIDE ONLY
SIDE SUPPLY OPENING NEAR SIDE
GAS BURNERS FAR SIDE
THIS COMP IS USED ONLY ON 050 UNIT
0'-1 1/4" NPT GAS PIPE CONN. FAR SIDE ONLY
AUX. DRAIN, BOTH SIDES
AUX. DRAIN, BOTH SIDES
11'-1 7/8" [3401] PRIMARY DRAIN FAR SIDE (SEE VIEW C)
28'-1/16" [8536] BASE FRAME
END RETURN OPENING
SEE VIEW B
ACCESS PANELS FOR PRESSURE TRANSDUCERS AND SMOKE DETECTION OPTIONS (BOTH SIDES) SEE NOTE#7
0'-1 3/8"DIA [34.9] HOLE IN LIFTING LUGS
BASE FRAME
LIFTING POSITION
OVERALL LIFTING SHIPPING DIM.
POWER EXHAUST/ BAR. RELIEF HOODS (OPTIONS) (BOTH SIDES)
ITC CLASSIFICATION U.S. ECCN: NSR
SHEET 1 OF 1
DATE 08/24/17
SUPERCEDES 10/01/10
48 P4/P5,HORIZONTAL SUPPLY & RETURN, GAS HEAT,SIZE 040-050
48ZZ502034
REV D

Performance Summary For RTU-Q-1

Project: Rio Mesa HS — 03/13/2020
Prepared By: — 07:05AM

Part Number: 48P5D0506404K0Z3T6

Unit Refrigerant:	**R410A**	
EER (ARI 340/360):	**9.8**	
IEER (ARI 340/360):	**12.1**	

Unit Dimensions

Unit Length:	**27' 11"**	
Unit Width:	**7' 8"**	
Unit Height:	**5' 11"**	
Unit Operating Weight:	**7955**	lb

***Unit operating weight does not include accessories or weight of packaging material for shipping**

Unit

Heating Type:	**Gas Heat**	
Supply/Return:	**Horizontal/Horizontal**	
Application Type:	**VAV**	
Voltage:	**460-3-60**	
Evaporator Type:	**Std Evap**	
Cooling Airflow:	**13000**	CFM
Altitude:	**0**	ft
Cond. Ent. Air Temp:	**86.0**	F
Ent. Air Dry Bulb:	**82.0**	F
Ent. Air Wet Bulb:	**72.0**	F
Ent. Air Enthalpy:	**35.65**	BTU/lb
Lvg. Air Dry Bulb:	**58.8**	F
Lvg. Air Wet Bulb:	**58.0**	F
Lvg. Air Enthalpy:	**25.05**	BTU/lb
Gross Cooling Capacity:	**619.98**	MBH
Gross Sensible Clg. Cap:	**326.19**	MBH
Compressor Power:	**38.0**	kW
Coil Bypass Factor:	**0.075**	
Refrigerant Charge, Circuit A:	**29.4**	lb
Refrigerant Charge, Circuit B:	**29.0**	lb

Part Load(%) Operation

Cooling Capacity Steps:	**12-23, 38-50, 62-73, 88-100**	

Gas Heating Data:

Heating Airflow:	**13000**	CFM
Heating Ent. Air Temp:	**60.0**	F
Gas Input:	**325**	MBH
Gas Output:	**263**	MBH
Heating Lvg. Air Temp:	**78.7**	F
Steady State Eff:	**81**	
Temp.Rise:	**18.7**	F

Supply Fan Information:

Ext.Static Pressure:	**2.00**	in wg
Low Gas Heat Loss:	**1.32**	in wg
Power Exhaust Loss(with PE Fan Off):	**0.35**	in wg
Selection Static Pressure:	**3.68**	in wg
Supply Fan Type:	**FC Supply Fan**	
Supply Fan RPM:	**883**	*
Supply Fan BHP:	**18.65**	BHP
Supply Fan Motor HP:	**20 Hp**	

Field supplied and installed sheave package may be required

Power Exhaust Information:

Airflow:	**13000**	CFM

Performance Summary For RTU-Q-1

Project: Rio Mesa HS 03/13/2020
Prepared By: 07:05AM

Ext. Static Pressure:	**0.50**	in wg
Selection Static Pressure:	**0.50**	in wg
Return Fan RPM:	**705**	*
Return Fan BHP:	**6.5**	BHP
Motor HP:	**6 Hp Exhaust/Return Fan**	

Field supplied and installed sheave package may be required.

Performance Summary For RTU-Q-1

Project: Rio Mesa HS
Prepared By:

03/13/2020
07:05AM

Electrical Data

Voltage Range:	**414 - 508**
Compressor #1 Qty:	**2**
Compressor #1 RLA:	**17.9**
Compressor #1 LRA:	**125**
Compressor #2 Qty:	**2**
Compressor #2 RLA:	**17.9**
Compressor #2 LRA:	**125**
Outdoor Fan Motor Qty:	**4**
Outdoor Fan FLA (ea):	**3.3**
Indoor Fan Motor HP:	**20**
Indoor Fan Motor FLA:	**27**
Power Supply MCA:	**130**
Power Supply MOCP (Fuse or HACR):	**150**
Power Exhaust [Qty / Hp(ea) / FLA(ea)]:	**2 / 3 / 4.8**
Minimum Disconnect Size:	**137.08**

SCCR, Short Circuit Current Rating: 5kA

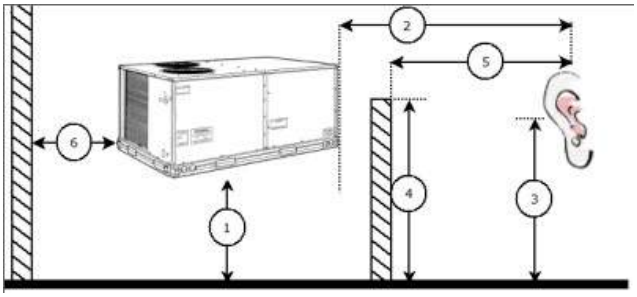
Acoustic Information

	Discharge, Lw	Inlet, Lw	Outdoor, Lw
63 Hz	100.4	92.4	100.0
125 Hz	100.6	82.6	97.0
250 Hz	95.8	76.8	95.0
500 Hz	96.4	76.4	93.0
1000 Hz	86.6	69.6	92.0
2000 Hz	80.6	69.6	88.0
4000 Hz	73.4	60.4	87.0
8000 Hz	64.1	48.1	88.0

Discharge / Inlet Duct Sound Power test data rated in accordance with the AHRI 260 Standard. Return fan or power exhuast fans not included in sound data.

Calculation methods used in this program are patterned after the ASHRAE Guide; other ASHRAE Publications and the AHRI Acoustical Standards. While a very significant effort has been made to insure the technical accuracy of this program, it is assumed that the user is knowledgeable in the art of system sound estimation and is aware of the tolerances involved in real world acoustical estimation. This program makes certain assumptions as to the dominant sound sources and sound paths which may not always be appropriate to the real system being estimated. Because of this, no assurances can be offered that this software will always generate an accurate sound prediction from user supplied input data. If in doubt about the estimation of expected sound levels in a space, an Acoustical Engineer or a person with sound prediction expertise should be consulted.

Advanced Acoustics



Performance Summary For RTU-Q-1

Project: Rio Mesa HS 03/13/2020
Prepared By: 07:05AM

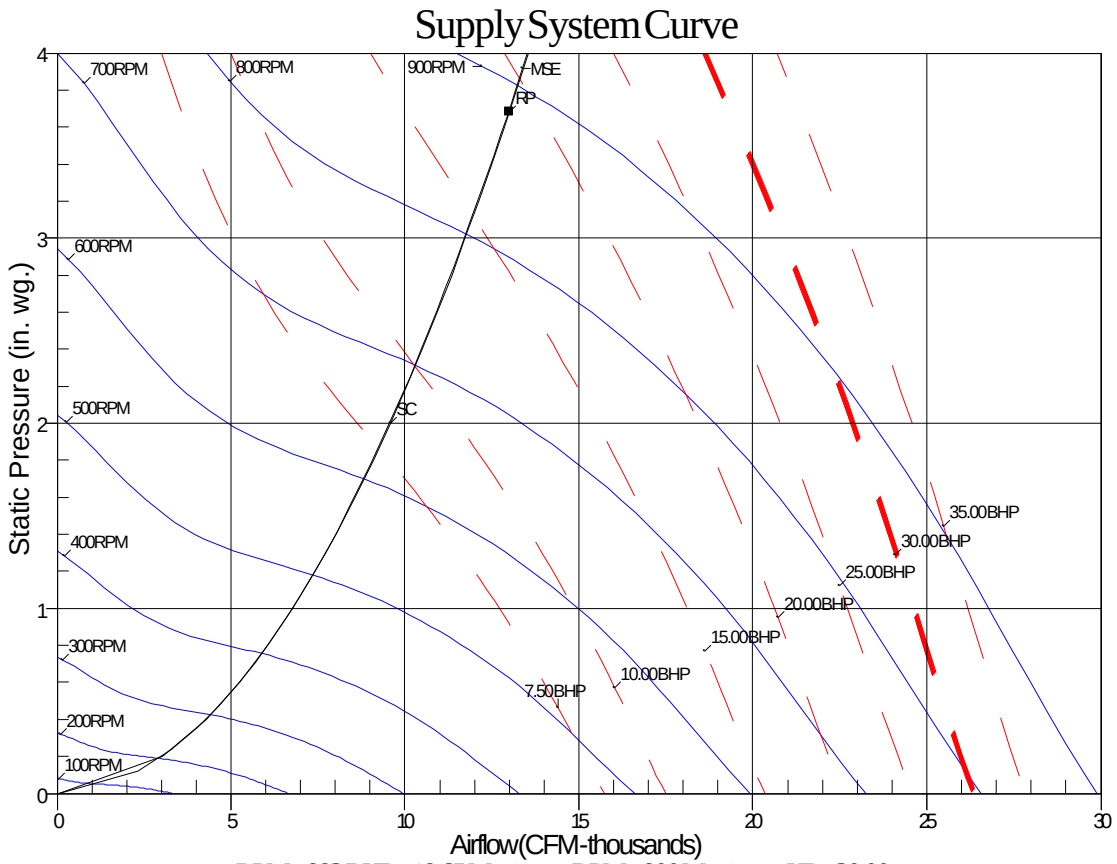
Advanced Accoustics Parameters

1. Unit height above ground: **30.0** ft
2. Horizontal distance from unit to receiver: **50.0** ft
3. Receiver height above ground: **5.7** ft

Detailed Acoustics Information

Octave Band Center Freq. Hz	63	125	250	500	1k	2k	4k	8k	Overall
A	100.0	97.0	95.0	93.0	92.0	88.0	87.0	88.0	103.7 Lw
B	73.8	80.9	86.4	89.8	92.0	89.2	88.0	86.9	97.1 LwA
C	66.7	63.7	61.7	59.7	58.7	54.7	53.7	54.7	70.4 Lp
D	40.5	47.6	53.1	56.5	58.7	55.9	54.7	53.6	63.7 LpA

Legend
A Sound Power Levels at Unit's Acoustic Center, Lw
B A-Weighted Sound Power Levels at Unit's Acoustic Center, LwA
C Sound Pressure Levels at Specific Distance from Unit, Lp
D A-Weighted Sound Pressure Levels at Specific Distance from Unit, LpA

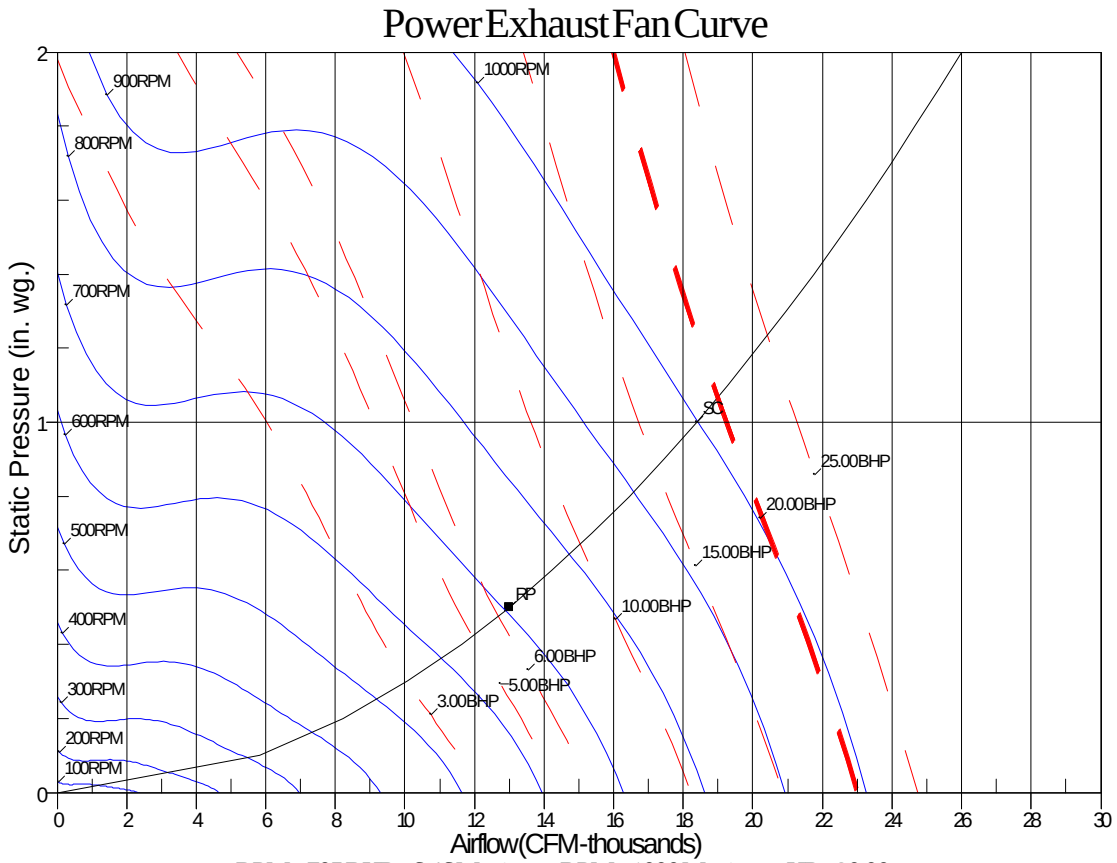


RPM=883 BHP=18.65 Maximum RPM=900 Maximum HP=30.00
SC-System Curve RP-Rated Point

Performance Summary For RTU-Q-1

Project: Rio Mesa HS
Prepared By:

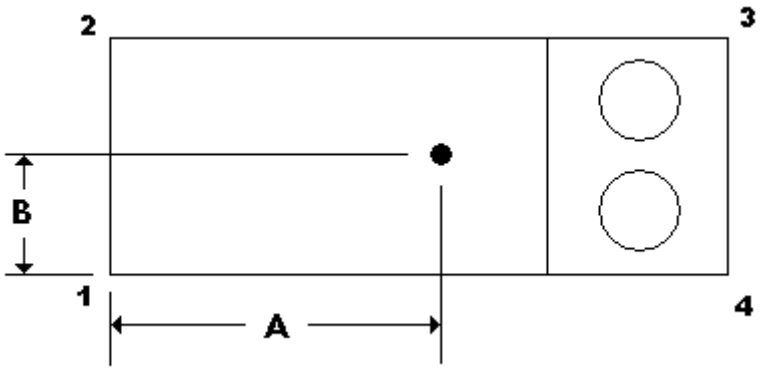
03/13/2020
07:05AM



RPM=705 BHP=6.46 Maximum RPM=1000 Maximum HP=20.00
SC-System Curve RP-Rated Point

Corner Weight / Center of Gravity Report For RTU-Q-1

Project: Rio Mesa HS 03/13/2020
Prepared By: 07:05AM



Rooftop Unit Part Number: **48P5D0506404K0Z3T6**

CG Dimension (A):	**16' 9"**	
CG Dimension (B):	**3' 10"**	
Unit Length:	**27' 11"**	
Unit Width:	**7' 8"**	
Unit Height:	**5' 11"**	
Unit Weight:	**7990.0**	lb
Unit Shipping Weight:	**7990.0**	lb
Corner Weight (1):	**1599.6**	lb
Corner Weight (2):	**1597.2**	lb
Corner Weight (3):	**2394.7**	lb
Corner Weight (4):	**2398.4**	lb
Total Corner Weight:	**7990.0**	lb

**** This is not the same as the shipping weight.**

48P 30 Ton

Tag Cover Sheet
Unit Report
Certified Drawing
Performance Report
Corner Weight

Unit Report For 48P 30 Ton

Project: Oxnard, channel islands, HS Cafeteria 05/21/2020
Prepared By: 01:05PM

Unit Parameters

Unit Size: **30 Tons**
Volts-Phase-Hertz: **460-3-60**
Supply / Return: **Horizontal/Horizontal**
Configuration: **VAV**
Evaporator Coil Type: **Std Evap**
Heating Capacity: **Low Gas Heat**
Filter Option: **2" MERV 5 Filters**

Shipping Dimensions

Unit Length: **21' 5"**
Unit Width: **7' 8"**
Unit Height: **5' 11"**

Unit Operating Weight: **6826** lb

***Weights and Dimensions are approximate. Weight does not include curbs and accessories. Approximate dimensions are provided primarily for shipping purposes. For exact dimensions refer to certified drawings.

** Shipping Weight does not include extended leadtime options' weight.

Weight (lbs):

Unit: 6,826
Curb: 407

Unit: 7,233 lbs

Factory Installed Options

Application Type: **VAV**
Digital Compressor: **Selected**

Exhaust/Outdoor Air

OA Intake/Return: **Economizer with Modulating Power Exhaust**
P.E./ R.F. Motor HP: **6 Hp Exhaust/Return Fan**

Supply Fan

Supply Fan Type: **FC Supply Fan**
Supply Fan Motor HP: **10 Hp**

Condenser Coil

Cond. Coil Fin Coating: **Coated MCHX**

Mixed-Air and Outdoor Air Filters

Mixed-Air Filter Type: **2 in. MERV 5**
Mixed-Air Filter (Quantity) Size: **(8) 20x 25 x 2, (8) 20 x 20 x 2**
Outdoor Air Filter (Cleanable Mesh): **(5) 20 x 20 x 2, (2) 20 x 25 x 1**

No Optional Warranty Specified

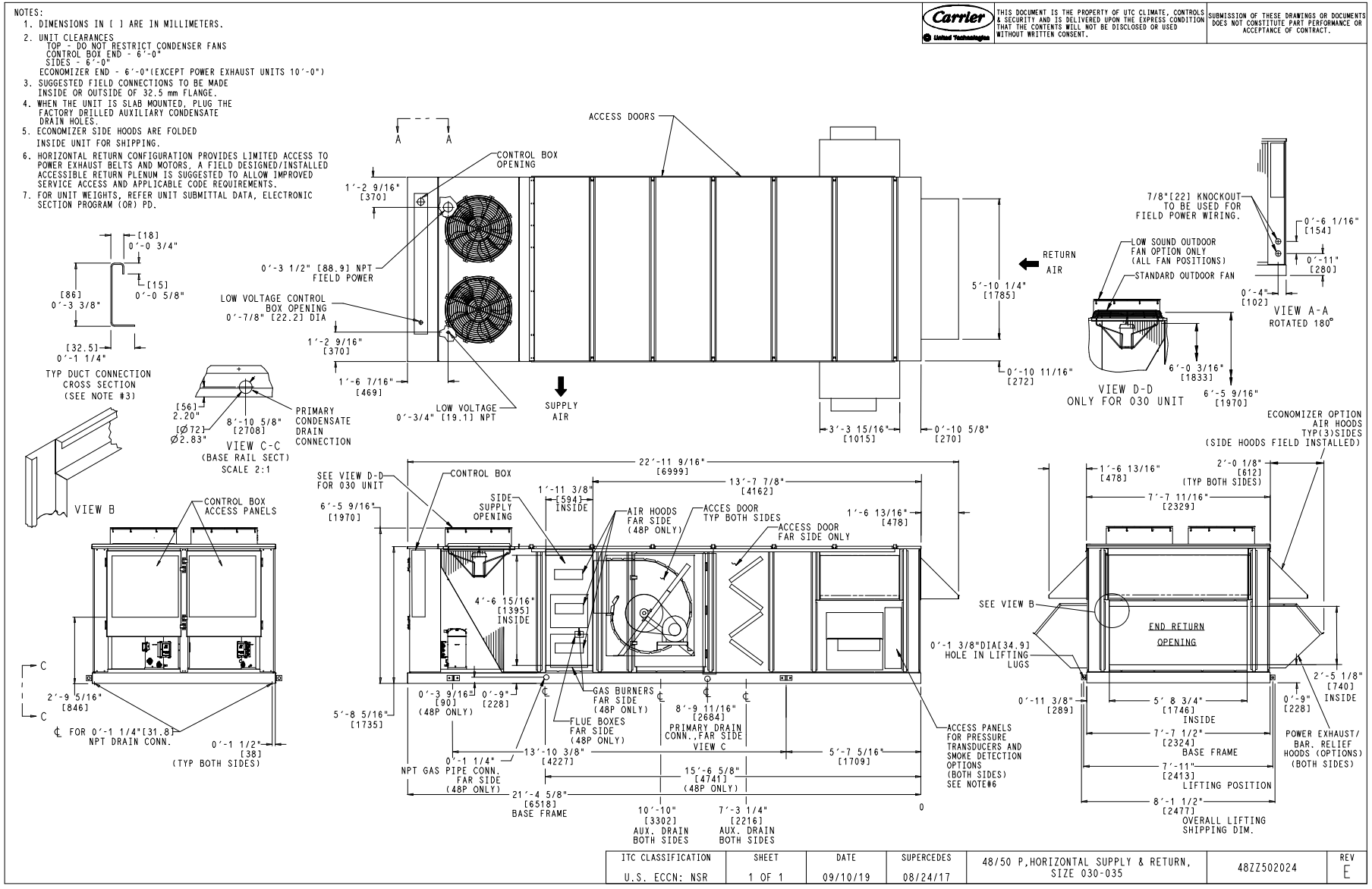
NOTE: Please see Warranty Catalog 808-218 for explanation of policies and ordering methods.

Ordering Information

Part Number	Description	Quantity
48P5D0306497FH1LSG	Rooftop Unit	1
	Base Unit	
	Coated MCHX	
	Economizer with Modulating Power Exhaust	
	6 Hp Exhaust/Return Fan	
	BACnet	
	Supply Smoke Detector	
	Double Wall	
	Digital Compressor	
	Low Sound Condenser Fans	
	Supply VFD	
	10 Hp Supply Fan Motor	
	Low Leak Economizer Damper	

Accessories

Accessory Part #	Description	Quantity
CRFLTKTZ009A00	MERV 13 Filter Kit	1


NOTES:
1. DIMENSIONS IN [ ] ARE IN MILLIMETERS.
2. UNIT CLEARANCES
TOP - DO NOT RESTRICT CONDENSER FANS
CONTROL BOX END - 6'-0"
SIDES - 6'-0"
ECONOMIZER END - 6'-0"(EXCEPT POWER EXHAUST UNITS 10'-0")
3. SUGGESTED FIELD CONNECTIONS TO BE MADE INSIDE OR OUTSIDE OF 32.5 mm FLANGE.
4. WHEN THE UNIT IS SLAB MOUNTED, PLUG THE FACTORY DRILLED AUXILIARY CONDENSATE DRAIN HOLES.
5. ECONOMIZER SIDE HOODS ARE FOLDED INSIDE UNIT FOR SHIPPING.
6. HORIZONTAL RETURN CONFIGURATION PROVIDES LIMITED ACCESS TO POWER EXHAUST BELTS AND MOTORS, A FIELD DESIGNED/INSTALLED ACCESSIBLE RETURN PLENUM IS SUGGESTED TO ALLOW IMPROVED SERVICE ACCESS AND APPLICABLE CODE REQUIREMENTS.
7. FOR UNIT WEIGHTS, REFER UNIT SUBMITTAL DATA, ELECTRONIC SECTION PROGRAM (OR) PD.
Carrier
United Technologies
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ACCESS DOORS
CONTROL BOX OPENING
1'-2 9/16" [370]
0'-3 1/2" [88.9] NPT FIELD POWER
LOW VOLTAGE CONTROL BOX OPENING 0'-7/8" [22.2] DIA
1'-2 9/16" [370]
1'-6 7/16" [469]
LOW VOLTAGE 0'-3/4" [19.1] NPT
SUPPLY AIR
RETURN AIR
5'-10 1/4" [1785]
0'-10 11/16" [272]
3'-3 15/16" [1015]
0'-10 5/8" [270]
[18] 0'-0 3/4"
[15] 0'-0 5/8"
[86] 0'-3 3/8"
[32.5] 0'-1 1/4"
TYP DUCT CONNECTION CROSS SECTION (SEE NOTE #3)
[56] 2.20"
[Ø72] Ø2.83"
8'-10 5/8" [2708]
PRIMARY CONDENSATE DRAIN CONNECTION
VIEW C-C
(BASE RAIL SECT)
SCALE 2:1
7/8"[22] KNOCKOUT TO BE USED FOR FIELD POWER WIRING.
LOW SOUND OUTDOOR FAN OPTION ONLY (ALL FAN POSITIONS)
STANDARD OUTDOOR FAN
0'-6 1/16" [154]
0'-11" [280]
0'-4" [102]
VIEW A-A
ROTATED 180°
6'-0 3/16" [1833]
6'-5 9/16" [1970]
VIEW D-D
ONLY FOR 030 UNIT
ECONOMIZER OPTION AIR HOODS TYP(3)SIDES (SIDE HOODS FIELD INSTALLED)
VIEW B
CONTROL BOX ACCESS PANELS
2'-9 5/16" [846]
℄ FOR 0'-1 1/4"[31.8] NPT DRAIN CONN.
0'-1 1/2" [38] (TYP BOTH SIDES)
SEE VIEW D-D FOR 030 UNIT
CONTROL BOX
22'-11 9/16" [6999]
13'-7 7/8" [4162]
1'-11 3/8" [594] INSIDE
SIDE SUPPLY OPENING
6'-5 9/16" [1970]
AIR HOODS FAR SIDE (48P ONLY)
ACCES DOOR TYP BOTH SIDES
ACCESS DOOR FAR SIDE ONLY
1'-6 13/16" [478]
4'-6 15/16" [1395] INSIDE
0'-3 9/16" [90] (48P ONLY)
0'-9" [228]
5'-8 5/16" [1735]
GAS BURNERS FAR SIDE (48P ONLY)
FLUE BOXES FAR SIDE (48P ONLY)
8'-9 11/16" [2684] PRIMARY DRAIN CONN.,FAR SIDE VIEW C
0'-1 1/4" NPT GAS PIPE CONN. FAR SIDE (48P ONLY)
13'-10 3/8" [4227]
5'-7 5/16" [1709]
15'-6 5/8" [4741] (48P ONLY)
21'-4 5/8" [6518] BASE FRAME
10'-10" [3302] AUX. DRAIN BOTH SIDES
7'-3 1/4" [2216] AUX. DRAIN BOTH SIDES
ACCESS PANELS FOR PRESSURE TRANSDUCERS AND SMOKE DETECTION OPTIONS (BOTH SIDES) SEE NOTE#6
1'-6 13/16" [478]
2'-0 1/8" [612] (TYP BOTH SIDES)
7'-7 11/16" [2329]
SEE VIEW B
END RETURN OPENING
0'-1 3/8"DIA[34.9] HOLE IN LIFTING LUGS
0'-11 3/8" [289]
5' 8 3/4" [1746] INSIDE
7'-7 1/2" [2324] BASE FRAME
7'-11" [2413] LIFTING POSITION
8'-1 1/2" [2477] OVERALL LIFTING SHIPPING DIM.
2'-5 1/8" [740] INSIDE
0'-9" [228]
POWER EXHAUST/ BAR. RELIEF HOODS (OPTIONS) (BOTH SIDES)
ITC CLASSIFICATION
U.S. ECCN: NSR
SHEET
1 OF 1
DATE
09/10/19
SUPERCEDES
08/24/17
48/50 P,HORIZONTAL SUPPLY & RETURN, SIZE 030-035
48ZZ502024
REV
E

Performance Summary For 48P 30 Ton

Project: Oxnard, channel islands, HS Cafeteria 05/21/2020
Prepared By: 01:05PM

Part Number: **48P5D0306497FH1LSG**

Unit Refrigerant:	**R410A**	
EER (ARHI 340/360):	**9.9**	
IEER (ARHI 340/360):	**11.7**	

Unit Dimensions

Unit Length:	**21' 5"**	
Unit Width:	**7' 8"**	
Unit Height:	**5' 11"**	
Unit Operating Weight:	**6826**	lb

***Unit operating weight does not include accessories or weight of packaging material for shipping**

Unit

Heating Type:	**Gas Heat**	
Supply/Return:	**Horizontal/Horizontal**	
Application Type:	**VAV**	
Voltage:	**460-3-60**	
Evaporator Type:	**Std Evap**	
Cooling Airflow:	**9000**	CFM
Altitude:	**0**	ft
Cond. Ent. Air Temp:	**95.0**	F
Ent. Air Dry Bulb:	**82.5**	F
Ent. Air Wet Bulb:	**66.3**	F
Ent. Air Enthalpy:	**30.89**	BTU/lb
Lvg. Air Dry Bulb:	**56.0**	F
Lvg. Air Wet Bulb:	**54.0**	F
Lvg. Air Enthalpy:	**22.55**	BTU/lb
Gross Cooling Capacity:	**337.52**	MBH
Gross Sensible Clg. Cap:	**257.67**	MBH
Compressor Power:	**27.2**	kW
Coil Bypass Factor:	**0.187**	
Refrigerant Charge, Circuit A:	**15.4**	lb
Refrigerant Charge, Circuit B:	**14.8**	lb

Part Load(%) Operation

Cooling Capacity Steps:	**25-50, 75-100**	

Gas Heating Data:

Heating Airflow:	**9000**	CFM
Heating Ent. Air Temp:	**68.0**	F
Gas Input:	**325**	MBH
Gas Output:	**263**	MBH
Heating Lvg. Air Temp:	**95.1**	F
Steady State Eff:	**81**	
Temp.Rise:	**27.1**	F

Supply Fan Information:

Ext.Static Pressure:	**2.00**	in wg
Low Gas Heat Loss:	**0.55**	in wg
Power Exhaust Loss(with PE Fan Off):	**0.18**	in wg
Selection Static Pressure:	**2.73**	in wg
Supply Fan Type:	**FC Supply Fan**	
Supply Fan RPM:	**744**	*
Supply Fan BHP:	**10.65**	BHP
Supply Fan Motor HP:	**10 Hp**	

Field supplied and installed sheave package may be required

Power Exhaust Information:

Airflow:	**7000**	CFM

Performance Summary For 48P 30 Ton

Project: Oxnard, channel islands, HS Cafeteria 05/21/2020
Prepared By: 01:05PM

Ext. Static Pressure:	**0.50**	in wg
Selection Static Pressure:	**0.50**	in wg
Return Fan RPM:	**531**	*
Return Fan BHP:	**2.0**	BHP
Motor HP:	**6 Hp Exhaust/Return Fan**	

Field supplied and installed sheave package may be required.

Electrical Data

Voltage Range:	**414 - 508**
Compressor #1 Qty:	**2**
Compressor #1 RLA:	**23.1**
Compressor #1 LRA:	**150**
Outdoor Fan Motor Qty:	**2**
Outdoor Fan FLA (ea):	**2.9**
Indoor Fan Motor HP:	**10**
Indoor Fan Motor FLA:	**14**
Power Supply MCA:	**81**
Power Supply MOCP (Fuse or HACR):	**100**
Power Exhaust [Qty / Hp(ea) / FLA(ea)]:	**2 / 3 / 4.8**
Minimum Non-Fused Disconnect Amperage:	**82.8**

SCCR, Short Circuit Current Rating: 5kA

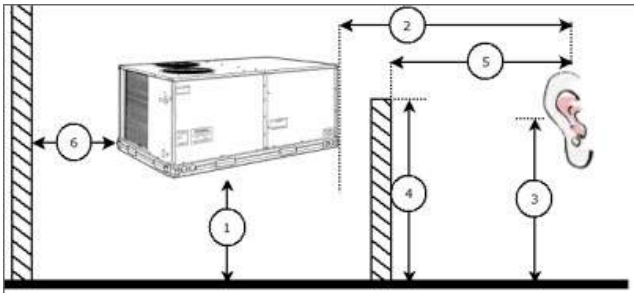
Acoustic Information

	Discharge, Lw	Inlet, Lw	Outdoor, Lw
63 Hz	97.4	89.4	64.2
125 Hz	97.6	79.6	72.2
250 Hz	92.8	73.8	78.9
500 Hz	93.4	73.4	82.1
1000 Hz	83.6	66.6	84.4
2000 Hz	77.6	66.6	82.5
4000 Hz	70.4	57.4	75.9
8000 Hz	61.1	45.1	69.4

Discharge / Inlet Duct Sound Power test data rated in accordance with the AHRI 260 Standard. Return fan or power exhuast fans not included in sound data.

Calculation methods used in this program are patterned after the ASHRAE Guide; other ASHRAE Publications and the AHRI Acoustical Standards. While a very significant effort has been made to insure the technical accuracy of this program, it is assumed that the user is knowledgeable in the art of system sound estimation and is aware of the tolerances involved in real world acoustical estimation. This program makes certain assumptions as to the dominant sound sources and sound paths which may not always be appropriate to the real system being estimated. Because of this, no assurances can be offered that this software will always generate an accurate sound prediction from user supplied input data. If in doubt about the estimation of expected sound levels in a space, an Acoustical Engineer or a person with sound prediction expertise should be consulted.

Advanced Acoustics



Advanced Accoustics Parameters

Performance Summary For 48P 30 Ton

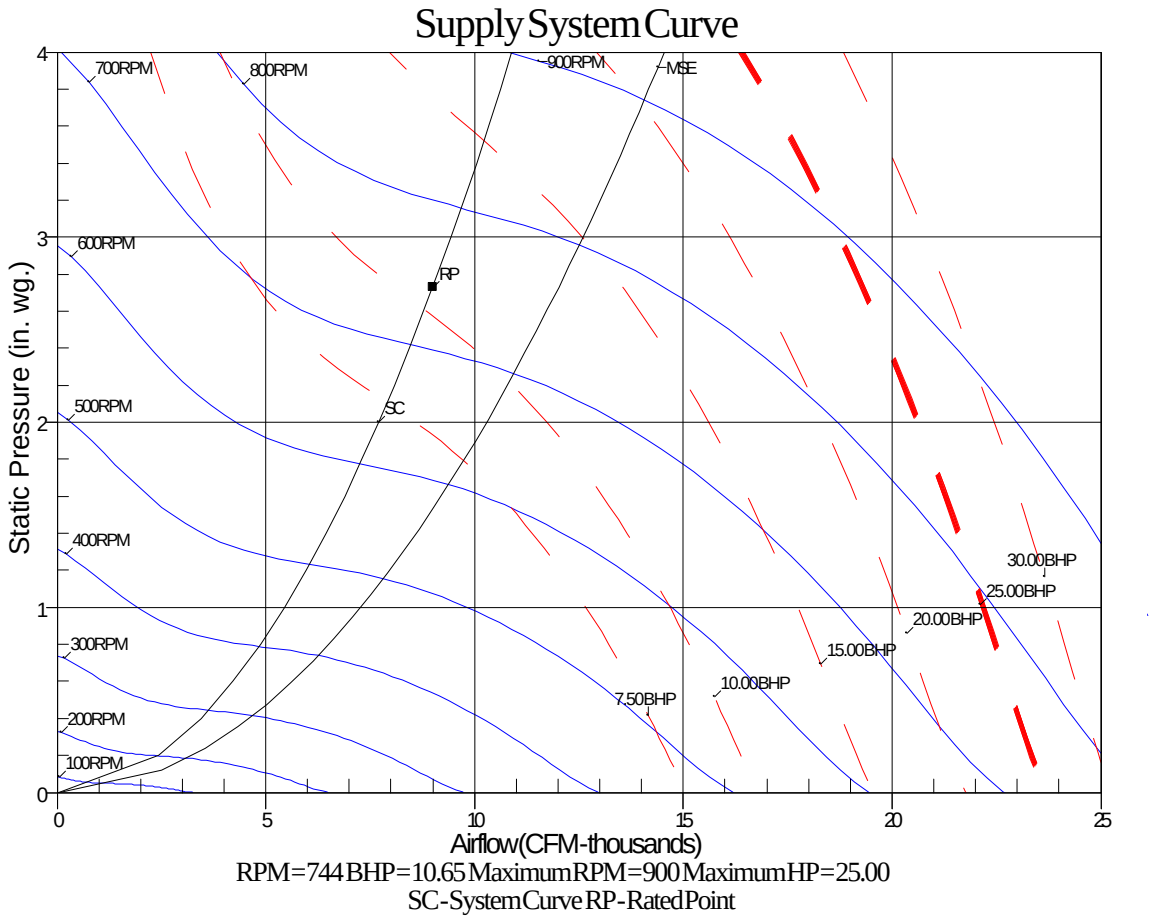
Project: Oxnard, channel islands HS Cafeteria 05/21/2020
Prepared By: 01:05PM

1. Unit height above ground: **30.0** ft
2. Horizontal distance from unit to receiver: **50.0** ft
3. Receiver height above ground: **5.7** ft

Detailed Acoustics Information

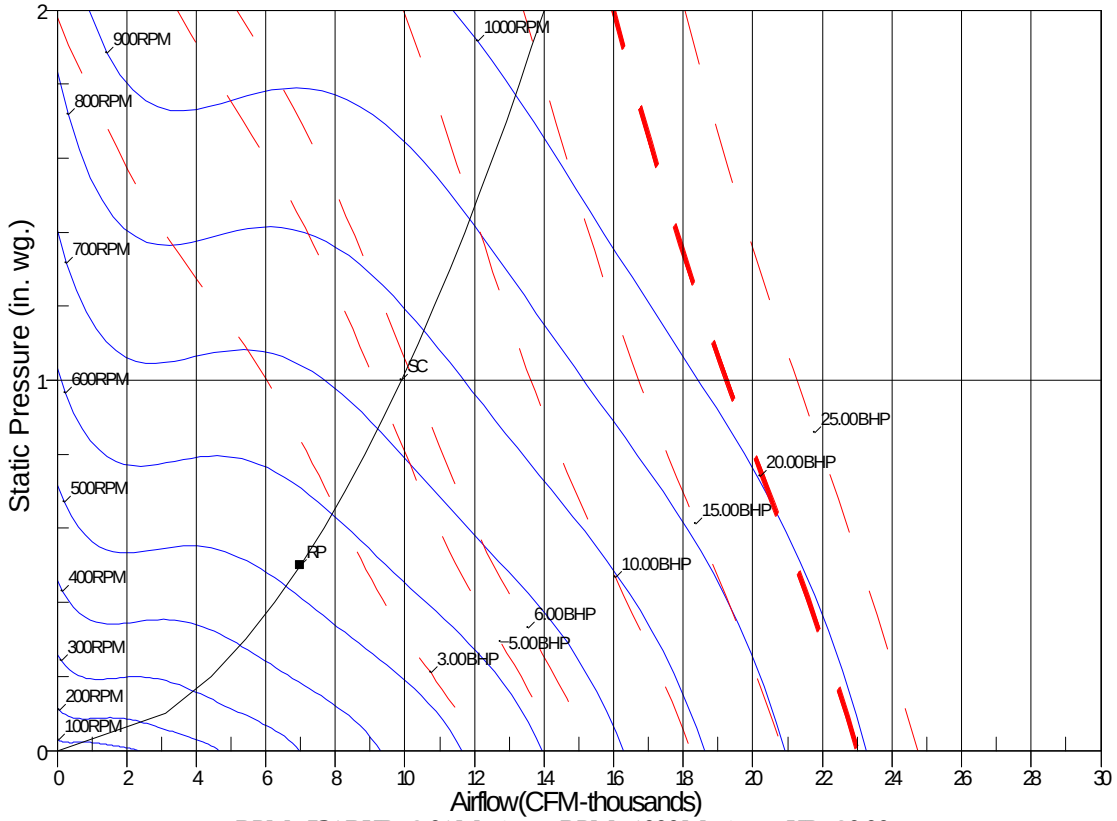
Octave Band Center Freq. Hz	63	125	250	500	1k	2k	4k	8k	Overall
A	64.2	72.2	78.9	82.1	84.4	82.5	75.9	69.4	88.8 Lw
B	38.0	56.1	70.3	78.9	84.4	83.7	76.9	68.3	88.2 LwA
C	30.9	38.9	45.6	48.8	51.1	49.2	42.6	36.1	55.5 Lp
D	4.7	22.8	37.0	45.6	51.1	50.4	43.6	35.0	54.9 LpA

Legend
A Sound Power Levels at Unit's Acoustic Center, Lw
B A-Weighted Sound Power Levels at Unit's Acoustic Center, LwA
C Sound Pressure Levels at Specific Distance from Unit, Lp
D A-Weighted Sound Pressure Levels at Specific Distance from Unit, LpA



RPM=744 BHP=10.65 Maximum RPM=900 Maximum HP=25.00
SC-System Curve RP-Rated Point

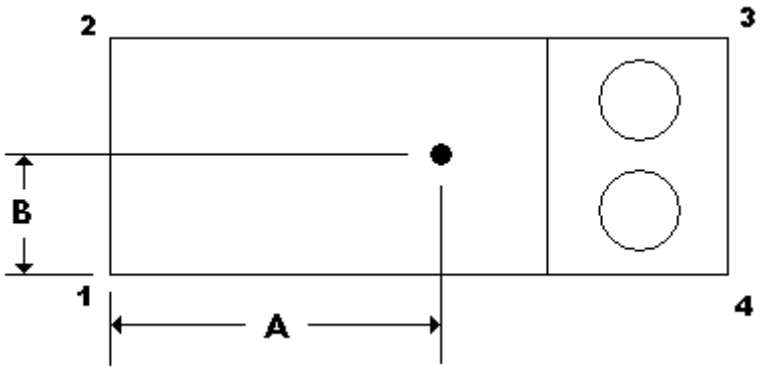
Power Exhaust Fan Curve



RPM=531 BHP=2.01 Maximum RPM=1000 Maximum HP=20.00
SC-System Curve RP-Rated Point

Corner Weight / Center of Gravity Report For 48P 30 Ton

Project: Oxnard, channel islands HS Cafeteria 05/21/2020
Prepared By: 01:05PM



Rooftop Unit Part Number: **48P5D0306497FH1LSG**

CG Dimension (A):	**14' 3"**	
CG Dimension (B):	**3' 10"**	
Unit Length:	**21' 5"**	
Unit Width:	**7' 8"**	
Unit Height:	**5' 11"**	
Unit Weight:	**6825.6**	lb
Unit Shipping Weight:	**6825.6**	lb
Corner Weight (1):	**2270.6**	lb
Corner Weight (2):	**1144.6**	lb
Corner Weight (3):	**1143.0**	lb
Corner Weight (4):	**2267.5**	lb
Total Corner Weight:	**6825.6**	lb

**** This is not the same as the shipping weight.**

Outdoor Unit Single Zone Heat Pump Ductless System

Outdoor Model: 38MAQB09R--3

Submittal Data

Job Data: _____ Location: _____

Buyer: _____ Buyer P.O. #: _____ Carrier #: _____

Unit Number: _____ Model Number: _____

Performance Data Certified By: _____ Date: _____



NOTE: Images for illustration purposes only. Actual models may be slightly different.

STANDARD FEATURES

- Variable Speed (Inverter)
- Factory installed Base Pan Heater
- Factory installed Crankcase Heater
- Low Voltage Controls
- Auto-Restart function
- Condenser High Temp Protection
- Refrigerant Leakage Detection
- Modes: Cool, Heat, Dry, Fan, Auto
- Quiet operation
- Aluminum Golden Hydrophilic pre-coated fins

LIMITED WARRANTY*
• 10 year limited to original purchaser on compressor and parts upon timely registration, otherwise 5 years
*For residential applications.
See warranty for full details.

System	Size		9
	Outdoor Model		38MAQB09R--3
Electrical	Voltage, Phase, Cycle	V/Ph/Hz	208/230-1-60
	MCA	A.	9
	MOCP - Fuse Rating	A.	15
Operating Range	Cooling Outdoor DB Min - Max	°F(°C)	-13~122 (-25~50)
	Heating Outdoor DB Min - Max	°F(°C)	-22~86 (-30~30)
Piping	Total Piping Length	ft (m)	82 (25)
	Piping Lift*	ft (m)	32 (10)
	Pipe Connection Size - Liquid	in (mm)	1/4 (6.35)
	Pipe Connection Size - Suction	in (mm)	3/8 (9.52)
Refrigerant	Refrigerant Type		R410A
	Metering Device		EEV
	Charge	lbs (kg)	3.31 (1.5)

* Condensing unit above or below indoor unit
For Compatibility See Product Data

Outdoor Coil	Face Area	Sq. Ft.	4.5
	No. Rows		2
	Fins per inch		18
	Circuits		4
Compressor	Type		Rotary Inverter
	Model		ATM115D43UFZ2
	Oil Type		VG74
	Oil Charge	Fl. Oz.	17.6
	Rated Current	RLA	5.3
Outdoor	Unit Width	in (mm)	32.09 (815)
	Unit Height	in (mm)	21.81 (554)
	Unit Depth	in (mm)	13.11 (333)
	Net Weight	lbs (kg)	91.5 (41.5)
	Airflow	CFM	1,200
	Sound Pressure	dB(A)	55.5

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Performance

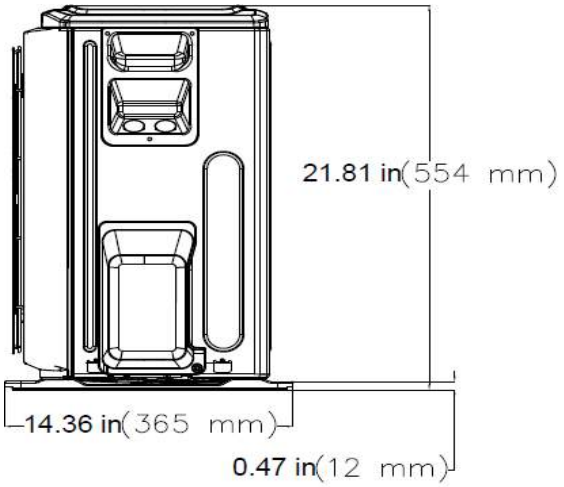
High Wall	Indoor Model		40MAQB09B--3
	Indoor Model		619PEQ009BBMA
	Indoor Model		DHMSHAQ09XA3
	Energy Star		YES
	Cooling Rated Capacity	Btu/h	9,000
	Cooling Cap. Range Min - Max	Btu/h	3,500~13,000
	SEER		25.0
	EER		14.5
	Heating Rated Capacity (47°F)	Btu/h	10,900
	Heating Rated Capacity (17°F)	Btu/h	6,900
	Heating Maximum Capacity (17°F)	Btu/h	10,900
	Heating Maximum Capacity (5°F)	Btu/h	10,900
	Heating Cap. Range Min - Max	Btu/h	4,500~14,500
	HSPF		11.2
	COP (47°F)	W/W	3.80
	COP (17°F)	W/W	2.74
	COP (5°F)	W/W	2.12
Cassette	Indoor Model		40MBCQ09---3
	Energy Star		YES
	Cooling Rated Capacity	Btu/h	9,000
	Cooling Cap. Range Min - Max	Btu/h	3,500~11,000
	SEER		20.0
	EER		13
	Heating Rated Capacity (47°F)	Btu/h	10,000
	Heating Rated Capacity (17°F)	Btu/h	6,700
	Heating Maximum Capacity (17°F)	Btu/h	9,000
	Heating Maximum Capacity (5°F)	Btu/h	9,000
	Heating Cap. Range Min - Max	Btu/h	4,500~11,500
	HSPF		10.8
	COP (47°F)	W/W	3.30
	COP (17°F)	W/W	2.37
	COP (5°F)	W/W	1.83
Ducted	Indoor Model		40MBDQ09---3
	Energy Star		YES
	Cooling Rated Capacity	Btu/h	9,000
	Cooling Cap. Range Min - Max	Btu/h	3,500~12,000
	SEER		23.0
	EER		13.5
	Heating Rated Capacity (47°F)	Btu/h	10,000
	Heating Rated Capacity (17°F)	Btu/h	7,200
	Heating Maximum Capacity (17°F)	Btu/h	10,000
	Heating Maximum Capacity (5°F)	Btu/h	10,000
	Heating Cap. Range Min - Max	Btu/h	4,000~15,000
	HSPF		12.0
	COP (47°F)	W/W	3.60
	COP (17°F)	W/W	2.92
	COP (5°F)	W/W	1.91

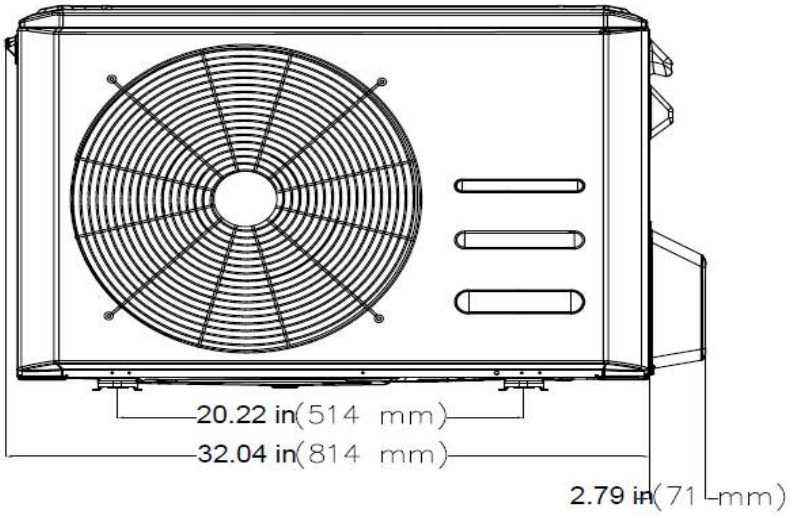
Backward compatible with 40MBQB*C Cassette, 40MBQB*D Ducted Systems.

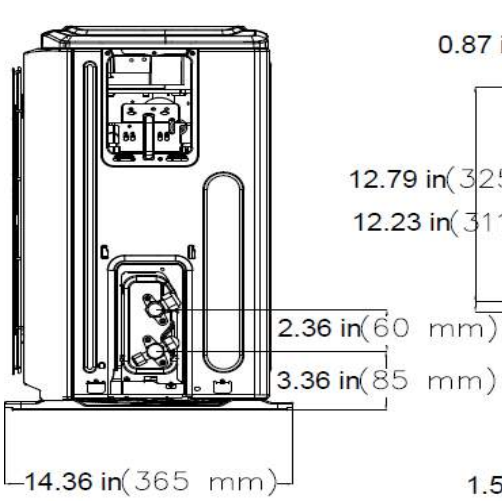
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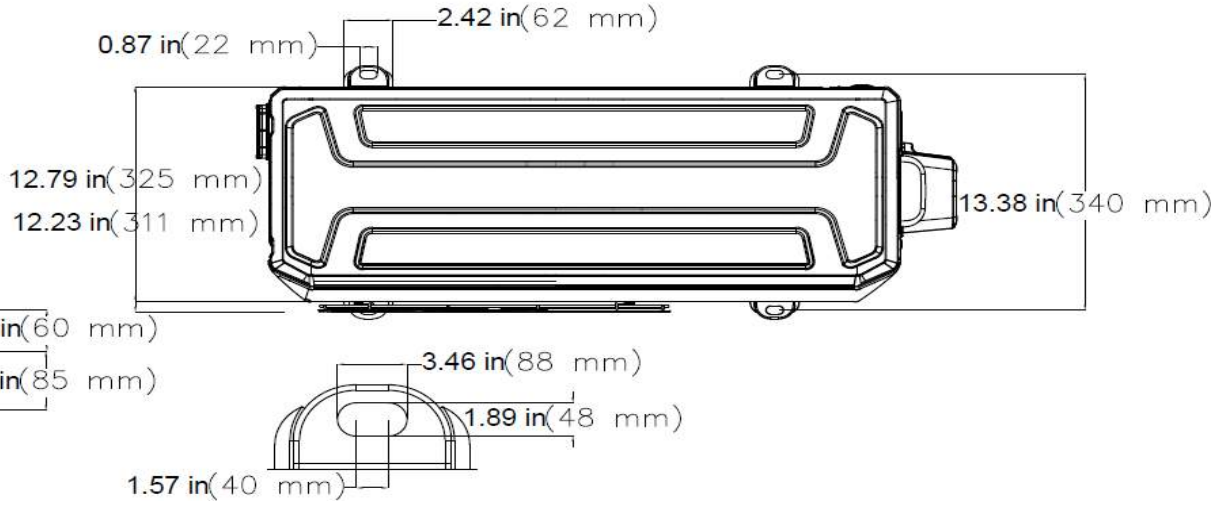
Construction View

Outdoor Model: 38MAQB09R--3









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Edition Date: 07/2019

Catalog No: 38MAR-09-3-06SB

Outdoor Unit Single Zone Heat Pump Ductless System

Outdoor Model: 38MAQB12R--3

Submittal Data

Job Data:		Location:	
Buyer:		Buyer P.O. #:	
Carrier #:			
Unit Number:		Model Number:	
Performance Data Certified By:		Date:	



NOTE: Images for illustration purposes only. Actual models may be slightly different.

STANDARD FEATURES

- Variable Speed (Inverter)
- Factory installed Base Pan Heater
- Factory installed Crankcase Heater
- Low Voltage Controls
- Auto-Restart function
- Condenser High Temp Protection
- Refrigerant Leakage Detection
- Modes: Cool, Heat, Dry, Fan, Auto
- Quiet operation
- Aluminum Golden Hydrophilic pre-coated fins

LIMITED WARRANTY*
• 10 year limited to original purchaser on compressor and parts upon timely registration, otherwise 5 years
*For residential applications.
See warranty for full details.

System	Size		12
	Outdoor Model		38MAQB12R--3
Electrical	Voltage, Phase, Cycle	V/Ph/Hz	208/230-1-60
	MCA	A.	9
	MOCP - Fuse Rating	A.	15
Operating Range	Cooling Outdoor DB Min - Max	°F(°C)	-13~122 (-25~50)
	Heating Outdoor DB Min - Max	°F(°C)	-22~86 (-30~30)
Piping	Total Piping Length	ft (m)	82 (25)
	Piping Lift*	ft (m)	32 (10)
	Pipe Connection Size - Liquid	in (mm)	1/4 (6.35)
	Pipe Connection Size - Suction	in (mm)	1/2 (12.7)
Refrigerant	Refrigerant Type		R410A
	Metering Device		EEV
	Charge	lbs (kg)	3.31 (1.5)

* Condensing unit above or below indoor unit
For Compatibility See Product Data

Outdoor Coil	Face Area	Sq. Ft.	4.5
	No. Rows		2
	Fins per inch		18
	Circuits		4
Compressor	Type		Rotary Inverter
	Model		ATM115D43UFZ2
	Oil Type		VG74
	Oil Charge	Fl. Oz.	17.6
	Rated Current	RLA	5.7
Outdoor	Unit Width	in (mm)	32.09 (815)
	Unit Height	in (mm)	21.81 (554)
	Unit Depth	in (mm)	13.11 (333)
	Net Weight	lbs (kg)	91.5 (41.5)
	Airflow	CFM	1,200
	Sound Pressure	dB(A)	56.0

Accessories

RCD# 331831-701	Piping Adaptor Kit, to facilitate piping installation when matched with FMA/FMC/FMU or FV4

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Catalog No: 38MAR-12-3-07SB

Performance

High Wall	Indoor Model		40MAQB12B--3
	Indoor Model		619PEQ012BBMA
	Indoor Model		DHMSHAQ12XA3
	Energy Star		YES
	Cooling Rated Capacity	Btu/h	12,000
	Cooling Cap. Range Min - Max	Btu/h	4,000~13,800
	SEER		22.5
	EER		13
	Heating Rated Capacity (47°F)	Btu/h	12,000
	Heating Rated Capacity (17°F)	Btu/h	7,800
	Heating Maximum Capacity (17°F)	Btu/h	12,000
	Heating Maximum Capacity (5°F)	Btu/h	12,000
	Heating Cap. Range Min - Max	Btu/h	5,000~15,500
	HSPF		12.0
	COP (47°F)	W/W	3.56
	COP (17°F)	W/W	2.64
	COP (5°F)	W/W	2.12
Cassette	Indoor Model		40MBCQ12---3
	Energy Star		YES
	Cooling Rated Capacity	Btu/h	12,000
	Cooling Cap. Range Min - Max	Btu/h	4,000~13000
	SEER		19.5
	EER		12.5
	Heating Rated Capacity (47°F)	Btu/h	12,000
	Heating Rated Capacity (17°F)	Btu/h	8,700
	Heating Maximum Capacity (17°F)	Btu/h	12,000
	Heating Maximum Capacity (5°F)	Btu/h	12,000
	Heating Cap. Range Min - Max	Btu/h	5,000~13500
	HSPF		10.6
	COP (47°F)	W/W	3.67
	COP (17°F)	W/W	2.40
	COP (5°F)	W/W	1.84
Ducted	Indoor Model		40MBDQ12---3
	Energy Star		YES
	Cooling Rated Capacity	Btu/h	12,000
	Cooling Cap. Range Min - Max	Btu/h	4,000~12,900
	SEER		20.5
	EER		12.5
	Heating Rated Capacity (47°F)	Btu/h	12,000
	Heating Rated Capacity (17°F)	Btu/h	8,500
	Heating Maximum Capacity (17°F)	Btu/h	13,000
	Heating Maximum Capacity (5°F)	Btu/h	12,000
	Heating Cap. Range Min - Max	Btu/h	4,500~15,700
	HSPF		11.0
	COP (47°F)	W/W	3.30
	COP (17°F)	W/W	2.36
	COP (5°F)	W/W	1.79
Console	Indoor Model		40MBFQ12---3
	Energy Star		YES
	Cooling Rated Capacity	Btu/h	12,000
	Cooling Cap. Range Min - Max	Btu/h	4,000~13,000
	SEER		19.4
	EER		12.5
	Heating Rated Capacity (47°F)	Btu/h	12,000
	Heating Rated Capacity (17°F)	Btu/h	9,600
	Heating Maximum Capacity (17°F)	Btu/h	12,000
	Heating Maximum Capacity (5°F)	Btu/h	12,000
	Heating Cap. Range Min - Max	Btu/h	5,000~13,500
	HSPF		10.5
	COP (47°F)	W/W	3.17
	COP (17°F)	W/W	2.49
	COP (5°F)	W/W	1.76

Backward compatible with 40MBQB*C Cassette, 40MBQB*D Ducted, 40MBQB*F Floor Console Systems.

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Edition Date: 07/2019

Catalog No: 38MAR-12-3-07SB

Performance

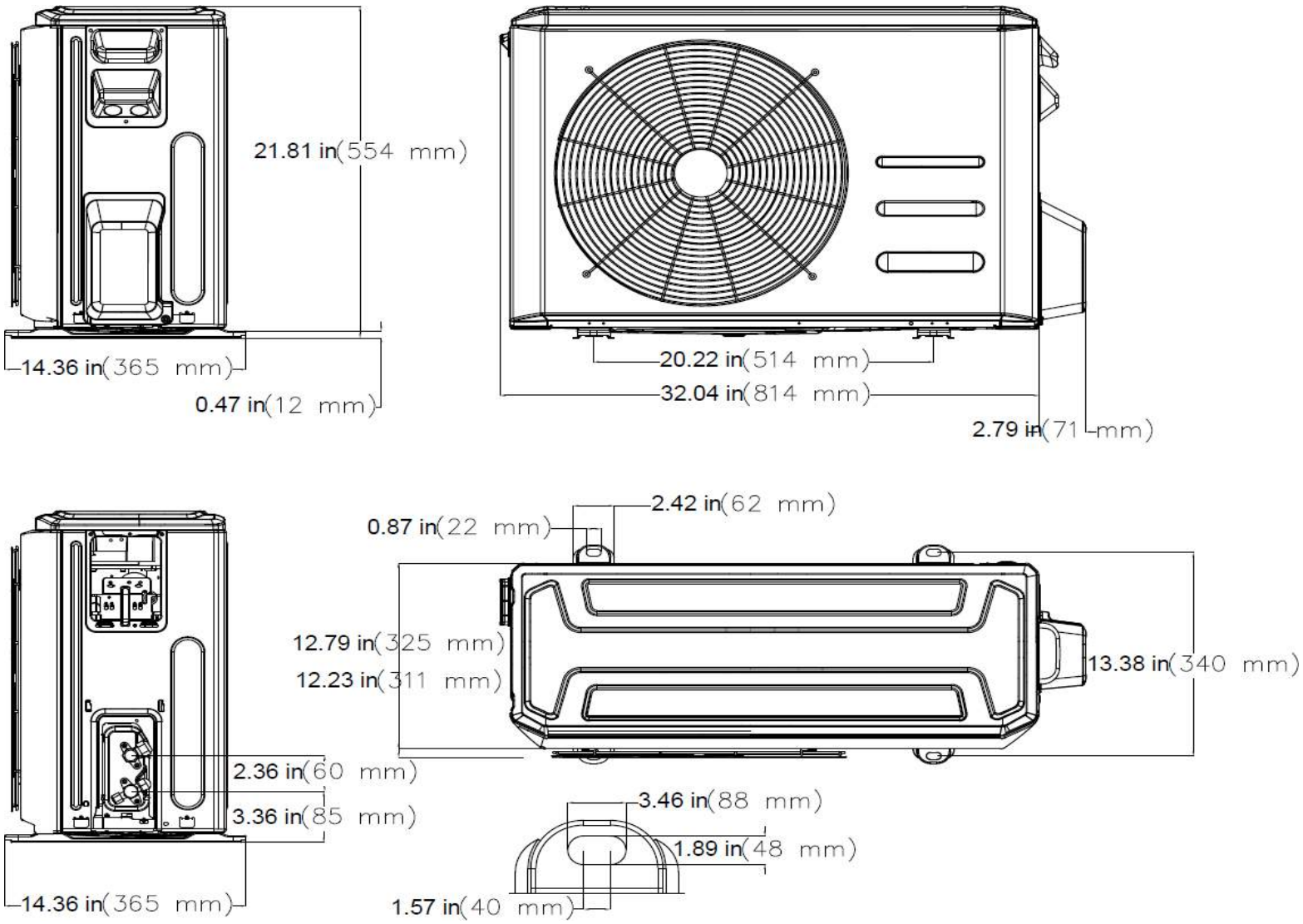
FMA Fan Coil	Indoor Model		FMA4X1800AL
	Energy Star		NO
	Cooling Rated Capacity	Btu/h	11,800
	Cooling Cap. Range Min - Max	Btu/h	6,400~17,000
	SEER		17.6
	EER		12.25
	Heating Rated Capacity (47°F)	Btu/h	12,200
	Heating Rated Capacity (17°F)	Btu/h	7,600
	Heating Maximum Capacity (17°F)	Btu/h	14,100
	Heating Maximum Capacity (5°F)	Btu/h	9,900
	Heating Cap. Range Min - Max	Btu/h	4,000~14,800
	HSPF		9.7
	COP (47°F)	W/W	4.10
	COP (17°F)	W/W	2.65
	COP (5°F)	W/W	2.17
FMC - FMU Fan Coil	Indoor Model		FMC4Z1800AL
	Indoor Model		FMU4Z1800AL
	Energy Star		NO
	Cooling Rated Capacity	Btu/h	11,800
	Cooling Cap. Range Min - Max	Btu/h	5,000~18,000
	SEER		18.4
	EER		11.6
	Heating Rated Capacity (47°F)	Btu/h	11,800
	Heating Rated Capacity (17°F)	Btu/h	7,400
	Heating Maximum Capacity (17°F)	Btu/h	14,000
	Heating Maximum Capacity (5°F)	Btu/h	9,400
	Heating Cap. Range Min - Max	Btu/h	4,100~15,500
	HSPF		8.2
	COP (47°F)	W/W	4.36
	COP (17°F)	W/W	2.86
	COP (5°F)	W/W	1.96
FV4 Fan Coil	Indoor Model		FV4CNF002L00
	Energy Star		NO
	Cooling Rated Capacity	Btu/h	11,200
	Cooling Cap. Range Min - Max	Btu/h	5,900~17,090
	SEER		18.0
	EER		12.0
	Heating Rated Capacity (47°F)	Btu/h	10,400
	Heating Rated Capacity (17°F)	Btu/h	6,400
	Heating Maximum Capacity (17°F)	Btu/h	16,440
	Heating Maximum Capacity (5°F)	Btu/h	11,710
	Heating Cap. Range Min - Max	Btu/h	3,700~17,800
	HSPF		10.0
	COP (47°F)	W/W	3.60
	COP (17°F)	W/W	2.50
	COP (5°F)	W/W	2.15

Applications with the FMA4, FMC, FMU and FV4 fan coils require the 24V interface 2nd Generation KSAIC0301230 and a Piping Adaptor Kit to facilitate piping installation when removing the TXV kit from the indoor unit

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Construction View

Outdoor Model: **38MAQB12R--3**



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Edition Date: 07/2019

Catalog No: 38MAR-12-3-07SB

Outdoor Unit Single Zone Heat Pump Ductless System

Outdoor Model: 38MAQB18R--3

Submittal Data

Job Data: | Location:

Buyer: | Buyer P.O. #: | Carrier #:

Unit Number: | Model Number:

Performance Data Certified By: | Date:



NOTE: Images for illustration purposes only. Actual models may be slightly different.

STANDARD FEATURES

- Variable Speed (Inverter)
- Factory installed Base Pan Heater
- Factory installed Crankcase Heater
- Low Voltage Controls
- Auto-Restart function
- Condenser High Temp Protection
- Refrigerant Leakage Detection
- Modes: Cool, Heat, Dry, Fan, Auto
- Quiet operation
- Aluminum Golden Hydrophilic pre-coated fins

LIMITED WARRANTY*
• 10 year limited to original purchaser on compressor and parts upon timely registration, otherwise 5 years
*For residential applications.
See warranty for full details.

System	Size		18
	Outdoor Model		38MAQB18R--3
Electrical	Voltage, Phase, Cycle	V/Ph/Hz	208/230-1-60
	MCA	A.	18
	MOCP - Fuse Rating	A.	25
Operating Range	Cooling Outdoor DB Min - Max	°F(°C)	-13~122 (-25~50)
	Heating Outdoor DB Min - Max	°F(°C)	-22~86 (-30~30)
Piping	Total Piping Length	ft (m)	98 (30)
	Piping Lift*	ft (m)	65 (20)
	Pipe Connection Size - Liquid	in (mm)	1/4 (6.35)
	Pipe Connection Size - Suction	in (mm)	1/2 (12.7)
Refrigerant	Refrigerant Type		R410A
	Metering Device		EEV
	Charge	lbs (kg)	4.30 (1.95)

* Condensing unit above or below indoor unit
For Compatibility See Product Data

Outdoor Coil	Face Area	Sq. Ft.	5.2
	No. Rows		2
	Fins per inch		18
	Circuits		4
Compressor	Type		Rotary Inverter
	Model		ATF235D22UMT
	Oil Type		VG74
	Oil Charge	Fl. Oz.	23.6
	Rated Current	RLA	12.3
Outdoor	Unit Width	in (mm)	33.66 (855)
	Unit Height	in (mm)	27.63 (702)
	Unit Depth	in (mm)	14.17 (360)
	Net Weight	lbs (kg)	118.2 (53.6)
	Airflow	CFM	1,390
	Sound Pressure	dB(A)	57.5

Accessories

RCD# 331831-701	Piping Adaptor Kit, to facilitate piping installation when matched with FMA/FMC/FMU or FV4

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Edition Date: 07/2019
Catalog No: 38MAR-18-3-06SB

Performance

High Wall	Indoor Model		40MAQB18B--3
	Indoor Model		619PEQ018BBMA
	Indoor Model		DHMSHAQ18XA3
	Energy Star		YES
	Cooling Rated Capacity	Btu/h	17,000
	Cooling Cap. Range Min - Max	Btu/h	4,500~18,800
	SEER		20.0
	EER		12.5
	Heating Rated Capacity (47°F)	Btu/h	18,000
	Heating Rated Capacity (17°F)	Btu/h	10,800
	Heating Maximum Capacity (17°F)	Btu/h	18,000
	Heating Maximum Capacity (5°F)	Btu/h	18,000
	Heating Cap. Range Min - Max	Btu/h	5,500~24,000
	HSPF		10.3
	COP (47°F)	W/W	3.14
	COP (17°F)	W/W	2.64
	COP (5°F)	W/W	1.75
Cassette	Indoor Model		40MBCQ18---3
	Energy Star		YES
	Cooling Rated Capacity	Btu/h	16,000
	Cooling Cap. Range Min - Max	Btu/h	4,500~18,000
	SEER		20.0
	EER		12.5
	Heating Rated Capacity (47°F)	Btu/h	18,000
	Heating Rated Capacity (17°F)	Btu/h	12,000
	Heating Maximum Capacity (17°F)	Btu/h	18,000
	Heating Maximum Capacity (5°F)	Btu/h	18,000
	Heating Cap. Range Min - Max	Btu/h	5,500~19,000
	HSPF		10.5
	COP (47°F)	W/W	3.43
	COP (17°F)	W/W	2.55
	COP (5°F)	W/W	2.07
Ducted	Indoor Model		40MBDQ18---3
	Energy Star		YES
	Cooling Rated Capacity	Btu/h	16,500
	Cooling Cap. Range Min - Max	Btu/h	4,500~18,000
	SEER		19.6
	EER		12.5
	Heating Rated Capacity (47°F)	Btu/h	19,000
	Heating Rated Capacity (17°F)	Btu/h	13,400
	Heating Maximum Capacity (17°F)	Btu/h	20,200
	Heating Maximum Capacity (5°F)	Btu/h	19,000
	Heating Cap. Range Min - Max	Btu/h	5,500~19,000
	HSPF		11.0
	COP (47°F)	W/W	2.93
	COP (17°F)	W/W	2.71
	COP (5°F)	W/W	1.75
Console	Indoor Model		40MBFQ18---3
	Energy Star		YES
	Cooling Rated Capacity	Btu/h	17,000
	Cooling Cap. Range Min - Max	Btu/h	6830-19800
	SEER		19.9
	EER		12.5
	Heating Rated Capacity (47°F)	Btu/h	18,000
	Heating Rated Capacity (17°F)	Btu/h	13,400
	Heating Maximum Capacity (17°F)	Btu/h	21,500
	Heating Maximum Capacity (5°F)	Btu/h	21,300
	Heating Cap. Range Min - Max	Btu/h	12900-29000
	HSPF		10.6
	COP (47°F)	W/W	3.48
	COP (17°F)	W/W	2.38
	COP (5°F)	W/W	1.77

Backward compatible with 40MBQB*C Cassette, 40MBQB*D Ducted

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Edition Date: 07/2019

Catalog No: 38MAR-18-3-06SB

Performance

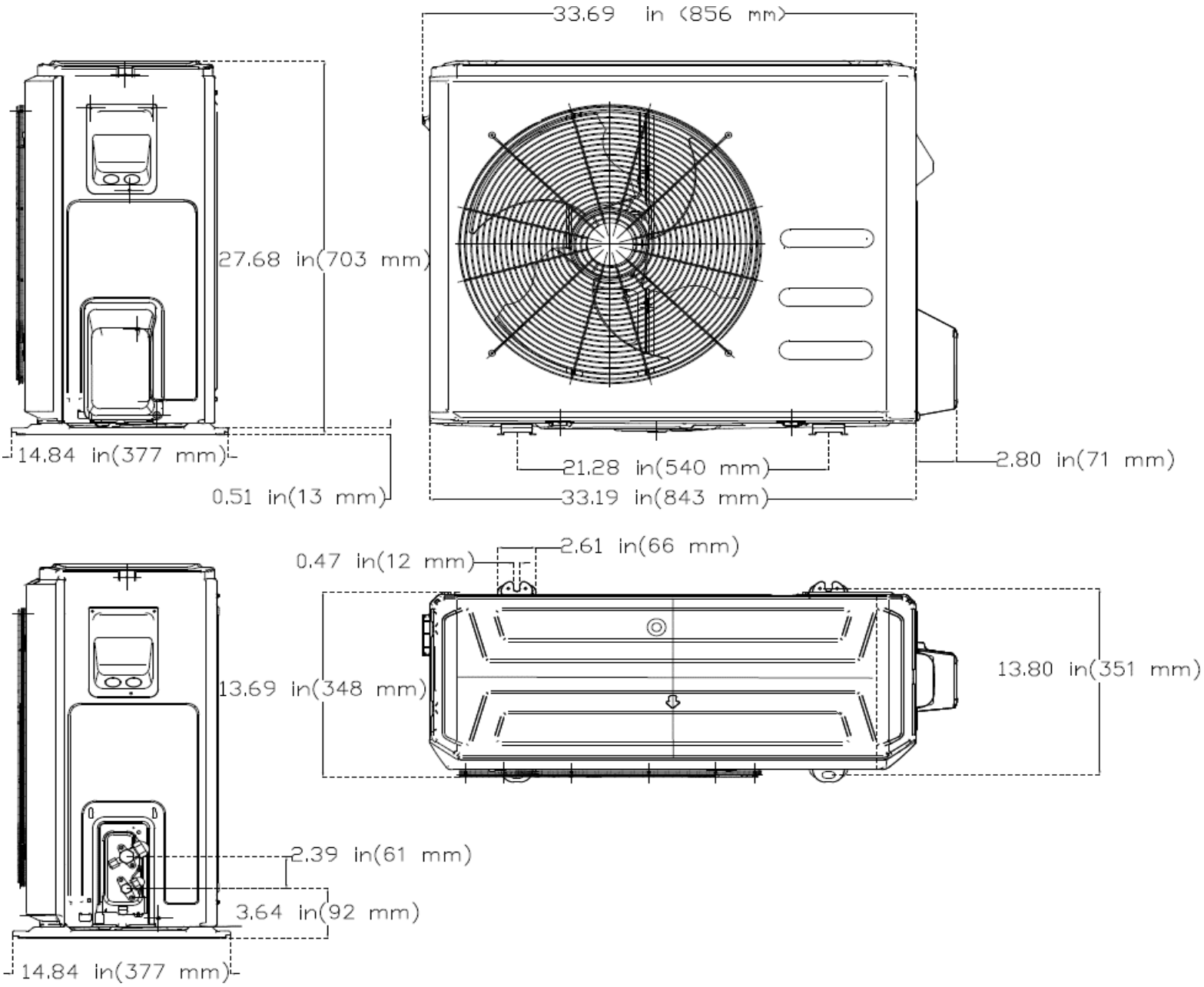
FMA Fan Coil	Indoor Model		FMA4X1800AL
	Energy Star		NO
	Cooling Rated Capacity	Btu/h	17,200
	Cooling Cap. Range Min - Max	Btu/h	8500~28,000
	SEER		15.5
	EER		10.9
	Heating Rated Capacity (47°F)	Btu/h	17,800
	Heating Rated Capacity (17°F)	Btu/h	10,800
	Heating Maximum Capacity (17°F)	Btu/h	23,100
	Heating Maximum Capacity (5°F)	Btu/h	17,800
	Heating Cap. Range Min - Max	Btu/h	7,800~23,000
	HSPF		9.8
	COP (47°F)	W/W	4.00
	COP (17°F)	W/W	2.50
	COP (5°F)	W/W	2.10
FMC - FMU Fan Coil	Indoor Model		FMC4Z1800AL
	Indoor Model		FMU4Z1800AL
	Energy Star		NO
	Cooling Rated Capacity	Btu/h	17,600
	Cooling Cap. Range Min - Max	Btu/h	7,000~29,000
	SEER		19.0
	EER		11
	Heating Rated Capacity (47°F)	Btu/h	17,400
	Heating Rated Capacity (17°F)	Btu/h	12,200
	Heating Maximum Capacity (17°F)	Btu/h	23,700
	Heating Maximum Capacity (5°F)	Btu/h	19,500
	Heating Cap. Range Min - Max	Btu/h	9,000~24,000
	HSPF		10.3
	COP (47°F)	W/W	3.78
	COP (17°F)	W/W	2.76
	COP (5°F)	W/W	2.18
FV4 Fan Coil	Indoor Model		FV4CNF002L00
	Energy Star		NO
	Cooling Rated Capacity	Btu/h	17,800
	Cooling Cap. Range Min - Max	Btu/h	9,200~27,650
	SEER		18.0
	EER		11.5
	Heating Rated Capacity (47°F)	Btu/h	18,600
	Heating Rated Capacity (17°F)	Btu/h	11,000
	Heating Maximum Capacity (17°F)	Btu/h	18,600
	Heating Maximum Capacity (5°F)	Btu/h	15,960
	Heating Cap. Range Min - Max	Btu/h	7,500~20,300
	HSPF		10.0
	COP (47°F)	W/W	3.65
	COP (17°F)	W/W	2.50
	COP (5°F)	W/W	3.02

Applications with the FMA4, FMC, FMU and FV4 fan coils require the 24V interface 2nd Generation KSAIC0301230 and a Piping Adaptor Kit to facilitate piping installation when removing the TXV kit from the indoor unit

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Catalog No: 38MAR-18-3-06SB

Construction View

Outdoor Model: **38MAQB18R--3**



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Outdoor Unit Single Zone Heat Pump Ductless System

Outdoor Model: 38MAQB24R--3

Submittal Data

Job Data: _____ Location: _____

Buyer: _____ Buyer P.O. #: _____ Carrier #: _____

Unit Number: _____ Model Number: _____

Performance Data Certified By: _____ Date: _____



NOTE: Images for illustration purposes only. Actual models may be slightly different.

STANDARD FEATURES

- Variable Speed (Inverter)
- Factory installed Base Pan Heater
- Factory installed Crankcase Heater
- Low Voltage Controls
- Auto-Restart function
- Condenser High Temp Protection
- Refrigerant Leakage Detection
- Modes: Cool, Heat, Dry, Fan, Auto
- Quiet operation
- Aluminum Golden Hydrophilic pre-coated fins

LIMITED WARRANTY*
- 10 year limited to original purchaser on compressor and parts upon timely registration, otherwise 5 years

*For residential applications.
See warranty for full details.

System	Size		24
	Outdoor Model		38MAQB24R--3
Electrical	Voltage, Phase, Cycle	V/Ph/Hz	208/230-1-60
	MCA	A.	20
	MOCP - Fuse Rating	A.	30
Operating Range	Cooling Outdoor DB Min - Max	°F(°C)	-13~122 (-25~50)
	Heating Outdoor DB Min - Max	°F(°C)	-22~86 (-30~30)
Piping	Total Piping Length	ft (m)	164 (50)
	Piping Lift*	ft (m)	65 (20)
	Pipe Connection Size - Liquid	in (mm)	3/8 (9.52)
	Pipe Connection Size - Suction	in (mm)	5/8 (16)
Refrigerant	Refrigerant Type		R410A
	Metering Device		EEV
	Charge	lbs (kg)	5.73 (2.60)

* Condensing unit above or below indoor unit
For Compatibility See Product Data

Outdoor Coil	Face Area	Sq. Ft.	8.0
	No. Rows		2
	Fins per inch		20
	Circuits		4
Compressor	Type		Rotary Inverter
	Model		ATF235D22UMT
	Oil Type		VG74
	Oil Charge	Fl. Oz.	23.6
	Rated Current	RLA	14.0
Outdoor	Unit Width	in (mm)	37.24 (946)
	Unit Height	in (mm)	31.89 (810)
	Unit Depth	in (mm)	16.14 (410)
	Net Weight	lbs (kg)	145.5 (66)
	Airflow	CFM	2,130
	Sound Pressure	dB(A)	60.5

Accessories

RCD# 331831-701	Piping Adaptor Kit, to facilitate piping installation when matched with FMA/FMC/FMU or FV4

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Edition Date: 07/2019
Catalog No: 38MAR-24-3-07SB

Performance

High Wall	Indoor Model		40MAQB24B--3
	Indoor Model		619PEQ024BBMA
	Indoor Model		DHMSHAQ24XA3
	Energy Star		YES
	Cooling Rated Capacity	Btu/h	24,000
	Cooling Cap. Range Min - Max	Btu/h	5,500~24,500
	SEER		20.5
	EER		13
	Heating Rated Capacity (47°F)	Btu/h	24,000
	Heating Rated Capacity (17°F)	Btu/h	15,400
	Heating Maximum Capacity (17°F)	Btu/h	24,000
	Heating Maximum Capacity (5°F)	Btu/h	24,000
	Heating Cap. Range Min - Max	Btu/h	6,000~32,000
	HSPF		11.5
	COP (47°F)	W/W	3.10
	COP (17°F)	W/W	2.64
	COP (5°F)	W/W	1.88
Cassette	Indoor Model		40MBCQ24---3
	Energy Star		NO
	Cooling Rated Capacity	Btu/h	24,000
	Cooling Cap. Range Min - Max	Btu/h	8500-26500
	SEER		20.0
	EER		11
	Heating Rated Capacity (47°F)	Btu/h	24,000
	Heating Rated Capacity (17°F)	Btu/h	16,200
	Heating Maximum Capacity (17°F)	Btu/h	24,000
	Heating Maximum Capacity (5°F)	Btu/h	24,000
	Heating Cap. Range Min - Max	Btu/h	13200-32000
	HSPF		11.5
	COP (47°F)	W/W	3.46
	COP (17°F)	W/W	2.73
	COP (5°F)	W/W	1.88
Ducted	Indoor Model		40MBDQ24---3
	Energy Star		YES
	Cooling Rated Capacity	Btu/h	24,000
	Cooling Cap. Range Min - Max	Btu/h	5,500~24,500
	SEER		20.5
	EER		12.5
	Heating Rated Capacity (47°F)	Btu/h	24,000
	Heating Rated Capacity (17°F)	Btu/h	17,200
	Heating Maximum Capacity (17°F)	Btu/h	25,400
	Heating Maximum Capacity (5°F)	Btu/h	24,000
	Heating Cap. Range Min - Max	Btu/h	6,000~26,000
	HSPF		12.5
	COP (47°F)	W/W	3.82
	COP (17°F)	W/W	2.56
	COP (5°F)	W/W	1.83
Console	Indoor Model		40MBFQ24---3
	Energy Star		NO
	Cooling Rated Capacity	Btu/h	24,000
	Cooling Cap. Range Min - Max	Btu/h	8000-28150
	SEER		20.0
	EER		11.5
	Heating Rated Capacity (47°F)	Btu/h	24,000
	Heating Rated Capacity (17°F)	Btu/h	17,200
	Heating Maximum Capacity (17°F)	Btu/h	26,600
	Heating Maximum Capacity (5°F)	Btu/h	26,560
	Heating Cap. Range Min - Max	Btu/h	20500-36750
	HSPF		11.5
	COP (47°F)	W/W	3.52
	COP (17°F)	W/W	2.82
	COP (5°F)	W/W	1.81

Backward compatible with 40MBQB*D Ducted

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Edition Date: 07/2019

Catalog No: 38MAR-24-3-07SB

Performance

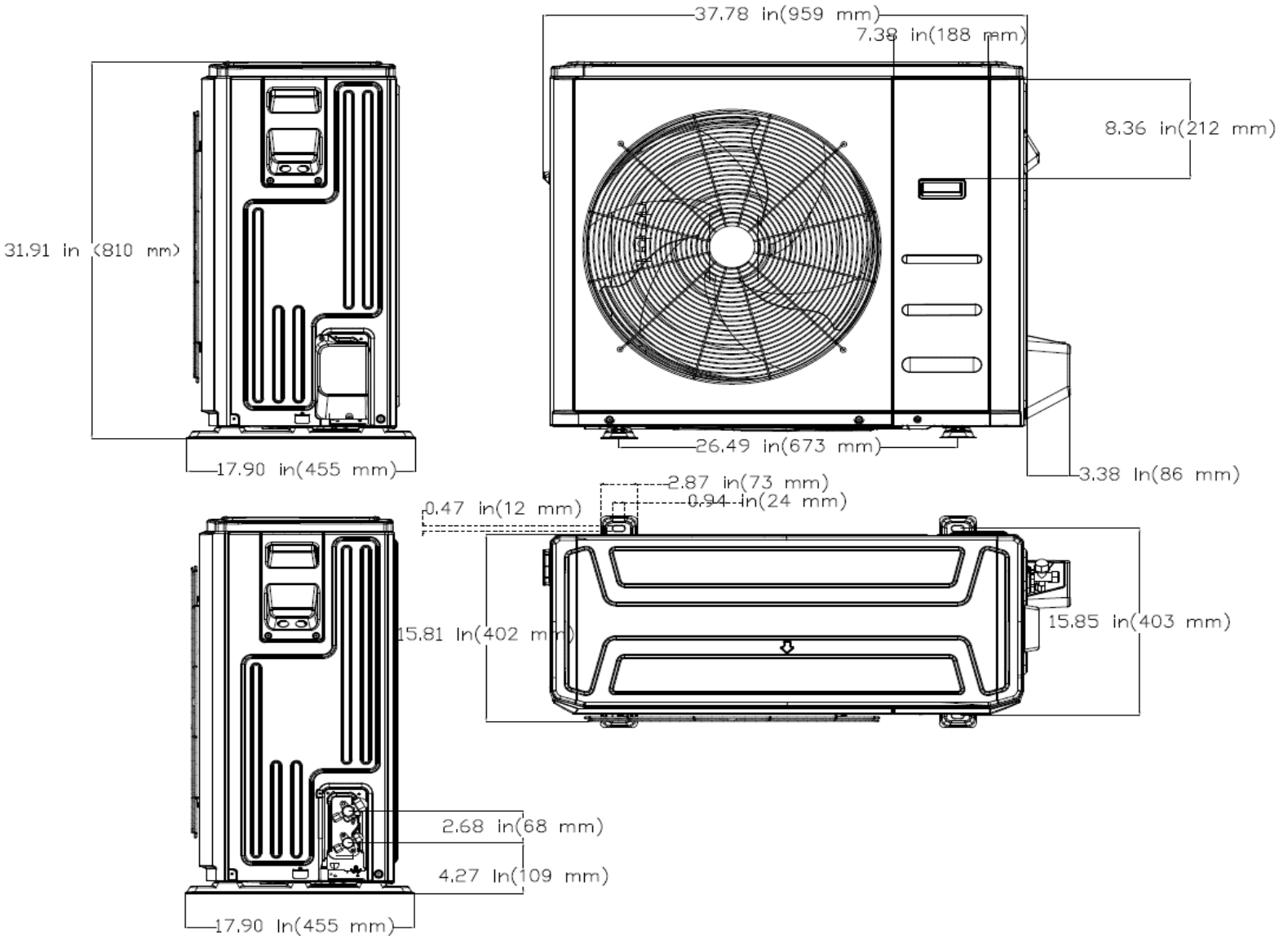
FMA Fan Coil	Indoor Model		FMA4X2400AL
	Energy Star		NO
	Cooling Rated Capacity	Btu/h	23,000
	Cooling Cap. Range Min - Max	Btu/h	7,900~36,500
	SEER		14.5
	EER		11
	Heating Rated Capacity (47°F)	Btu/h	24,000
	Heating Rated Capacity (17°F)	Btu/h	15,800
	Heating Maximum Capacity (17°F)	Btu/h	28,900
	Heating Maximum Capacity (5°F)	Btu/h	28,700
	Heating Cap. Range Min - Max	Btu/h	11,600~36,500
	HSPF		9.5
	COP (47°F)	W/W	3.80
	COP (17°F)	W/W	2.75
	COP (5°F)	W/W	2.30
FMC - FMU Fan Coil	Indoor Model		FMC4Z2400AL
	Indoor Model		FMU4Z2400AL
	Energy Star		NO
	Cooling Rated Capacity	Btu/h	23,000
	Cooling Cap. Range Min - Max	Btu/h	9,300~37,000
	SEER		20.0
	EER		12.2
	Heating Rated Capacity (47°F)	Btu/h	23,200
	Heating Rated Capacity (17°F)	Btu/h	15,000
	Heating Maximum Capacity (17°F)	Btu/h	28,400
	Heating Maximum Capacity (5°F)	Btu/h	28,400
	Heating Cap. Range Min - Max	Btu/h	9,300~35,000
	HSPF		11.2
	COP (47°F)	W/W	3.74
	COP (17°F)	W/W	2..74
	COP (5°F)	W/W	2.19
FV4 Fan Coil	Indoor Model		FV4CNF002L00
	Energy Star		NO
	Cooling Rated Capacity	Btu/h	23,000
	Cooling Cap. Range Min - Max	Btu/h	8,400~33,670
	SEER		17.0
	EER		11.5
	Heating Rated Capacity (47°F)	Btu/h	23,600
	Heating Rated Capacity (17°F)	Btu/h	14,000
	Heating Maximum Capacity (17°F)	Btu/h	23,910
	Heating Maximum Capacity (5°F)	Btu/h	23,890
	Heating Cap. Range Min - Max	Btu/h	11,900~32,580
	HSPF		10.5
	COP (47°F)	W/W	3.85
	COP (17°F)	W/W	2.70
	COP (5°F)	W/W	2.59

Applications with the FMA4, FMC, FMU and FV4 fan coils require the 24V interface 2nd Generation KSAIC0301230 and a Piping Adaptor Kit to facilitate piping installation when removing the TXV kit from the indoor unit

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Catalog No: 38MAR-24-3-07SB

Construction View

Outdoor Model: 38MAQB24R--3



Outdoor Unit Single Zone Heat Pump Ductless System

Outdoor Model: 38MAQB36R--3

Submittal Data

Job Data:		Location:	
Buyer:		Buyer P.O. #:	
Carrier #:			
Unit Number:		Model Number:	
Performance Data Certified By:		Date:	



STANDARD FEATURES

- Variable Speed (Inverter)
- Factory installed Base Pan Heater
- Factory installed Crankcase Heater
- Low Voltage Controls
- Auto-Restart function
- Condenser High Temp Protection
- Refrigerant Leakage Detection
- Modes: Cool, Heat, Dry, Fan, Auto
- Quiet operation
- Aluminum Golden Hydrophilic pre-coated fins

LIMITED WARRANTY*
• 10 year limited to original purchaser on compressor and parts upon timely registration, otherwise 5 years
*For residential applications.
See warranty for full details.

NOTE: Images for illustration purposes only. Actual models may be slightly different.

System	Size		36
	Outdoor Model		38MAQB36R--3
Electrical	Voltage, Phase, Cycle	V/Ph/Hz	208/230-1-60
	MCA	A.	25
	MOCP - Fuse Rating	A.	35
Operating Range	Cooling Outdoor DB Min - Max	°F(°C)	-13~122 (-25~50)
	Heating Outdoor DB Min - Max	°F(°C)	-13~86 (-25~30)
Piping	Total Piping Length	ft (m)	164 (50)
	Piping Lift*	ft (m)	82 (25)
	Pipe Connection Size - Liquid	in (mm)	3/8 (9.52)
	Pipe Connection Size - Suction	in (mm)	5/8 (16)
Refrigerant	Refrigerant Type		R410A
	Metering Device		EEV
	Charge	lbs (kg)	7.50 (3.40)

* Condensing unit above or below indoor unit
For Compatibility See Product Data

Outdoor Coil	Face Area	Sq. Ft.	8.0
	No. Rows		3
	Fins per inch		18
	Circuits		6
Compressor	Type		Rotary Inverter
	Model		ATF250D22UMT
	Oil Type		VG74
	Oil Charge	Fl. Oz.	23.6
	Rated Current	RLA	17.0
Outdoor	Unit Width	in (mm)	37.24 (946)
	Unit Height	in (mm)	31.89 (810)
	Unit Depth	in (mm)	16.14 (410)
	Net Weight	lbs (kg)	147.3 (66.8)
	Airflow	CFM	2,130
	Sound Pressure	dB(A)	60.5

Accessories

RCD# 331831-701	Piping Adaptor Kit, to facilitate piping installation when matched with FMA/FMC/FMU or FV4

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Edition Date: 07/2019
Catalog No: 38MAR-36-3-06SB

Performance

High Wall	Indoor Model		40MAQB36B--3
	Indoor Model		619PEQ036BBMA
	Indoor Model		DHMSHAQ36XA3
	Energy Star		NO
	Cooling Rated Capacity	Btu/h	36,000
	Cooling Cap. Range Min - Max	Btu/h	8,000~36,200
	SEER		16.0
	EER		8.6
	Heating Rated Capacity (47°F)	Btu/h	36,000
	Heating Rated Capacity (17°F)	Btu/h	21,000
	Heating Maximum Capacity (17°F)	Btu/h	21,000
	Heating Maximum Capacity (5°F)	Btu/h	16,380
	Heating Cap. Range Min - Max	Btu/h	9,000~37,000
	HSPF		8.5
	COP (47°F)	W/W	2.56
	COP (17°F)	W/W	2.12
	COP (5°F)	W/W	1.50
FMA Fan Coil	Indoor Model		FMA4X3600AL
	Energy Star		NO
	Cooling Rated Capacity	Btu/h	34,000
	Cooling Cap. Range Min - Max	Btu/h	10,500~43,500
	SEER		14.5
	EER		9
	Heating Rated Capacity (47°F)	Btu/h	37,000
	Heating Rated Capacity (17°F)	Btu/h	22,200
	Heating Maximum Capacity (17°F)	Btu/h	20,700
	Heating Maximum Capacity (5°F)	Btu/h	19,900
	Heating Cap. Range Min - Max	Btu/h	10,900~36,500
	HSPF		8.7
	COP (47°F)	W/W	3.30
	COP (17°F)	W/W	1.75
	COP (5°F)	W/W	1.98
FMC - FMU Fan Coil	Indoor Model		FMC4Z3600AL
	Indoor Model		FMU4Z3600AL
	Energy Star		NO
	Cooling Rated Capacity	Btu/h	35,000
	Cooling Cap. Range Min - Max	Btu/h	8,700~46,000
	SEER		16.0
	EER		9
	Heating Rated Capacity (47°F)	Btu/h	36,000
	Heating Rated Capacity (17°F)	Btu/h	19,000
	Heating Maximum Capacity (17°F)	Btu/h	26,500
	Heating Maximum Capacity (5°F)	Btu/h	19,000
	Heating Cap. Range Min - Max	Btu/h	10,800~36,500
	HSPF		9.0
	COP (47°F)	W/W	3.30
	COP (17°F)	W/W	2.35
	COP (5°F)	W/W	2.00
FV4 Fan Coil	Indoor Model		FV4CNF003L00
	Energy Star		NO
	Cooling Rated Capacity	Btu/h	34,600
	Cooling Cap. Range Min - Max	Btu/h	11,600~40,610
	SEER		15.5
	EER		8.8
	Heating Rated Capacity (47°F)	Btu/h	37,800
	Heating Rated Capacity (17°F)	Btu/h	21,200
	Heating Maximum Capacity (17°F)	Btu/h	25,710
	Heating Maximum Capacity (5°F)	Btu/h	19,900
	Heating Cap. Range Min - Max	Btu/h	12,200~36,500
	HSPF		8.7
	COP (47°F)	W/W	3.05
	COP (17°F)	W/W	2.15
	COP (5°F)	W/W	1.98

Applications with the FMA4, FMC, FMU and FV4 fan coils require the 24V interface 2nd Generation KSAIC0301230 and a Piping Adaptor Kit to facilitate piping installation when removing the TXV kit from the indoor unit

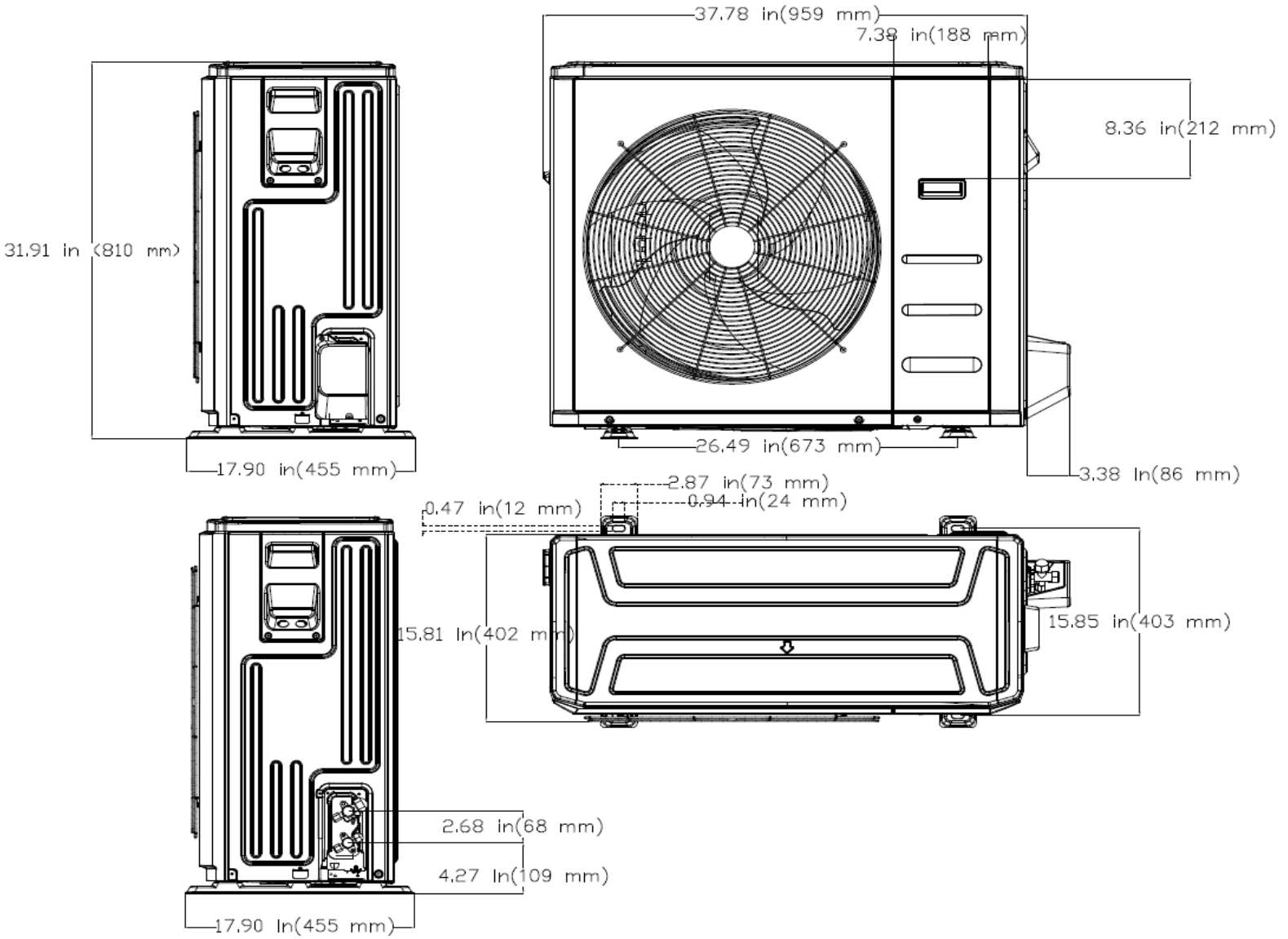
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Edition Date: 07/2019

Catalog No: 38MAR-36-3-06SB

Construction View

Outdoor Model: **38MAQB36R--3**



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Edition Date: 07/2019

Catalog No: 38MAR-36-3-06SB

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QUALITY HVAC ACCESSORIES

TATTOO

Condensate Removal System

- The Tattoo series is the **most silent** condensate removal system on the market today.
- Compact size compared to a tank pump
- Built-in check valve
- Thermal security of 230°F (110°C)
- 5ft communication wire
- **Normally Open/Normally Closed alarm 100V to 240V/8A**
- Delivered complete with mounting accessories - **ready to use**



SUITABILITY

- Split, multisplit and VRF/VRV systems
- Tattoo 10 is for air-conditioner systems up to 36,000 BTU 3 tons
- Tattoo 16 is for air-conditioner systems up to 54,000 BTU 5 tons
- High wall split systems, Ducted units, Floor standing, and Chassis units

CONTENTS

- Tattoo pump body (1)
- Mounting bracket for horizontal and vertical positioning (2)
- Plug & Play detection unit with 5ft communication wire (3)
- Connection elbow (4)
- Ventilation tube (5)
- Fixing screws and anchors (6)
- Double sided foam adhesive (7)



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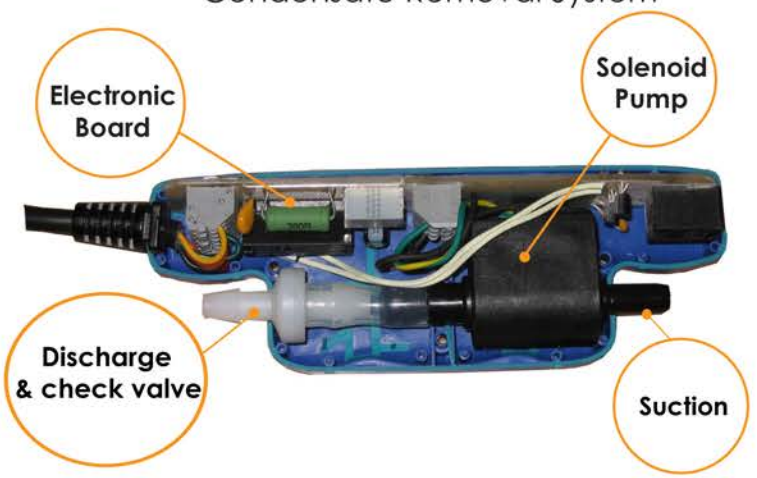
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QUALITY HVAC ACCESSORIES

CONDENSATE PUMPS

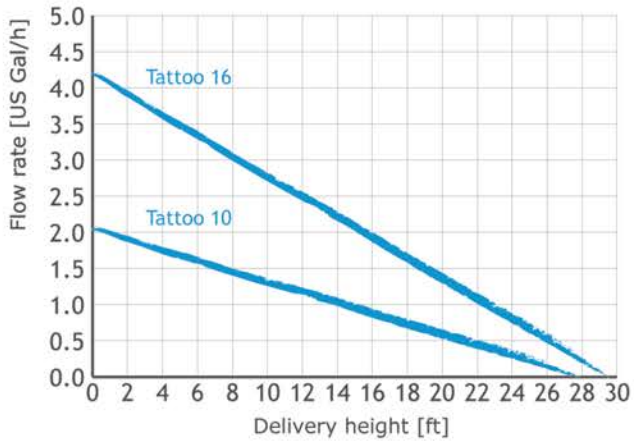
TATTOO

Condensate Removal System

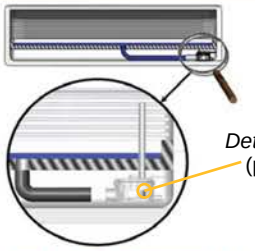
	TATTOO 10	TATTOO 16
Max flow rate	2.1 gal/h	4.3 gal/h
Flow rate at 3 ft	1.9 gal/h	3.8 gal/h
Flow rate at 10 ft	1.4 gal/h	2.8 gal/h
Max dry suction height	3.3 ft	3.3 ft
Max wet suction height	6.6 ft	6.6 ft
Max delivery height	28 ft	29.5 ft
Alarm contact	NO/NC-120v/8A	NO/NC-120v/8A
Pump dimensions	5.9" x 2.2" x 1.1"	5.9" x 2.2" x 1.1"
Sensor unit dimensions	3.2" x 1.6" x 1.6"	3.2" x 1.6" x 1.6"
Weight	15.5 oz	15.5 oz
Power supply	120v or 230v	120v or 230v
Noise level	<19 dBA	22 dBA

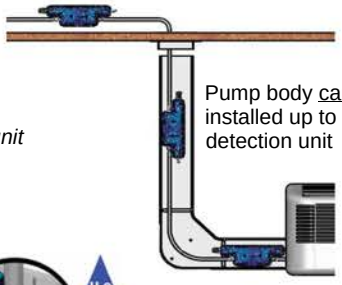


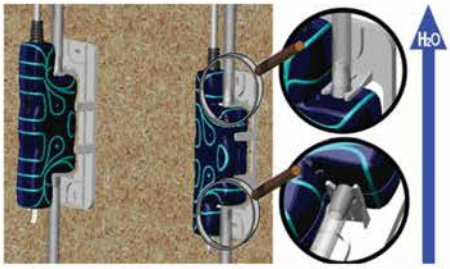
FLOW RATE

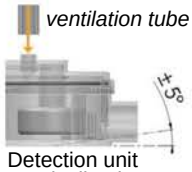


INSTALLATION OPTIONS

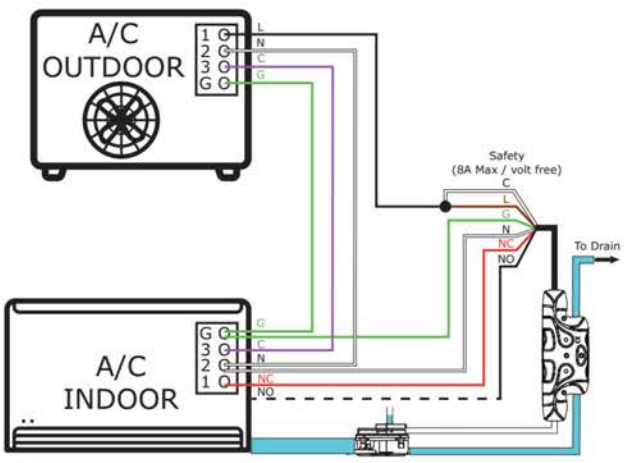




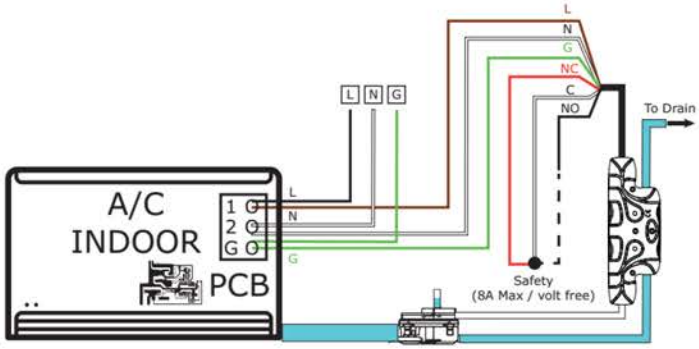




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Inline Fans Options

Featuring TD-MIXVENT/TD-SILENT





Advancing Ventilation

The World's Leading Producer of Air Movement Products

Soler&Palau Ventilation Group

TD_0319
March 2019

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Overview TD-MIXVENT & TD-SILENT Series

Compact Size-TD Fans require minimum space

The S&P TD-MIXVENT & TD-SILENT series of in-line duct fans have been specially designed to maximize the airflow performance with minimal noise levels within the smallest and most compact of housing sizes. This makes the TD-MIXVENT & TD-SILENT series the ultimate solution for small to medium sized ventilation installations which require a high airflow to pressure ratio and occupy only the minimum space possible. Example: false ceiling voids, cabinets and many other limited space environments.

Easy to Install...fit and forget!

All the models in the TD-MIXVENT & TD-SILENT range have been designed with the professional contractor/ engineer in mind. All models include a “removable body” feature that enables the motor-impeller assembly to be completely removed or replaced without the need to interfere with the attached ducting.



Internal parts can be easily removed for mounting & servicing

Multitude of features-high specification

All models within the TD-MIXVENT & TD-SILENT range incorporate a powerful mixed flow impeller and internal air vanes located at the discharge end of the fan housing. This impeller and guide vane combination provides a smooth laminar air flow which in turn minimizes turbulence and noise, and generates an **excellent air flow to pressure performance ratio.**

Description

All of the TD-fans include the combination of a powerful motor, factory installed, to a mixed flow impeller. This motor and impeller combination enables the TD-fans to deliver high airflow performances with minimum noise generation against high static pressures typically found in ducted ventilation systems. The unique design of the support brackets, allows the motor and impeller assembly to be fitted or removed without dismantling the adjacent ducting and therefore, facilitating any installation or maintenance. The internal aerodynamic design of the TD-MIXVENT & TD-SILENT fans enable the units to generate large air volumes and pressures with the minimum of in-duct or radiated noise. The TD-fans offer the ideal in-line duct fan solution for a wide range of HVAC ventilation applications.

TD-MIXVENT & TD-SILENT Practical Installations

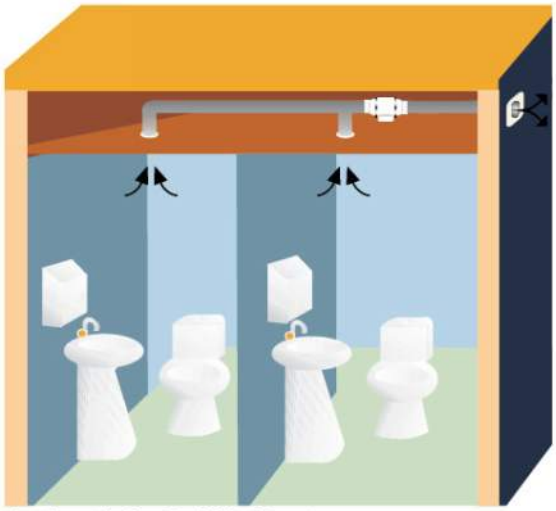
The TD-MIXVENT & TD-SILENT system offers the most versatile installation range on the market, as a result of its multiple combinations; it can be used in a large number of small and mid-range ventilation installations.



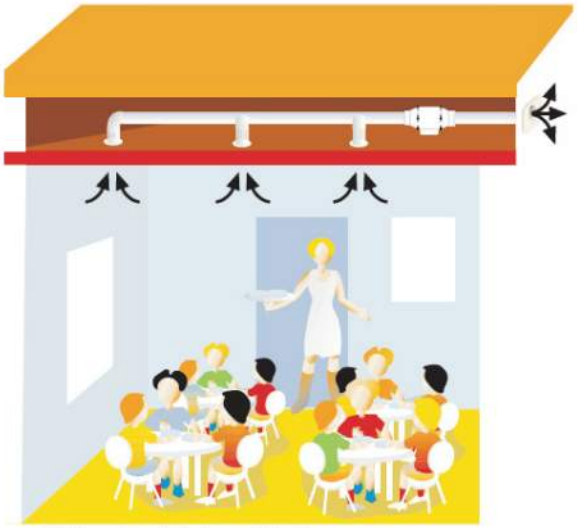
Domestic - Range Hood Exhaust



Commercial - Office



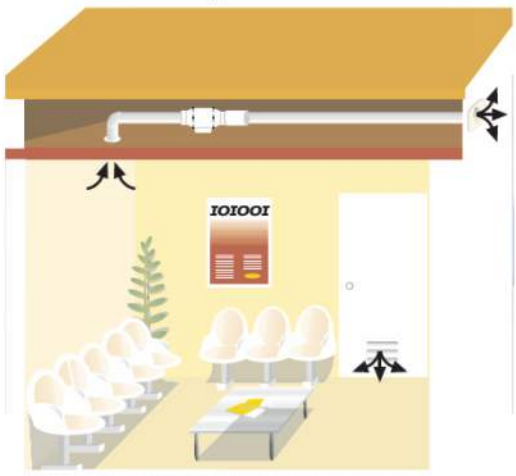
Industrial - Public Restroom



School - Dining Hall



Industrial - Locker Room



Health - Waiting Room

General Details of the TD-MIXVENT Range

S&P Exclusive Product



Low profile mixed flow fans, manufactured in plastic material (up to model 200) or in **galvanized steel** sheet protected with Epoxy paint (models 200, 250, 315, 355, and 400), with external terminal box, removable motor-impeller assembly and adjustable single-phase motor, Class B, IP44.



Construction characteristics

	100	100x1	125	150	200	250	315	355	400
Polypropylene housing	•	•	•	•	•				
Steel housing with epoxy coating						•	•	•	•
ABS fan blades	•	•	•	•	•				
Aluminum fan blades						•	•	•	•
Thermal link via fuse	•								
Thermal link with automatic reset		•	•	•	•	•	•	•	•
Permanently lubricated ball bearings	•	•	•	•	•	•	•	•	•

The extensive range of the TD-MIXVENT series makes it an effective solution for a wide range of residential and light commercial ventilation installations.

TD-MIXVENT Installation & Maintenance

Low Profile



The low profile of the fans in the TD-MIXVENT range makes them the ideal product for installations with low height limits, such as the case of suspended ceilings.

Easy to Install

1



Secure the support.

2



Make the connections.

3



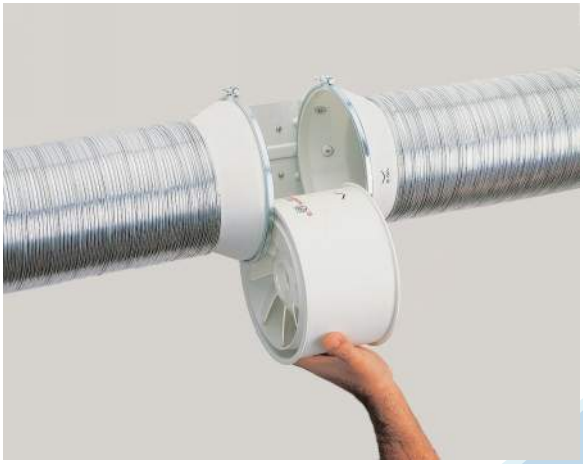
Connect the ducts.

Flexibility in Location



The fans can be connected at any point along the ventilation duct: along the duct or at the end.

Easy Maintenance



Removable body, for repair or cleaning, **without the need to touch the ducts.**

HVI CERTIFIED 2100

TD-MIXVENT Technical Specifications



Warranty
Five (5) year limited warranty.

Range
The TD-MIXVENT series consists of nine (9) nominal sized in-line fans. All models are specifically designed for direct connection in-line with industry standard diameter round ducting.

Construction
The TD-MIXVENT models 100, 100X1, 125, 150, and 200 are manufactured in tough reinforced plastic, models 250, 315, 355, and 400 have a metal casing and are finished in a tough epoxy-polyester paint coating. The TD fan duct connection flanges are manufactured from reinforced plastic, except for models 200, 250, 315, 355, and 400 which are constructed from epoxy-polyester coated metal.

Impellers
The impeller blades for models 100, 100X1, 125, 150, and 200 are molded in tough ABS plastic. Models 200, 250, 315, 355, and 400 are metal.

Long Life
Permanently lubricated motors are engineered for trouble-free continuous operation for 40,000 hours.

Motors
Models 100, 100X1 and 125 :
- Single-phase, 120V 60Hz, shaded pole (model 100), or permanent split capacitor (models 100X and 125). All motors include direct single speed connection and are also suitable for voltage speed control.
- Class ll electrical insulation (model 100) & Class l (models 100X1 and 125)
- IP 44 Protection
- Safety auto reset Thermal Overload Protection (fuse type)
- Self-lubricating sleeve bearings.
- Sizes 100-125: Suitable for working airstreams up to 104° F (40C)

Models 150, 200, 250, 315, 355, and 400:
- Single-phase induction asynchronous motor, with permanent capacitor and external rotor constructed of die cast aluminum. Models 150, 200, 355 and 400 feature single speed, fully speed controllable motors. Models 250 and 315 include direct dual speed (LS/HS) connection motors and are also suitable for voltage speed control.
- Class I electrical insulation
- IP 44 Protection
- Thermal Overload Protection
- Sealed For Life, ball bearings
- Size 200: Suitable for working airstreams up to 104 deg F (40C)
- Sizes 150, 250-400: Suitable for working airstreams up to 140 deg F (60C)

Performance characteristics

Models 250 and 315 include a direct single speed motor connection.

Model	Nom. RPM	Volts	Max. Watts	Speed	CFM v Static Pressure (SP) Ins. WG							Max. SP	Max operating temp. (ºF)	Wgt. (lbs)	Duct Dia. Ins.
					0"	0.125"	0.25"	0.375"	0.5"	0.75"	1.0"				
TD-100	2516	120	26	-	101	85	57	-	-	-	-	.4	104	4	4"
TD-100x1	2500	120	29	-	138	119	96	66	21	-	-	.45	104	6	4"
TD-125	2146	120	38	-	197	168	133	86	22	-	-	.55	104	6	5"
TD-150	2289	120	65	-	293	273	250	227	206	131	35	1.15	140	9	6"
TD-200	2781	120	184	-	538	495	458	418	367	190	10	1.625	104	13	8"
TD-250	2400	120	162	LS	541	475	418	355	295	218	170	2.03	140	21	10"
	3200	120	241	HS	754	715	680	640	606	520	405	2.53	140	21	10"
TD-315	2000	120	208	LS	751	670	545	420	285	190	130	1.62	140	31	12.4"
	2500	120	335	HS	1050	990	932	850	770	600	420	2.95	140	31	12.4"
TD-355	1536	120	522	-	2089	2013	1934	1855	1775	1591	1306	1.0	140	68	14"
TD-400	1559	120	916	-	3124	3032	2936	2836	2733	2505	2210	1.2	140	78	16"

Performance certified is for installation Type D: Ducted Inlet, Ducted Outlet. Performance ratings do not include the effects of appurtenances.

LS= Low Speed
HS = High Speed

S&P USA Ventilation Systems, LLC. certifies that all TD fan sizes shown herein are licensed to bear the AMCA Seal. The ratings shown are based on tests and procedures performed in accordance with AMCA Publication 211 and comply with the requirements of the AMCA Certified Ratings Program.

TD-100x1, TD-125, 150, and 200 are ENERGY STAR® qualified.

The TD-MIXVENT Models 100, 100x1 and 150 are California Title 24 compliant and meet ASHRAE 62.2 when installed with a CVC and other TD models are compliant when installed with a 3 way switch and remotely mounted speed control.

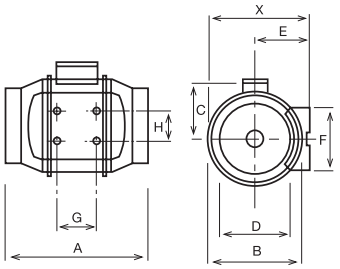
TD 250 & 315 are UL listed for outdoor use.

Sound characteristics

Fan sound levels are measured in sones. At this time there are no sone level test standards available through HVI due to the fact that remote mounted fan noise levels are in proportion to the following: type of duct, length of duct, fan distance from the intake source and other miscellaneous factors. However, it is generally accepted that remote mounted venting is usually quieter than standard (in room) venting.

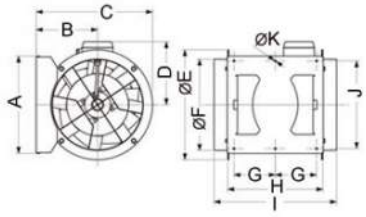
Dimensions (inches/mm)

Models 100-315



Model	X	A	B	C	D	E	F	G	H
TD-100	5 15/16 151	9 1/8 232	5 7/16 138	3 3/4 96	3 7/8 98	3 1/4 82	3 3/4 95	1 7/8 48	2 1/16 52
TD-100x1	7 3/8 188	11 15/16 303	6 15/16 176	4 1/2 115	3 13/16 97	3 15/16 100	3 9/16 90	3 1/8 80	2 3/8 60
TD-125	7 3/8 188	10 3/16 258	6 15/16 176	4 1/2 115	4 13/16 123	3 15/16 100	3 9/16 90	3 1/8 80	2 3/8 60
TD-150	8 3/8 212	11 5/8 295	7 7/8 200	5 127	5 13/16 147	4 7/16 112	5 1/8 130	3 1/8 80	2 3/8 60
TD-200	9 3/16 233	11 7/8 302	8 9/16 217	5 9/16 141	7 13/16 198	4 7/8 124	5 1/2 140	3 15/16 100	3 11/16 94
TD-250	11 7/16 291	15 3/16 386	10 11/16 272	7 9/16 192	9 3/4 248	6 1/8 155	6 5/8 168	5 11/16 145	5 1/2 140
TD-315	14 356	17 11/16 450	13 1/4 336	8 13/16 224	12 5/16 312	7 3/8 188	8 1/4 210	7 3/16 182	7 178

Models 355 - 400



Model	A	B	C	D	E	F	G	H	I	J	K
TD-355	14 13/16 376	9 3/8 238	17 3/4 451	8 13/16 224	16 3/4 425	13 15/16 354	6 5/16 160	14 1/2 368	18 11/16 475	13 3/8 340	5/16 8
TD-400	16 407	9 13/16 249	19 3/8 492	10 1/2 267	19 3/16 487	15 11/16 398	6 5/16 160	16 3/4 425	21 1/2 546	14 9/16 370	5/16 8

TD-MIXVENT KIT Bathroom Kits

If the strongest, quietest, bathroom exhaust system is what you seek…look no further. S&P offers the perfect solution with the most options. The TD-MIXVENT fan kits provide all the hardware needed to complete a simple in-line ducted ventilation installation. The kit includes a powerful TD in-line fan and exterior and interior grilles (with or without lights). Available in both Standard Exhaust Kits, for venting a single location, and Deluxe Exhaust Kits, for venting multiple locations with one fan.

The TD-MIXVENT fan kit is the ideal solution for any simple in-line ducted fan installation.
All TD kits have standard 7-year warranty.

Standard Exhaust Kits



KIT-TD100
- 1 TD100 exhaust fan
- 1 plastic round grille (PG-100)
- 1 exterior louvered grille (PER-100W)
- Integral mounting bracket

KIT-TD100x1
- 1 TD100x1 exhaust fan
- 1 plastic round grille (PG-100)
- 1 exterior louvered grille (PER-100W)
- Integral mounting bracket

KIT-TD150
- 1 TD150 exhaust fan
- 1 plastic round grille (PG-150)
- 1 exterior louvered grille (PER-150W)
- Integral mounting bracket

Deluxe Exhaust Kits



KIT-TD150-DV
- 1 TD150 exhaust fan
- 2 plastic round grilles (PG-150)
- 1 exterior louvered grille (PER-150W)
- 1 Y-fitting (SY-6)
- Integral mounting bracket

IMPORTANT: If venting in an non-insulated attic space, or in a cold climate, insulated flexible duct is strongly recommended for condensation issues.

Lighted Standard Exhaust Kits



KIT-TD100X1L
- 1 TD100x1 exhaust fan
- 1 Vent Light with LED Bulb (VLED-100)
- Integral mounting bracket

KIT-TD100X1H
- 1 TD100x1 exhaust fan
- 1 Vent Light with Halogen Bulb (VLH-100)
- Integral mounting bracket

KIT-TD100X1F
- 1 TD100x1 exhaust fan
- 1 Vent Light with Fluorescent Bulb (VLF-100)
- Integral mounting bracket

Lighted Deluxe Exhaust Kits



KIT-TD150L
- 1 TD150 exhaust fan
- 2 Vent Lights with LED Bulb (VLED-100)
- 1 Y-fitting (SY44-6)
- Integral mounting bracket

KIT-TD150H
- 1 TD150 exhaust fan
- 2 Vent Lights with Halogen Bulb (VLH-100)
- 1 Y-fitting (SY44-6)
- Integral mounting bracket

KIT-TD150F
- 1 TD150 exhaust fan
- 2 Vent Lights with Fluorescent Bulb (VLF-100)
- 1 Y-fitting (SY44-6)
- Integral mounting bracket

General Details of the TD-SILENT Range

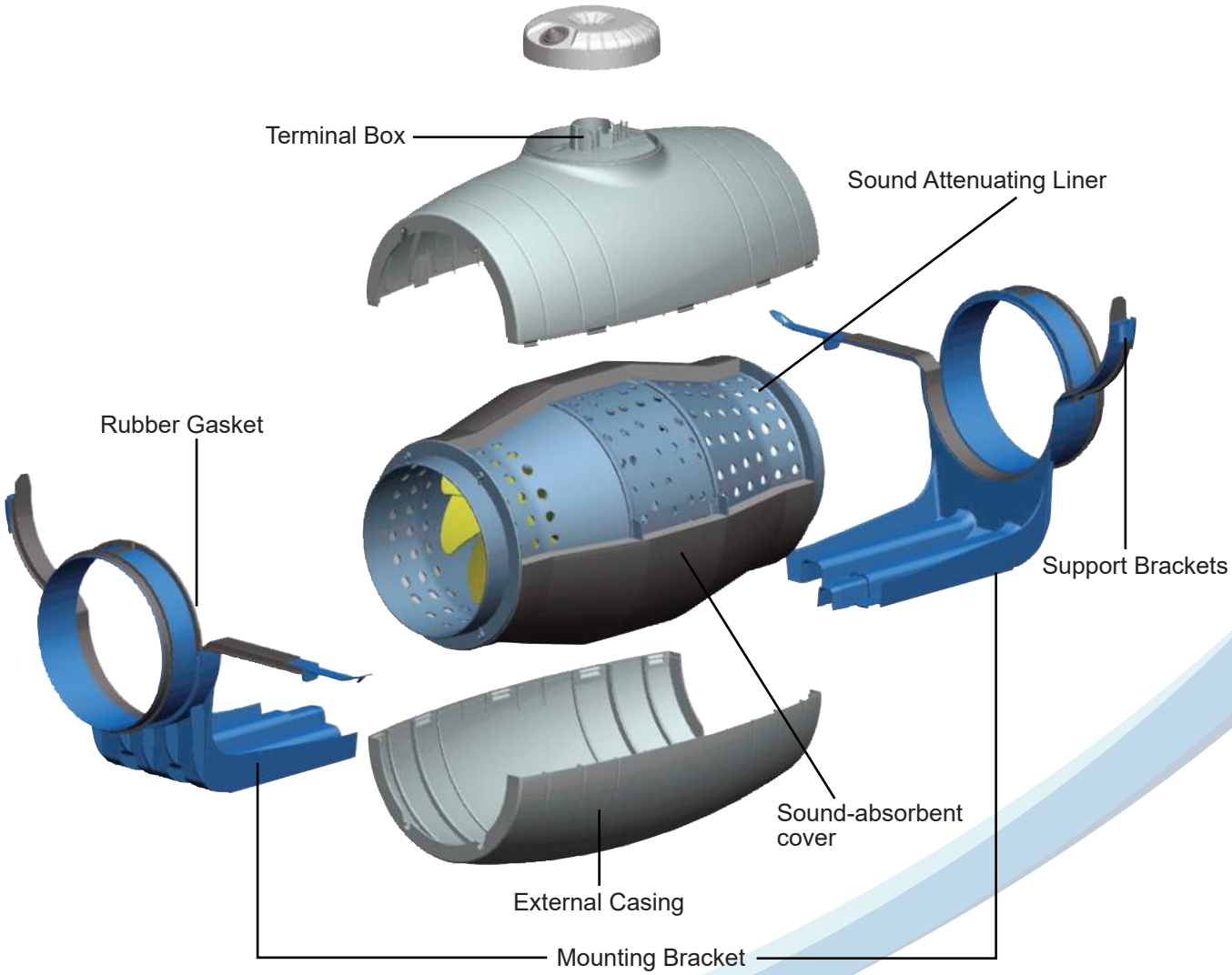
S&P Exclusive Product



As the name suggests these fans are extremely quiet, low profile “Mixed-flow” fans. Manufactured in plastic material with an external connection box, the body is easily dismantled with a full speed controllable, single speed motor. Sound waves are directed through the perforated inner skin and absorbed by a layer of sound-absorbent insulation. Plus the TD-SILENT is fitted with rubber gaskets on the inlet and outlet to absorb vibrations.

Construction characteristics

	125XS	150S	200S
Polypropylene housing	•	•	•
ABS fan blades	•	•	•
Thermal link with automatic reset	•	•	•
Permanently lubricated ball bearings	•	•	•



TD-SILENT Innovative Design Features

Low Profile



The low profile of the fans in the TD-SILENT range makes them the ideal product for installations with low height limits, such as the case of suspended ceilings.

Low Noise Levels



Sound waves produced inside the TD, are directed through the perforated inner skin and absorbed by the layer of sound-absorbent material.

Easy Maintenance



Bi-material support brackets, which in addition to simplifying installation, serve as joint seals.

Connection Box Rotates 360°



Connection box can be rotated 360º, to facilitate easy connection of the power cable.

Duct Air-Seals



Bi-material inlet and outlet incorporating a flexible washer to facilitate installation, absorb vibrations and provide a virtually **air-tight** seal.

Integral Mounting Bracket



Mounting bracket for installing on a wall or ceiling, incorporating twin-material support brackets for the motor section that absorbs vibration.

TD-SILENT Easy Installation

1



Loosen the clamps.

2



Open the clamps on both ends.

3



Remove the fan body.

4



Remove the terminal box lid.

5



Connect electrical supply.

6



Re-mount fan body by tightening the clamps.

TD-SILENT Technical Specifications



Warranty
Five (5) year limited warranty.

Range
The TD-SILENT consists of three (3) nominal sized in-line fans. All models are specifically designed for direct connection in-line with industry standard diameter round ducting.

Construction
The TD-SILENT models 125XS, 150S and 200S are manufactured in tough reinforced plastic. Sound waves are directed through the perforated inner skin and absorbed by a layer of sound-absorbent insulation. Plus the TD-SILENT is fitted with rubber gaskets on the inlet and outlet to absorb vibrations.

Long Life
Permanently lubricated motors are engineered for trouble-free continuous operation for 40,000 hours.

Impellers
The impeller blades are molded in tough ABS plastic.

Motors
Models 125XS:
Single-phase, 120V 60Hz, shaded pole induction asynchronous motor in die cast aluminum. All motors include direct single speed connection and are also suitable for voltage speed control.

- Class I electrical insulation
- IP 44 Protection
- Safety auto reset Thermal Overload Protection (fuse type)
- Self-lubricating sleeve bearings.
- Suitable for working airstreams up to 104 deg F (40°C)

Models 150S and 200S:
Single-phase induction asynchronous motor, with permanent capacitor and external rotor in die cast aluminum. All models include direct single speed connection and are also suitable for voltage speed control.

- Suitable for working airstreams up to 140° F (60°C).
- Class I electrical insulation
- IP 44 Protection
- Thermal Overload Protection
- Sealed For Life, ball bearings
- Sizes 200S: Suitable for working airstreams up to 104° F (40°C)
- Sizes 150S: Suitable for working airstreams up to 140° F (60°C)

Code Approval

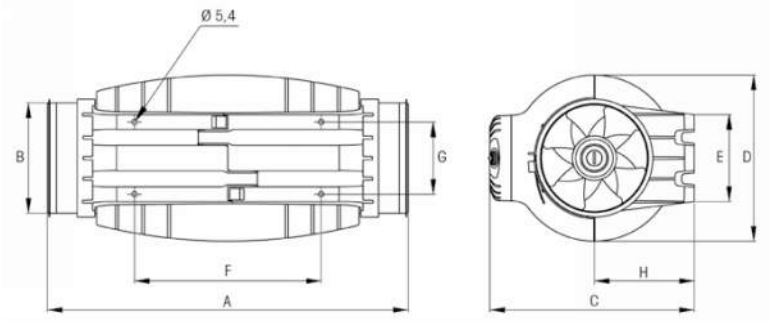
- All models have been independently safety tested by Underwriters Laboratories, Inc. and are UL and cUL Listed.
- Independently tested for Airflow Performance.
- The TD product range is certified by the Home Ventilating Institute (HVI) for Air Performance.
- All models are ENERGY STAR® qualified.

Air Performance

Model	Duct Dia. Ins.	Nom. RPM	Volts	Max. Watts	CFM v Static Pressure (SP) Ins. WG							Max. SP	Max operating temp. (ºF)	Wgt. (lbs)
					0”	0.125”	0.25”	0.375”	0.5”	0.75”	1.0”			
TD-125XS	5”	2500	120	36	203	175	138	84	33	-	-	0.6	104	11.9
TD-150S	6”	2700	120	65	333	315	286	271	257	178	77	1.2	140	13.2
TD-200S	8”	2200	120	122	530	503	472	443	415	349	204	1.2	140	19.2

The TD-SILENT Models 125XS and 150S are California Title 24 compliant and meet ASHRAE 62.2 when installed with a CVC and other TD models are compliant when installed with a 3 way switch and remotely mounted speed control.

Dimensions (inches)



Model	A	B Ø	C	D Ø	E	F	G	H
TD-125XS	22 5/8	3 13/16	9 15/16	8 1/16	3 15/16	9 13/16	3 1/4	4 3/4
TD-150S	19 1/16	5 13/16	10 13/16	8 11/16	4 9/16	9 13/16	3 3/4	5 1/4
TD-200S	22 3/8	7 13/16	12 7/8	10 3/8	5 11/16	13 3/8	5 1/16	6 7/16

TD-MIXVENT & TD-SILENT Accessories

FT622 - ASHRAE 62.2 Bath Fan Ventilation Control



The FT622 is designed to replace bathroom fan and light switches and provide both functions with one easy operation. The FT622 delivers a precise amount of ventilation, and is a simple solution to meet ASHRAE 62.2 in conjunction with an S&P fan.

FT247 - Programmable Fan Timer



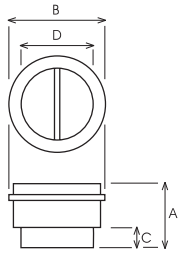
S&P offers the FT247 with easy programming for your bathroom fan ventilation needs. Simply set what time you want the fan to turn on and off and what day or days you want the fan to run.



MCA
Backdraft dampers are installed at the fans' discharge. They prevent the entry of odors, air currents and prevent heat leaks when the exhauster is not in operation.

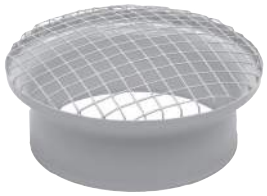
Model	Type TD
MCA-100	100
MCA-125	125
MCA-150	150
MCA-200	200
MCA-250	250
MCA-315	315

Dimensions (inches/mm)



MCA-100-315

Model	A	B	C	D
MCA-100	4 3/16 / 107	4 3/8 / 111	1 1/4 / 31	3 11/16 / 94
MCA-125	4 3/16 / 107	5 3/8 / 136	1 1/4 / 31	4 11/16 / 119
MCA-150	4 3/4 / 121	6 7/16 / 163	1 3/8 / 35	5 13/16 / 147
MCA-200	5 3/16 / 131	8 7/16 / 214	1 3/8 / 35	7 3/4 / 197
MCA-250	6 3/16 / 164	10 3/8 / 264	1 5/8 / 42	9 3/4 / 248
MCA-315	8 1/16 / 205	13 / 330	1 15/16 / 50	12 5/16 / 312



MRJ
Grilles fit on the suction and the discharge sides of the installation. They prevent the entry of foreign bodies which could damage the fan.

Model	Type TD
MRJ100	100
MRJ125	125
MRJ150	150
MRJ200	200
MRJ250	250



MBR
Flanges enable TD devices to connect in a series.

Model	Type TD
MBR-125	125
MBR-150	150
MBR-200	200
MBR-250	250

TD Bathroom Exhaust Grilles

Featuring Vent Lights and Premium Grilles

S&P's Grille Options give you the choice of seven (7) aesthetically pleasing grilles designed to match any bathroom decor. You can choose from our Vent Lights, Premium Grilles or Adjustable Grilles to fit your needs.

These grilles are designed to be used exclusively with one of S&P's TD remotely mounted inline for virtually silent bathroom ventilation. Inline fans give you the option to mount your grille over the shower, toilet, tub, or in multiple locations (dual vent).

With S&P's Grille Options the choice is yours!

Vent Lights

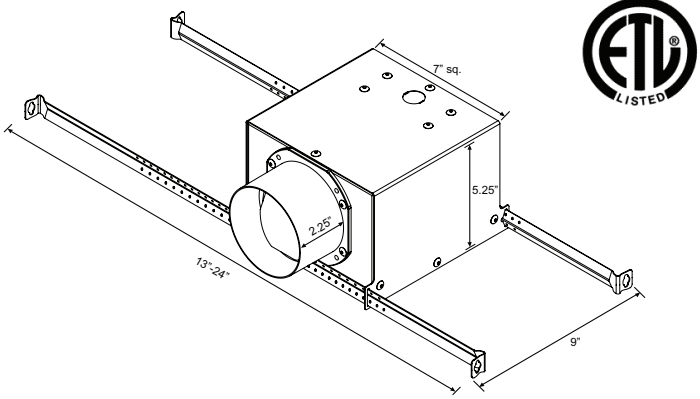
Available with LED Bulbs



S&P's new Vent Lights give you ventilation that is *"Out-of-Sight and Out-of-Mind"!* The Vent Lights appear to be a regular can light, and when combined with a remotely mounted fan, the noise and unsightly look of the traditional bathroom fan are gone! The Vent Lights are aesthetically pleasing grilles with lights that will match any bathroom decor.

Model	Description
VLED-100	Vent Light with PAR30 LED Bulb
VLH-100	Vent Light with PAR30 Halogen Bulb
VLF-100	Vent Light with Energy Star Rated Compact Fluorescent Bulb

Dimensions (inches)



Features:

- Longer duct collar for 4" duct
- Extendable hanger bars up to 24"
- 7.5" grille
- Built-in backdraft damper
- 3 bulb options

Why Choose the Vent Light with LED Bulbs?

S&P's respect for the environment extends to its Vent Lights with the optional LED Bulb. The benefits to the LED Bulbs include:

- Built to last a minimum of 60,000 hours, plus the LED's use a fraction of the energy that a traditional incandescent or halogen lamp uses
- LED's contain no mercury so they are easy to dispose of, unlike other energy efficient bulbs
- The LED lamps run cool and are shock resistant, making them safer for use in your home

Premium Grilles

PG



S&P's premium grilles come standard with steel collars for easy mounting and installation.

Model	Description
PG-100	4" Plastic Grille with 4" Steel Collar
PG-150	6" Plastic Grille with 6" Steel Collar

Grille Dimensions (in inches)



Grille	Dia.	Height	Fits Duct Dia.	Fits Collars
PG-150G	8 1/8	1 5/8	6"	PG-150D
PG-100G	4 5/8	1 1/2	4"	PG-100D

Collar Dimensions (in inches)



PG Collar

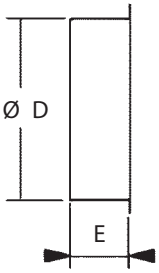
Collar	Diameter	Length
PG-100D	3 3/4	3 1/4
PG-150D	5 3/4	4 5/8

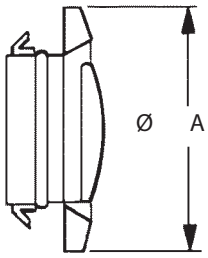
Adjustable Grilles

BOR/BOC



Exhaust grilles for bathrooms, toilets and other small rooms. All models offer an adjustable central valve to regulate the airflow.





Model	A	D	E	Weight (lbs)
BOR/BOC-100	145	100	50	1
BOR/BOC-125	145	125	50	1
BOR/BOC-150	204	160	50	1
BOR/BOC-200	244	200	50	1

Additional general assembly accessories



BOR/BOC
Round plastic/metal adjustable grille



MBR
Connection Flanges



FB
Filtering Box



PER-W
Plastic louver shutter



PER
High pressure aluminum louver shutter



GRA
Aluminum exterior fixed grilles



SR
Reducer



SY
Y sheet metal adapter



SIL
Acoustic attenuators

Electrical accessories



EPBT
Electronic push button timer



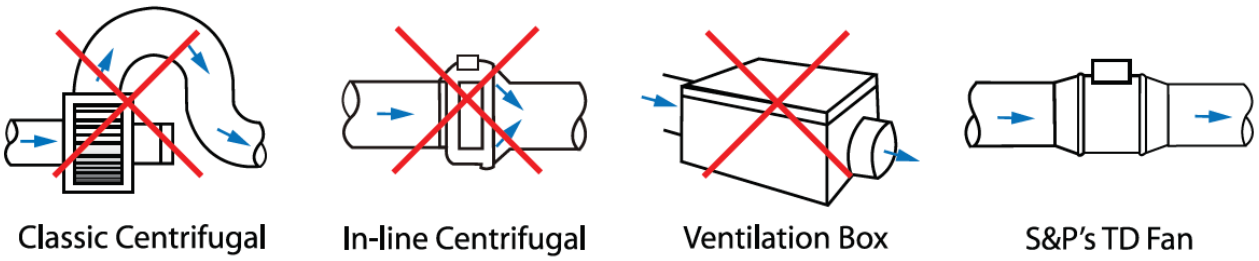
SCS
Speed control slide type



SC
Speed control

Mixed Flow Fans vs. Axial & Centrifugal Fans

	Noise Level	Air Volume	Static Pressure
Axial Fans • Low noise levels • High air volumes • Very little static pressure capability*	High Low	High Low	High Low
Centrifugal Fans • Higher noise levels • Lower air volumes • Very high static pressure capability*	High Low	High Low	High Low
Mixed Flow Fans** • Low noise levels • High air volumes • Significant static pressure capability*	High Low	High Low	High Low



*Static pressure is the ability of the fan to overcome resistance such as long or complicated duct runs.

Mixed flow fans (TD series) offer the best of both axial and centrifugal fans and are suitable for most air movement applications. S&P's **TD-MIXVENT & TD-SILENT Series has all the benefits of a mixed flow fan, plus it requires minimal space and it is easy to install.

PRF - Radon Mitigation Fans



PRF-100



PRF-150

Application

PRF fans are specifically designed for radon mitigation.

Specifications

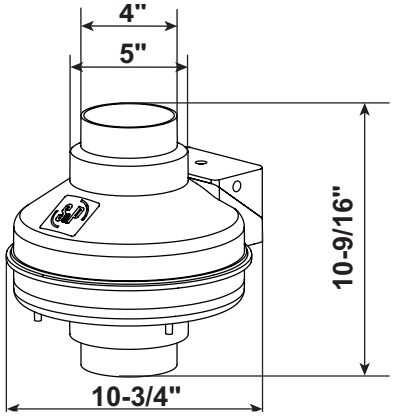
- Duct connections sized for easy fit with standard PVC couplings typically used in radon mitigation applications
- Totally Enclosed Air Over
- Fully sealed, high quality plastic housing
- Large, easily accessible, watertight electrical box for unobstructed wiring process
- Easily mount on duct pipe or use heavy-duty metal mounting bracket (sold separately)
- Significantly less expensive than comparable alternatives
- Thermal overload protection
- HVI Certified Performance
- cETLus certified
- 5-year warranty

PRF Performance

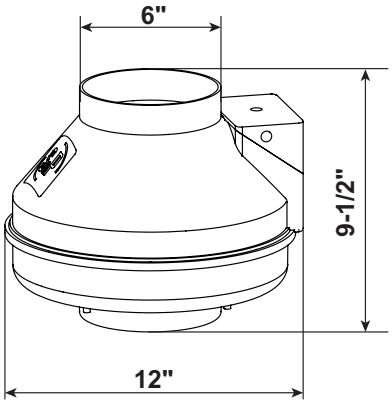
Model	Size	Electrical	Power (W)	Current (A)	CFM @ SP				RPM
					0.00	0.25	0.50	1.00	
PRF-100	4"	1/60/120V	91	0.77	169	147	126	82	3080
PRF-150	6"	1/60/120V	135	1.15	321	287	254	193	2890

Dimensions

PRF-100



PRF-150



Radon Installation Kits

Kits include two flexible white couplings with stainless steel hose clamps, a U-tube manometer, and radon system labels. The U-tube manometer (PR-M) is available to purchase separately.



Kit	Used with Model	PVC pipe size
PRFIK-43	PRF-100	3”
PRFIK-44	PRF-100	4”
PRFIK-64	PRF-150	4”

All specifications are subject to change without notice unless approved in submittal by S&P USA.

Also Available from S&P

PV-POWERVENT Fans



MODEL FEATURES

- Exhaust air up to 942 CFM with static pressure capabilities to 1.5” w.g.
- Galvanized steel casing with black backed enamel coating
- Pre-wired junction box
- Ideal for applications where space is limited
- Non-overloading backward inclined wheel for efficiency at higher static pressures
- AMCA Seal for Air Performance
- cULus Listed, Standard 507 & 705

Air Performance

Model No.	Nom. RPM	Volts	Max. Watts	CFM v Static Pressure (SP) Ins. WG									Max. SP	Duct Dia. Ins.
				0”	0.125”	0.25”	0.375”	0.5”	0.75”	1.0”	1.25”	1.5”		
PV-100	1400	115	57	108	100	92	85	78	66	52	33	18	1.70	4”
PV-100x	2880	115	84	153	142	130	120	111	96	80	63	34	1.85	4”
PV-125	2350	115	58	128	104	85	74	63	47	32	15	-	1.43	5”
PV-125x	2745	115	85	206	190	170	153	135	110	88	62	33	1.77	5”
PV-150x	2750	115	135	390	367	340	312	285	233	193	153	110	2.05	6”
PV-200	3100	115	130	402	375	350	327	296	239	179	135	85	1.94	8”
PV-200x	2930	115	180	544	515	485	446	415	360	312	273	230	2.64	8”
PV-250	3000	115	170	568	533	502	471	440	370	312	263	221	2.61	10”
PV-250x	3045	115	214	618	595	570	540	510	450	390	340	297	2.80	10”
PV-315	2920	115	200	669	640	610	581	552	489	427	368	309	2.21	12.4"
PV-315x	2730	115	365	943	903	860	815	766	628	511	440	389	3.9	12.4"

S&P USA Ventilation Systems, LLC. certifies that the PV range shown herein is licensed to bear the AMCA Seal. The ratings shown are based on tests and procedures performed in accordance with AMCA Publication 211 and comply with the requirements of the AMCA Certified Ratings Program.

Performance certified is for installation type D-Ducted inlet, Ducted outlet. Performance ratings do not include the effects of appurtenances (accessories). Speed (RPM or RPS) shown is nominal. Performance is based on actual speed of test.

SWF-SIDEWALL Fan



MODEL FEATURES

- Exhaust air up to 416 CFM with static pressure capabilities to 1.5” w.g.
- Galvanized steel casing with black backed enamel coating
- Pre-wired junction box
- Ideal for applications where space is limited
- Non-overloading backward inclined wheel for efficiency at higher static pressures
- cULus Listed

Air Performance

Model	RPM	Volts	Fre-quency	Current	Watts	CFM vs. Static Pressure (SP) Ins. WG								
						0”	0.125”	0.25”	0.375”	0.5”	0.75”	1.0”	1.25”	1.5”
SWF-100	2200	120	60 Hz	0.52 A	57	119	106	92	78	64	44	26	-	-
SWF-100X	2600	120	60 Hz	0.8 A	90	171	162	152	142	118	90	66	46	28
SWF-150	2600	120	60 Hz	0.8 A	90	235	221	197	181	168	122	81	60	27
SWF-150X	2800	120	60 Hz	1.0 A	115	354	332	310	287	266	230	192	147	96
SWF-200	2800	120	60 Hz	1.0 A	115	416	395	368	341	324	287	233	184	132

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S&P Canada Ventilation Products, Inc.
6710 Maritz Drive Unit #7
Mississauga, ON L5W 0A1 - Canada
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www.solerpalaucanada.com

Soler&Palau Ventilation Group

SMMSe / SHRMe VRF Indoor Unit
MMC-AP0181H2UL—Underceiling

TOSHIBA
Carrier

Submittal Data

Job Data _____ Location _____
Buyer _____ Buyer PO # _____ Carrier # _____
Unit Number _____ Model Number _____
Performance Data Certified By _____ Date _____



SMMSe / SHRMe VRF Underceiling Features

- R-410A refrigerant
- Four sizes from 18,000 to 42,000 Btu/h
- Quiet operation, as low as 32.5 dBA
- Vertical airflow can be set to swing or fixed position
- Auto or manually set three fan speeds
- Easy to remove cleanable filter
- Five-year parts limited warranty

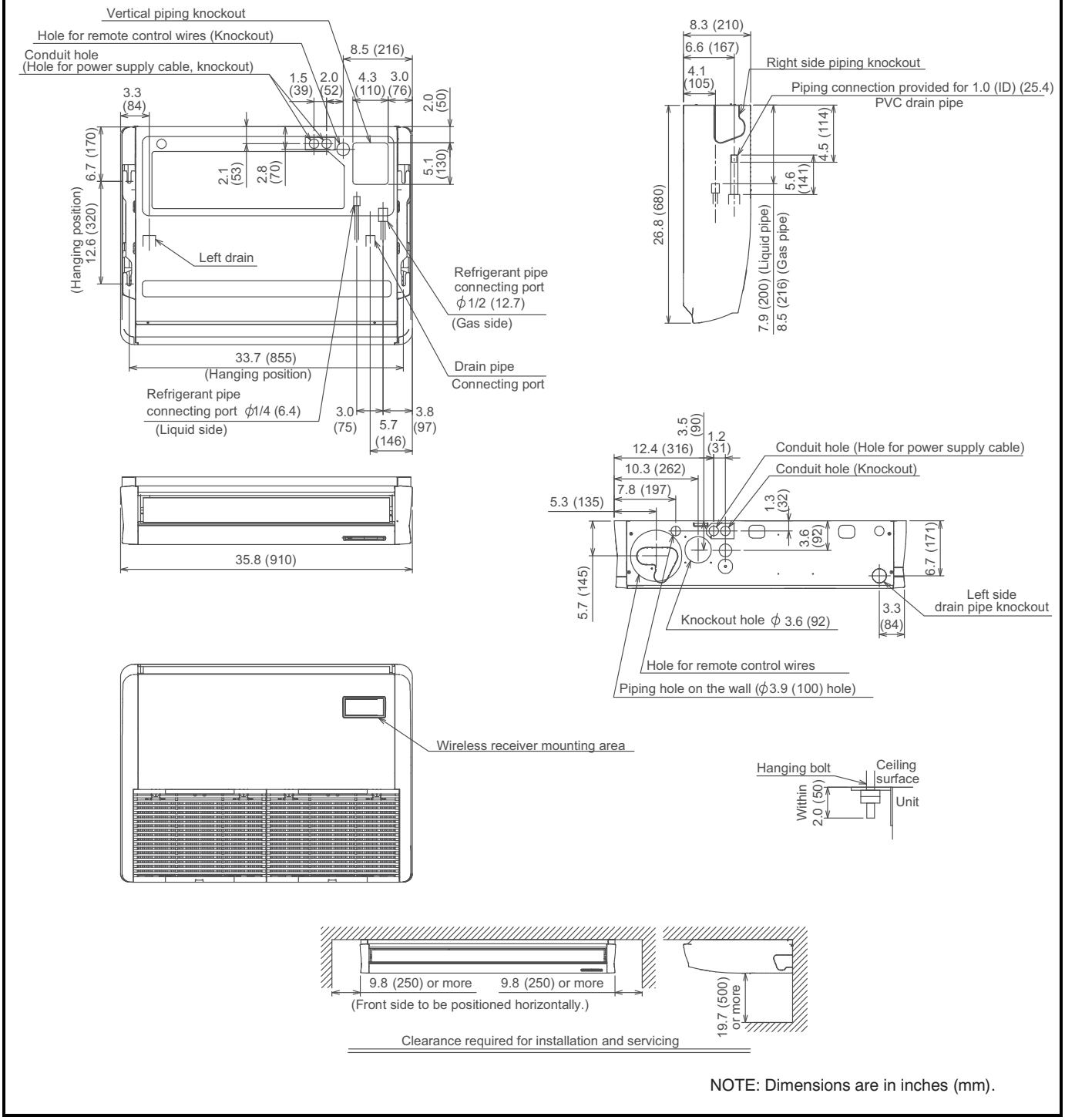
INDOOR UNIT MODEL		MMC-AP0181H2UL
PERFORMANCE		
Cooling Rated Capacity	Btu/h	18,000
Heating Rated Capacity	Btu/h	20,000
Fan Type (Qty)		Centrifugal (2)
Air Flow (L / M / H)	CFM	320 / 360 / 410
Sound Pressure (L / M / H)	dBA	32.5 / 35 / 38.5
ELECTRICAL		
Power Supply	V/Ph/Hz	208-230/1/60
Power Consumption (Input)	kW	0.038
Full Load Amps (FLA)	A	0.4
Minimum Circuit Amps (MCA)	A	0.5
Maximum Overcurrent Protection	A	15

MOTOR		
Motor Type	DC Inverter Driven	
Motor Watts	W	60
PHYSICAL DATA		
Pipe Connection Size - Liquid (High Pressure)	in.	1/4 (Flare)
Pipe Connection Size - Gas (Low Pressure)	in.	1/2 (Flare)
Pipe Connection Size - Drain (OD)	in.	1
Pipe Connection Size - Drain (ID)	in.	13/16
Refrigerant		R-410A
External Finish	Munsell 10Y9.3/0.4	
Unit Width	in.	35-3/4
Unit Height	in.	8-5/16
Unit Depth	in.	26-3/4
Net Weight	lb	46

ACCESSORIES

- ☐ Wired Remote Controller (7-Day Programmable) - RBC-AMS54E-UL
- ☐ Simple Wired Remote Control - RBC-AS41UL
- ☐ Stand Alone Receiver with Wireless Remote TCB-AX32UL
- ☐ Integral Receiver with Wireless Remote RBC-AX33CUL
- ☐ Remote Sensor TCB-TC41LUL
- ☐ Wired Remote Controller - RBC-AMT32UL
- ☐ Elbow Piping Kit TCB-KP12CUL
- ☐ Condensate Drain Pump Kit TCB-DP22CUL

DIMENSIONAL DRAWING
INDOOR UNIT UNDERCEILING MMC-AP0181H2UL



NOTE: Dimensions are in inches (mm).

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SMMSe / SHRMe VRF Indoor Unit
MMK-AP0073H2UL—HIGH WALL

TOSHIBA
Carrier

Submittal Data

Job Data _____ Location _____
Buyer _____ Buyer PO # _____ Carrier # _____
Unit Number _____ Model Number _____
Performance Data Certified By _____ Date _____



SMMSe / SHRMe VRF High Wall Features

- R-410A refrigerant
- Six sizes from 7,000 to 24,000 Btu/h
- Quiet operation, as low as 30 dBA
- Vertical airflow can be set to swing or fixed position
- Air throw up to 23 feet
- Auto or manually set three fan speeds
- Easy to remove cleanable filter
- Five-year parts limited warranty

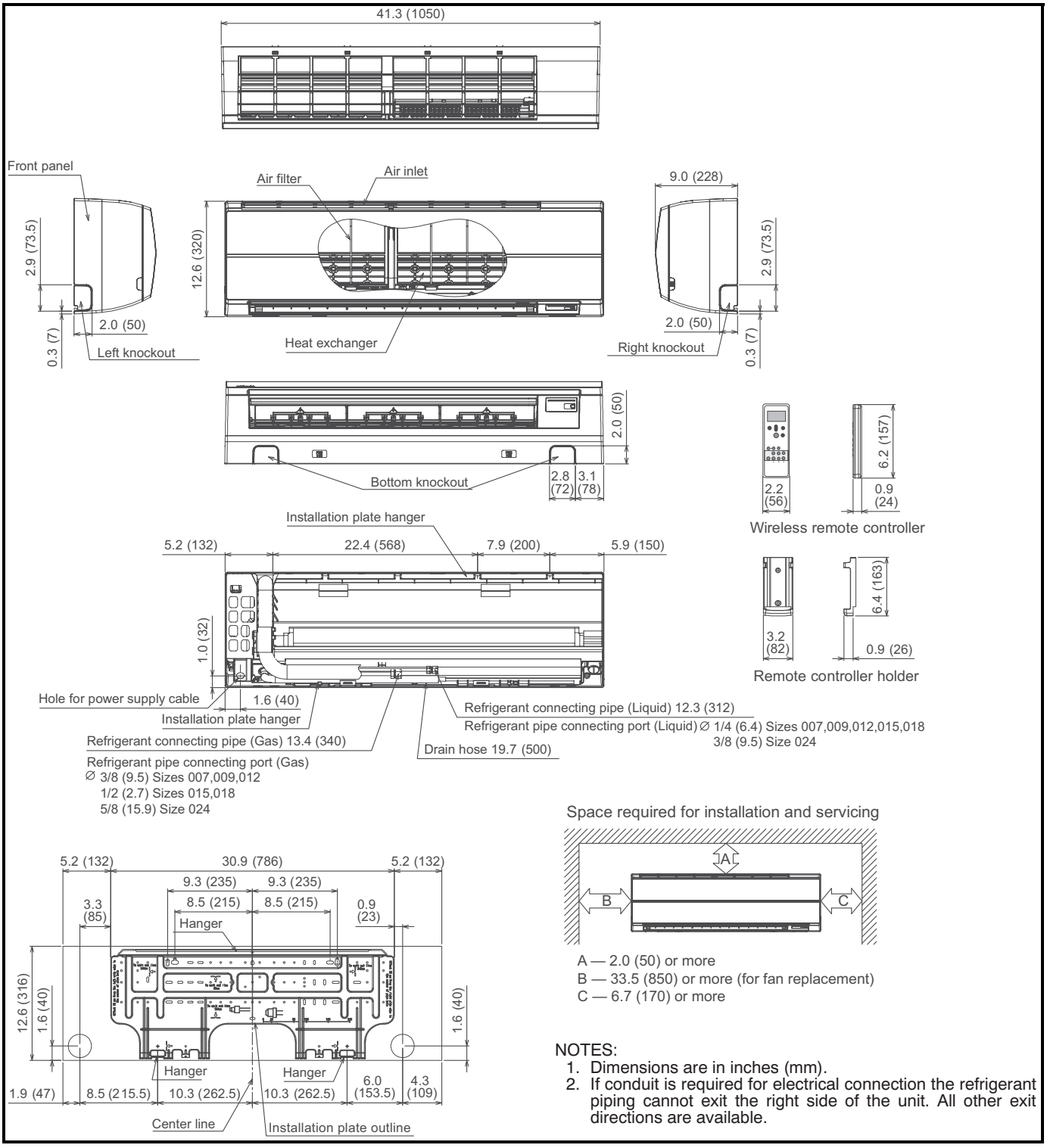
INDOOR UNIT MODEL		MMK-AP0073H2UL
PERFORMANCE		
Cooling Rated Capacity	Btu/h	7,500
Heating Rated Capacity	Btu/h	8,500
Fan Type (Qty)		Cross-Flow (1)
Airflow (L / M / H)	CFM	230 / 270 / 340
Sound Pressure (L / M / H)	dBA	30 / 32.5 / 36
ELECTRICAL		
Power Supply	V/Ph/Hz	208-230/1/60
Power Consumption (Input)	kW	0.018
Full Load Amps (FLA)	A	0.2
Minimum Circuit Amps (MCA)	A	0.3
Maximum Overcurrent Protection	A	15
MOTOR		
Motor Type		DC Inverter Driven
Motor Watts	W	30

PHYSICAL DATA		
Pipe Connection Size - Liquid (High Pressure)	in.	1/4 (Flare)
Pipe Connection Size - Gas (Low Pressure)	in.	3/8 (Flare)
Pipe Connection Size - Drain (OD)	in.	7/8
Pipe Connection Size - Drain (ID)	in.	5/8
Refrigerant		R-410A
External Finish		Munsell 2.5GY9.0/0.5
Unit Width	in.	41-5/16
Unit Height	in.	12-9/16
Unit Depth	in.	9
Net Weight	lb	33
CONTROLS		
Wireless Remote Controller (Standard)		

ACCESSORIES

- ☐ Wired Remote Controller (7-Day Programmable) - RBC-AMS54E-UL
- ☐ Simple Wired Remote Control - RBC-AS41UL
- ☐ Remote Sensor TCB-TC41LUL
- ☐ Wired Remote Controller - RBC-AMT32UL
- ☐ Condensate Drain Pump Kit 53DS-900---118

DIMENSIONAL DRAWING
INDOOR UNIT HIGH WALL MMK-AP0073H2UL



Space required for installation and servicing

A — 2.0 (50) or more
B — 33.5 (850) or more (for fan replacement)
C — 6.7 (170) or more

NOTES:
1. Dimensions are in inches (mm).
2. If conduit is required for electrical connection the refrigerant piping cannot exit the right side of the unit. All other exit directions are available.

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SMMSe / SHRMe VRF Indoor Unit
MMK-AP0093H2UL—HIGH WALL

TOSHIBA
Carrier

Submittal Data

Job Data _____ Location _____
Buyer _____ Buyer PO # _____ Carrier # _____
Unit Number _____ Model Number _____
Performance Data Certified By _____ Date _____



SMMSe / SHRMe VRF High Wall Features

- R-410A refrigerant
- Six sizes from 7,000 to 24,000 Btu/h
- Quiet operation, as low as 30 dBA
- Vertical airflow can be set to swing or fixed position
- Air throw up to 23 feet
- Auto or manually set three fan speeds
- Easy to remove cleanable filter
- Five-year parts limited warranty

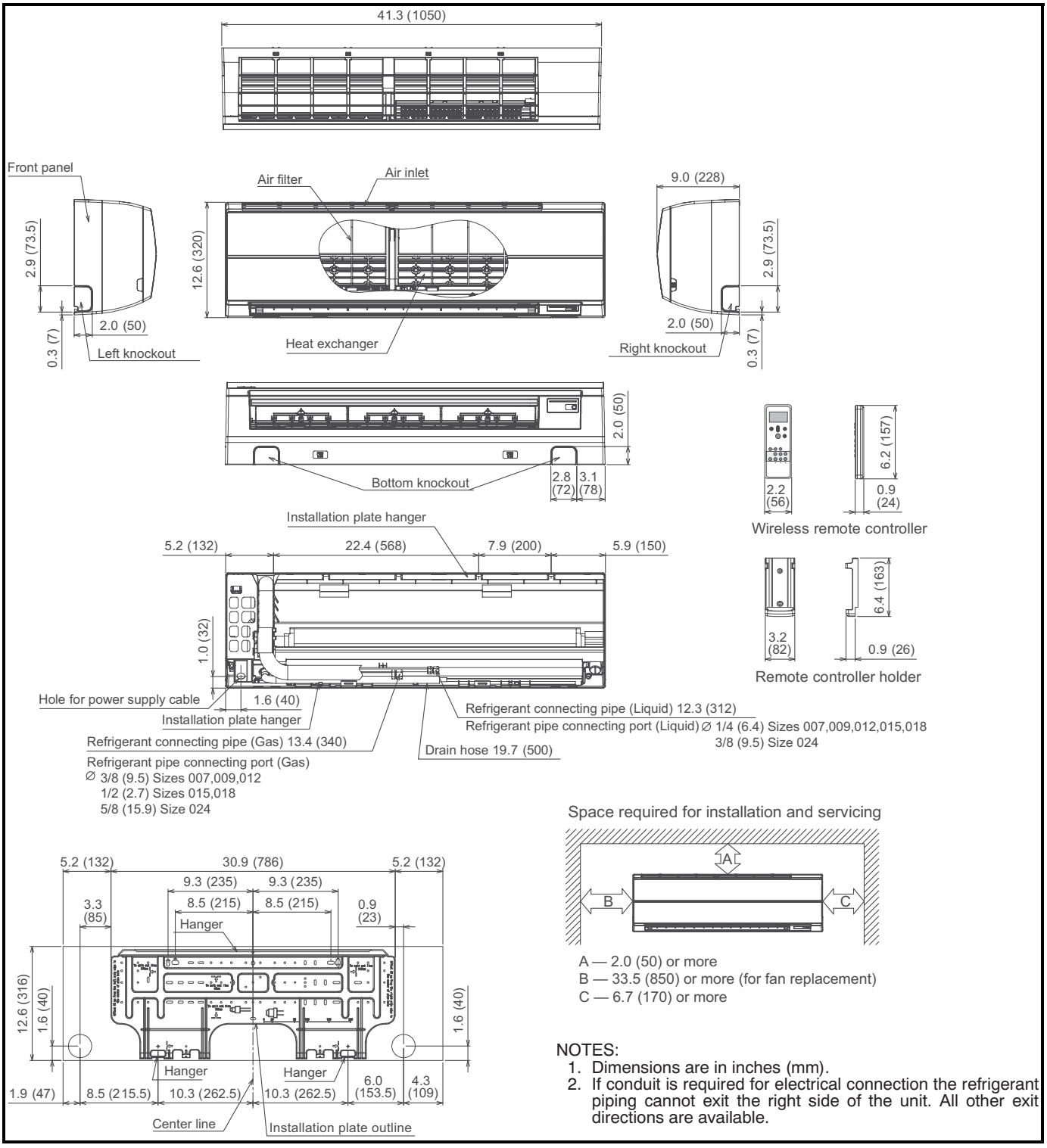
INDOOR UNIT MODEL		MMK-AP0093H2UL
PERFORMANCE		
Cooling Rated Capacity	Btu/h	9,500
Heating Rated Capacity	Btu/h	10,500
Fan Type (Qty)		Cross-Flow (1)
Airflow (L / M / H)	CFM	230 / 280 / 350
Sound Pressure (L / M / H)	dBA	30 / 34 / 39
ELECTRICAL		
Power Supply	V/Ph/Hz	208-230/1/60
Power Consumption (Input)	kW	0.021
Full Load Amps (FLA)	A	0.2
Minimum Circuit Amps (MCA)	A	0.3
Maximum Overcurrent Protection	A	15
MOTOR		
Motor Type		DC Inverter Driven
Motor Watts	W	30

PHYSICAL DATA		
Pipe Connection Size - Liquid (High Pressure)	in.	1/4 (Flare)
Pipe Connection Size - Gas (Low Pressure)	in.	3/8 (Flare)
Pipe Connection Size - Drain (OD)	in.	7/8
Pipe Connection Size - Drain (ID)	in.	5/8
Refrigerant		R-410A
External Finish		Munsell 2.5GY9.0/0.5
Unit Width	in.	41-5/16
Unit Height	in.	12-9/16
Unit Depth	in.	9
Net Weight	lb	33
CONTROLS		
Wireless Remote Controller (Standard)		

ACCESSORIES

- ☐ Wired Remote Controller (7-Day Programmable) - RBC-AMS54E-UL
- ☐ Simple Wired Remote Control - RBC-AS41UL
- ☐ Remote Sensor TCB-TC41LUL
- ☐ Wired Remote Controller - RBC-AMT32UL
- ☐ Condensate Drain Pump Kit 53DS-900---118

DIMENSIONAL DRAWING
INDOOR UNIT HIGH WALL MMK-AP0093H2UL



A — 2.0 (50) or more
B — 33.5 (850) or more (for fan replacement)
C — 6.7 (170) or more

NOTES:
1. Dimensions are in inches (mm).
2. If conduit is required for electrical connection the refrigerant piping cannot exit the right side of the unit. All other exit directions are available.

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SMMSe / SHRMe VRF Indoor Unit
MMK-AP0123H2UL—HIGH WALL

TOSHIBA
Carrier

Submittal Data

Job Data _____ Location _____
Buyer _____ Buyer PO # _____ Carrier # _____
Unit Number _____ Model Number _____
Performance Data Certified By _____ Date _____



SMMSe / SHRMe VRF High Wall Features

- R-410A refrigerant
- Six sizes from 7,000 to 24,000 Btu/h
- Quiet operation, as low as 30 dBA
- Vertical airflow can be set to swing or fixed position
- Air throw up to 23 feet
- Auto or manually set three fan speeds
- Easy to remove cleanable filter
- Five-year parts limited warranty

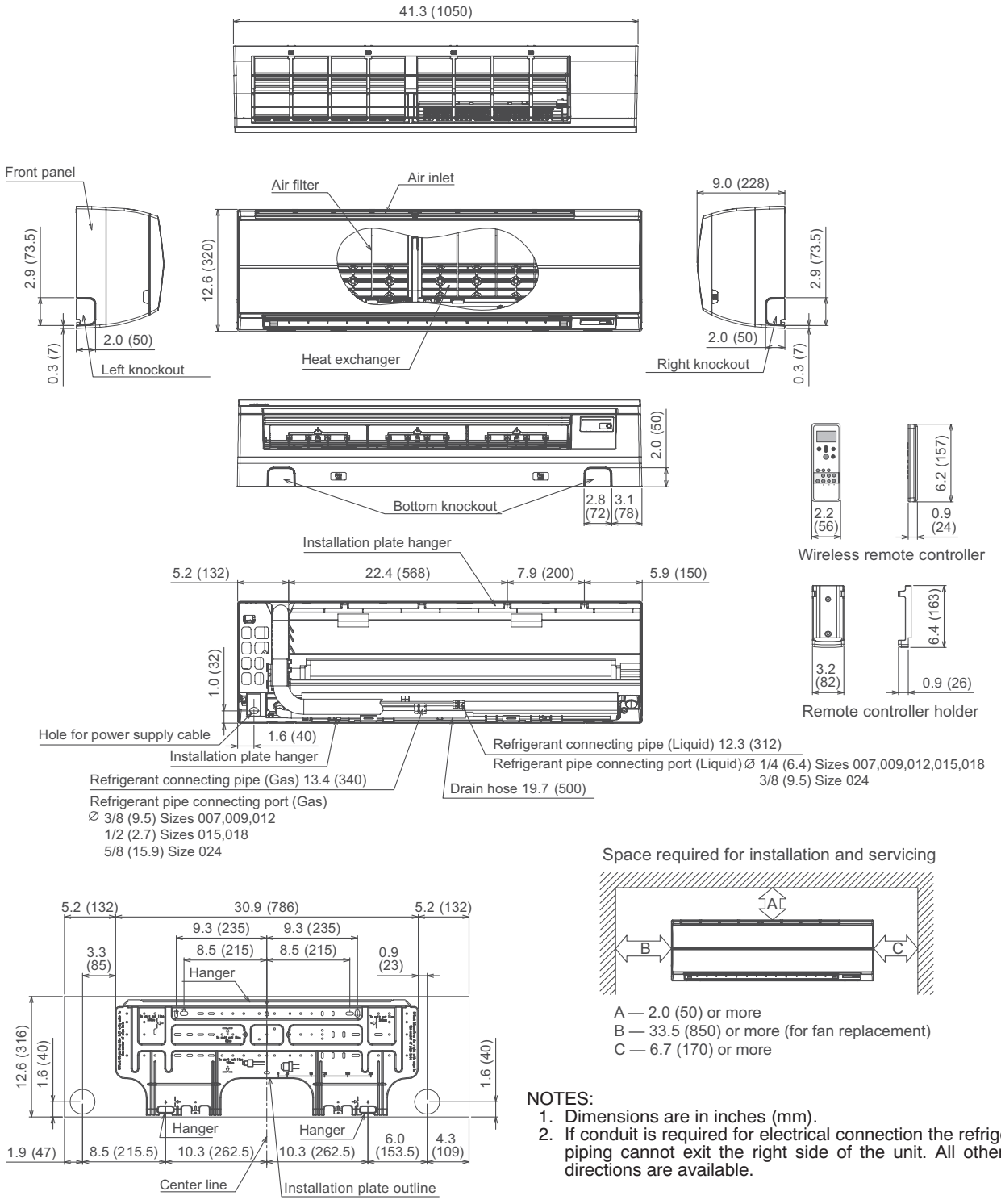
INDOOR UNIT MODEL		MMK-AP0123H2UL
PERFORMANCE		
Cooling Rated Capacity	Btu/h	12,000
Heating Rated Capacity	Btu/h	13,500
Fan Type (Qty)		Cross-Flow (1)
Airflow (L / M / H)	CFM	230 / 280 / 350
Sound Pressure (L / M / H)	dBA	30 / 34 / 39
ELECTRICAL		
Power Supply	V/Ph/Hz	208-230/1/60
Power Consumption (Input)	kW	0.021
Full Load Amps (FLA)	A	0.2
Minimum Circuit Amps (MCA)	A	0.3
Maximum Overcurrent Protection	A	15
MOTOR		
Motor Type		DC Inverter Driven
Motor Watts	W	30

PHYSICAL DATA		
Pipe Connection Size - Liquid (High Pressure)	in.	1/4 (Flare)
Pipe Connection Size - Gas (Low Pressure)	in.	3/8 (Flare)
Pipe Connection Size - Drain (OD)	in.	7/8
Pipe Connection Size - Drain (ID)	in.	5/8
Refrigerant		R-410A
External Finish		Munsell 2.5GY9.0/0.5
Unit Width	in.	41-5/16
Unit Height	in.	12-9/16
Unit Depth	in.	9
Net Weight	lb	33
CONTROLS		
Wireless Remote Controller (Standard)		

ACCESSORIES

- ☐ Wired Remote Controller (7-Day Programmable) - RBC-AMS54E-UL
- ☐ Simple Wired Remote Control - RBC-AS41UL
- ☐ Remote Sensor TCB-TC41LUL
- ☐ Wired Remote Controller - RBC-AMT32UL
- ☐ Condensate Drain Pump Kit 53DS-900---118

DIMENSIONAL DRAWING
INDOOR UNIT HIGH WALL MMK-AP0123H2UL



NOTES:
1. Dimensions are in inches (mm).
2. If conduit is required for electrical connection the refrigerant piping cannot exit the right side of the unit. All other exit directions are available.

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SMMSe / SHRMe VRF Indoor Unit
MMK-AP0153H2UL—HIGH WALL

TOSHIBA
Carrier

Submittal Data

Job Data _____ Location _____
Buyer _____ Buyer PO # _____ Carrier # _____
Unit Number _____ Model Number _____
Performance Data Certified By _____ Date _____



SMMSe / SHRMe VRF High Wall Features

- R-410A refrigerant
- Six sizes from 7,000 to 24,000 Btu/h
- Quiet operation, as low as 30 dBA
- Vertical airflow can be set to swing or fixed position
- Air throw up to 23 feet
- Auto or manually set three fan speeds
- Easy to remove cleanable filter
- Five-year parts limited warranty

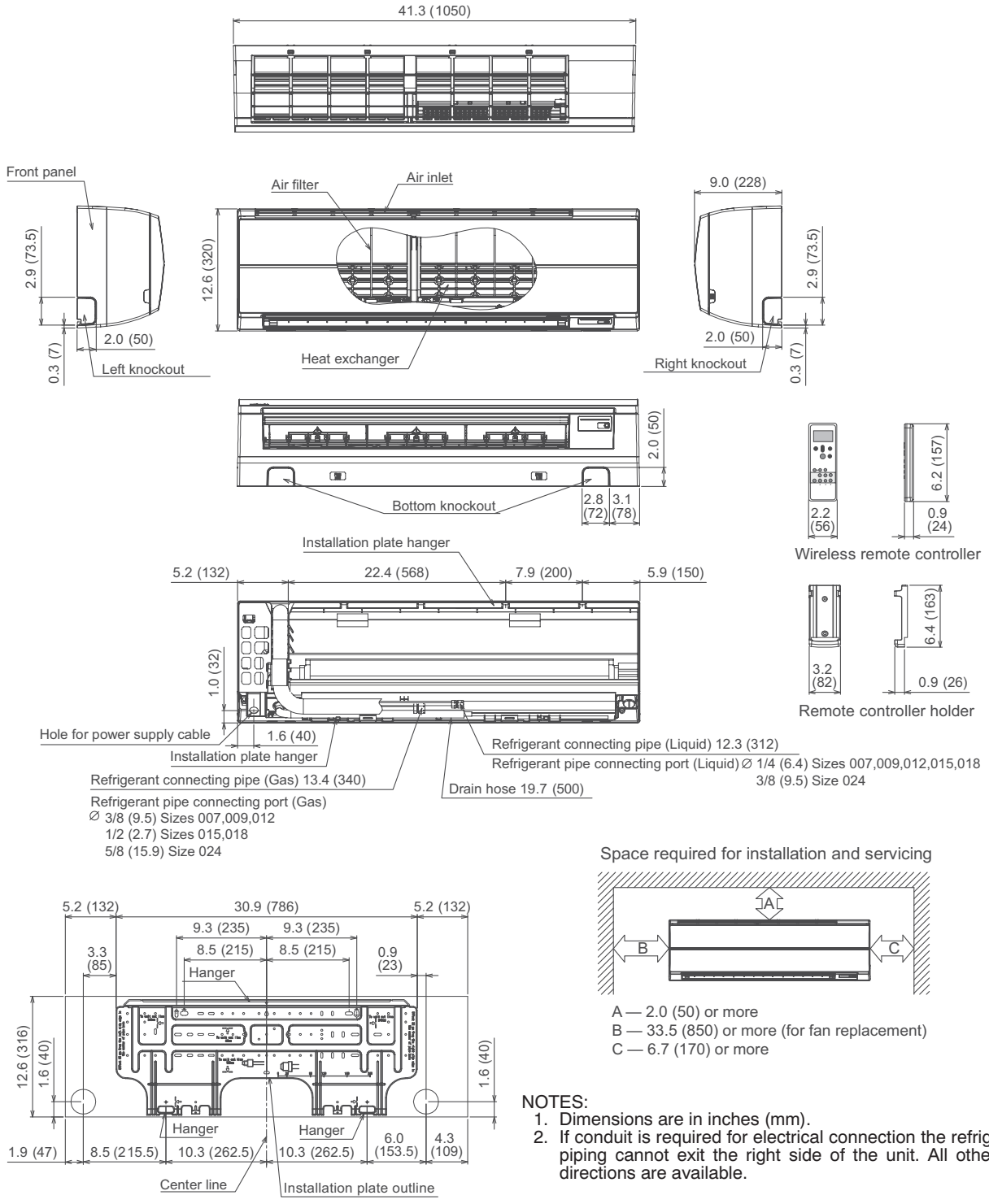
INDOOR UNIT MODEL		MMK-AP0153H2UL
PERFORMANCE		
Cooling Rated Capacity	Btu/h	15,400
Heating Rated Capacity	Btu/h	17,000
Fan Type (Qty)		Cross-Flow (1)
Airflow (L / M / H)	CFM	320 / 390 / 490
Sound Pressure (L / M / H)	dBA	34.5 / 38 / 43
ELECTRICAL		
Power Supply	V/Ph/Hz	208-230/1/60
Power Consumption (Input)	kW	0.043
Full Load Amps (FLA)	A	0.4
Minimum Circuit Amps (MCA)	A	0.5
Maximum Overcurrent Protection	A	15
MOTOR		
Motor Type		DC Inverter Driven
Motor Watts	W	30

PHYSICAL DATA		
Pipe Connection Size - Liquid (High Pressure)	in.	1/4 (Flare)
Pipe Connection Size - Gas (Low Pressure)	in.	1/2 (Flare)
Pipe Connection Size - Drain (OD)	in.	7/8
Pipe Connection Size - Drain (ID)	in.	5/8
Refrigerant		R-410A
External Finish		Munsell 2.5GY9.0/0.5
Unit Width	in.	41-5/16
Unit Height	in.	12-9/16
Unit Depth	in.	9
Net Weight	lb	33
CONTROLS		
Wireless Remote Controller (Standard)		

ACCESSORIES

- ☐ Wired Remote Controller (7-Day Programmable) - RBC-AMS54E-UL
- ☐ Simple Wired Remote Control - RBC-AS41UL
- ☐ Remote Sensor TCB-TC41LUL
- ☐ Wired Remote Controller - RBC-AMT32UL
- ☐ Condensate Drain Pump Kit 53DS-900---118

DIMENSIONAL DRAWING
INDOOR UNIT HIGH WALL MMK-AP0153H2UL



NOTES:
1. Dimensions are in inches (mm).
2. If conduit is required for electrical connection the refrigerant piping cannot exit the right side of the unit. All other exit directions are available.

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SHRMe VRF Outdoor Unit
MMY-AP2886FT6P-UL - Heat Recovery

TOSHIBA Carrier

Submittal Data

Job Data _____ Location _____
Buyer _____ Buyer PO # _____ Carrier # _____
Unit Number _____ Model Number _____
Performance Data Certified By _____ Date _____



SHRMe VRF Heat Recovery Features

- Two 12-ton modules are combined to form a 24-ton system
- Capable of simultaneous cooling and heating (flow selector boxes required)
- Modules have 2 inverter-driven twin rotary compressors
- Backup capability due to multiple compressors
- Compressor speed varied in 0.1 Hz increments for comfort and efficiency
- Direct drive, inverter-driven 64-step outdoor motor
- Up to 3281 ft (1000 m) actual total system piping (liquid line)
- Up to 591 ft (180 m) actual piping length from outdoor unit to furthest fan coil
- Up to 330 ft (100 m) outdoor control wiring
- Up to 6560 ft (2000 m) control wiring between outdoor and indoor units
- Operating temperature range
  Cooling (db): 14 to 122 F (–10 to 50 C)
  Heating (wb): –13 to 60 F (–25 to 15.6 C)
- Protection: high pressure switch, low pressure sensor and switch, PC board fuse, inverter overload protection
- 7-year compressor limited warranty, 5-year parts limited warranty

Header Unit Model	MMY-MAP1446FT6P-UL	
Follower Unit Model	MMY-MAP1446FT6P-UL	
PERFORMANCE		
Nominal Cooling Capacity	Btu/h	288,000
Nominal Heating Capacity	Btu/h	324,000
Maximum Total Connected Indoor Unit Capacity		Up to 150%
SIMULTANEOUS COOLING AND HEATING EFFICIENCY*		
SCHE, Ducted FCUs		26.60
SCHE, Ductless FCUs		28.10
COOLING EFFICIENCY*		
EER/IEER, Ducted FCUs		11.50/22.00
EER/IEER, Ductless FCUs		11.40/23.50
HEATING EFFICIENCY*		
COP at 47 F, Ducted FCUs		3.50
COP at 47 F, Ductless FCUs		3.45
Fan Type (Qty)		Propeller (4)
Airflow, Standard Range	CFM	10,852 + 10,852
Combined System Sound Pressure, Cooling/Heating	dBA	66/67
External Static Pressure†	in. wg	0.16
ELECTRICAL		
Power Supply	V/Ph/Hz	460/3/60
Minimum Circuit Amps (MCA)**	A	23.4 + 23.4
Recommended Fuse Size**	A	30 + 30

COMPRESSORS		
Type (Number)		Inverter Twin Rotary (4)
Motor Output	kW	2 x 5.4 + 2 x 5.4
FAN MOTOR		
Motor Type (Steps)	Inverter Direct Driven (64)	
Motor Output	kW	1.0 + 1.0 + 1.0 + 1.0
PHYSICAL DATA		
Main Pipe Connection Size - Liquid (High Pressure)††	in.	7/8 (Flare)
Main Pipe Connection Size - Gas (Low Pressure)††	in.	1-3/8 (Brazed)
Main Discharge (High Pressure)††	in.	1-1/8 (Flare)
Balance	in.	3/8 (Flare)
Refrigerant		R-410A
Factory Charge***	lb	2 x 24.3
External Finish	Munsell 1Y8.5/0.5	
Header Unit/Follower Unit Width	in.	63.0 / 63.0
Header Unit/Follower Unit Height	in.	72.9 / 72.9
Header Unit/Follower Unit Depth	in.	30.7/ 30.7
Header Unit/Follower Unit Net Weight	lb	838 + 838
REQUIRED ACCESSORY		
Connection Kit		RBM-BT24FUL

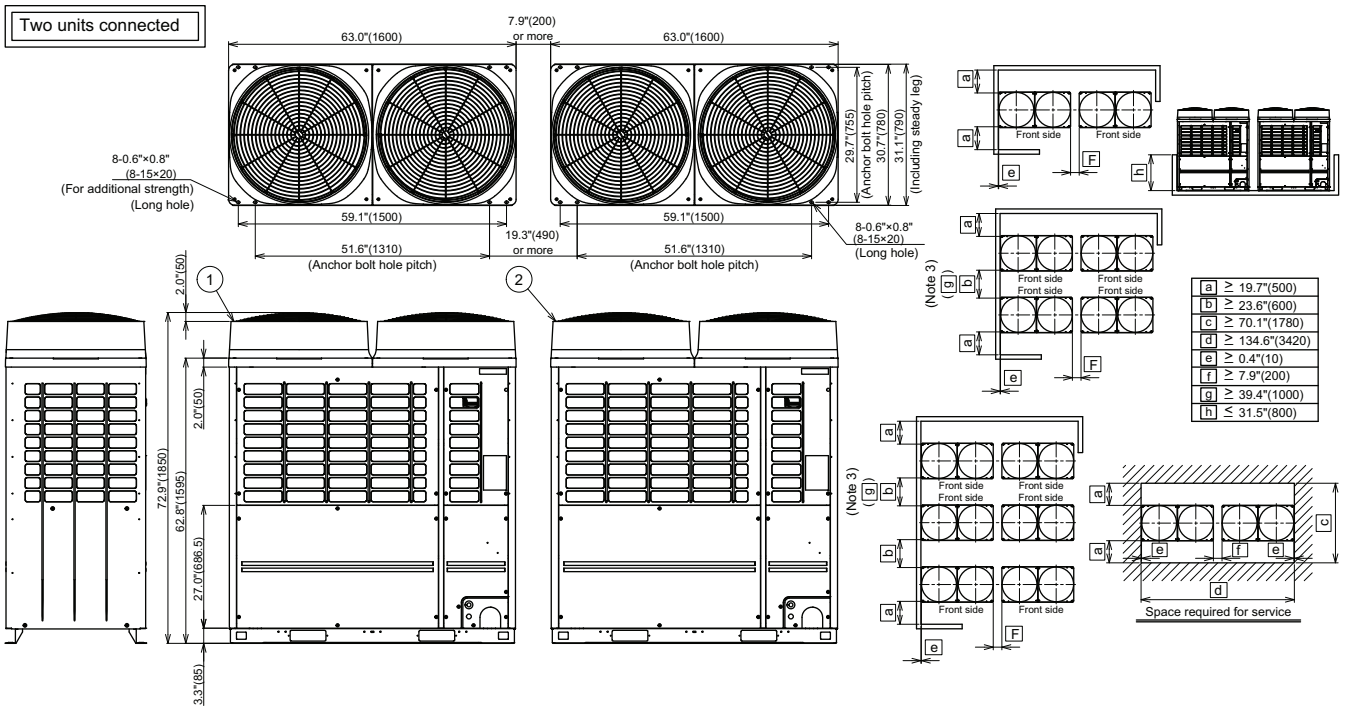
LEGEND

db	—	Dry Bulb
COP	—	Coefficient of Performance
EER	—	Energy Efficiency Ratio
FCU	—	Fan Coil Unit
IEER	—	Integrated Energy Efficiency Ratio
SCHE	—	Simultaneous Cooling and Heating Efficiency
wb	—	Wet Bulb

*Rated per AHRI (Air-Conditioning, Heating and Refrigeration Institute) 1230 Standard.
Cooling: Indoor 80 F (35 C) db/67 F (27 C) wb; Outdoor 95 F (35 C) db
Heating: Indoor 70 F (21 C) db; Outdoor 47 F (8 C) db/43 F (6 C) wb
†Requires setting by DIP switches.
**Separate power supply is required. MCA and fuse size for both units are given.
††Main pipe size leaving connection kit.
***Additional charges required.

NOTE: Unit cabinet and coil slab shall be capable of withstanding 500-hour salt spray test in accordance with the ASTM (American Society for Testing and Materials, U.S.A.) B-117 Standard.

DIMENSIONAL DRAWING
OUTDOOR UNIT COMBINATION HEAT RECOVERY MMY-AP2886FT6P-UL



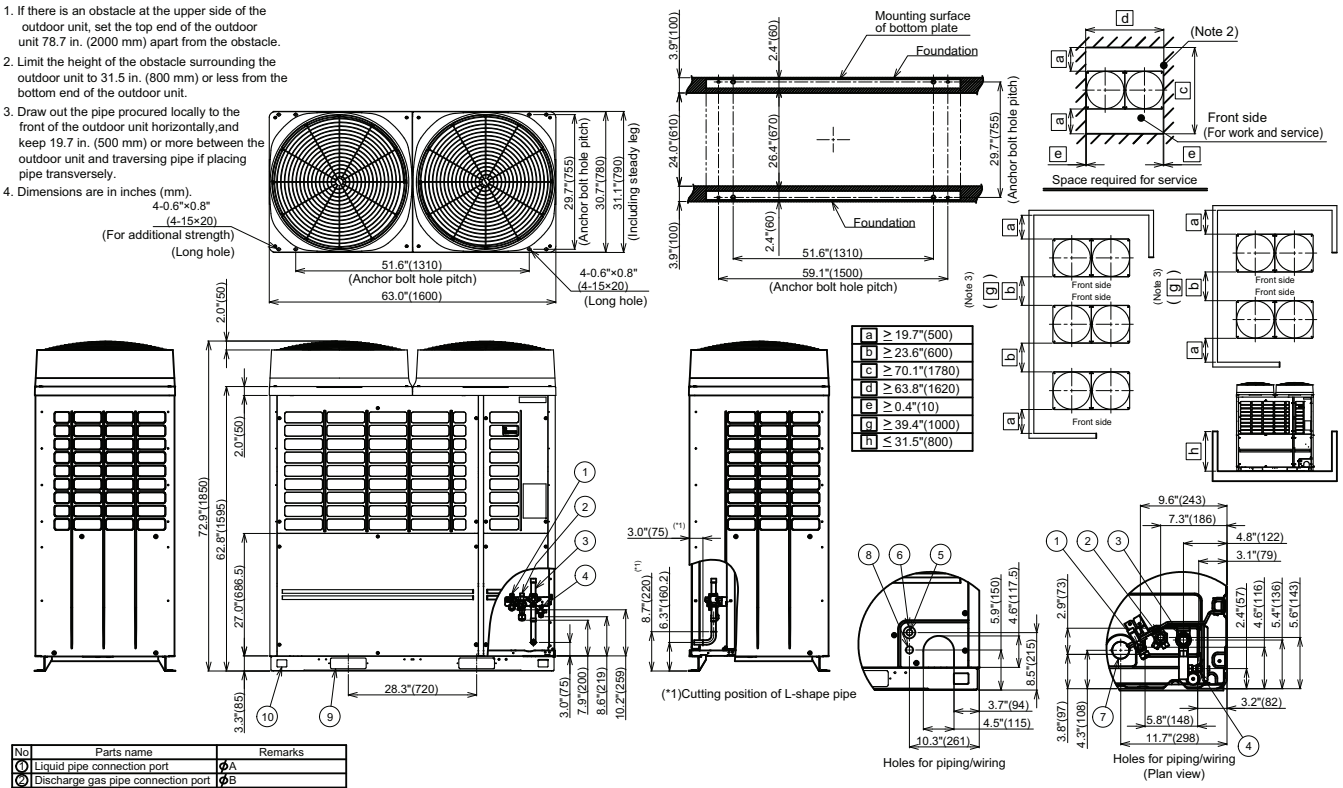
NOTES:
1. If there is an obstacle at the upper side of the outdoor unit, set the top end of the outdoor unit 78.7 in. (2000 mm) apart from the obstacle.
2. Limit the height of the obstacle surrounding the outdoor unit to 31.5 in. (800 mm) or less from the bottom end of the outdoor unit.
3. Draw out the pipe procured locally to the front of the outdoor unit horizontally, and keep 19.7 in. (500 mm) or more between the outdoor unit and traversing pipe if placing pipe transversely.
4. Arrange each outdoor unit in order of its capacity. (Header unit ① ≥ Follower unit ②)
5. Dimensional drawing of corrosion protection and corrosion heavy protection model is the same as that of standard model.
6. Dimensions are in inches (mm).

MODEL	OUTDOOR UNIT	
	HEADER UNIT ①	FOLLOWER UNIT ②
MMY-AP2886FT6P-UL	MMY-MAP1446FT6P-UL	MMY-MAP1446FT6P-UL

DIMENSIONAL DRAWING
OUTDOOR UNIT HEAT RECOVERY/SINGLE UNIT MMY-MAP1446FT6P-UL

NOTES:

1. If there is an obstacle at the upper side of the outdoor unit, set the top end of the outdoor unit 78.7 in. (2000 mm) apart from the obstacle.
2. Limit the height of the obstacle surrounding the outdoor unit to 31.5 in. (800 mm) or less from the bottom end of the outdoor unit.
3. Draw out the pipe procured locally to the front of the outdoor unit horizontally,and keep 19.7 in. (500 mm) or more between the outdoor unit and traversing pipe if placing pipe transversely.
4. Dimensions are in inches (mm).



a	≥ 19.7"(500)
b	≥ 23.6"(600)
c	≥ 70.1"(1780)
d	≥ 63.8"(1620)
e	≥ 0.4"(10)
g	≥ 39.4"(1000)
h	≤ 31.5"(800)

No	Parts name	Remarks
①	Liquid pipe connection port	ϕA
②	Discharge gas pipe connection port	ϕB
③	Suction gas pipe connection port	ϕ1-1/8"(28.6)
④	Balance pipe connection port	ϕ3/8"(9.5)
⑤	Knockout hole for power wiring 1	ϕ0.9"(22.2)
⑥	Knockout hole for power wiring 2	ϕ1.7"(43.7)
⑦	Knockout hole for power wiring 2	ϕ1.9"(48)
⑧	Knockout hole for control wiring	ϕ1.1"(27)
⑨	Square hole (for freight handling)	4-2.4"×7.9"(4-60×200)
⑩	Square hole (for hanging)	4-1.6"×2.2"(4-40×55)

Model Name	A	B
MAP 1446 type	5/8"(15.9)	1"(25.4)
MAP 1686 type	3/4"(19.1)	1-1/8"(28.6)

Variable Refrigerant Flow (VRF) Multi-Split AC and HP
AHRI Standard 1230

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SHRMe VRF Outdoor Unit
MMY-AP4566FT6P-UL - Heat Recovery

TOSHIBA
Carrier

Submittal Data

Job Data _____ Location _____
Buyer _____ Buyer PO # _____ Carrier # _____
Unit Number _____ Model Number _____
Performance Data Certified By _____ Date _____



SHRMe VRF Heat Recovery Features

- 14 and 12-ton modules are combined to form a 38-ton system
- Capable of simultaneous cooling and heating (flow selector boxes required)
- Modules have 2 inverter-driven twin rotary compressors
- Backup capability due to multiple compressors
- Compressor speed varied in 0.1 Hz increments for comfort and efficiency
- Direct drive, inverter-driven 64-step outdoor motor
- Up to 3281 ft (1000 m) actual total system piping (liquid line)
- Up to 591 ft (180 m) actual piping length from outdoor unit to furthest fan coil
- Up to 330 ft (100 m) outdoor control wiring
- Up to 6560 ft (2000 m) control wiring between outdoor and indoor units
- Operating temperature range
  Cooling (db): 14 to 122 F (–10 to 50 C)
  Heating (wb): –13 to 60 F (–25 to 15.6 C)
- Protection: high pressure switch, low pressure sensor and switch, PC board fuse, inverter overload protection
- 7-year compressor limited warranty, 5-year parts limited warranty

Header Unit Model	MMY-MAP1686FT6P-UL	
Follower Unit Model	MMY-MAP1446FT6P-UL MMY-MAP1446FT6P-UL	
PERFORMANCE		
Nominal Cooling Capacity	Btu/h	451,500
Nominal Heating Capacity	Btu/h	513,000
Maximum Total Connected Indoor Unit Capacity		Up to 150%
SIMULTANEOUS COOLING AND HEATING EFFICIENCY*		
SCHE, Ducted FCUs		21.00
SCHE, Ductless FCUs		23.20
COOLING EFFICIENCY*		
EER/IEER, Ducted FCUs		9.50/20.00
EER/IEER, Ductless FCUs		9.50/20.00
HEATING EFFICIENCY*		
COP at 47 F, Ducted FCUs		3.20
COP at 47 F, Ductless FCUs		3.20
Fan Type (Qty)		Propeller (6)
Airflow, Standard Range	CFM	10,852+10,852+10,852
Combined System Sound Pressure, Cooling/Heating	dBA	68.1/69.1
External Static Pressure†	in. wg	0.16
ELECTRICAL		
Power Supply	V/Ph/Hz	460/3/60
Minimum Circuit Amps (MCA)**	A	29.7 + 23.4 + 23.4
Recommended Fuse Size**	A	35 + 30 + 30

LEGEND

db	—	Dry Bulb
COP	—	Coefficient of Performance
EER	—	Energy Efficiency Ratio
FCU	—	Fan Coil Unit
IEER	—	Integrated Energy Efficiency Ratio
SCHE	—	Simultaneous Cooling and Heating Efficiency
wb	—	Wet Bulb

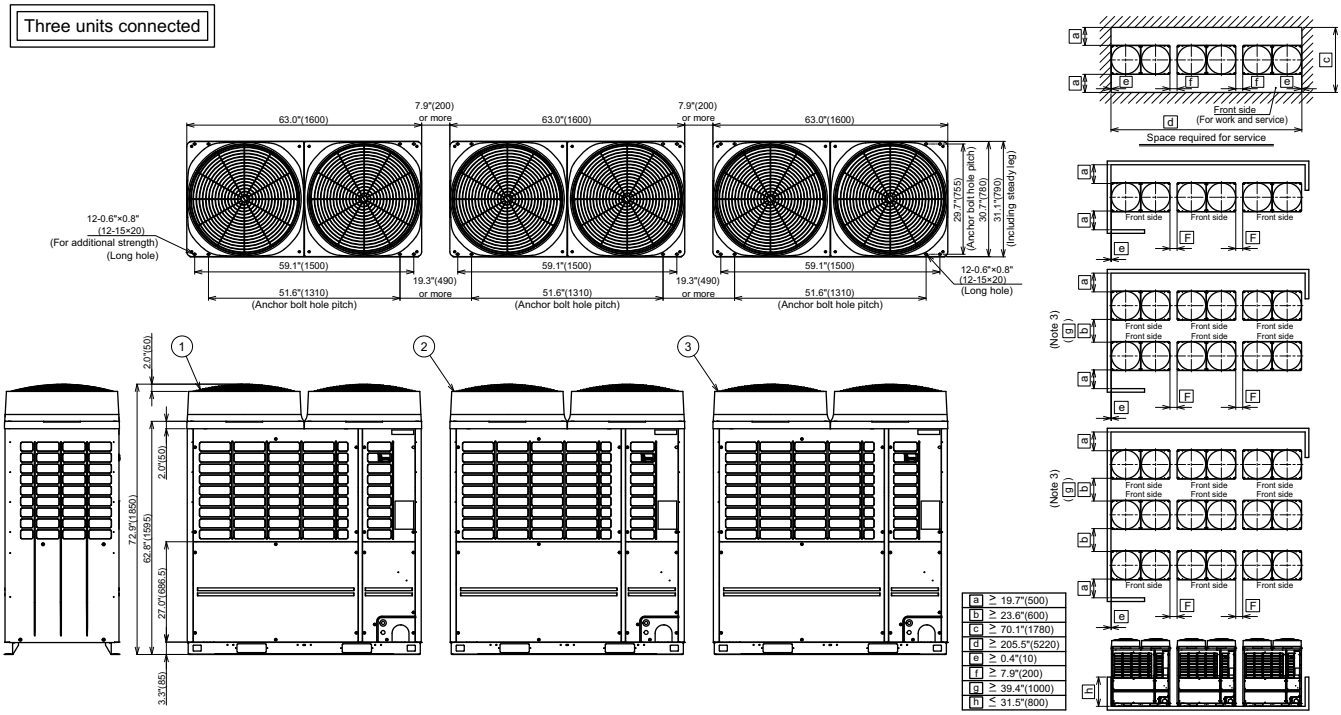
COMPRESSORS		
Type (Number)		Inverter Twin Rotary (6)
Motor Output	kW	2 x 6.5 + 2 x 5.4 + 2 x 5.4
FAN MOTOR		
Motor Type (Steps)	Inverter Direct Driven (64)	
Motor Output	kW	1.0 + 1.0 + 1.0 + 1.0 + 1.0 + 1.0
PHYSICAL DATA		
Main Pipe Connection Size - Liquid (High Pressure)††	in.	7/8 (Flare)
Main Pipe Connection Size - Gas (Low Pressure)††	in.	1-5/8 (Brazed)
Main Discharge (High Pressure)††	in.	1-3/8 (Flare)
Balance	in.	3/8 (Flare)
Refrigerant		R-410A
Factory Charge***	lb	3 x 24.3
External Finish	Munsell 1Y8.5/0.5	
Header Unit/Follower Unit Width	in.	63.0 / 63.0 / 63.0
Header Unit/Follower Unit Height	in.	72.9 / 72.9 / 72.9
Header Unit/Follower Unit Depth	in.	30.7 / 30.7 / 30.7
Header Unit/Follower Unit Net Weight	lb	838 + 838 + 838
REQUIRED ACCESSORY		
Connection Kit		RBM-BT24FUL RBM-BT24FUL

*Rated per AHRI (Air-Conditioning, Heating and Refrigeration Institute) 1230 Standard.
Cooling: Indoor 80 F (35 C) db/67 F (27 C) wb; Outdoor 95 F (35 C) db
Heating: Indoor 70 F (21 C) db; Outdoor 47 F (8 C) db/43 F (6 C) wb
†Requires setting by DIP switches.
**Separate power supply is required. MCA and fuse size for both units are given.
††Main pipe size leaving connection kit.
***Additional charges required.

NOTE: Unit cabinet and coil slab shall be capable of withstanding 500-hour salt spray test in accordance with the ASTM (American Society for Testing and Materials, U.S.A.) B-117 Standard.

DIMENSIONAL DRAWING
OUTDOOR UNIT COMBINATION HEAT RECOVERY MMY-AP4566FT6P-UL

Three units connected



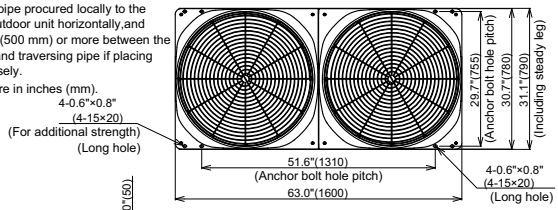
NOTES:
1. If there is an obstacle at the upper side of the outdoor unit, set the top end of the outdoor unit 78.7 in. (2000 mm) apart from the obstacle.
2. Limit the height of the obstacle surrounding the outdoor unit to 31.5 in. (800 mm) or less from the bottom end of the outdoor unit.
3. Draw out the pipe procured locally to the front of the outdoor unit horizontally, and keep 19.7 in. (500 mm) or more between the outdoor unit and traversing pipe if placing pipe transversely.
4. Arrange each outdoor unit in order of its capacity. (Header unit ① ≥ Follower unit ② ≥ Follower unit ③)
5. Dimensional drawing of corrosion protection and corrosion heavy protection model is the same as that of standard model.
6. Dimensions are in inches (mm).

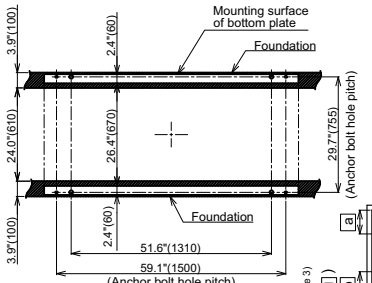
MODEL	OUTDOOR UNIT		
	HEADER UNIT ①	FOLLOWER UNIT ②	FOLLOWER UNIT ③
MMY-AP4566FT6P-UL	MMY-MAP1686FT6P-UL	MMY-MAP1446FT6P-UL	MMY-MAP1446FT6P-UL

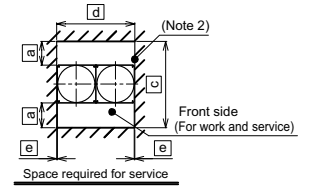
DIMENSIONAL DRAWING
OUTDOOR UNIT HEAT RECOVERY/SINGLE UNIT MMY-MAP1686FT6P-UL

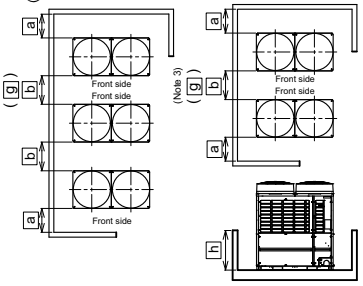
NOTES:

1. If there is an obstacle at the upper side of the outdoor unit, set the top end of the outdoor unit 78.7 in. (2000 mm) apart from the obstacle.
2. Limit the height of the obstacle surrounding the outdoor unit to 31.5 in. (800 mm) or less from the bottom end of the outdoor unit.
3. Draw out the pipe procured locally to the front of the outdoor unit horizontally,and keep 19.7 in. (500 mm) or more between the outdoor unit and traversing pipe if placing pipe transversely.
4. Dimensions are in inches (mm).

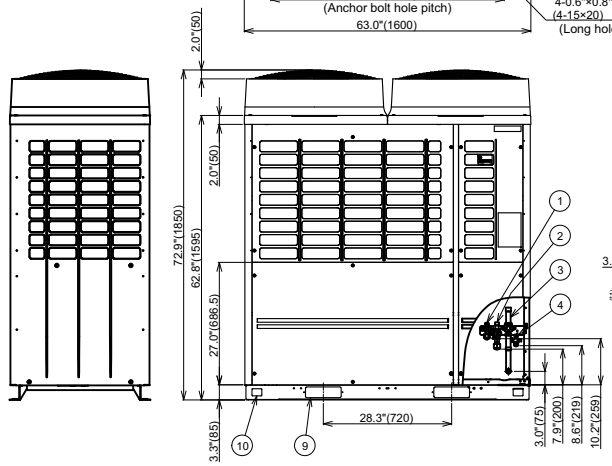


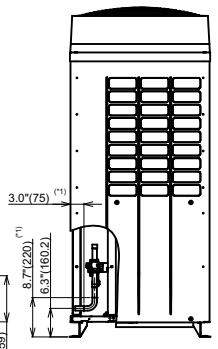




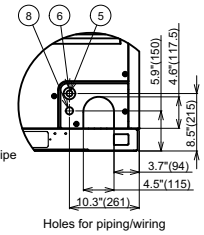


a	≥ 19.7"(500)
b	≥ 23.6"(600)
c	≥ 70.1"(1780)
d	≥ 63.8"(1620)
e	≥ 0.4"(10)
g	≥ 39.4"(1000)
h	≤ 31.5"(800)

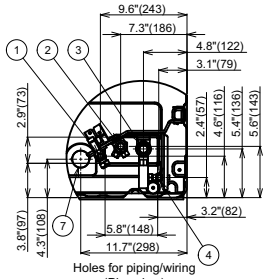




(*1)Cutting position of L-shape pipe



Holes for piping/wiring



Holes for piping/wiring
(Plan view)

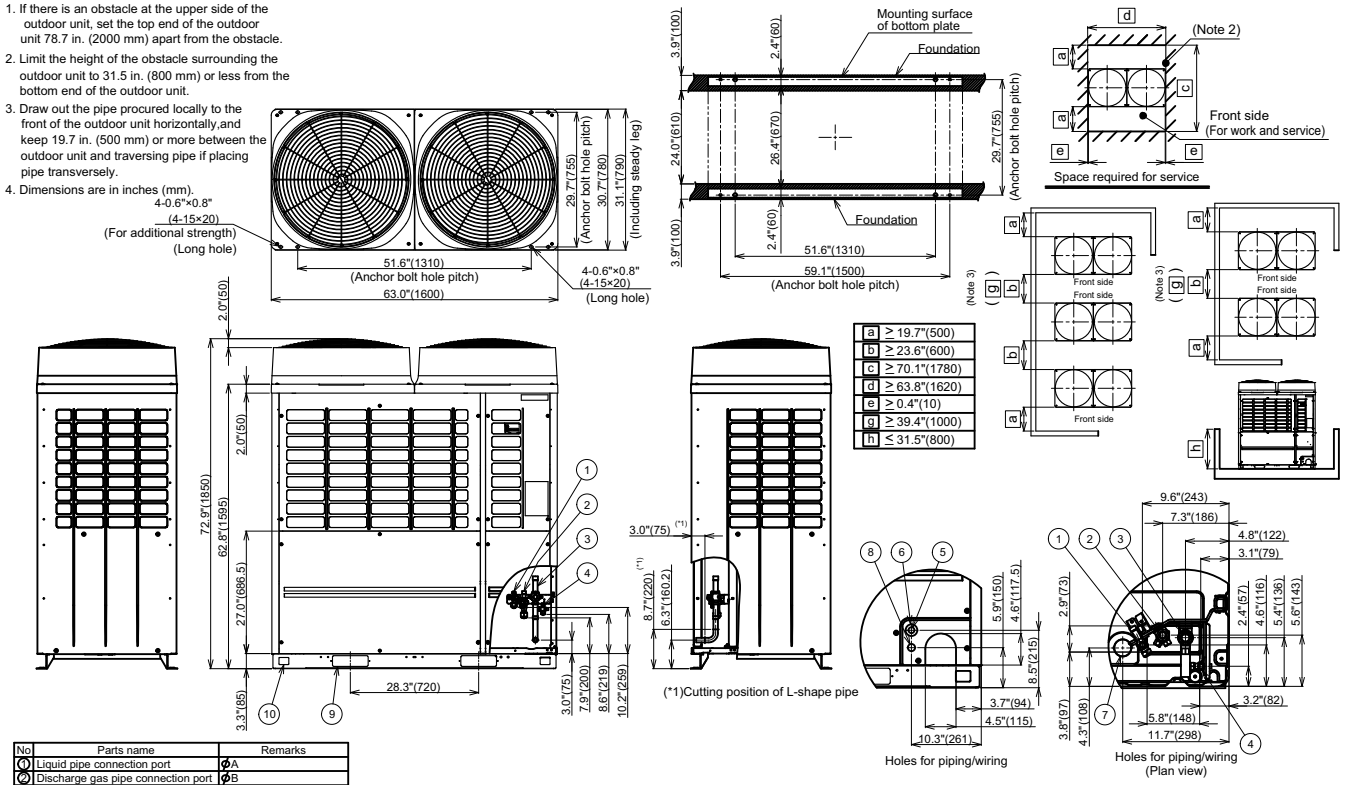
No	Parts name	Remarks
①	Liquid pipe connection port	ϕA
②	Discharge gas pipe connection port	ϕB
③	Suction gas pipe connection port	ϕ1-1/8"(28.6)
④	Balance pipe connection port	ϕ3/8"(9.5)
⑤	Knockout hole for power wiring 1	ϕ0.9"(22.2)
⑥	Knockout hole for power wiring 2	ϕ1.7"(43.7)
⑦	Knockout hole for power wiring 2	ϕ1.9"(48)
⑧	Knockout hole for control wiring	ϕ1.1"(27)
⑨	Square hole (for freight handling)	4-2.4"×7.9"(4-60×200)
⑩	Square hole (for hanging)	4-1.6"×2.2"(4-40×55)

Model Name	A	B
MAP 1446 type	5/8"(15.9)	1"(25.4)
MAP 1686 type	3/4"(19.1)	1-1/8"(28.6)

DIMENSIONAL DRAWING
OUTDOOR UNIT HEAT RECOVERY/SINGLE UNIT MMY-MAP1446FT6P-UL

NOTES:

1. If there is an obstacle at the upper side of the outdoor unit, set the top end of the outdoor unit 78.7 in. (2000 mm) apart from the obstacle.
2. Limit the height of the obstacle surrounding the outdoor unit to 31.5 in. (800 mm) or less from the bottom end of the outdoor unit.
3. Draw out the pipe procured locally to the front of the outdoor unit horizontally,and keep 19.7 in. (500 mm) or more between the outdoor unit and traversing pipe if placing pipe transversely.
4. Dimensions are in inches (mm).



No	Parts name	Remarks
1	Liquid pipe connection port	ϕA
2	Discharge gas pipe connection port	ϕB
3	Suction gas pipe connection port	ϕ1-1/8"(28.6)
4	Balance pipe connection port	ϕ3/8"(9.5)
5	Knockout hole for power wiring 1	ϕ0.9"(22.2)
6	Knockout hole for power wiring 2	ϕ1.7"(43.7)
7	Knockout hole for power wiring 2	ϕ1.9"(48)
8	Knockout hole for control wiring	ϕ1.1"(27)
9	Square hole (for freight handling)	4-2.4"×7.9"(4-60×200)
10	Square hole (for hanging)	4-1.6"×2.2"(4-40×55)

Model Name	A	B
MAP 1446 type	5/8"(15.9)	1"(25.4)
MAP 1686 type	3/4"(19.1)	1-1/8"(28.6)

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Variable Refrigerant Flow (VRF) Multi-Split AC and HP
AHRI Standard 1230

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SHRMe VRF Outdoor Unit
MMY-MAP1446FT6P-UL - Heat Recovery

TOSHIBA Carrier

Submittal Data

Job Data _____ Location _____
Buyer _____ Buyer PO # _____ Carrier # _____
Unit Number _____ Model Number _____
Performance Data Certified By _____ Date _____



SHRMe VRF Heat Recovery Features

- 6, 8, 10, 12, and 14-ton modules available
- Capable of simultaneous cooling and heating (flow selector boxes required)
- Modules have 2 inverter-driven twin rotary compressors
- Backup capability due to multiple compressors
- Compressor speed varied in 0.1 Hz increments for comfort and efficiency
- Direct drive, inverter-driven 64-step outdoor motor
- Modules can be combined to form larger systems, up to 38 tons
- Up to 3281 ft (1000 m) actual total system piping (liquid line)
- Up to 591 ft (180 m) actual piping length from outdoor unit to furthest fan coil
- Up to 330 ft (100 m) outdoor control wiring
- Up to 6560 ft (2000 m) control wiring between outdoor and indoor units
- Operating temperature range
  Cooling (db): 14 to 122 F (–10 to 50 C)
  Heating (wb): –13 to 60 F (–25 to 15.6 C)
- Protection: high pressure switch, low pressure sensor and switch, PC board fuse, inverter overload protection
- 7-year compressor limited warranty, 5-year parts limited warranty

Header Unit Model	MMY-MAP1446FT6P-UL	
PERFORMANCE		
Nominal Cooling Capacity	Btu/h	144,000
Nominal Heating Capacity	Btu/h	162,000
Maximum Total Connected Indoor Unit Capacity		Up to 150%
SIMULTANEOUS COOLING AND HEATING EFFICIENCY*		
SCHE, Ducted FCUs		31.60
SCHE, Ductless FCUs		33.60
COOLING EFFICIENCY*		
EER/IEER, Ducted FCUs		12.00/23.00
EER/IEER, Ductless FCUs		12.50/26.60
HEATING EFFICIENCY*		
COP at 47 F, Ducted FCUs		3.60
COP at 47 F, Ductless FCUs		3.75
Fan Type (Qty)		Propeller (2)
Airflow, Standard Range	CFM	10,852
Sound Pressure, Cooling/Heating	dBA	63/64
External Static Pressure†	in. wg	0.16

LEGEND

db — Dry Bulb
COP — Coefficient of Performance
EER — Energy Efficiency Ratio
FCU — Fan Coil Unit
IEER — Integrated Energy Efficiency Ratio
SCHE — Simultaneous Cooling and Heating Efficiency
wb — Wet Bulb

NOTE: Unit cabinet and coil slab shall be capable of withstanding 500-hour salt spray test in accordance with the ASTM (American Society for Testing and Materials, U.S.A.) B-117 Standard.

ELECTRICAL		
Power Supply	V/Ph/Hz	460/3/60
Minimum Circuit Amps (MCA)	A	23.4
Recommended Fuse Size	A	30
COMPRESSORS		
Type (Number)		Inverter Twin Rotary (2)
Motor Output	kW	2 x 5.4
FAN MOTOR		
Motor Type (Steps)	Inverter Direct Driven (64)	
Motor Output	kW	1.0 + 1.0
PHYSICAL DATA		
Pipe Connection Size - Liquid (High Pressure)	in.	5/8 (Flare)
Pipe Connection Size - Gas (Low Pressure)	in.	1-1/8 (Brazed)
Discharge (High Pressure)	in.	7/8 (Flare)
Balance	in.	3/8 (Flare)
Refrigerant		R-410A
Factory Charge**	lb	24.3
External Finish	Munsell 1Y8.5/0.5	
Unit Width	in.	63.0
Unit Height	in.	72.9
Unit Depth	in.	30.7
Unit Net Weight	lb	838

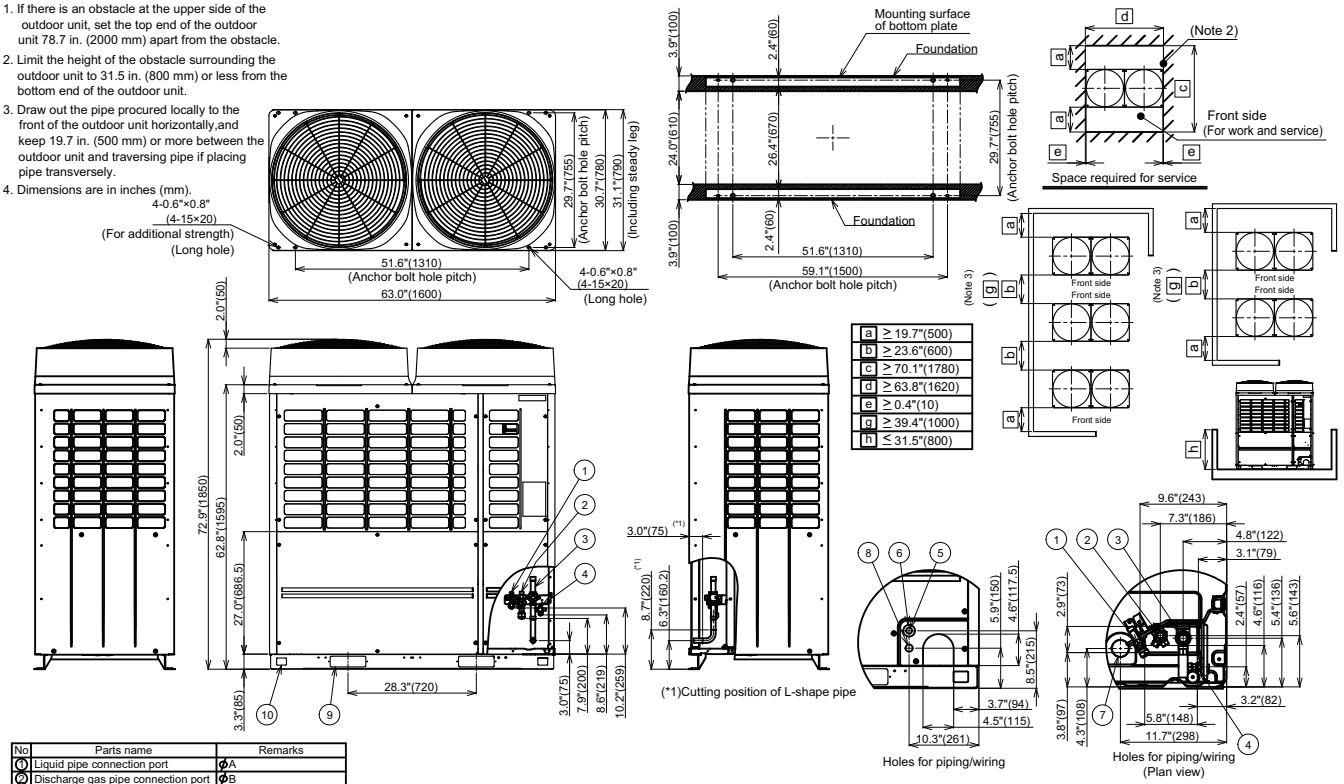
*Rated per AHRI (Air-Conditioning, Heating and Refrigeration Institute) 1230 Standard.
Cooling: Indoor 80 F (35 C) db/67 F (27 C) wb; Outdoor 95 F (35 C) db
Heating: Indoor 70 F (21 C) db; Outdoor 47 F (8 C) db/43 F (6 C) wb
†Requires setting by DIP switches.
**Additional charge required.

Manufacturer reserves the right to discontinue, or change at any time, specifications or designs without notice and without incurring obligations.

DIMENSIONAL DRAWING
OUTDOOR UNIT HEAT RECOVERY/SINGLE UNIT MMY-MAP1446FT6P-UL

NOTES:

1. If there is an obstacle at the upper side of the outdoor unit, set the top end of the outdoor unit 78.7 in. (2000 mm) apart from the obstacle.
2. Limit the height of the obstacle surrounding the outdoor unit to 31.5 in. (800 mm) or less from the bottom end of the outdoor unit.
3. Draw out the pipe procured locally to the front of the outdoor unit horizontally,and keep 19.7 in. (500 mm) or more between the outdoor unit and traversing pipe if placing pipe transversely.
4. Dimensions are in inches (mm).



a	≥ 19.7"(500)
b	≥ 23.6"(600)
c	≥ 70.1"(1780)
d	≥ 63.8"(1620)
e	≥ 0.4"(10)
g	≥ 39.4"(1000)
h	≤ 31.5"(800)

No	Parts name	Remarks
①	Liquid pipe connection port	ϕA
②	Discharge gas pipe connection port	ϕB
③	Suction gas pipe connection port	ϕ1-1/8"(28.6)
④	Balance pipe connection port	ϕ3/8"(9.5)
⑤	Knockout hole for power wiring 1	ϕ0.9"(22.2)
⑥	Knockout hole for power wiring 2	ϕ1.7"(43.7)
⑦	Knockout hole for power wiring 2	ϕ1.9"(48)
⑧	Knockout hole for control wiring	ϕ1.1"(27)
⑨	Square hole (for freight handling)	4-2.4"×7.9"(4-60×200)
⑩	Square hole (for hanging)	4-1.6"×2.2"(4-40×55)

Model Name	A	B
MAP 1446 type	5/8"(15.9)	1"(25.4)
MAP 1686 type	3/4"(19.1)	1-1/8"(28.6)

Variable Refrigerant Flow (VRF) Multi-Split AC and HP
AHRI Standard 1230

© Carrier Corporation 2016

SHRMe VRF Outdoor Unit
MMY-MAP1686FT6P-UL - Heat Recovery

TOSHIBA Carrier

Submittal Data

Job Data _____ Location _____
Buyer _____ Buyer PO # _____ Carrier # _____
Unit Number _____ Model Number _____
Performance Data Certified By _____ Date _____



SHRMe VRF Heat Recovery Features

- 6, 8, 10, 12, and 14-ton modules available
- Capable of simultaneous cooling and heating (flow selector boxes required)
- Modules have 2 inverter-driven twin rotary compressors
- Backup capability due to multiple compressors
- Compressor speed varied in 0.1 Hz increments for comfort and efficiency
- Direct drive, inverter-driven 64-step outdoor motor
- Modules can be combined to form larger systems, up to 38 tons
- Up to 3281 ft (1000 m) actual total system piping (liquid line)
- Up to 591 ft (180 m) actual piping length from outdoor unit to furthest fan coil
- Up to 330 ft (100 m) outdoor control wiring
- Up to 6560 ft (2000 m) control wiring between outdoor and indoor units
- Operating temperature range
  Cooling (db): 14 to 122 F (–10 to 50 C)
  Heating (wb): –13 to 60 F (–25 to 15.6 C)
- Protection: high pressure switch, low pressure sensor and switch, PC board fuse, inverter overload protection
- 7-year compressor limited warranty, 5-year parts limited warranty

Header Unit Model	MMY-MAP1686FT6P-UL	
PERFORMANCE		
Nominal Cooling Capacity	Btu/h	168,000
Nominal Heating Capacity	Btu/h	189,000
Maximum Total Connected Indoor Unit Capacity		Up to 150%
SIMULTANEOUS COOLING AND HEATING EFFICIENCY*		
SCHE, Ducted FCUs		28.30
SCHE, Ductless FCUs		30.20
COOLING EFFICIENCY*		
EER/IEER, Ducted FCUs		11.00/22.00
EER/IEER, Ductless FCUs		11.00/24.00
HEATING EFFICIENCY*		
COP at 47 F, Ducted FCUs		3.30
COP at 47 F, Ductless FCUs		3.44
Fan Type (Qty)		Propeller (2)
Airflow, Standard Range	CFM	10,852
Sound Pressure, Cooling/Heating	dBA	64/65
External Static Pressure†	in. wg	0.16

LEGEND

db — Dry Bulb
COP — Coefficient of Performance
EER — Energy Efficiency Ratio
FCU — Fan Coil Unit
IEER — Integrated Energy Efficiency Ratio
SCHE — Simultaneous Cooling and Heating Efficiency
wb — Wet Bulb

NOTE: Unit cabinet and coil slab shall be capable of withstanding 500-hour salt spray test in accordance with the ASTM (American Society for Testing and Materials, U.S.A.) B-117 Standard.

ELECTRICAL		
Power Supply	V/Ph/Hz	460/3/60
Minimum Circuit Amps (MCA)	A	29.7
Recommended Fuse Size	A	35
COMPRESSORS		
Type (Number)		Inverter Twin Rotary (2)
Motor Output	kW	2 x 6.5
FAN MOTOR		
Motor Type (Steps)	Inverter Direct Driven (64)	
Motor Output	kW	1.0 + 1.0
PHYSICAL DATA		
Pipe Connection Size - Liquid (High Pressure)	in.	3/4 (Flare)
Pipe Connection Size - Gas (Low Pressure)	in.	1-1/8 (Brazed)
Discharge (High Pressure)	in.	7/8 (Flare)
Balance	in.	3/8 (Flare)
Refrigerant		R-410A
Factory Charge**	lb	24.3
External Finish	Munsell 1Y8.5/0.5	
Unit Width	in.	63.0
Unit Height	in.	72.9
Unit Depth	in.	30.7
Unit Net Weight	lb	838

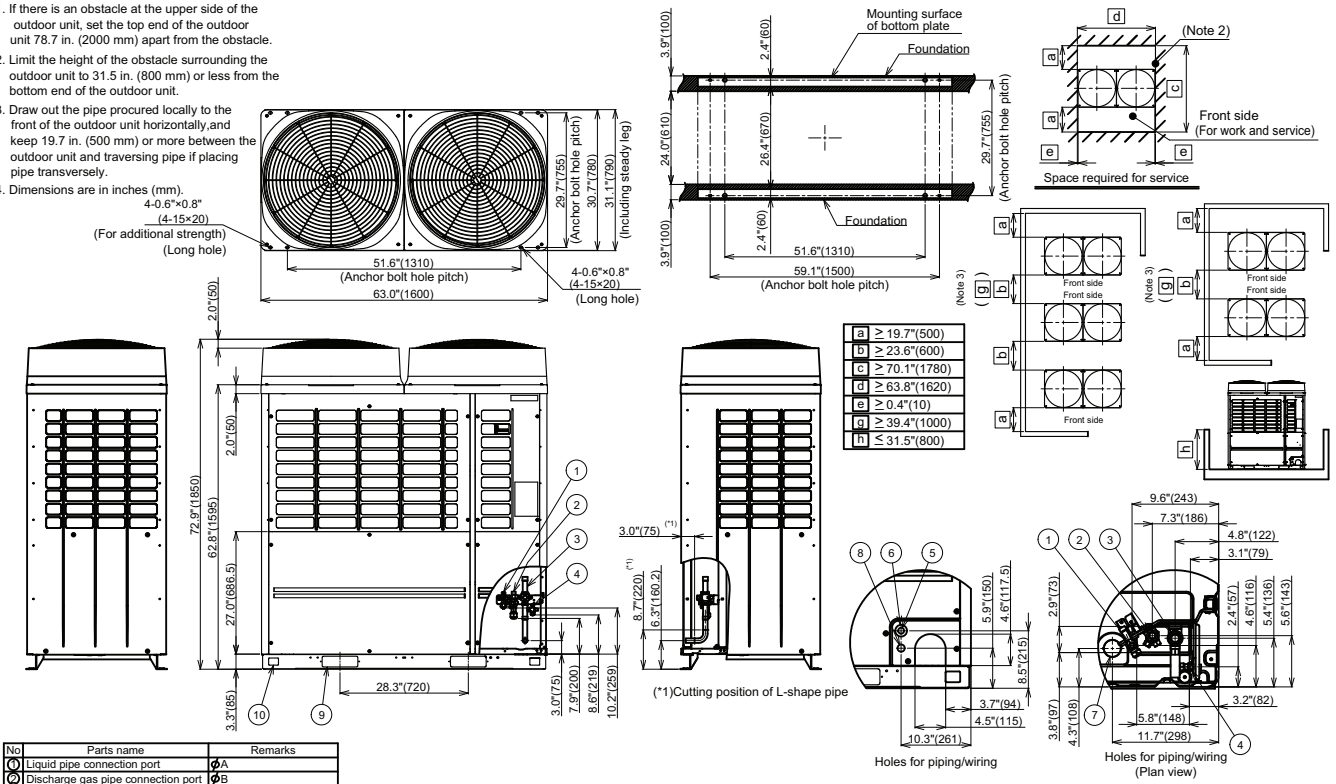
*Rated per AHRI (Air-Conditioning, Heating and Refrigeration Institute) 1230 Standard.
Cooling: Indoor 80 F (35 C) db/67 F (27 C) wb; Outdoor 95 F (35 C) db
Heating: Indoor 70 F (21 C) db; Outdoor 47 F (8 C) db/43 F (6 C) wb
†Requires setting by DIP switches.
**Additional charge required.

Manufacturer reserves the right to discontinue, or change at any time, specifications or designs without notice and without incurring obligations.

DIMENSIONAL DRAWING
OUTDOOR UNIT HEAT RECOVERY/SINGLE UNIT MMY-MAP1686FT6P-UL

NOTES:

1. If there is an obstacle at the upper side of the outdoor unit, set the top end of the outdoor unit 78.7 in. (2000 mm) apart from the obstacle.
2. Limit the height of the obstacle surrounding the outdoor unit to 31.5 in. (800 mm) or less from the bottom end of the outdoor unit.
3. Draw out the pipe procured locally to the front of the outdoor unit horizontally,and keep 19.7 in. (500 mm) or more between the outdoor unit and traversing pipe if placing pipe transversely.
4. Dimensions are in inches (mm).



a	≥ 19.7"(500)
b	≥ 23.6"(600)
c	≥ 70.1"(1780)
d	≥ 63.8"(1620)
e	≥ 0.4"(10)
g	≥ 39.4"(1000)
h	≤ 31.5"(800)

No	Parts name	Remarks
①	Liquid pipe connection port	ϕA
②	Discharge gas pipe connection port	ϕB
③	Suction gas pipe connection port	ϕ1-1/8"(28.6)
④	Balance pipe connection port	ϕ3/8"(9.5)
⑤	Knockout hole for power wiring 1	ϕ0.9"(22.2)
⑥	Knockout hole for power wiring 2	ϕ1.7"(43.7)
⑦	Knockout hole for power wiring 2	ϕ1.9"(48)
⑧	Knockout hole for control wiring	ϕ1.1"(27)
⑨	Square hole (for freight handling)	4-2.4"×7.9"(4-60×200)
⑩	Square hole (for hanging)	4-1.6"×2.2"(4-40×55)

Model Name	A	B
MAP 1446 type	5/8"(15.9)	1"(25.4)
MAP 1686 type	3/4"(19.1)	1-1/8"(28.6)

Variable Refrigerant Flow (VRF) Multi-Split AC and HP
AHRI Standard 1230

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SMMSe / SHRMe VRF Controls and Accessories
RBC-AMS54E-UL – Wired Remote Controller

TOSHIBA Carrier

Submittal Data

Job Data _____ Location _____
Buyer _____ Buyer PO # _____ Carrier # _____
Unit Number _____ Model Number _____
Performance Data Certified By _____ Date _____

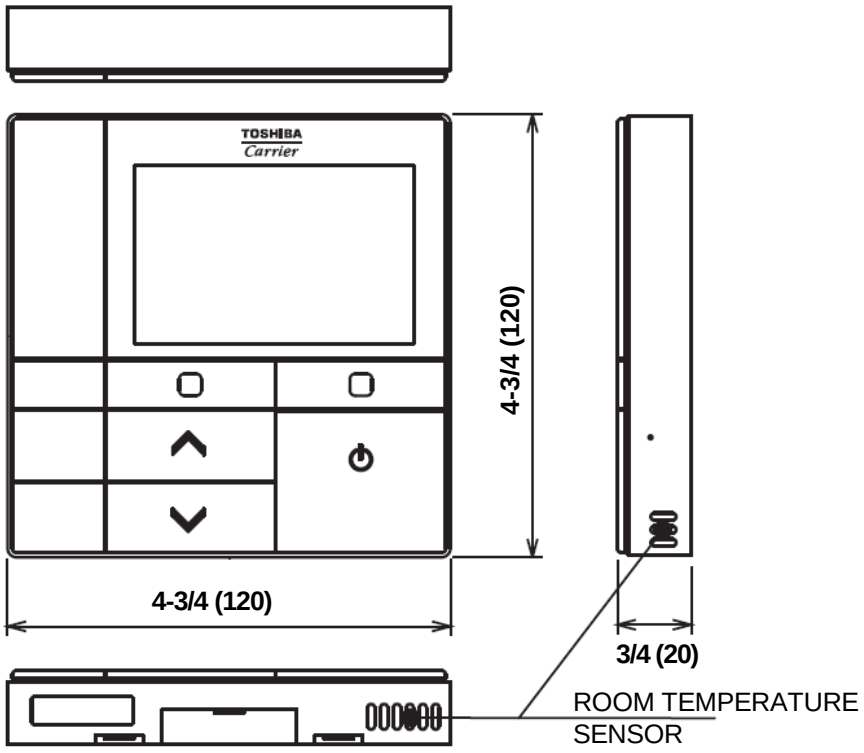


SMMSe / SHRMe VRF Wired Remote Controller Features

- Group control up to 8 indoor units
- Mode of operation
- Fan speed control
- ON/OFF
- Set temperature range limit
- Dual set point (HR only)
- Schedule weekly timer
- Clock setting
- Temperature display in 1ºF
- Individual louver control
- Back lit
- Multiple languages
- DN code setting
- Compatible with Toshiba Carrier VRF and RAV systems

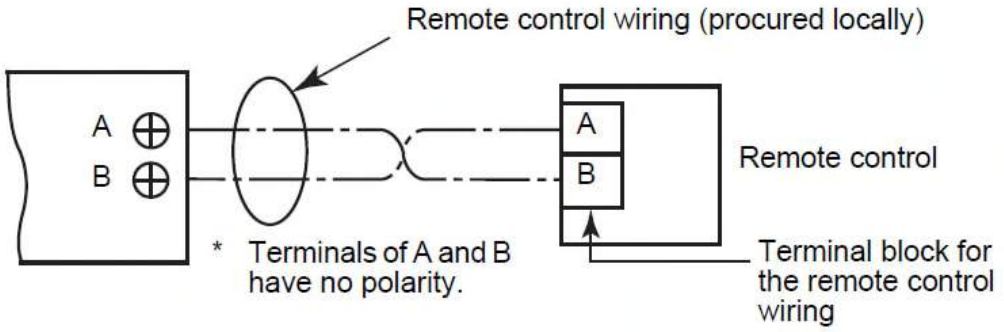
DIMENSIONAL DRAWING

WIRED REMOTE CONTROLLER RBC-AMS54E-UL



NOTE: Dimensions are in inches (mm).

WIRING DIAGRAM



* Use wire of AWG20 to AWG14.
* A crimp-style terminal cannot be used.

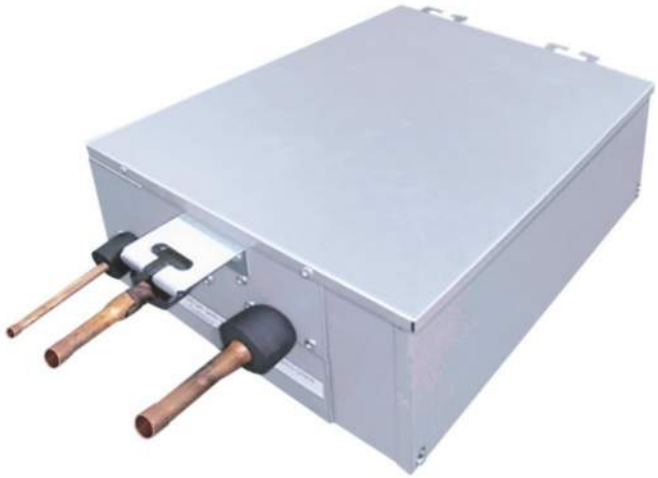
© Carrier Corporation 2016

SHRMe
RBM-Y0384FUL–Single Port Flow Selector (Long)

TOSHIBA Carrier

Submittal Data

Job Data _____ Location _____
Buyer _____ Buyer PO # _____ Carrier # _____
Unit Number _____ Model Number _____
Performance Data Certified By _____ Date _____



Single Port Flow Selector (Long) Features

- Maximum piping length between port and indoor unit is 164 ft.
- Power and control cable are field supplied and installed.
- Multiple indoor units can be connected to one box.

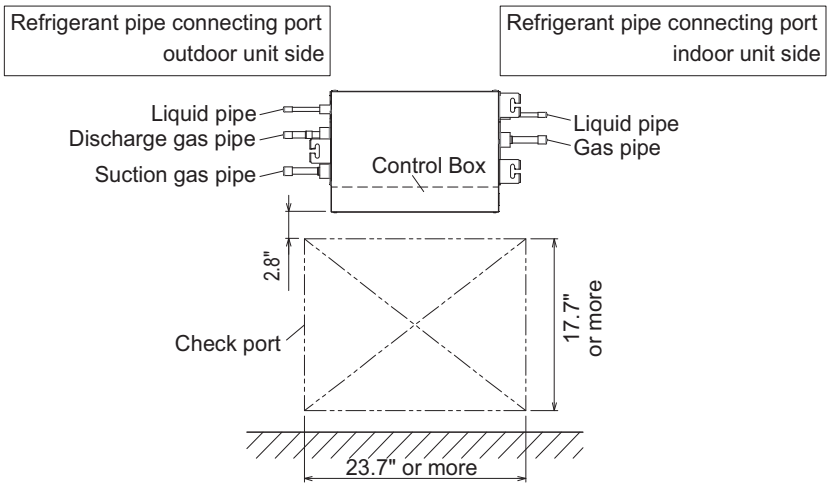
MODEL NAME		RBM-Y0384FUL
POWER SUPPLY		208-230/1/60
Current Draw	A	<1
MOCP	A	15
Number of Connectable Indoor Units		5
Connectible indoor unit capacity/port	kBtu/h	Below 38
DIMENSIONS	Height (in)	7.10
	Width (in)	16.80
	Depth (in)	11.80
TOTAL WEIGHT	lbs	27
Connecting Port Diameter (Indoor Unit Side)	Liquid Side (in)	3/8
	Gas Side (in)	5/8
Connecting Port Diameter (Outdoor Unit Side)	Liquid Side (in)	3/8
	Discharge Gas Side (in)	1/2
	Suction Gas Side (in)	5/8
Connection		Braze

LEGEND

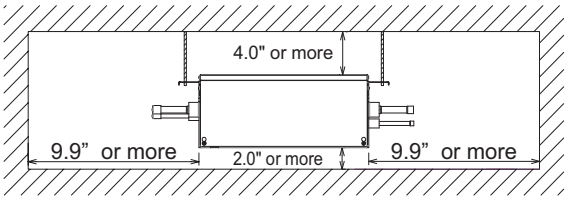
MOCP — Maximum Over Current Protection

SINGLE PORT FLOW SELECTOR CLEARANCE (RBM-Y0384FUL)

Installation space



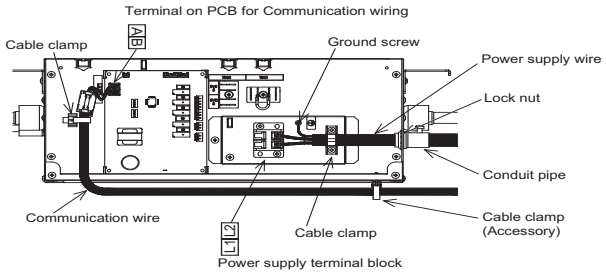
When attached pipes are used

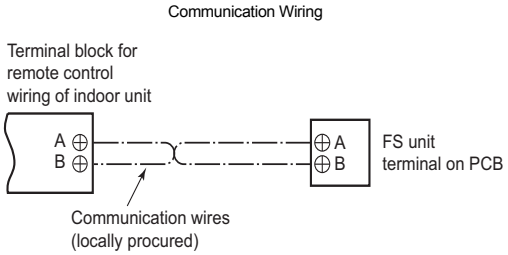


* In case of using the attached pipe (accessory) ;
13.8" (For Y0384FUL)

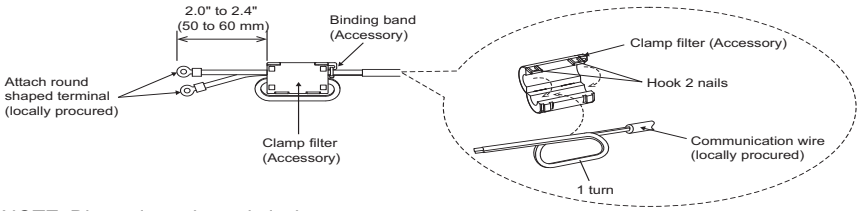
NOTE: Dimensions shown in inches.

SINGLE PORT FLOW SELECTOR (RBM-Y0384FUL) WIRING DIAGRAM



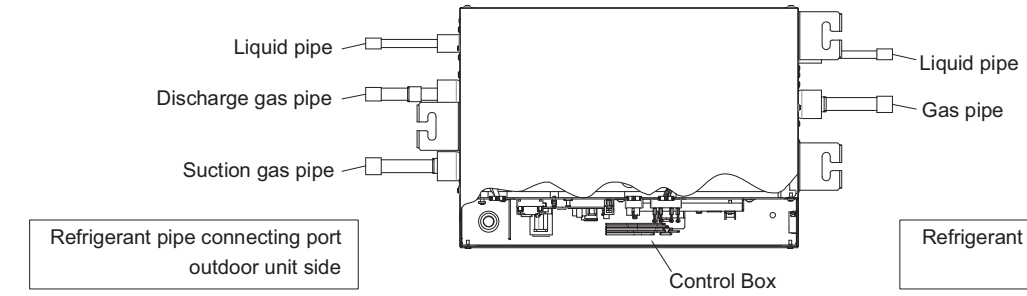


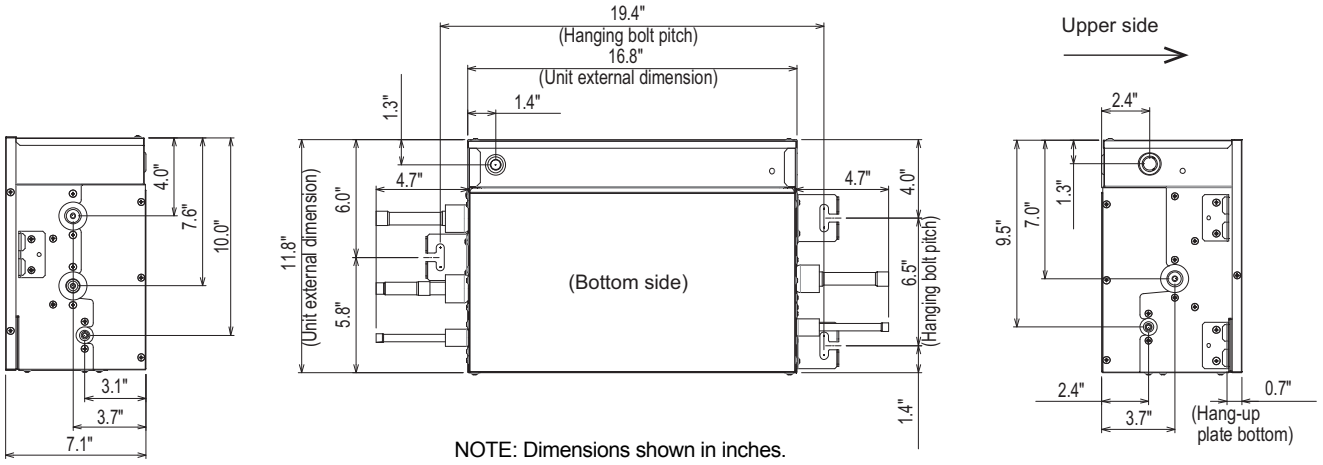
For communication wire, attach the Clamp filter (accessory) as shown in the picture below.



NOTE: Dimensions shown in inches.

SINGLE PORT FLOW SELECTOR (RBM-Y0384FUL) DIMENSIONS





NOTE: Dimensions shown in inches.

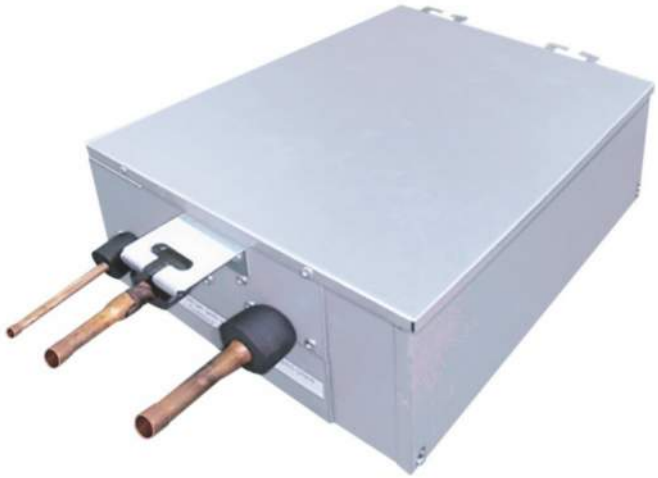
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SHRMe
RBM-Y0614FUL–Single Port Flow Selector (Long)

TOSHIBA Carrier

Submittal Data

Job Data _____ Location _____
Buyer _____ Buyer PO # _____ Carrier # _____
Unit Number _____ Model Number _____
Performance Data Certified By _____ Date _____



Single Port Flow Selector (Long) Features

- Maximum piping length between port and indoor unit is 164 ft.
- Power and control cable are field supplied and installed.
- Multiple indoor units can be connected to one box.

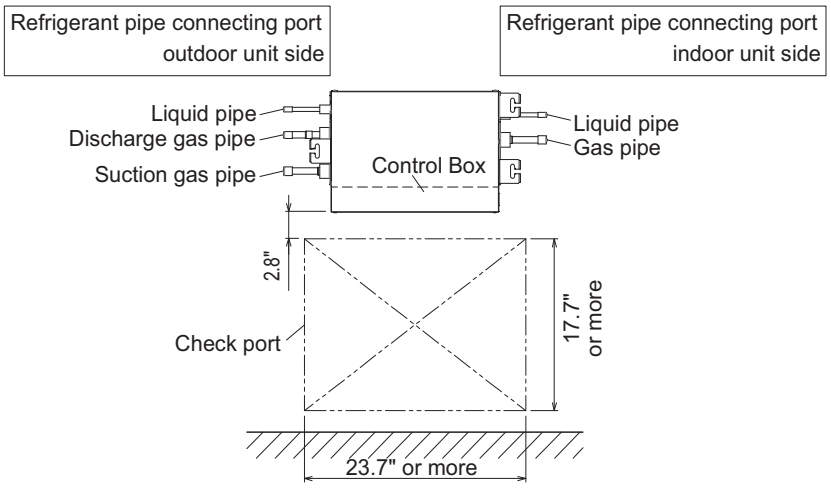
MODEL NAME		RBM-Y0614FUL
POWER SUPPLY		208-230/1/60
Current Draw	A	<1
MOCP	A	15
Number of Connectable Indoor Units		5
Connectible indoor unit capacity/port	kBtu/h	38~61
DIMENSIONS	Height (in)	7.10
	Width (in)	16.80
	Depth (in)	11.80
TOTAL WEIGHT	lbs	27
Connecting Port Diameter (Indoor Unit Side)	Liquid Side (in)	3/8
	Gas Side (in)	5/8
Connecting Port Diameter (Outdoor Unit Side)	Liquid Side (in)	3/8
	Discharge Gas Side (in)	1/2
	Suction Gas Side (in)	5/8
Connection		Braze

LEGEND

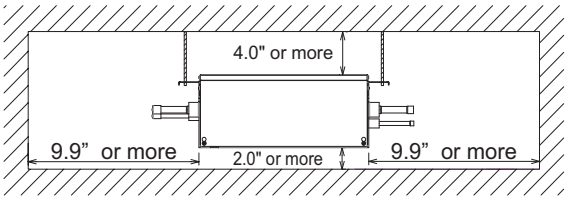
MOCP — Maximum Over Current Protection

SINGLE PORT FLOW SELECTOR CLEARANCE (RBM-Y0614FUL)

Installation space

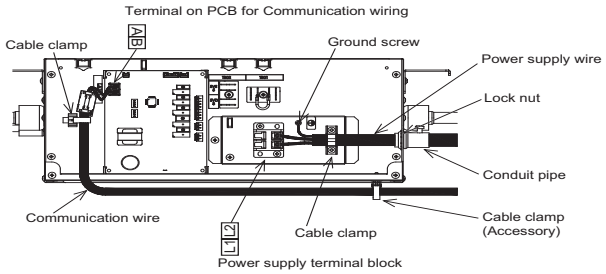


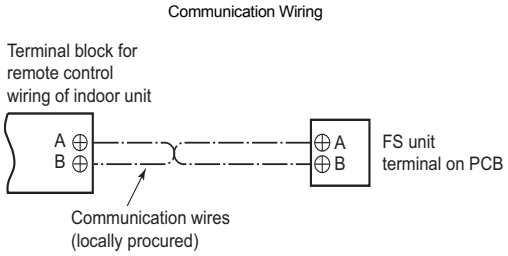
When attached pipes are used



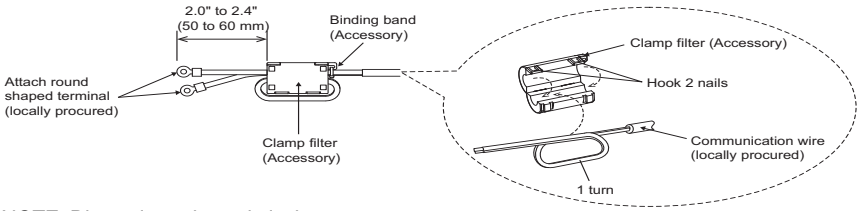
NOTE: Dimensions shown in inches.

SINGLE PORT FLOW SELECTOR (RBM-Y0614FUL) WIRING DIAGRAM



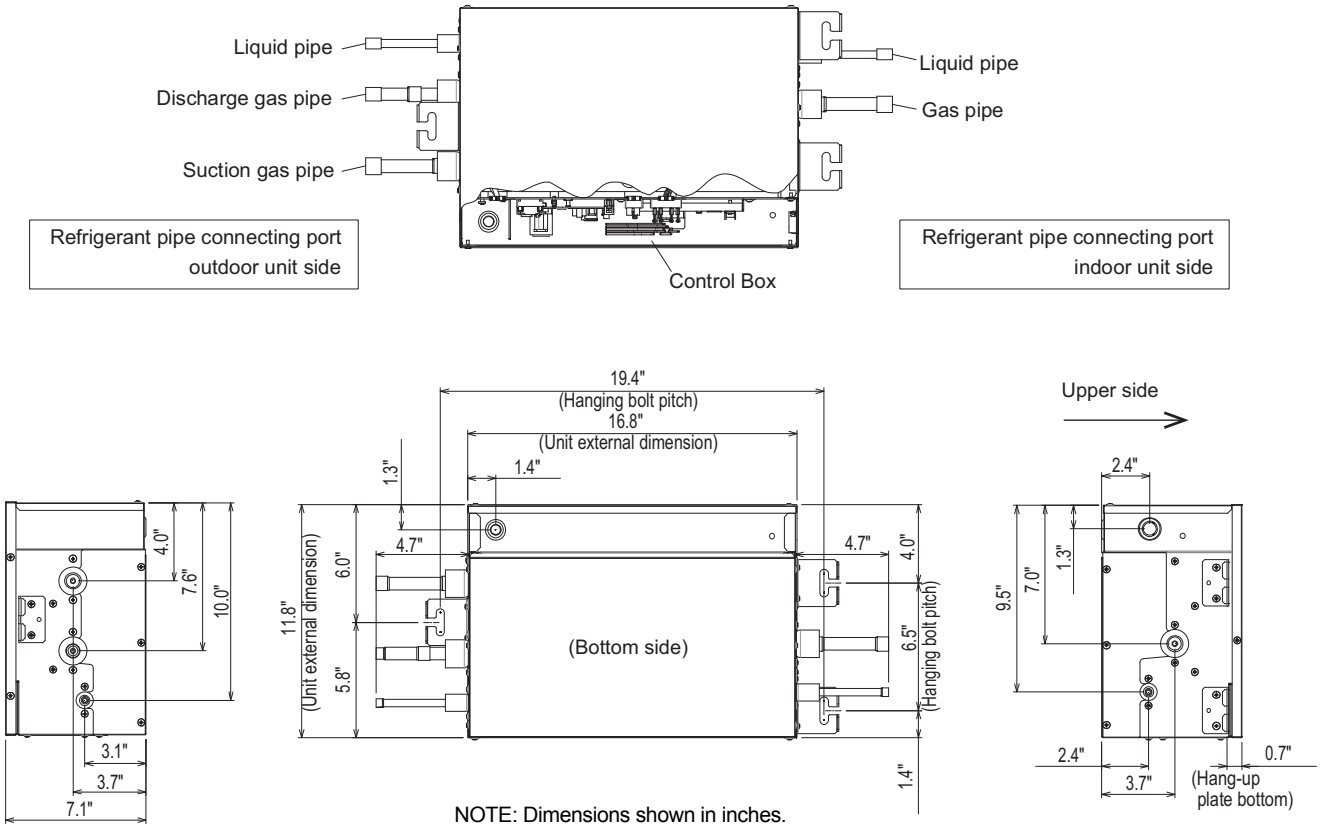


For communication wire, attach the Clamp filter (accessory) as shown in the picture below.



NOTE: Dimensions shown in inches.

SINGLE PORT FLOW SELECTOR (RBM-Y0614FUL) DIMENSIONS



NOTE: Dimensions shown in inches.

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SHRMe
RBM-Y0964FUL–Single Port Flow Selector (Long)

TOSHIBA Carrier

Submittal Data

Job Data _____ Location _____
Buyer _____ Buyer PO # _____ Carrier # _____
Unit Number _____ Model Number _____
Performance Data Certified By _____ Date _____



Single Port Flow Selector Features

- Maximum piping length between port and indoor unit is 164 ft.
- Power and control cable are field supplied and installed.
- Multiple indoor units can be connected to one box.

MODEL NAME		RBM-Y0964FUL
POWER SUPPLY		208-230/1/60
Current Draw	A	<1
MOCP	A	15
Number of Connectable Indoor Units		8*
Connectible indoor unit capacity/port	kBtu/h	61~96
DIMENSIONS	Height (in)	7.10
	Width (in)	19.50
	Depth (in)	13.80
TOTAL WEIGHT	lbs	38
Connecting Port Diameter (Indoor Unit Side)	Liquid Side (in)	1/2
	Gas Side (in)	7/8
Connecting Port Diameter (Outdoor Unit Side)	Liquid Side (in)	1/2
	Discharge Gas Side (in)	3/4
	Suction Gas Side (in)	7/8
Connection		Braze

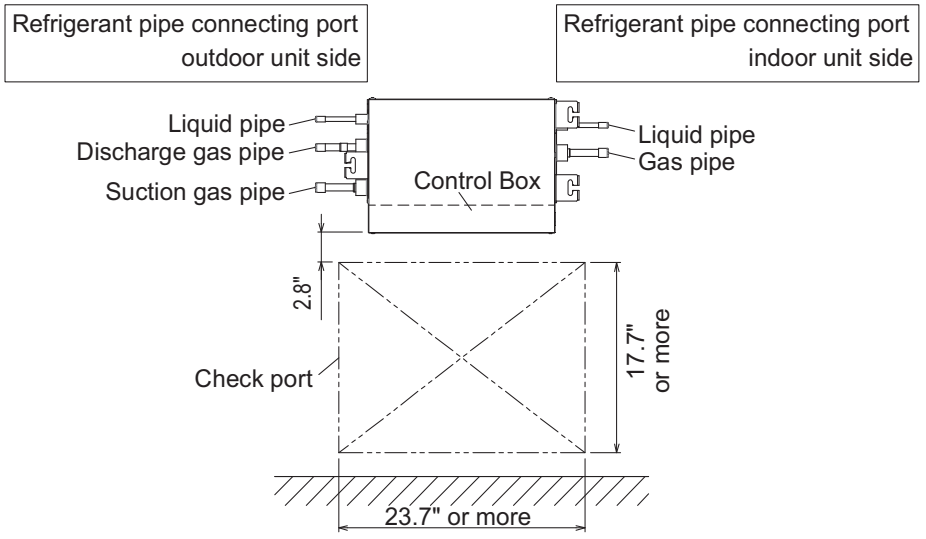
LEGEND

MOCP — Maximum Over Current Protection

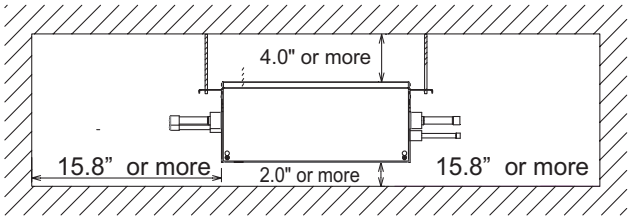
* If using 2 remote controllers, maximum connectable indoor units is 7.

SINGLE PORT FLOW SELECTOR CLEARANCE (RBM-Y0964FUL)

Installation space

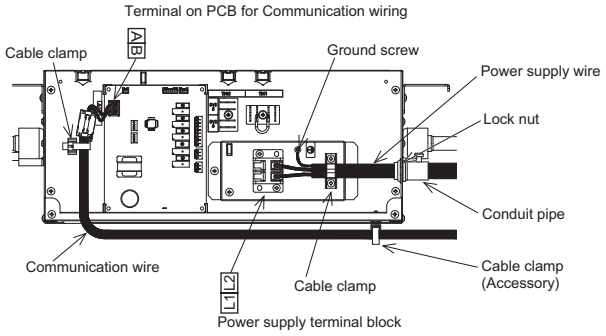


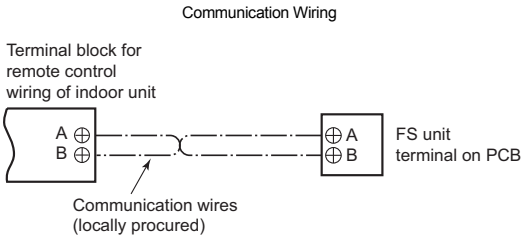
When attached pipes are used



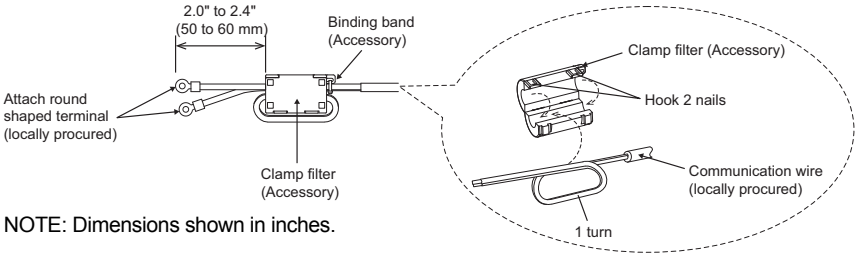
NOTE: Dimensions shown in inches.

SINGLE PORT FLOW SELECTOR (RBM-Y0964FUL) WIRING DIAGRAM



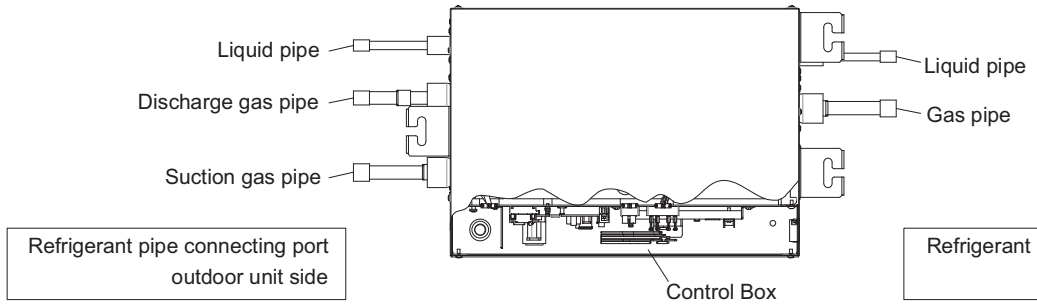


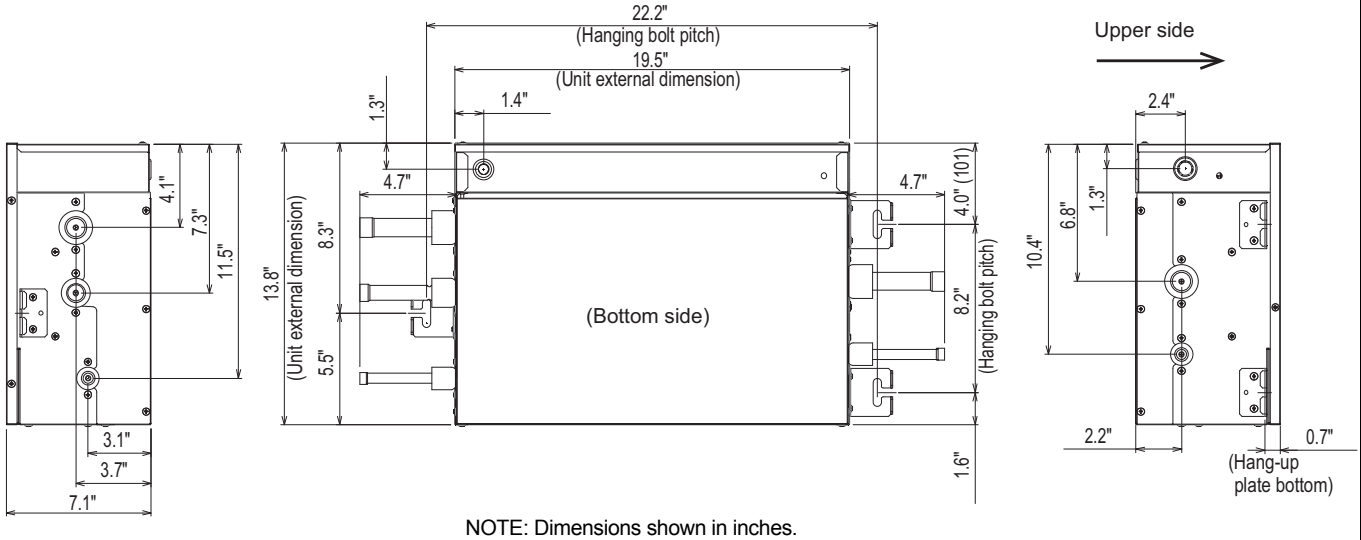
For communication wire, attach the Clamp filter (accessory) as shown in the picture below.



NOTE: Dimensions shown in inches.

SINGLE PORT FLOW SELECTOR (RBM-Y0964FUL) DIMENSIONS



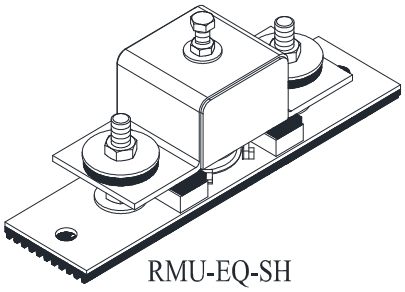


NOTE: Dimensions shown in inches.

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CALCULATIONS FOR VIBREX TYPE RMU-EQ-SH VIBRATION ISOLATORS/SEISMIC RESTRAINTS - 2015 IBC/2016 CB

CALCULATES WORST CASE LOADING FOR (4) ISOLATORS. (UNITS: LBS & INCHES)
USING COMBINED LOAD EQUATIONS 16-5: U = 1.2D + 1.0E & 16-7: U = 0.9D + 1.0E

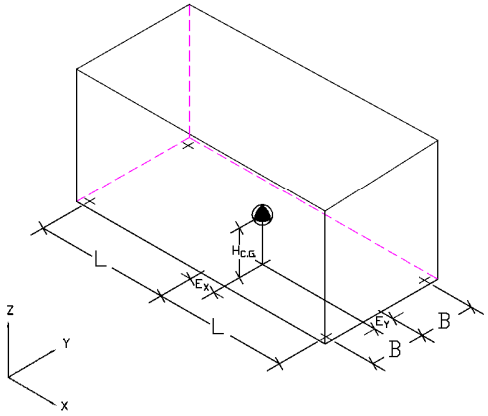


SEISMIC FORCES - CH. 13 OF ASCE 7

13.3-2: $F_p = 1.6 * S_{DS} * I_p * Wp$ (MAX)	=	240.00 lbs
13.3-1: $F_p = (0.4 * a_p * S_{DS}/(R_p/I_p))(1+2z/h_r)Wp$	=	225.00 lbs
13.3-3: $F_p = 0.3 * S_{DS} * I_p * Wp$ (MIN)	=	45.00 lbs
CONTROLLING HOR. SEISMIC FORCE: F_p	=	225.00 lbs
OVERTURNING MOMENT: $M = F_p * H_{C.G.}$	=	3825.00 lb-in
* SUPP. VERT. SEISM. FORCE: $F_{pv} = 0.2 S_{DS} Wp$	=	30.00 lbs
DESIGN SPECTRAL RESP. ACCELERATION: S_{DS}	=	1.00
IMPORTANCE FACTOR: I_p	=	1.00
COMPONENT AMPLIFICATION FACTOR: a_p	=	2.50
COMP. RESPONSE MODIFICATION FACTOR: R_p	=	2.00
EQUIPMENT ELEVATION / ROOF ELEVATION: z/h_r (WITH RESPECT TO GRADE)	=	1.00

EQUIPMENT WEIGHT & GEOMETRY

EQUIPMENT WEIGHT: Wp	=	150.00 lbs
L:	=	10.00 in
B:	=	6.50 in
E_X:	=	1.00 in
E_Y:	=	1.00 in
HEIGHT TO CG.: $H_{C.G.}$	=	17.00 in
MAX SPRING REACTION	=	50.00 lbs



ISOLATOR FORCES

$I_X = 4*B*B$	=	169.00 in^4
$I_Y = 4*L*L$	=	400.00 in^4
γ (DIR. OF Vrot-CRIT. ANCHOR): $\tan^{-1}(B/L)$	=	33.02
α (DIR. OF Vdir-CRIT. ANCHOR): tan-1(E_Y/E_X)	=	45.00
β: $\gamma - \alpha$ =	=	168.02
θ (DIR. OF F_{ph} FOR MAX UPLIFT): tan-1((L*I_X)/(B*I_Y))	=	33.02

VERTICAL REACTIONS (WITH 1.2D OR 0.9D)

R_m (DUE TO OVERTURNING MOMENT)	=	175.46 lbs
$R_{e\ MAX}$ (DUE TO ECCENTRICITY):	=	13.33 lbs
$R_{e\ MIN}$ (DUE TO ECCENTRICITY):	=	6.66 lbs
$R_{v\ MAX}$ (DUE TO VERTICAL LOADS):	=	52.50 lbs
$R_{v\ MIN}$ (DUE TO VERTICAL LOADS):	=	26.25 lbs
P_{MAX} (MAX DOWNWARD REACTION): $R_m + R_{e\ MAX} + R_{v\ MAX}$	=	241.29 lbs
P_{MIN} (MAX UPLIFT/ANCH. POINT - IF POS.): $R_m + R_{e\ MIN} - R_{v\ MIN}$	=	155.88 lbs

HORIZONTAL REACTIONS:

V_{rot} (SHEAR DUE TO ECCENTRICITY):	=	6.67 lbs
V_{dir} (DIRECT SHEAR):	=	56.25 lbs
V_{MAX} (TOTAL SHEAR/ANCH. POINT):	=	62.79 lbs

SELECT ISOLATOR → RMUJ-EQ-SH

ISOLATOR CAPACITIES: V_C	=	840.00		T_C (ADJUSTED) =	1266.00
$V_{MAX}/V_C + P_{MIN}/T_C$	=	0.20	<= 1.00		

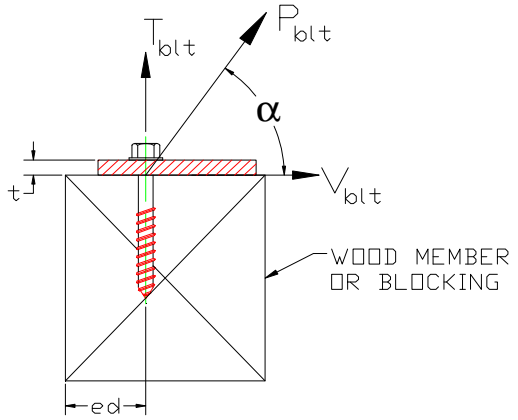
LAG BOLT FORCES

P_{MIN} (MAX UPLIFT/ANCH. POINT - IF POS.): $R_m + R_{e\ MIN} - R_{v\ MIN}$	=	**155.88 lbs**
V_{MAX} (TOTAL SHEAR/ANCH. POINT):	=	**62.79 lbs**
# OF LAG BOLTS: n	=	2
LAG BOLT TENSION DUE TO UPLIFT: T_1	=	77.94 lbs
LAG BOLT TENSION DUE TO ISO. OVERTURNING: T_2	=	43.95 lbs
COMBINED LAG BOLT TENSION: $N_{ua} = (T_1 + T_2)$	=	121.89 lbs
LAG BOLT SHEAR: $V_{ua} = V_{MAX}/n$	=	31.39 lbs

LAG BOLT DIAMETER: = 3/8
LAG BOLT INTO DOUGLAS FIR WOOD. SEE THE FOLLOWING CALCULATIONS FOR DESIGN AND COMBINED LOAD CHECK PER CHAPTER 12 OF THE 2015 NDS.

JOB NAME: CHANNEL ISLANDS HS	**M.W. SAUSSE' & CO., INC.**
CUST.:	PREPARED BY : JO
MECH. ENG.: BUDLONG	DATE : 05-Feb-20
MARK: CU's	SHEET NO. : -C13

LAG BOLT INTO WOOD CALCULATIONS - 2015 NDS - LRFD



TENSION AND SHEAR VALUES FROM SHEET: **-C13**

T_{blt} (lbs) =	=	122
V_{blt} (lbs) =	=	31
Resultant: $P_{blt} = (T_{blt}^2 + V_{blt}^2)^{0.5}$	**=**	**126**
Slope of resultant.: (α) = arctan (T_{blt}/V_{blt})	=	76

INPUT LAG SCREW INFO:

Nom. screw diameter: D	=	3/8
Nom. length of screw: L	=	3.0
Thickness of member to be anchored: t	=	1/2"
Spacing between screws: sp	=	2.00
Edge distance: ed	=	2.00
End distance: e	=	3.50
Length of tapered tip: E	=	7/32
Length of threaded portion of screw: T	=	2.00
Effective length of threaded portion of screw: p_t	=	1.78
Embedment in main member, less tip: p_d	=	2.28
Length of thread penetration into main member	=	1.78

INPUT DESIGN VALUES FROM TABLES:

Withdrawl (Tension): W	(pli)	=	305
Lateral (Shear): Z	(lbs)	=	180

MINIMUM REQUIREMENTS FOR 100% DESIGN VALUES:

Min. edge dist.: 4D	=	1.50
Min. end dist.: 7D	=	2.63
Min. spacing: 4D	=	1.50
Min. penetration: 8D	=	3.00

LOAD ADJUSTMENT FACTORS:

Time Effect Factor: λ	=	1.00
Resistance Factor: ϕ	=	0.65
Format Conversion Factor: K_F	=	3.32
Wet service factor: C_m (1 typ., 0.7 when wet)	=	1.00
Temp. factor: C_t (1 typ., 0.8 when t>100°F)	=	0.80
Group action fact.: Cg (1 typ., See Table 7.3.6C)	=	1.00
End grain factor: C_{eg} (1 typ., 0.75 @ end grain)	=	1.00

Geometry factors:

$C_{\Delta, sp}$ = actual spacing / 4D (1 typ., 0.5 min)	=	1.00
$C_{\Delta, ed}$ = actual edge dist. / 4D (1 typ., 0.5 min)	=	1.00
$C_{\Delta, e}$ = actual end dist. / 7D (1 typ., 0.5 min)	=	1.00
Penetration depth factor: $C_d = p_d/8D$ (1 typ., 0.5 Min.)	=	0.76

ALLOWABLE LAG SCREW DESIGN VALUES:

WITHDRAWAL (TENSION): (pli)

$W' = W*K_F*\lambda*\phi*C_m*C_t*C_{eg}$ **=** **527**

LATERAL (SHEAR): (lbs)

$Z' = Z*K_F*\lambda*\phi*C_m*C_t*C_g*C_{\Delta(s,ed\ \&\ e)}*C_d*C_{eg}$ **=** **236**

RESULTANT @ SLOPE alpha (a): (lbs)

$Z_\alpha' = (W'*p*Z')/(W'*p*(COS\alpha)^2+Z'*(SIN\alpha)^2)$ **=** **792**

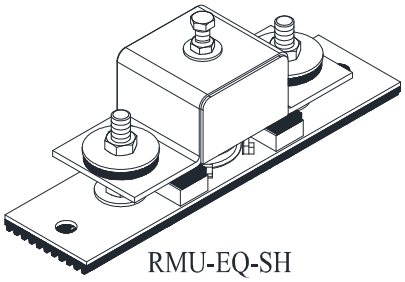
IF Z_α' >= P_{blt}, SELECTED BOLT OK!

USE 3/8" DIA. LAG BOLT 3" LONG W/ MIN. 1-1/2" EDGE DISTANCE & MIN. 2-5/8" END DISTANCE INTO MIN. 4X4 DOUGLAS FIR WOOD.

JOB NAME: CHANNEL ISLANDS HS	**M. W. SAUSSE' & CO., INC.**
CUST.:	PREPARED BY : JO
MECH. ENG.: BUDLONG	DATE : 05-Feb-20
MARK: CU's	SHEET NO. : -C13.1

CALCULATIONS FOR VIBREX TYPE RMU-EQ-SH VIBRATION ISOLATORS/SEISMIC RESTRAINTS - 2015 IBC/2016 CBC, LRFD

CALCULATES WORST CASE LOADING FOR (4) ISOLATORS. (UNITS: LBS & INCHES)
USING COMBINED LOAD EQUATIONS 16-5: U = 1.2D + 1.0E & 16-7: U = 0.9D + 1.0E

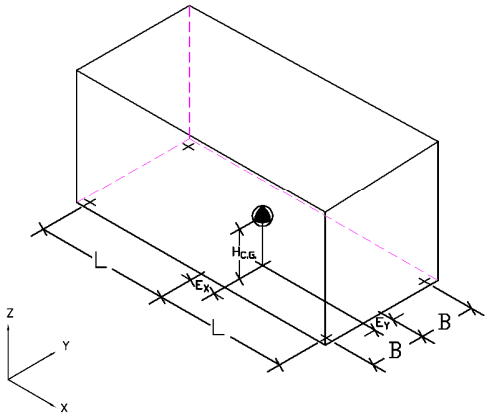


SEISMIC FORCES - CH. 13 OF ASCE 7

13.3-2: $F_p = 1.6 * S_{DS} * I_p * Wp$ (MAX)	=	262.92	lbs
13.3-1: $F_p = (0.4 * a_p * S_{DS}/(R_p/I_p))(1+2z/h_r)Wp$	=	246.49	lbs
13.3-3: $F_p = 0.3 * S_{DS} * I_p * Wp$ (MIN)	=	49.30	lbs
CONTROLLING HOR. SEISMIC FORCE: F_p	=	246.49	lbs
OVERTURNING MOMENT: $M = F_p * H_{C.G.}$	=	2957.85	lb-in
* SUPP. VERT. SEISM. FORCE: $F_{pv} = 0.2 S_{DS} Wp$	=	32.87	lbs
DESIGN SPECTRAL RESP. ACCELERATION: S_{DS}	=	1.57	
IMPORTANCE FACTOR: I_p	=	1.00	
COMPONENT AMPLIFICATION FACTOR: a_p	=	2.50	
COMP. RESPONSE MODIFICATION FACTOR: R_p	=	2.00	
EQUIPMENT ELEVATION / ROOF ELEVATION: z/h_r (WITH RESPECT TO GRADE)	=	1.00	

EQUIPMENT WEIGHT & GEOMETRY

EQUIPMENT WEIGHT: Wp	=	105.00	lbs
L:	=	11.50	in
B:	=	6.00	in
E_X:	=	1.00	in
E_Y:	=	1.00	in
HEIGHT TO CG.: $H_{C.G.}$	=	12.00	in
MAX SPRING REACTION	=	50.00	lbs



ISOLATOR FORCES

$I_X = 4*B*B$	=	144.00	in^4
$I_Y = 4*L*L$	=	529.00	in^4
γ (DIR. OF Vrot-CRIT. ANCHOR): $\tan^{-1}(B/L)$	=	27.55	
α (DIR. OF Vdir-CRIT. ANCHOR): $\tan\text{-}1(E_Y/E_X)$	=	45.00	
β: $\gamma - \alpha$ =	=	162.55	
θ (DIR. OF F_{ph} FOR MAX UPLIFT): $\tan\text{-}1((L*I_X)/(B*I_Y))$	=	27.55	

VERTICAL REACTIONS (WITH 1.2D OR 0.9D)

R_m (DUE TO OVERTURNING MOMENT)	=	139.01	lbs
$R_{e\ MAX}$ (DUE TO ECCENTRICITY):	=	10.07	lbs
$R_{e\ MIN}$ (DUE TO ECCENTRICITY):	=	3.91	lbs
$R_{v\ MAX}$ (DUE TO VERTICAL LOADS):	=	39.72	lbs
$R_{v\ MIN}$ (DUE TO VERTICAL LOADS):	=	15.41	lbs
P_{MAX} (MAX DOWNWARD REACTION): $R_m+R_{e\ MAX}+R_{v\ MAX}$	=	188.80	lbs
P_{MIN} (MAX UPLIFT/ANCH. POINT - IF POS.): $R_m+R_{e\ MIN}-R_{v\ MIN}$	=	127.51	lbs

HORIZONTAL REACTIONS:

V_{rot} (SHEAR DUE TO ECCENTRICITY):	=	6.72	lbs
V_{dir} (DIRECT SHEAR):	=	61.62	lbs
V_{MAX} (TOTAL SHEAR/ANCH. POINT):	=	68.06	lbs

SELECT ISOLATOR ⟶ RMUJ-EQ-SH

ISOLATOR CAPACITIES: V_C	=	840.00		T_C (ADJUSTED) =	1266.00
$V_{MAX}/V_C + P_{MIN}/T_C$	=	0.18	<= 1.00		

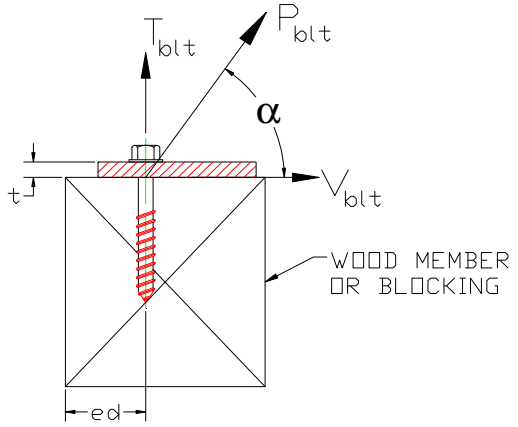
LAG BOLT FORCES

P_{MIN} (MAX UPLIFT/ANCH. POINT - IF POS.): $R_m+R_{e\ MIN}-R_{v\ MIN}$	=	**127.51**	**lbs**
V_{MAX} (TOTAL SHEAR/ANCH. POINT):	=	**68.06**	**lbs**
# OF LAG BOLTS: n	=	2	
LAG BOLT TENSION DUE TO UPLIFT: T_1	=	63.75	lbs
LAG BOLT TENSION DUE TO ISO. OVERTURNING: T_2	=	47.64	lbs
COMBINED LAG BOLT TENSION: $N_{ua} = (T_1+T_2)$	=	111.40	lbs
LAG BOLT SHEAR: $V_{ua} = V_{MAX}/n$	=	34.03	lbs

LAG BOLT DIAMETER: = 3/8
LAG BOLT INTO DOUGLAS FIR WOOD. SEE THE FOLLOWING CALCULATIONS FOR DESIGN AND COMBINED LOAD CHECK PER CHAPTER 12 OF THE 2015 NDS.

JOB NAME: CHANNEL ISLANDS HS	**M.W. SAUSSE' & CO., INC.**
CUST.:	PREPARED BY : JO
MECH. ENG.: BUDLONG	DATE : 18-Dec-19
MARK: RAV-SP180	SHEET NO. : -C6

LAG BOLT INTO WOOD CALCULATIONS - 2015 NDS - LRFD



TENSION AND SHEAR VALUES FROM SHEET: -C6

T_{blt} (lbs) =	=	111
V_{blt} (lbs) =	=	34
Resultant: $P_{blt} = (T_{blt}^2 + V_{blt}^2)^{0.5}$	=	**116**
Slope of resultant.: (α) = arctan (T_{blt}/V_{blt})	=	73

INPUT LAG SCREW INFO:

Nom. screw diameter: D	=	3/8
Nom. length of screw: L	=	3.0
Thickness of member to be anchored: t	=	1/2"
Spacing between screws: sp	=	2.00
Edge distance: ed	=	1.50
End distance: e	=	2.62
Length of tapered tip: E	=	7/32
Length of threaded portion of screw: T	=	2.00
Effective length of threaded portion of screw: p_t	=	1.78
Embedment in main member, less tip: p_d	=	2.28
Length of thread penetration into main member: p	=	1.78

INPUT DESIGN VALUES FROM TABLES:

Withdrawl (Tension): W	(pli)	=	305
Lateral (Shear): Z	(lbs)	=	180

MINIMUM REQUIREMENTS FOR 100% DESIGN VALUES:

Min. edge dist.: 4D	=	1.50
Min. end dist.: 7D	=	2.63
Min. spacing: 4D	=	1.50
Min. penetration: 8D	=	3.00

LOAD ADJUSTMENT FACTORS:

Time Effect Factor: λ	=	1.00
Resistance Factor: ϕ	=	0.65
Format Conversion Factor: K_F	=	3.32
Wet service factor: C_m (1 typ., 0.7 when wet)	=	1.00
Temp. factor: C_t (1 typ., 0.8 when t>100°F)	=	0.80
Group action fact.: Cg (1 typ., See Table 7.3.6C)	=	1.00
End grain factor: C_{eg} (1 typ., 0.75 @ end grain)	=	1.00

Geometry factors:

$C_{\Delta, ep}$ = actual spacing / 4D (1 typ., 0.5 min)	=	1.00
$C_{\Delta, ed}$ = actual edge dist. / 4D (1 typ., 0.5 min)	=	1.00
$C_{\Delta, e}$ = actual end dist. / 7D (1 typ., 0.5 min)	=	1.00
Penetration depth factor: $C_d = p_d/8D$ (1 typ., 0.5 Min.)	=	0.76

ALLOWABLE LAG SCREW DESIGN VALUES:

WITHDRAWAL (TENSION): (pli)

$W' = W*K_F*\lambda*\phi*C_m*C_t*C_{eg}$ = 527

LATERAL (SHEAR): (lbs)

$Z' = Z*K_F*\lambda*\phi*C_m*C_t*C_g*C_{\Delta(ep,ed\ \&\ e)}*C_d*C_{eg}$ = 235

RESULTANT @ SLOPE alpha (a): (lbs)

$Z_\alpha' = (W'*p*Z')/(W'*p*(COS\alpha)^2+Z'*(SIN\alpha)^2)$ = 748

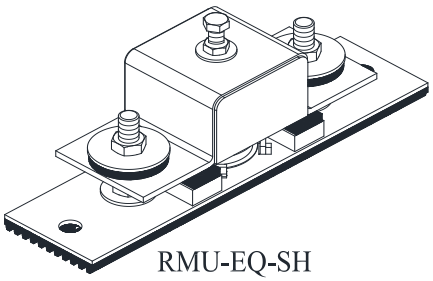
IF Z_α' >= P_{blt}, SELECTED BOLT OK!

USE 3/8" DIA. LAG BOLT 3" LONG W/ MIN. 1-1/2" EDGE DISTANCE & MIN. 2-5/8" END DISTANCE INTO MIN. 4X4 DOUGLAS FIR WOOD.

JOB NAME: CHANNEL ISLANDS HS	**M. W. SAUSSE' & CO., INC.**
CUST.:	PREPARED BY : JO
MECH. ENG.: BUDLONG	DATE : 18-Dec-19
MARK: RAV-SP180	SHEET NO. : -C6.1

CALCULATIONS FOR VIBREX TYPE RMU-EQ-SH VIBRATION ISOLATORS/SEISMIC RESTRAINTS - 2015 IBC/2016 CBC, LI

CALCULATES WORST CASE LOADING FOR (6) ISOLATORS. (UNITS: LBS & INCHES)
USING COMBINED LOAD EQUATIONS 16-5: U = 1.2D + 1.0E & 16-7: U = 0.9D + 1.0E

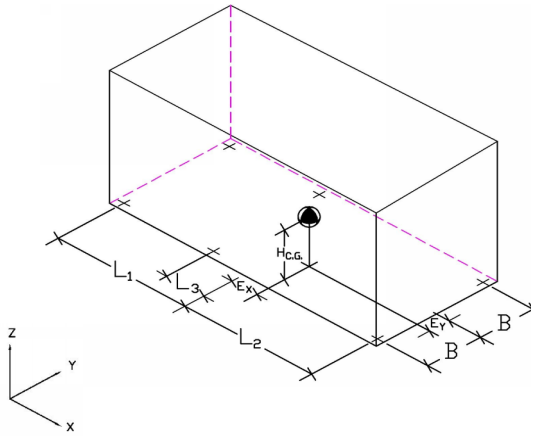

RMU-EQ-SH

SEISMIC FORCES - CH. 13 OF ASCE 7

13.3-2: $F_p = \Omega_0 1.6 S_{DS} I_p W_p$ (MAX)	=	12895.60	lbs
13.3-1: $F_p = \Omega_0 (0.4 a_p S_{DS}/(R_p/I_p))(1+2z/h_r) W_p$	=	12089.63	lbs
13.3-3: $F_p = \Omega_0 0.3 S_{DS} I_p W_p$ (MIN)	=	2417.93	lbs
Ω_0 PER ASCE 7-10, NOTE C, TABLE 13.6-1	=	2.50	
CONTROLLING HOR. SEISMIC FORCE: F_p	=	12089.63	lbs
OVERTURNING MOMENT: $M=F_p H_{C.G.}$	=	338509.50	lb-in
* SUPP. VERT. SEISM. FORCE: $F_{pv} = 0.2 S_{DS} W_p$	=	644.78	lbs
DESIGN SPECTRAL RESP. ACCELERATION: S_{DS}	=	1.57	
IMPORTANCE FACTOR: I_p	=	1.00	
COMPONENT AMPLIFICATION FACTOR: a_p	=	2.50	
COMP. RESPONSE MODIFICATION FACTOR: R_p	=	2.00	
EQUIPMENT ELEVATION / ROOF ELEVATION: z/h_r (WITH RESPECT TO GRADE)	=	1.00	

EQUIPMENT WEIGHT & GEOMETRY

EQUIPMENT WEIGHT: Wp	=	2060.00	lbs
L_2:	=	66.00	in
L_3:	=	0.00	in
L_1:	=	66.00	in
B:	=	19.50	in
E_X:	=	0.97	in
E_Y:	=	0.67	in
HEIGHT TO CG.: $H_{C.G.}$	=	28.00	in
MAX SPRING REACTION	=	400.00	lbs



ISOLATOR FORCES (W/0 Ω_0)

$I_X = 6*B*B$	=	2281.50	in^4
$I_Y = 2*(L_1^2+L_2^2+L_3^2)$	=	17424.00	in^4
γ (DIR. OF Vrot-CRIT. ANCHOR): $\tan^{-1}(B/L)$	=	16.46	
α (DIR. OF Vdir-CRIT. ANCHOR): tan-1(E_Y/E_X)	=	34.74	
β: $\gamma - \alpha$ =	=	161.72	
θ (DIR. OF F_{ph} FOR MAX UPLIFT): tan-1(($L*I_X$)/($B*I_Y$))	=	23.90	

VERTICAL REACTIONS (WITH 1.2D OR 0.9D)

R_m (DUE TO OVERTURNING MOMENT)	=	3164.65	lbs
$R_{e\ MAX}$ (DUE TO ECCENTRICITY):	=	29.33	lbs
$R_{e\ MIN}$ (DUE TO ECCENTRICITY):	=	11.38	lbs
$R_{v\ MAX}$ (DUE TO VERTICAL LOADS):	=	519.46	lbs
$R_{v\ MIN}$ (DUE TO VERTICAL LOADS):	=	201.54	lbs
P_{MAX} (MAX DOWNWARD REACTION): $R_m/\Omega_0+R_{e\ MAX}+R_{v\ MAX}$	=	1814.65	lbs
P_{MIN} (MAX UPLIFT/ANCH. POINT - IF POS.): $R_m/\Omega_0+R_{e\ MIN}-R_{v\ MIN}$	=	1075.70	lbs

HORIZONTAL REACTIONS:

V_{rot} (SHEAR DUE TO ECCENTRICITY):	=	51.77	lbs
V_{dir} (DIRECT SHEAR):	=	2014.94	lbs
V_{MAX} (TOTAL SHEAR/ANCH. POINT WITHOUT Ω_0):	=	825.66	lbs

SELECT ISOLATOR ⟶ RMUH-EQ-SH-2

ISOLATOR CAPACITIES: V_C	=	3000.00		T_C (ADJUSTED) =	3500.00
$V_{MAX}/V_C + P_{MIN}/T_C$	=	0.58	<= 1.00		

ANCHOR BOLT FORCES (WITH Ω_0)

P_{MIN} (MAX UPLIFT/ANCH. POINT - IF POS.): $R_m+R_{e\ MIN}-R_{v\ MIN}$	=	**2974.49**	**lbs**
V_{MAX} (TOTAL SHEAR/ANCH. POINT):	=	**2064.16**	**lbs**
# OF ANCHOR BOLTS: n	=	2	
ANCHOR BOLT TENSION DUE TO UPLIFT: T_1	=	1487.24	lbs
ANCHOR BOLT TENSION DUE TO ISO. OVERTURNING: T_2	=	722.46	lbs
COMBINED ANCHOR BOLT TENSION: $N_{ua} = (T_1+T_2)$	=	2209.70	lbs
ANCHOR BOLT SHEAR: $V_{ua} = V_{MAX}/n$	=	1032.08	lbs

ANCHOR BOLT DIAMETER: = 3/4
TYPE OF ANCHOR BOLT: CARBON STEEL HILTI KB-TZ ANCHOR BOLT IN MIN. 3000psi. SEE SHEETS -C15.1 & C15.2

JOB NAME:	CHANNEL ISLAND	**M.W. SAUSSE' & CO., INC.**	
CUST.:		PREPARED BY :	JO
MECH. ENG.:	BUDLONG	DATE :	06-May-20
MARK:	CU-C3.1, D1.1	SHEET NO. :	-C15

HILTI KB-TZ CARBON AND STAINLESS STEEL ANCHORS IN CONCRETE
(U.S. CUSTOMARY UNITS, ESR-1917 (REVISED SEPTEMBER 2016) AND ACI-318-14, CHAPTER 17)

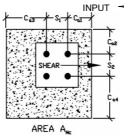
STEEL STRENGTH (TENSION AND SHEAR)

INPUT
- n = 2 (NUMBER OF BOLTS PER ANCHOR POINT)
- d_a = 3/4 in (DIAMETER OF ANCHOR BOLT)
- SEISMIC?: YES *TOPSIDE OF DECK?: NO
- STEEL: STAINLESS

N_{sa} = 24055 lbs (FROM TABLES 3 & 4)
V_{sa} = 12890 lbs (FROM TABLES 3 & 4)
Φ_{dN} = 0.75 (TENSION STRENGTH REDUCTION FACTOR FOR DUCTILE STEEL; ACI-318 17.3.3)
Φ_{dV} = 0.65 (SHEAR STRENGTH REDUCTION FACTOR FOR DUCTILE STEEL; ACI-318 17.3.3)
$\Phi_{dN}*N_{sa}$ = 18041.25 lbs (ACI 318, 17.4.1.2) ← DESIGN STEEL TENSION STRENGTH
$\Phi_{dV}*V_{sa}$ = 8378.5 lbs (ACI 318, 17.5.1.2) ← DESIGN STEEL SHEAR STRENGTH

CONCRETE

CONCRETE BREAKOUT TENSION STRENGTH

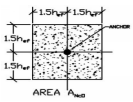


INPUT
- h_{nom} = 4.3125 in (NOMINAL EMBED., ESR-1917 TABLES 3 & 4)
- h_a = 8 in (MEMBER THICKNESS, USE AT LEAST MIN. VALUES IN ESR-1917, TABLES 3 OR 4)
- h_{ef} = 3.75 in (EFFECTIVE EMBED., ESR-1917 TABLES 3 & 4)
- C_{ac} = 7 in C_{min} = 4.25 h_{min} = 6.00 s_{min} = 6.57
- C_{a1} = 8 in (USE AT LEAST $C_{a,min}$ GIVEN IN TABLES 3 & 4 IN ESR-1917, INCREASE IF NECESSARY)
- C_{a2} = 8 in (USE AT LEAST $C_{a,min}$ & $\geq C_{a1}$ GIVEN IN TABLES 3 & 4 IN ESR-1917, INCREASE IF NECESSARY)
- C_{a3} = 12 in (USE AT LEAST $C_{a,min}$ & $\geq C_{a1}$ GIVEN IN TABLES 3 & 4 IN ESR-1917, INCREASE IF NECESSARY)
- C_{a4} = 11.25 in (USE AT LEAST $C_{a,min}$ & $\geq C_{a2}$ GIVEN IN TABLES 3 & 4 IN ESR-1917, INCREASE IF NECESSARY)
- S_{MIN} = 13 in (CLOSEST SPACING DIST. BETWEEN (2) ANCHORS IN THE ANCHOR GROUP)
- S_1 = 0 in (USE AT LEAST S_{min} FROM TABLES 3 & 4, ENTER 0 IF SINGLE ANCHOR)
- S_2 = 13.00 in (USE AT LEAST S_{min} FROM TABLES 3 & 4, ENTER 0 IF SINGLE ANCHOR)
- $\Psi_{ec,N}$ = 1 (ACI 17.4.2.4; 1.0 WHEN NO LOAD ECCENTRICITY)
- f'_c = 3000 psi (CONCRETE COMPRESSIVE STRENGTH)
- λ = 0.68 (1.0 FOR NW CONCRETE, 0.68 FOR STRUCTURAL SAND LW, 0.6 FOR ALL LW, 4.1.12 OF ESR-1917)
- CRACKED CONCRETE CONDITION...
- k_c = 24 (ESR-1917 TABLES 3 & 4)
- $\Psi_{c,N}$ = 1.00 (FROM ESR-1917 TABLES 3 & 4)
- Φ_{cN} = 0.65 (PULLOUT/CONCRETE BREAKOUT STRENGTH REDUCTION; ESR-1917 TABLES 3 & 4)

h_{ef} CHECK = $h_a/$ = 3.75 in (IF 3 OR MORE EDGES ARE LESS THAN 1.5*hef, 17.4.2.3 OF THE ACI-318)

$SIDE_\perp = \min(C_{a,2};1.5h_{ef}')+S_2+\min(C_{a4};1.5h_{ef}')$ = 24.25 in (LENGTH OF SIDE PERPENDICULAR TO SHEAR / SMALLEST EDGE DIST.)

$SIDE_\parallel = \min(C_{a1};1.5h_{ef}')+S_1+\min(C_{a3};1.5h_{ef}')$ = 11.25 in (LENGTH OF SIDE PARALLEL TO SHEAR / PERPENDICULAR TO CLOSEST EDGE)



$A_{Nc} = SIDE_\perp * SIDE_\parallel$ = 253.13 in^2 (PROJECTED FAILURE SURFACE AREA ACI-318 17.4.2.1)

$A_{Nco} = n*9*(h_{ef}')^2$ = 253.13 in^2 (PROJECTED FAILURE SURFACE AREA OF 1 ANCHOR, NO INFLUENCE 17.4.2.1)

$\Psi_{ed,N} = 0.7+0.3*C_{a1}/(1.5*h_{ef}')$ = 1.00 (IF $C_{a1} \geq 1.5h_{ef}$ THEN = 1.0)

$\Psi_{ch,N} = \frac{\max|C_{a1};1.5h_{ef}|}{C_{ac}}$ = 1.00 (ALWAYS ≤ 1.0)

$N_b = \lambda * k_c * \sqrt{f'_c} * h_{ef}^{1.5}$ = 6491.24 lbs

$N_{cb} = \frac{A_{Nc}}{A_{Nco}}\Psi_{ec,N}\Psi_{ed,N}\Psi_{c,N}\Psi_{ch,N}N_b$ = N/A (MORE THAN ONE ANCHOR)

$N_{cb} = \frac{A_{Nc}}{A_{Nco}}\Psi_{ec,N}\Psi_{ed,N}\Psi_{c,N}\Psi_{ch,N}N_b$ = 6491.24

(VALUES ARE IN POUNDS)

$\Phi_{cb}N_{cb}$ = 4219.306 lbs ← DESIGN CONRETE BREAKOUT TENSION STRENGTH

CHECK SIDE-FACE BLOWOUT

A_{brg} = 0.237 in^2 (BEARING AREA OF CONCRETE AT ANCHOR BOTTOM. USE A_{brg} FROM TABLES 3 & 4 OF ESR)

CHECK EDGE DISTANCE → $C_{a1} < 0.4h_{ef}$ → 8 > 1.5

FOR SINGLE ANCHORS -

CHECK C_{a2} → $C_{a2} < 3C_{a1}$ → 8 < 24

REDUCTION FACTOR FROM C_{a2} = $\frac{1+C_{a2}/C_{a1}}{4}$ =0.5 → WHERE $1.0 \leq C_{a2}/C_{a1} \leq 3.0$ → TRUE!

$N_{sb} = \lambda * 160 C_{a1}\sqrt{A_{brg}}\sqrt{f'_c}$ = 23208.853 lbs → REDUCED VALUE : 11604.4 lbs (ACI 318, 17.4.4.1)

FOR MULTIPLE ANCHORS (GROUPS) -

CHECK BOLT SPACING → S < 6C_{a1} → 13 < 48

$N_{sbg} = \left(1+\frac{S}{6C_{a1}}\right)N_{sb}$ =14747.292 lbs (ACI-318 17.4.4.2)

$\lambda_{ch}N_{sb} < \Phi_{cb}N_{cb}$ → 9585.7 lbs SIDE FACE BLOWOUT VALUE

JOB NAME:	CHANNEL ISLAND	M. W. SAUSSE' & CO., INC.	
CUST.:		PREPARED BY :	JO
MECH. ENG.:	BUDLONG	DATE :	06-May-20
MARK:	CU-C3.1, D1.1	SHEET NO. :	-C15.1

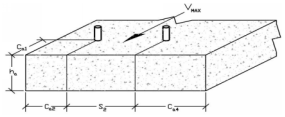
PULLOUT STRENGTH

N_p = 0 lbs (ESR-1917, TABLES 3 & 4)

$\Phi_{cp}*\lambda_c*N_{pn,f'c} = \Phi_{cp}N_p\sqrt{\frac{f'_c}{2500}}$ = N/A lbs (ANCHOR PULLOUT STRENGTH, 4.1.10 OF ESR-1917)

SHEAR BREAKOUT STRENGTH

- d_a = 0.75 in (OUTSIDE DIAMETER OF ANCHOR BOLT OR ROD)
- C_{a1} = 8 in (USE AT LEAST $C_{a,min}$ GIVEN IN TABLES 3 & 4 IN ESR-1917, INCREASE IF NECESSARY)
- C_{a2} = 8 in (USE AT LEAST $C_{a,min}$ & $\geq C_{a1}$ GIVEN IN TABLES 3 & 4 IN ESR-1917, INCREASE IF NECESSARY)
- ℓ_e = 3.75 in (MIN(h_{ef} OR $8d_a$)); ACI-318 SECTION 17.5.2.2)
- $\Psi_{ec,V}$ = 1 (ACI D.5.2.4; 1.0 WHEN NO LOAD ECCENTRICITY)
- h_a = 8 in (THICKNESS OF CONCRETE MEMBER)
- Φ_{cV} = 0.70 (SHEAR CONCRETE BREAKOUT STRENGTH REDUCTION; ESR-1917 TABLES 3 & 4)
- k_{cp} = 2 (PRYOUT COEFFICIENT, ESR-1917, TABLES 3 & 4)
- $\Psi_{c,V}$ = 1.2 (1.0 FOR CONC. W/O REINFORCEMENT, 1.2 FOR CONC. W/ REINFORCEMENT, 1.4 SEE 17.5.2.7)
- C_{a1}' = 7.5 in (C_{a1} ADJUSTED WHEN C_{a2} & C_{a4} ARE LESS THAN 1.5C_{a1}, 17.5.2.4)
- n_V = 2 (NO. OF ANCHORS IN ROW CLOSEST TO CONCRETE EDGE)



$\Psi_{ed,V} = 0.7+0.3*C_{a2}/(1.5*C_{a1}')$ = 0.91 (IF $C_{a2} \geq 1.5C_{a1}$ THEN = 1.0, ACI 318, SECTION D.6.2.6)

$\Psi_{h,V} = [(1.5*C_{a1}') / h_a]^{0.5}$ = 1.186 (ALWAYS GREATER THAN OR EQUAL TO 1.0, D.6.2.8)

$A_{Vc} = \min(h_a;1.5C_{a1}')*(\min(1.5C_{a1}';C_{a4})+S_2+\min(C_{a2};1.5C_{a1}')$ = 258.0 in^2 (REFER TO ACI-318 D.6.2.1 AND D.6.2.2)

$A_{Vc} = n_V4.5C_{a1}^2$ = 506.3 in^2 (REFER TO ACI-318 D.6.2.1 AND D.6.2.2)

$V_b = \lambda * 7\left(\frac{\ell_e}{d_a}\right)^{0.2}\sqrt{d_a}\sqrt{f'_c}(C_{a1}')^{1.5}$ = 6398.587 OR $V_b = 9\lambda_a(f'_c)^{1/2} * C_{a1}^{1.5}$ = 6885

V_b = 6398.6 lbs

$V_{cb} = \frac{A_{Vc}}{A_{VCO}}\Psi_{ec,V}\Psi_{ed,V}\Psi_{c,V}\Psi_{h,V}V_b$ = N/A (MORE THAN ONE ANCHOR)

$V_{cb} = \frac{A_{Vc}}{A_{VCO}}\Psi_{ec,V}\Psi_{ed,V}\Psi_{c,V}\Psi_{h,V}V_b$ = 4238.192

(VALUES ARE IN POUNDS)

$\Phi_{cV}V_{cb}$ = 2966.734 lbs ← DESIGN SHEAR CONRETE STRENGTH

PRYOUT STRENGTH FROM SHEAR (ACI-318 SECTION 17.5.3.1)

$V_{cp} = k_{cp}*\Phi_{cN}N_{cb}$ = 8438.61 lbs ← DESIGN PRYOUT (DUE TO SHEAR) STRENGTH

CONTROLLING STRENGTH FOR ANCHORAGE

TENSILE STRENGTH -

STEEL =	18041.25	lbs	
CONCRETE =	4219.3	lbs	<= CONTROLLING STRENGTH → N_d
PULLOUT =	N/A	lbs	
SIDE FACE BLOWOUT =	9585.7	lbs	

SHEAR STRENGTH -

STEEL =	8378.5	lbs	
CONCRETE =	2966.7342	lbs	<= CONTROLLING STRENGTH → V_d
PRYOUT FROM SHEAR =	8438.61	lbs	

ASD ADJUSTMENT FACTORS AND DESIGN LOADS

INPUT...

- α = 1.00 (ASD CONVERSION FACTOR IF APPLICABLE)
- SEISMIC TENSION FACTOR ($\Phi_{SEISMIC}$) = 0.75 (PER SECTION 17.2.3.4.4, REDUCE TO 0.75 FOR SEISMIC DESIGN TENSION FOR CONCRETE FAILURE M

$N_{asp} = \Phi_{SEISMIC}\Phi N_d/\alpha$ = **3164 lbs**

$V_{asp} = \Phi V_d/\alpha$ = **2967 lbs**

ENTER GIVEN BOLT FORCES FROM PAGE: -C15

INPUT HERE
- N_{ua} = 2209.70 lbs
- V_{ua} = 1032.08 lbs

CHECK COMBINED LOADING (ESR-1917 SECTION 4.2)

$\frac{N_{ua}}{N_{asp}} + \frac{V_{ua}}{V_{asp}} = 1.05 \leq 1.2$ **OK!**

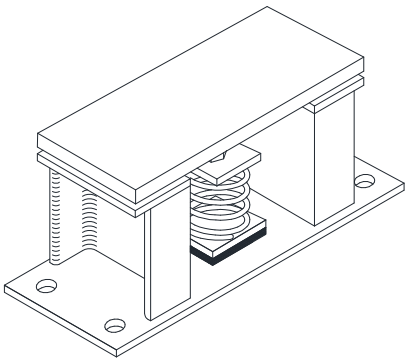
ANCHORAGE SUMMARY:

3/4 in DIAMETER
STAINLESS STEEL HILTI KB-TZ ANCHORS,
4.3125 in NOMINAL EMBEDMENT,
8 in MIN. EDGE DISTANCE,
8 in MIN. CONCRETE THICKNESS
3000 SAND-LIGHTWEIGHT CONCRETE
INSTALL W/ SPECIAL INSPECTION PER THE ICC ESR-1917.

JOB NAME:	CHANNEL ISLAND	M. W. SAUSSE' & CO., INC.	
CUST.:		PREPARED BY :	JO
MECH. ENG.:	BUDLONG	DATE :	06-May-20
MARK:	CU-C3.1, D1.1	SHEET NO. :	-C15.2

CALCULATIONS FOR VIBREX TYPE RMLS-EQ VIBRATION ISOLATORS/SEISMIC RESTRAINTS - 2015 IBC/2016 CBC, LRFD

CALCULATES WORST CASE LOADING FOR (8) ISOLATORS. (UNITS: LBS & INCHES)
USING COMBINED LOAD EQUATIONS 16-5: U = 1.2D + 1.0E & 16-7: U = 0.9D + 1.0E

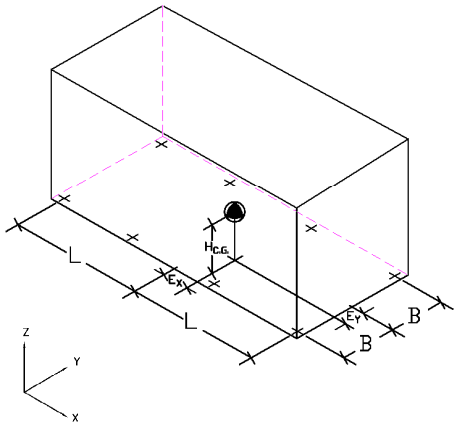


RMLS-EQ

SEISMIC FORCES - CH. 13 OF ASCE 7

13.3-2: $F_p = \Omega_O 1.6 S_{DS} I_p W_p$ (MAX)	=	23255.90 lbs
13.3-1: $F_p = \Omega_O (0.4 a_p S_{DS}/(R_p/I_p))(1+2z/h_r) W_p$	=	7267.47 lbs
13.3-3: $F_p = \Omega_O 0.3 S_{DS} I_p W_p$ (MIN)	=	4360.48 lbs
Ω_0 PER ASCE 7-10, NOTE C, TABLE 13.6-1	=	2.50
CONTROLLING HOR. SEISMIC FORCE: F_p	=	7267.47 lbs
OVERTURNING MOMENT: $M=F_p H_{C.G.}$	=	203489.13 lb-in
VERTICAL SEISMIC FORCE: $F_{pv} = 0.2 S_{DS} W_p$	=	1162.80 lbs
DESIGN SPECTRAL RESP. ACCELERATION: S_{DS}	=	1.57
IMPORTANCE FACTOR: I_p	=	1.00
COMPONENT AMPLIFICATION FACTOR: a_p	=	2.50
COMP. RESPONSE MODIFICATION FACTOR: R_p	=	2.00
EQUIPMENT ELEVATION / ROOF ELEVATION: z/h_r (WITH RESPECT TO GRADE)	=	0.00

EQUIPMENT WEIGHT & GEOMETRY



EQUIPMENT WEIGHT: Wp		3715.00 lbs
L:	=	95.00 in
B:	=	14.00 in
E_X:	=	13.60 in
E_Y:	=	2.13 in
HEIGHT TO CG.: $H_{C.G.}$	=	28.00 in
SPRING DIAMETER	=	3.00 lbs

ISOLATOR FORCES (W/O Ω_O)

$I_X = 8*B*B$	=	1568.00 in^4
$I_Y = 4L^2+4*(L/3)^2$	=	40111.11 in^4
γ (DIR. OF Vrot-CRIT. ANCHOR): $\tan^{-1}(B/L)$	=	8.38
α (DIR. OF Vdir-CRIT. ANCHOR): tan-1(E_Y/E_X)	=	8.88
β: $\gamma - \alpha$ =	=	179.50
θ (DIR. OF F_{ph} FOR MAX UPLIFT): tan-1((L*I_X)/(B*I_Y))	=	14.86

VERTICAL REACTIONS (WITH 1.2D OR 0.9D)

$W_{n\ MAX}$: $1.2W_p+F_{pv}$	=	5620.80 lbs
$W_{n\ MIN}$: $0.9W_p-F_{pv}$	=	2180.71 lbs
R_m (DUE TO OVERTURNING MOMENT)	=	1879.70 lbs
$R_{e\ MAX}$ (DUE TO ECCENTRICITY):	=	287.69 lbs
$R_{e\ MIN}$ (DUE TO ECCENTRICITY):	=	111.62 lbs
$R_{v\ MAX}$ (DUE TO VERTICAL LOADS):	=	702.60 lbs
$R_{v\ MIN}$ (DUE TO VERTICAL LOADS):	=	272.59 lbs
P_{MAX} (MAX DOWNWARD REACTION): $R_m/\Omega_O+R_{e\ MAX}+R_{v\ MAX}$	=	1742.17 lbs
P_{MIN} (MAX UPLIFT/ANCH. POINT - IF POS.): $R_m/\Omega_O+R_{e\ MIN}-R_{v\ MIN}$	=	**590.91** lbs

HORIZONTAL REACTIONS:

V_{rot} (SHEAR DUE TO ECCENTRICITY):	=	230.48 lbs
V_{dir} (DIRECT SHEAR):	=	908.43 lbs
V_{MAX} (TOTAL SHEAR/ANCH. POINT W/O Ω_O):	=	**455.56** lbs

ISOLATOR TYPE: USE RMLS - EQ - 3

ANCHOR BOLT FORCES (W/ Ω_O)

P_{MIN} (MAX UPLIFT/ANCH. POINT - IF POS.): $R_m+R_{e\ MIN}-R_{v\ MIN}$	=	**1718.73 lbs**
V_{MAX} (TOTAL SHEAR/ANCH. POINT):	=	**1138.91 lbs**
# OF ANCHOR BOLTS:	=	4.00
ANCHOR BLT TENSION DUE TO UPLIFT: T_1	=	429.68 lbs
ANCHOR BOLT TENSION DUE TO ISO. OVERTURNING: T_2	=	455.78 lbs
COMBINED ANCHOR BOLT TENSION: $N_{ua} = (T_1+T_2)$	=	885.47 lbs
ANCHOR BOLT SHEAR: $V_{ua} = V_{MAX}/n$	=	284.73 lbs

ANCHOR BOLT DIAMETER: = 1/2

TYPE OF ANCHOR BOLT: STAINLESS STEEL HILTI KB-TZ ANCHOR BOLT IN MIN. 3000psi HARDROCK CONCRETE. SEE SHEETS C9.1 & C9.2 FOR ANCHOR BOLT DESIGN AND COMBINED LOADING CHECK.

JOB NAME: CHANNEL ISLANDS HS	**M. W. SAUSSE' & CO., INC.**
CUST. : --	PREPARED BY : JO
MECH. ENGR.: BUDLONG	DATE : 03-Feb-20
MARK: CU-B1, B2, C1, C2	SHEET NO. : -C9

HILTI KB-TZ CARBON AND STAINLESS STEEL ANCHORS IN CONCRETE
(U.S. CUSTOMARY UNITS, ESR-1917 (REVISED MAY 2017) AND ACI-318-14, CHAPTER 17)

STEEL STRENGTH (TENSION AND SHEAR)

INPUT

n = 4 (NUMBER OF BOLTS PER ANCHOR POINT)

d_a = 0.5 in (DIAMETER OF ANCHOR BOLT)

SEISMIC?: YES *TOPSIDE OF DECK?: NO

STEEL: STAINLESS

N_{sa} = 11554 lbs (FROM TABLES 3 & 4)

V_{sa} = 6880 lbs (FROM TABLES 3 & 4)

Φ_{sN} = 0.75 (TENSION STRENGTH REDUCTION FACTOR FOR DUCTILE STEEL; ACI-318 17.3.3)

Φ_{sV} = 0.65 (SHEAR STRENGTH REDUCTION FACTOR FOR DUCTILE STEEL; ACI-318 17.3.3)

$\Phi_{sN}*N_{sa}$ = 8665.5 lbs (ACI 318, 17.4.1.2) ← DESIGN STEEL TENSION STRENGTH

$\Phi_{sV}*V_{sa}$ = 4472 lbs (ACI 318, 17.5.1.2) ← DESIGN STEEL SHEAR STRENGTH

CONCRETE

CONCRETE BREAKOUT TENSION STRENGTH

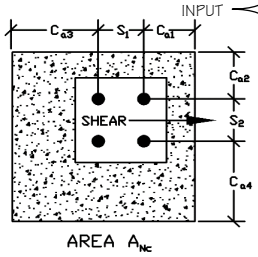
INPUT

h_{nom} = 2.375 in (NOMINAL EMBED., ESR-1917 TABLES 3 & 4)

h_a = 4 in (MEMBER THICKNESS, USE AT LEAST MIN. VALUES IN ESR-1917, TABLES 3 OR 4)

h_{ef} = 2 in (EFFECTIVE EMBED., ESR-1917 TABLES 3 & 4)

C_{ac} = 5.5 in C_{min} = 2.88 h_{min} = 4.00 s_{min} = 2.88



INPUT

C_{a1} = 6 in (USE AT LEAST $C_{a,min}$ GIVEN IN TABLES 3 & 4 IN ESR-1917, INCREASE IF NECESSARY)

C_{a2} = 16 in (USE AT LEAST $C_{a,min}$ & ≥ C_{a1} GIVEN IN TABLES 3 & 4 IN ESR-1917, INCREASE IF NECESSARY)

C_{a3} = 9 in (USE AT LEAST $C_{a,min}$ & ≥ C_{a2} GIVEN IN TABLES 3 & 4 IN ESR-1917, INCREASE IF NECESSARY)

C_{a4} = 9 in (USE AT LEAST $C_{a,min}$ & ≥ C_{a2} GIVEN IN TABLES 3 & 4 IN ESR-1917, INCREASE IF NECESSARY)

S_{MIN} = 12 in (CLOSEST SPACING DIST. BETWEEN (2) ANCHORS IN THE ANCHOR GROUP)

S_1 = 7.5 in (USE AT LEAST S_{min} FROM TABLES 3 & 4, ENTER 0 IF SINGLE ANCHOR)

S_2 = 12 in (USE AT LEAST S_{min} FROM TABLES 3 & 4, ENTER 0 IF SINGLE ANCHOR)

$\Psi_{ec,N}$ = 1 (ACI 17.4.2.4; 1.0 WHEN NO LOAD ECCENTRICITY)

f'_c = 3000 psi (CONCRETE COMPRESSIVE STRENGTH)

λ = 1.00 (1.0 FOR NW CONCRETE, 0.68 FOR STRUCTURAL SAND LW, 0.6 FOR ALL LW, 4.1.12 OF ESR-1917)

CRACKED CONCRETE CONDITION…

k_c = 24 (ESR-1917 TABLES 3 & 4)

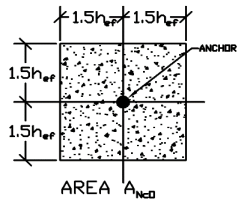
$\Psi_{c,N}$ = 1.00 (FROM ESR-1917 TABLES 3 & 4)

Φ_{cN} = 0.55 (PULLOUT/CONCRETE BREAKOUT STRENGTH REDUCTION; ESR-1917 TABLES 3 & 4)

h_{ef} CHECK = h_{ef}' = 2 in (IF 3 OR MORE EDGES ARE LESS THAN 1.5*hef, 17.4.2.3 OF THE ACI-318)

$SIDE_{\perp} = \min(C_{a2};1.5h_{ef}')+S_2+\min(C_{a4};1.5h_{ef}')$ = 18.00 in (LENGTH OF SIDE PERPENDICULAR TO SHEAR / SMALLEST EDGE DIST.)

$SIDE_{\parallel} = \min(C_{a1};1.5h_{ef}')+S_1+\min(C_{a3};1.5h_{ef}')$ = 13.50 in (LENGTH OF SIDE PARALLEL TO SHEAR / PERPENDICULAR TO CLOSEST EDGE)



$A_{Nc} = SIDE_{\perp} * SIDE_{\parallel}$ = 144.00 in² (PROJECTED FAILURE SURFACE AREA ACI-318 17.4.2.1)

$A_{NcO} = n*9*(h_{ef}')^2$ = 144.00 in² (PROJECTED FAILURE SURFACE AREA OF 1 ANCHOR, NO INFLUENCE 17.4.2.1)

$\Psi_{ed,N} = 0.7+0.3*C_{a1}/(1.5*h_{ef}')$ = 1.00 (IF C_{a1} ≥ $1.5h_{ef}$ THEN = 1.0)

$$\Psi_{cp,N} = \frac{\max|C_{a1};1.5h_{ef}|}{C_{ac}} = 1.00$$ (ALWAYS ≤ 1.0)

$$N_b = \lambda * k_c * \sqrt{f'_c} * h_{ef}^{1.5} = 3718.06 \text{ lbs}$$

$$N_{cb} = \frac{A_{Nc}}{A_{NcO}} \Psi_{ed,N} \Psi_{c,N} \Psi_{cp,N} N_b = \text{N/A (MORE THAN ONE ANCHOR)}$$

$$N_{cb} = \frac{A_{Nc}}{A_{NcO}} \Psi_{ec,N} \Psi_{ed,N} \Psi_{c,N} \Psi_{cp,N} N_b = 3718.06$$

} (VALUES ARE IN POUNDS)

$\Phi_{cN} N_{cb}$ = 2044.94 lbs ← DESIGN CONRETE BREAKOUT TENSION STRENGTH

CHECK SIDE-FACE BLOWOUT

A_{brg} = 0.101 in² (BEARING AREA OF CONCRETE AT ANCHOR BOTTOM. USE A_{se} FROM TABLES 3 & 4 OF ESR)

CHECK EDGE DISTANCE → $C_{a1} < 0.4h_{ef}$ → 6 > 0.8

FOR SINGLE ANCHORS -

CHECK C_{a2} → $C_{a2} < 3C_{a1}$ → 16 < 48

REDUCTION FACTOR FROM C_{a2} = $\frac{1+C_{a2}/C_{a1}}{4}$ = 0.9 → WHERE $1.0 \le C_{a2}/C_{a1} \le 3.0$ → TRUE!

$N_{sb} = \lambda * 160\, C_{a1} \sqrt{A_{brg}} \sqrt{f_c'}$ = 16710.62 lbs → REDUCED VALUE = 15318.1 lbs (ACI 318, 17.4.4.1)

FOR MULTIPLE ANCHORS (GROUPS) -

CHECK BOLT SPACING → $S < 6C_{a1}$ → 7.5 < 36

$$N_{sbg} = \left(1+\frac{S}{6C_{a1}}\right) N_{sb} = 18509.33 \text{ lbs}$$ (ACI-318 17.4.4.2)

$\Phi_{cN}N_{sb} < \Phi_{cN}N_{cb}$ → 10180.1 lbs SIDE FACE BLOWOUT VALUE

JOB NAME: CHANNEL ISLANDS HS	**M. W. SAUSSE' & CO., INC.**
CUST.:	PREPARED BY : JO
MECH. ENG.: BUDLONG	DATE : 03-Feb-20
MARK: CU-B1, B2, C1, C2	SHEET NO. : -C9.1

PULLOUT STRENGTH

N_p = 2735 lbs (ESR-1917, TABLES 3 & 4)

$\Phi_{cN}*\lambda*N_{pn,f'c} = \Phi_{cN} N_p \sqrt{\frac{f_c'}{2500}}$ = 1647.82 lbs (ANCHOR PULLOUT STRENGTH, 4.1.10 OF ESR-1917)

SHEAR BREAKOUT STRENGTH

d_a = 0.5 in (OUTSIDE DIAMETER OF ANCHOR BOLT OR ROD)

C_{a1} = 6 in (USE AT LEAST $C_{a,min}$ GIVEN IN TABLES 3 & 4 IN ESR-1917, INCREASE IF NECESSARY)

C_{a2} = 16 in (USE AT LEAST $C_{a,min}$ & ≥ C_{a1} GIVEN IN TABLES 3 & 4 IN ESR-1917, INCREASE IF NECESSARY)

ℓ_e = 2 in (MIN(h_{ef} OR $8d_a$); ACI-318 SECTION 17.5.2.2)

$\Psi_{ec,V}$ = 1 (ACI 17.5.2.5; 1.0 WHEN NO LOAD ECCENTRICITY)

h_a = 4 in (THICKNESS OF CONCRETE MEMBER)

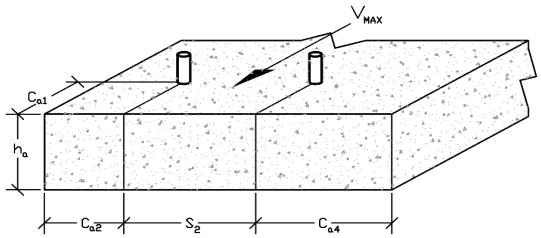
Φ_{cV} = 0.70 (SHEAR CONCRETE BREAKOUT STRENGTH REDUCTION; ESR-1917 TABLES 3 & 4)

k_{cp} = 1 (PRYOUT COEFFICIENT, ESR-1917, TABLES 3 & 4)

$\Psi_{c,V}$ = 1.2 (1.0 FOR CONC. W/O REINFORCEMENT, 1.2 FOR CONC. W/ REINFORCEMENT, 1.4 SEE 17.5.2.7)

C_{a1}' = 6 in (C_{a1} ADJUSTED WHEN C_{a2} & C_{a4} ARE LESS THAN $1.5C_{a1}$, 17.5.2.4)

n_V = 2 (NO. OF ANCHORS IN ROW CLOSEST TO CONCRETE EDGE)



$\Psi_{ed,V} = 0.7+0.3*C_{a2}/(1.5*C_{a1}')$ = 1.00 (IF $C_{a2} \geq 1.5C_{a1}$ THEN = 1.0, ACI 318, SECTION 17.5.2.6)

$\Psi_{h,V} = [(1.5*C_{a1}') / h_a]^{0.5}$ = 1.500 (ALWAYS GREATER THAN OR EQUAL TO 1.0, 17.5.2.8)

$A_{Vc} = \min(h_a;1.5C_{a1}')*(\min(1.5C_{a1}',C_{a4})+S_2+\min(C_{a2};1.5C_{a1}')$ = 120.0 in² (REFER TO ACI-318 17.5.2.1 AND 17.5.2.2)

$A_{Vc} = n_V 4.5C_{a1}'^2$ = 324.0 in² (REFER TO ACI-318 17.5.2.1 AND 17.5.2.2)

$V_b = \lambda * 7\left(\frac{\ell_e}{d_O}\right)^{0.2} \sqrt{d_O}\sqrt{f'_c}(C_{a1}')^{1.5}$ = 5257.54 OR $V_b = 9\lambda_a(f_c')^{1/2} * c_{a1}^{1.5}$ = 7244.86

V_b = 5257.5 lbs

$V_{cb} = \frac{A_{Vc}}{A_{VcO}}\Psi_{ed,V}\Psi_{c,V}\Psi_{h,V}V_b$ = N/A (MORE THAN ONE ANCHOR)

$V_{cb} = \frac{A_{Vc}}{A_{VcO}}\Psi_{ec,V}\Psi_{ed,V}\Psi_{c,V}\Psi_{h,V}V_b$ = 3505.03

(VALUES ARE IN POUNDS)

$\Phi_{cV}V_{cb}$ = 2453.52 lbs ← DESIGN SHEAR CONRETE STRENGTH

PRYOUT STRENGTH FROM SHEAR (ACI-318 SECTION 17.5.3.1)

$V_{cp} = k_{cp}*\Phi_{cN}N_{cb}$ = 2044.94 lbs ← DESIGN PRYOUT (DUE TO SHEAR) STRENGTH

CONTROLLING STRENGTH FOR ANCHORAGE

TENSILE STRENGTH -

STEEL =	8665.5 lbs		N_d
CONCRETE =	2044.9 lbs		
PULLOUT =	1647.823 lbs	<= CONTROLLING STRENGTH	
SIDE FACE BLOWOUT =	10180.1 lbs		

SHEAR STRENGTH -

STEEL =	4472 lbs		V_d
CONCRETE =	2453.518 lbs		
PRYOUT FROM SHEAR =	2044.94 lbs	<= CONTROLLING STRENGTH	

ASD ADJUSTMENT FACTORS AND DESIGN LOADS

INPUT...

α = 1.00 (ASD CONVERSION FACTOR IF APPLICABLE)

SEISMIC TENSION FACTOR ($\Phi_{SEISMIC}$) = 0.75 (PER SECTION 17.2.3.4.4, REDUCE TO 0.75 FOR SEISMIC DESIGN TENSION FOR CONCRETE FAILURE MODI

$N_{cap} = \Phi_{SEISMIC}\Phi N_n/\alpha$ = **1236 lbs**

$V_{cap} = \Phi V_n/\alpha$ = **2045 lbs**

ENTER GIVEN BOLT FORCES FROM PAGE: 63321-C1.8

INPUT HERE

N_{ua} = 885.00 lbs

V_{ua} = 285.00 lbs

CHECK COMBINED LOADING (ESR-1917 SECTION 4.2)

$\frac{N_{ua}}{N_{cap}} + \frac{V_{ua}}{V_{cap}} = 0.86 \leq 1.2$ **OK!**

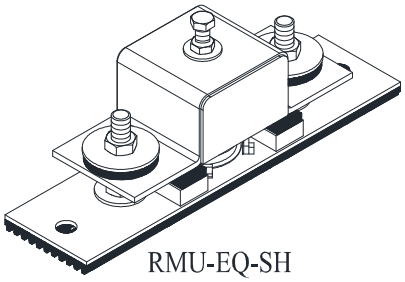
ANCHORAGE SUMMARY:

1/2 in DIAMETER
STAINLESS STEEL HILTI KB-TZ ANCHORS,
2.375 in NOMINAL EMBEDMENT,
6 in MIN. EDGE DISTANCE,
4 in MIN. CONCRETE THICKNESS
3000 psi NORMALWEIGHT CONCRETE.
INSTALL W/ SPECIAL INSPECTION PER THE ICC ESR-1917.

JOB NAME: CHANNEL ISLANDS HS	**M. W. SAUSSE' & CO., INC.**
CUST.:	PREPARED BY : JO
MECH. ENG.: BUDLONG	DATE : 03-Feb-20
MARK: CU-B1, B2, C1, C2	SHEET NO. : -C9.2

CALCULATIONS FOR VIBREX TYPE RMU-EQ-SH VIBRATION ISOLATORS/SEISMIC RESTRAINTS - 2015 IBC/2016 CBC, LRFD

CALCULATES WORST CASE LOADING FOR (4) ISOLATORS. (UNITS: LBS & INCHES)
USING COMBINED LOAD EQUATIONS 16-5: U = 1.2D + 1.0E & 16-7: U = 0.9D + 1.0E

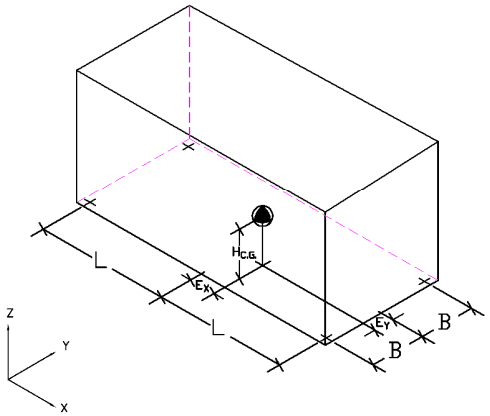


SEISMIC FORCES - CH. 13 OF ASCE 7

13.3-2: $F_p = 1.6 * S_{DS} * I_p * Wp$ (MAX)	=	1965.64 lbs
13.3-1: $F_p = (0.4 * a_p * S_{DS}/(R_p/I_p))(1+2z/h_r)Wp$	=	1842.79 lbs
13.3-3: $F_p = 0.3 * S_{DS} * I_p * Wp$ (MIN)	=	368.56 lbs
CONTROLLING HOR. SEISMIC FORCE: F_p	=	1842.79 lbs
OVERTURNING MOMENT: $M = F_p * H_{C.G.}$	=	51598.05 lb-in
* SUPP. VERT. SEISM. FORCE: $F_{pv} = 0.2 S_{DS} Wp$	=	245.71 lbs
DESIGN SPECTRAL RESP. ACCELERATION: S_{DS}	=	1.57
IMPORTANCE FACTOR: I_p	=	1.00
COMPONENT AMPLIFICATION FACTOR: a_p	=	2.50
COMP. RESPONSE MODIFICATION FACTOR: R_p	=	2.00
EQUIPMENT ELEVATION / ROOF ELEVATION: z/h_r	=	1.00
(WITH RESPECT TO GRADE)		

EQUIPMENT WEIGHT & GEOMETRY

EQUIPMENT WEIGHT: Wp	=	785.00 lbs
L:	=	22.50 in
B:	=	18.00 in
E_X:	=	1.00 in
E_Y:	=	1.00 in
HEIGHT TO CG.: $H_{C.G.}$	=	28.00 in
MAX SPRING REACTION	=	200.00 lbs



ISOLATOR FORCES

$I_X = 4*B*B$	=	1296.00 in^4
$I_Y = 4*L*L$	=	2025.00 in^4
γ (DIR. OF Vrot-CRIT. ANCHOR): $\tan^{-1}(B/L)$	=	38.66
α (DIR. OF Vdir-CRIT. ANCHOR): $\tan\text{-}1(E_Y/E_X)$	=	45.00
β: $\gamma - \alpha$ =	=	173.66
θ (DIR. OF F_{ph} FOR MAX UPLIFT): $\tan\text{-}1((L*I_X)/(B*I_Y))$	=	38.66

VERTICAL REACTIONS (WITH 1.2D OR 0.9D)

R_m (DUE TO OVERTURNING MOMENT)	=	917.75 lbs
$R_{e\,MAX}$ (DUE TO ECCENTRICITY):	=	29.69 lbs
$R_{e\,MIN}$ (DUE TO ECCENTRICITY):	=	11.52 lbs
$R_{v\,MAX}$ (DUE TO VERTICAL LOADS):	=	296.93 lbs
$R_{v\,MIN}$ (DUE TO VERTICAL LOADS):	=	115.20 lbs
P_{MAX} (MAX DOWNWARD REACTION): $R_m+R_{e\,MAX}+R_{v\,MAX}$	=	1244.37 lbs
P_{MIN} (MAX UPLIFT/ANCH. POINT - IF POS.): $R_m+R_{e\,MIN}-R_{v\,MIN}$	=	814.07 lbs

HORIZONTAL REACTIONS:

V_{rot} (SHEAR DUE TO ECCENTRICITY):	=	22.61 lbs
V_{dir} (DIRECT SHEAR):	=	460.70 lbs
V_{MAX} (TOTAL SHEAR/ANCH. POINT):	=	483.18 lbs

SELECT ISOLATOR ⟶ RMU-EQ-SH-1

ISOLATOR CAPACITIES: V_C	=	1540.00		T_C (ADJUSTED) =	1760.00
$V_{MAX}/V_C + P_{MIN}/T_C$	=	0.78	<= 1.00		

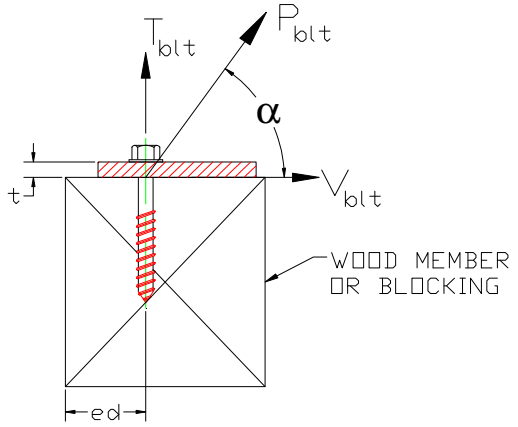
LAG BOLT FORCES

P_{MIN} (MAX UPLIFT/ANCH. POINT - IF POS.): $R_m+R_{e\,MIN}-R_{v\,MIN}$	=	**814.07 lbs**
V_{MAX} (TOTAL SHEAR/ANCH. POINT):	=	**483.18 lbs**
# OF LAG BOLTS: n	=	2
LAG BOLT TENSION DUE TO UPLIFT: T_1	=	407.03 lbs
LAG BOLT TENSION DUE TO ISO. OVERTURNING: T_2	=	261.72 lbs
COMBINED LAG BOLT TENSION: $N_{ua} = (T_1+T_2)$	=	668.75 lbs
LAG BOLT SHEAR: $V_{ua} = V_{MAX}/n$	=	241.59 lbs

LAG BOLT DIAMETER: = 1/2
LAG BOLT INTO DOUGLAS FIR WOOD. SEE THE FOLLOWING CALCULATIONS FOR DESIGN AND COMBINED LOAD CHECK PER CHAPTER 12 OF THE 2015 NDS.

JOB NAME: CHANNEL ISLANDS HS	**M.W. SAUSSE' & CO., INC.**
CUST.:	PREPARED BY : JO
MECH. ENG.: BUDLONG	DATE : 27-Nov-19
MARK: MMY-MAP120 WOOD	SHEET NO. : -C2

LAG BOLT INTO WOOD CALCULATIONS - 2015 NDS - LRFD



TENSION AND SHEAR VALUES FROM SHEET: -C2

T_{blt} (lbs) =	=	669
V_{blt} (lbs) =	=	242
Resultant: $P_{blt} = (T_{blt}^2 + V_{blt}^2)^{0.5}$	=	711
Slope of resultant.: (α) = arctan (T_{blt}/V_{blt})	=	70

INPUT LAG SCREW INFO:

Nom. screw diameter: D	=	1/2
Nom. length of screw: L	=	3.0
Thickness of member to be anchored: t	=	1/2"
Spacing between screws: sp	=	2.00
Edge distance: ed	=	2.00
End distance: e	=	3.50
Length of tapered tip: E	=	5/16
Length of threaded portion of screw: T	=	2.00
Effective length of threaded portion of screw: p_t	=	1.69
Embedment in main member, less tip: p_d	=	2.19
Length of thread penetration into main member: p	=	1.69

INPUT DESIGN VALUES FROM TABLES:

Withdrawl (Tension): W	(pli)	=	378
Lateral (Shear): Z	(lbs)	=	320

MINIMUM REQUIREMENTS FOR 100% DESIGN VALUES:

Min. edge dist.: 4D	=	2.00
Min. end dist.: 7D	=	3.50
Min. spacing: 4D	=	2.00
Min. penetration: 8D	=	4.00

LOAD ADJUSTMENT FACTORS:

Time Effect Factor: λ	=	1.00
Resistance Factor: ϕ	=	0.65
Format Conversion Factor: K_F	=	3.32
Wet service factor: C_m (1 typ., 0.7 when wet)	=	1.00
Temp. factor: C_t (1 typ., 0.8 when t>100°F)	=	0.80
Group action fact.: Cg (1 typ., See Table 7.3.6C)	=	1.00
End grain factor: C_{eg} (1 typ., 0.75 @ end grain)	=	1.00

Geometry factors:

$C_{\Delta, ep}$ = actual spacing / 4D (1 typ., 0.5 min)	=	1.00
$C_{\Delta, ed}$ = actual edge dist. / 4D (1 typ., 0.5 min)	=	1.00
$C_{\Delta, e}$ = actual end dist. / 7D (1 typ., 0.5 min)	=	1.00
Penetration depth factor: $C_d = p_d/8D$ (1 typ., 0.5 Min.)	=	0.55

ALLOWABLE LAG SCREW DESIGN VALUES:

WITHDRAWAL (TENSION): (pli)

$W' = W*K_F*\lambda*\phi*C_m*C_t*C_{eg}$ = 653

LATERAL (SHEAR): (lbs)

$Z' = Z*K_F*\lambda*\phi*C_m*C_t*C_g*C_{\Delta(ep,ed\ \&\ e)}*C_d*C_{eg}$ = 302

RESULTANT @ SLOPE alpha (a): (lbs)

$Z_\alpha' = (W'*p*Z')/(W'*p*(COS\alpha)^2+Z'*(SIN\alpha)^2)$ = 844

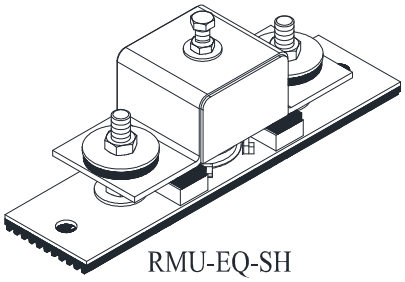
IF Z_α' >= P_{blt}, SELECTED BOLT OK!

USE 1/2" DIA. LAG BOLT 3" LONG W/ MIN. 2" EDGE DISTANCE & MIN. 3-1/2" END DISTANCE INTO MIN. 4X4 DOUGLAS FIR WOOD.

JOB NAME: CHANNEL ISLANDS HS	**M. W. SAUSSE' & CO., INC.**
CUST.:	PREPARED BY : JO
MECH. ENG.: BUDLONG	DATE : 27-Nov-19
MARK: MMY-MAP120 WOOD	SHEET NO. : -C2.1

CALCULATIONS FOR VIBREX TYPE RMU-EQ-SH VIBRATION ISOLATORS/SEISMIC RESTRAINTS - 2015 IBC/2016 CBC, LRFD

CALCULATES WORST CASE LOADING FOR (4) ISOLATORS. (UNITS: LBS & INCHES)
USING COMBINED LOAD EQUATIONS 16-5: U = 1.2D + 1.0E & 16-7: U = 0.9D + 1.0E

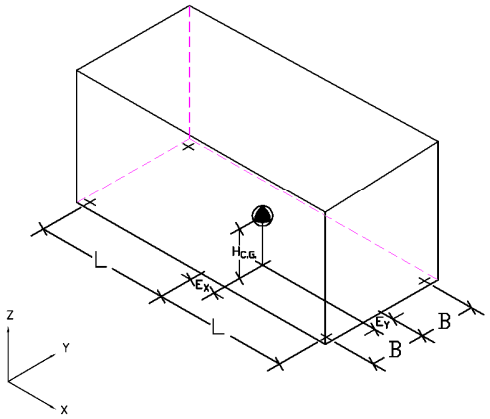


SEISMIC FORCES - CH. 13 OF ASCE 7

13.3-2: $F_p = \Omega_0 1.6 * S_{DS} * I_p * Wp$ (MAX)	=	5884.40 lbs
13.3-1: $F_p = \Omega_0 (0.4 * a_p * S_{DS}/(R_p/I_p))(1+2z/h_r)Wp$	=	1838.88 lbs
13.3-3: $F_p = \Omega_0 0.3 * S_{DS} * I_p * Wp$ (MIN)	=	1103.33 lbs
Ω_0 PER ASCE 7-10, NOTE C, TABLE 13.6-1	=	2.50
CONTROLLING HOR. SEISMIC FORCE: F_p	=	1838.88 lbs
OVERTURNING MOMENT: $M=F_p * H_{C.G.}$	=	51488.50 lb-in
* SUPP. VERT. SEISM. FORCE: $F_{pv} = 0.2 S_{DS} Wp$	=	294.22 lbs
DESIGN SPECTRAL RESP. ACCELERATION: S_{DS}	=	1.57
IMPORTANCE FACTOR: I_p	=	1.00
COMPONENT AMPLIFICATION FACTOR: a_p	=	2.50
COMP. RESPONSE MODIFICATION FACTOR: R_p	=	2.00
EQUIPMENT ELEVATION / ROOF ELEVATION: z/h_r	=	0.00
(WITH RESPECT TO GRADE)		

EQUIPMENT WEIGHT & GEOMETRY

EQUIPMENT WEIGHT: Wp	=	940.00 lbs
L:	=	22.50 in
B:	=	16.00 in
E_X:	=	1.00 in
E_Y:	=	1.00 in
HEIGHT TO CG.: $H_{C.G.}$	=	28.00 in
MAX SPRING REACTION	=	200.00 lbs



ISOLATOR FORCES (W/O Ω_0)

$I_X = 4*B*B$	=	1024.00 in^4
$I_Y = 4*L*L$	=	2025.00 in^4
γ (DIR. OF Vrot-CRIT. ANCHOR): $\tan^{-1}(B/L)$	=	35.42
α (DIR. OF Vdir-CRIT. ANCHOR): $\tan\text{-}1(E_Y/E_X)$	=	45.00
β: $\gamma - \alpha$ =	=	170.42
θ (DIR. OF F_{ph} FOR MAX UPLIFT): $\tan\text{-}1((L*I_X)/(B*I_Y))$	=	35.42

VERTICAL REACTIONS (WITH 1.2D OR 0.9D)

R_m (DUE TO OVERTURNING MOMENT)	=	987.18 lbs
$R_{e\ MAX}$ (DUE TO ECCENTRICITY):	=	38.02 lbs
$R_{e\ MIN}$ (DUE TO ECCENTRICITY):	=	14.75 lbs
$R_{v\ MAX}$ (DUE TO VERTICAL LOADS):	=	355.56 lbs
$R_{v\ MIN}$ (DUE TO VERTICAL LOADS):	=	137.95 lbs
P_{MAX} (MAX DOWNWARD REACTION): $R_m/\Omega_0 + R_{e\ MAX} + R_{v\ MAX}$	=	788.45 lbs
P_{MIN} (MAX UPLIFT/ANCH. POINT - IF POS.): $R_m/\Omega_0 + R_{e\ MIN} - R_{v\ MIN}$	=	271.68 lbs

HORIZONTAL REACTIONS:

V_{rot} (SHEAR DUE TO ECCENTRICITY):	=	23.55 lbs
V_{dir} (DIRECT SHEAR):	=	459.72 lbs
V_{MAX} (TOTAL SHEAR/ANCH. POINT WITHOUT Ω_0):	=	193.18 lbs

SELECT ISOLATOR ⟶ RMU-EQ-SH-1

ISOLATOR CAPACITIES: V_C	=	1540.00		T_C (ADJUSTED) =	1760.00
$V_{MAX}/V_C + P_{MIN}/T_C$	=	0.28	<= 1.00		

ANCHOR BOLT FORCES (WITH Ω_0)

P_{MIN} (MAX UPLIFT/ANCH. POINT - IF POS.): $R_m + R_{e\ MIN} - R_{v\ MIN}$	=	**863.99 lbs**
V_{MAX} (TOTAL SHEAR/ANCH. POINT):	=	**482.95 lbs**
# OF ANCHOR BOLTS: n	=	2
ANCHOR BOLT TENSION DUE TO UPLIFT: T_1	=	431.99 lbs
ANCHOR BOLT TENSION DUE TO ISO. OVERTURNING: T_2	=	261.60 lbs
COMBINED ANCHOR BOLT TENSION: $N_{ua} = (T_1+T_2)$	=	693.59 lbs
ANCHOR BOLT SHEAR: $V_{ua} = V_{MAX}/n$	=	241.48 lbs

ANCHOR BOLT DIAMETER: = 1/2
TYPE OF ANCHOR BOLT: CARBON STEEL HILTI KB-TZ ANCHOR BOLT IN MIN. 3000psi. SEE SHEETS -C1.1 & C1.2

JOB NAME: CHANNEL ISLANDS HS	**M.W. SAUSSE' & CO., INC.**
CUST.:	PREPARED BY : JO
MECH. ENG.: BUDLONG	DATE : 27-Nov-19
MARK: MMY-MAP-096, 120 144, 168 CONC	SHEET NO. : -C1

HILTI KB-TZ CARBON AND STAINLESS STEEL ANCHORS IN CONCRETE
(U.S. CUSTOMARY UNITS, ESR-1917 (REVISED SEPTEMBER 2016) AND ACI-318-14, CHAPTER 17)

STEEL STRENGTH (TENSION AND SHEAR)

INPUT

n = 2 (NUMBER OF BOLTS PER ANCHOR POINT)

d_a = 1/2 in (DIAMETER OF ANCHOR BOLT)

SEISMIC?: YES *TOPSIDE OF DECK?: NO

STEEL: STAINLESS

N_{sa} = 11554 lbs (FROM TABLES 3 & 4)

V_{sa} = 6880 lbs (FROM TABLES 3 & 4)

Φ_{sN} = 0.75 (TENSION STRENGTH REDUCTION FACTOR FOR DUCTILE STEEL; ACI-318 17.3.3)

Φ_{sV} = 0.65 (SHEAR STRENGTH REDUCTION FACTOR FOR DUCTILE STEEL; ACI-318 17.3.3)

$\Phi_{sN}*N_{sa}$ = 8665.5 lbs (ACI 318, 17.4.1.2) ← DESIGN STEEL TENSION STRENGTH

$\Phi_{sV}*V_{sa}$ = 4472 lbs (ACI 318, 17.5.1.2) ← DESIGN STEEL SHEAR STRENGTH

CONCRETE

CONCRETE BREAKOUT TENSION STRENGTH

INPUT

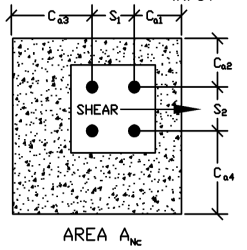
h_{nom} = 3.625 in (NOMINAL EMBED., ESR-1917 TABLES 3 & 4)

h_a = 6 in (MEMBER THICKNESS, USE AT LEAST MIN. VALUES IN ESR-1917, TABLES 3 OR 4)

h_{ef} = 3.25 in (EFFECTIVE EMBED., ESR-1917 TABLES 3 & 4)

C_{ac} = 7.5 in C_{min} = 5.25 h_{min} = 6.00 s_{min} = 2.00

INPUT



C_{a1} = 6 in (USE AT LEAST $C_{a,min}$ GIVEN IN TABLES 3 & 4 IN ESR-1917, INCREASE IF NECESSARY)

C_{a2} = 6 in (USE AT LEAST $C_{a,min}$ & ≥ C_{a1} GIVEN IN TABLES 3 & 4 IN ESR-1917, INCREASE IF NECESSARY)

C_{a3} = 9 in (USE AT LEAST $C_{a,min}$ & ≥ C_{a2} GIVEN IN TABLES 3 & 4 IN ESR-1917, INCREASE IF NECESSARY)

C_{a4} = 11.25 in (USE AT LEAST $C_{a,min}$ & ≥ C_{a2} GIVEN IN TABLES 3 & 4 IN ESR-1917, INCREASE IF NECESSARY)

S_{MIN} = 0 in (CLOSEST SPACING DIST. BETWEEN (2) ANCHORS IN THE ANCHOR GROUP)

S_1 = 0 in (USE AT LEAST S_{min} FROM TABLES 3 & 4, ENTER 0 IF SINGLE ANCHOR)

S_2 = 10.00 in (USE AT LEAST S_{min} FROM TABLES 3 & 4, ENTER 0 IF SINGLE ANCHOR)

$\Psi_{ec,N}$ = 1 (ACI 17.4.2.4; 1.0 WHEN NO LOAD ECCENTRICITY)

f'_c = 3000 psi (CONCRETE COMPRESSIVE STRENGTH)

λ = 1.00 (1.0 FOR NW CONCRETE, 0.68 FOR STRUCTURAL SAND LW, 0.6 FOR ALL LW, 4.1.12 OF ESR-1917)

CRACKED CONCRETE CONDITION…

k_c = 17 (ESR-1917 TABLES 3 & 4)

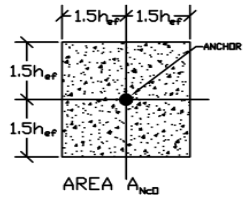
$\Psi_{c,N}$ = 1.00 (FROM ESR-1917 TABLES 3 & 4)

Φ_{cN} = 0.65 (PULLOUT/CONCRETE BREAKOUT STRENGTH REDUCTION; ESR-1917 TABLES 3 & 4)

h_{ef} CHECK = h_{ef}' = 3.25 in (IF 3 OR MORE EDGES ARE LESS THAN 1.5*hef, 17.4.2.3 OF THE ACI-318)

$SIDE_{\perp} = \min(C_{a,2};1.5h_{ef}')+S_2+\min(C_{a4};1.5h_{ef}')$ = 19.75 in (LENGTH OF SIDE PERPENDICULAR TO SHEAR / SMALLEST EDGE DIST.)

$SIDE_{\parallel} = \min(C_{a1};1.5h_{ef}')+S_1+\min(C_{a3};1.5h_{ef}')$ = 9.75 in (LENGTH OF SIDE PARALLEL TO SHEAR / PERPENDICULAR TO CLOSEST EDGE)



$A_{Nc} = SIDE_{\perp} * SIDE_{\parallel}$ = 190.13 in^2 (PROJECTED FAILURE SURFACE AREA ACI-318 17.4.2.1)

$A_{NcO} = n*9*(h_{ef}')^2$ = 190.13 in^2 (PROJECTED FAILURE SURFACE AREA OF 1 ANCHOR, NO INFLUENCE 17.4.2.1)

$\Psi_{ed,N} = 0.7+0.3*C_{a1}/(1.5*h_{ef}')$ = 1.00 (IF $C_{a1} \geq 1.5h_{ef}$ THEN = 1.0)

$$\Psi_{cp,N} = \frac{\max|C_{a1};1.5h_{ef}|}{C_{ac}} = 0.80 \quad \text{(ALWAYS} \leq 1.0\text{)}$$

$$N_b = \lambda * k_c * \sqrt{f'_c} * h_{ef}^{1.5} = 5455.5 \text{ lbs}$$

$$N_{cb} = \frac{A_{Nc}}{A_{NcO}} \Psi_{ed,N} \Psi_{c,N} \Psi_{cp,N} N_b = \text{N/A (MORE THAN ONE ANCHOR)}$$

$$N_{cb} = \frac{A_{Nc}}{A_{NcO}} \Psi_{ec,N} \Psi_{ed,N} \Psi_{c,N} \Psi_{cp,N} N_b = 4364.4$$

} (VALUES ARE IN POUNDS)

$\Phi_{cN} N_{cb}$ = 2836.86 lbs ← DESIGN CONRETE BREAKOUT TENSION STRENGTH

CHECK SIDE-FACE BLOWOUT

A_{brg} = 0.101 in^2 (BEARING AREA OF CONCRETE AT ANCHOR BOTTOM. USE A_{se} FROM TABLES 3 & 4 OF ESR)

CHECK EDGE DISTANCE → $C_{a1} < 0.4h_{ef}$ → 6 > 1.3

FOR SINGLE ANCHORS -

CHECK C_{a2} → $C_{a2} < 3C_{a1}$ → 6 < 18

REDUCTION FACTOR FROM C_{a2} = $\frac{1+C_{a2}/C_{a1}}{4}$ = 0.5 → WHERE $1.0 \leq C_{a2}/C_{a1} \leq 3.0$ → TRUE!

$N_{sb} = \lambda * 160\, C_{a1} \sqrt{A_{brg}} \sqrt{f_c'}$ = 16710.6 lbs → REDUCED VALUE = 8355.3 lbs (ACI 318, 17.4.4.1)

FOR MULTIPLE ANCHORS (GROUPS) -

CHECK BOLT SPACING → $S < 6C_{a1}$ → 10 < 36

$$N_{sbg} = \left(1+\frac{S}{6C_{a1}}\right) N_{sb} = 10676.2 \text{ lbs} \quad \text{(ACI-318 17.4.4.2)}$$

$\Phi_{cN}N_{sb} < \Phi_{cN}N_{cb}$ → 6939.5 lbs SIDE FACE BLOWOUT VALUE

JOB NAME:	CHANNEL ISLANDS HS	**M. W. SAUSSE' & CO., INC.**	
CUST.:		PREPARED BY :	JO
MECH. ENG.:	BUDLONG	DATE :	27-Nov-19
MARK:	MMY-MAP-096, 120 144, 168 CONC	SHEET NO. :	-C1.1

PULLOUT STRENGTH

N_p = 0 lbs (ESR-1917, TABLES 3 & 4)

$\Phi_{cN}*\lambda*N_{pn,f'c} = \Phi_{cN} N_p \sqrt{\frac{f_c'}{2500}}$ = N/A lbs (ANCHOR PULLOUT STRENGTH, 4.1.10 OF ESR-1917)

SHEAR BREAKOUT STRENGTH

d_a = 0.5 in (OUTSIDE DIAMETER OF ANCHOR BOLT OR ROD)

C_{a1} = 6 in (USE AT LEAST $C_{a,min}$ GIVEN IN TABLES 3 & 4 IN ESR-1917, INCREASE IF NECESSARY)

C_{a2} = 6 in (USE AT LEAST $C_{a,min}$ & ≥ C_{a1} GIVEN IN TABLES 3 & 4 IN ESR-1917, INCREASE IF NECESSARY)

ℓ_e = 3.25 in (MIN(h_{ef} OR $8d_a$); ACI-318 SECTION 17.5.2.2)

$\Psi_{ec,V}$ = 1 (ACI D.5.2.4; 1.0 WHEN NO LOAD ECCENTRICITY)

h_a = 6 in (THICKNESS OF CONCRETE MEMBER)

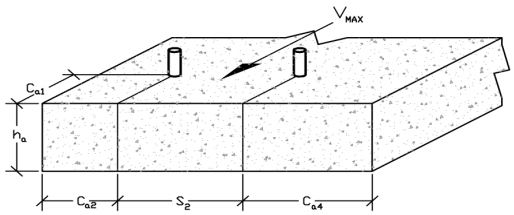
Φ_{cV} = 0.70 (SHEAR CONCRETE BREAKOUT STRENGTH REDUCTION; ESR-1917 TABLES 3 & 4)

k_{cp} = 2 (PRYOUT COEFFICIENT, ESR-1917, TABLES 3 & 4)

$\Psi_{c,V}$ = 1.2 (1.0 FOR CONC. W/O REINFORCEMENT, 1.2 FOR CONC. W/ REINFORCEMENT, 1.4 SEE 17.5.2.7)

C_{a1}' = 6 in (C_{a1} ADJUSTED WHEN C_{a2} & C_{a4} ARE LESS THAN $1.5C_{a1}$, 17.5.2.4)

n_V = 2 (NO. OF ANCHORS IN ROW CLOSEST TO CONCRETE EDGE)



$\Psi_{ed,V} = 0.7+0.3*C_{a2}/(1.5*C_{a1}')$ = 0.90 (IF $C_{a2} \geq 1.5C_{a1}$ THEN = 1.0, ACI 318, SECTION D.6.2.6)

$\Psi_{h,V} = [(1.5*C_{a1}') / h_a]^{0.5}$ = 1.225 (ALWAYS GREATER THAN OR EQUAL TO 1.0, D.6.2.8)

$A_{Vc} = \min(h_a;1.5C_{a1}')*(\min(1.5C_{a1}',C_{a4})+S_2+\min(C_{a2};1.5C_{a1}')$ = 150.0 in² (REFER TO ACI-318 D.6.2.1 AND D.6.2.2)

$A_{Vc} = n_V 4.5C_{a1}'^2$ = 324.0 in² (REFER TO ACI-318 D.6.2.1 AND D.6.2.2)

$V_b = \lambda * 7\left(\frac{\ell_e}{d_O}\right)^{0.2} \sqrt{d_O}\sqrt{f'_c}(C_{a1}')^{1.5}$ = 5793.66 OR $V_b = 9\lambda_a(f_c')^{1/2} * c_{a1}^{1.5}$ = 7244.86

V_b = 5793.7 lbs

$V_{cb} = \frac{A_{Vc}}{A_{VcO}}\Psi_{ed,V}\Psi_{c,V}\Psi_{h,V}V_b$ = N/A (MORE THAN ONE ANCHOR)

$V_{cb} = \frac{A_{Vc}}{A_{VcO}}\Psi_{ec,V}\Psi_{ed,V}\Psi_{c,V}\Psi_{h,V}V_b$ = 3547.88

(VALUES ARE IN POUNDS)

$\Phi_{cV}V_{cb}$ = 2483.52 lbs ← DESIGN SHEAR CONRETE STRENGTH

PRYOUT STRENGTH FROM SHEAR (ACI-318 SECTION 17.5.3.1)

$V_{cp} = k_{cp}*\Phi_{cN}N_{cb}$ = 5673.72 lbs ← DESIGN PRYOUT (DUE TO SHEAR) STRENGTH

CONTROLLING STRENGTH FOR ANCHORAGE

TENSILE STRENGTH -

STEEL =	8665.5 lbs		
CONCRETE =	2836.9 lbs	<= CONTROLLING STRENGTH	N_d
PULLOUT =	N/A lbs		
SIDE FACE BLOWOUT =	6939.5 lbs		

SHEAR STRENGTH -

STEEL =	4472 lbs		
CONCRETE =	2483.52 lbs	<= CONTROLLING STRENGTH	V_d
PRYOUT FROM SHEAR =	5673.72 lbs		

ASD ADJUSTMENT FACTORS AND DESIGN LOADS

INPUT...

α = 1.00 (ASD CONVERSION FACTOR IF APPLICABLE)

SEISMIC TENSION FACTOR ($\Phi_{SEISMIC}$) = 0.75 (PER SECTION 17.2.3.4.4, REDUCE TO 0.75 FOR SEISMIC DESIGN TENSION FOR CONCRETE FAILURE MODES)

$N_{cap} = \Phi_{SEISMIC}\Phi N_n/\alpha$ = **2128 lbs**

$V_{cap} = \Phi V_n/\alpha$ = **2484 lbs**

ENTER GIVEN BOLT FORCES FROM PAGE: -C1

INPUT HERE

N_{ua} = 693.59 lbs

V_{ua} = 241.48 lbs

CHECK COMBINED LOADING (ESR-1917 SECTION 4.2)

$\frac{N_{ua}}{N_{cap}} + \frac{V_{ua}}{V_{cap}}$ = 0.42 ≤ 1.2 **OK!**

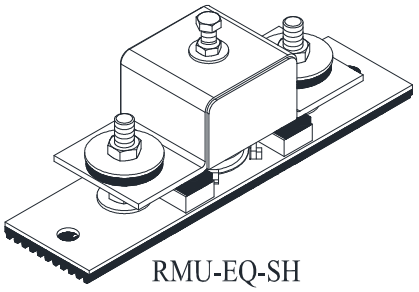
ANCHORAGE SUMMARY:

1/2 in DIAMETER
STAINLESS STEEL HILTI KB-TZ ANCHORS,
3.625 in NOMINAL EMBEDMENT,
6 in MIN. EDGE DISTANCE,
6 in MIN. CONCRETE THICKNESS
3000 psi NORMALWEIGHT CONCRETE.
INSTALL W/ SPECIAL INSPECTION PER THE ICC ESR-1917.

JOB NAME:	CHANNEL ISLANDS HS	**M. W. SAUSSE' & CO., INC.**	
CUST.:		PREPARED BY :	JO
MECH. ENG.:	BUDLONG	DATE :	27-Nov-19
MARK:	MMY-MAP-096, 120 144, 168 CONC	SHEET NO. :	-C1.2

CALCULATIONS FOR VIBREX TYPE RMU-EQ-SH VIBRATION ISOLATORS/SEISMIC RESTRAINTS - 2015 IBC/2016 CBC, LRFD

CALCULATES WORST CASE LOADING FOR (4) ISOLATORS. (UNITS: LBS & INCHES)
USING COMBINED LOAD EQUATIONS 16-5: U = 1.2D + 1.0E & 16-7: U = 0.9D + 1.0E

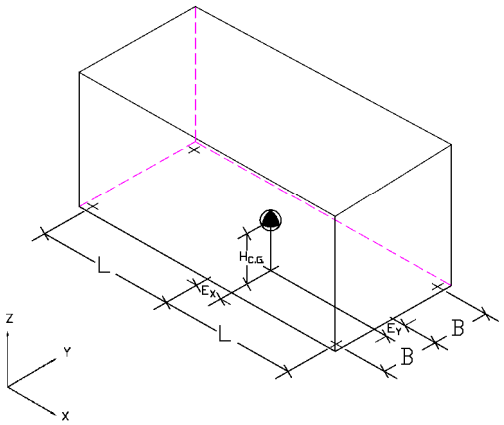


SEISMIC FORCES - CH. 13 OF ASCE 7

13.3-2: $F_p = 1.6 S_{DS} I_p W_p$ (MAX)	=	1713.41 lbs
13.3-1: $F_p = (0.4 a_p S_{DS}/(R_p/I_p))(1+2z/h_r)W_p$	=	1606.32 lbs
13.3-3: $F_p = 0.3 S_{DS} I_p W_p$ (MIN)	=	321.26 lbs
CONTROLLING HOR. SEISMIC FORCE: F_p	=	1606.32 lbs
OVERTURNING MOMENT: $M=F_p H_{C.G.}$	=	44976.96 lb-in
* SUPP. VERT. SEISM. FORCE: $F_{pv} = 0.2 S_{DS} W_p$	=	214.18 lbs
DESIGN SPECTRAL RESP. ACCELERATION: S_{DS}	=	1.38
IMPORTANCE FACTOR: I_p	=	1.00
COMPONENT AMPLIFICATION FACTOR: a_p	=	2.50
COMP. RESPONSE MODIFICATION FACTOR: R_p	=	2.00
EQUIPMENT ELEVATION / ROOF ELEVATION: z/h_r (WITH RESPECT TO GRADE)	=	1.00

EQUIPMENT WEIGHT & GEOMETRY

EQUIPMENT WEIGHT +STEEL BASE: Wp	=	776.00 lbs
L:	=	33.00 in
B:	=	21.25 in
E_X:	=	1.00 in
E_Y:	=	1.00 in
HEIGHT TO CG.: $H_{C.G.}$	=	28.00 in
MAX SPRING REACTION	=	300.00 lbs



ISOLATOR FORCES

$I_X = 4*B*B$	=	1806.25 in^4
$I_Y = 4*L*L$	=	4356.00 in^4
γ (DIR. OF Vrot-CRIT. ANCHOR): $\tan^{-1}(B/L)$	=	32.78
α (DIR. OF Vdir-CRIT. ANCHOR): $\tan\text{-}1(E_Y/E_X)$	=	45.00
β: $\gamma - \alpha$ =	=	167.78
θ (DIR. OF F_{ph} FOR MAX UPLIFT): $\tan\text{-}1((L*I_X)/(B*I_Y))$	=	32.78

VERTICAL REACTIONS (WITH 1.2D OR 0.9D)

R_m (DUE TO OVERTURNING MOMENT)	=	629.36 lbs
$R_{e\ MAX}$ (DUE TO ECCENTRICITY):	=	22.15 lbs
$R_{e\ MIN}$ (DUE TO ECCENTRICITY):	=	9.37 lbs
$R_{v\ MAX}$ (DUE TO VERTICAL LOADS):	=	286.34 lbs
$R_{v\ MIN}$ (DUE TO VERTICAL LOADS):	=	121.06 lbs
P_{MAX} (MAX DOWNWARD REACTION): $R_m+R_{e\ MAX}+R_{v\ MAX}$	=	937.85 lbs
P_{MIN} (MAX UPLIFT/ANCH. POINT - IF POS.): $R_m+R_{e\ MIN}-R_{v\ MIN}$	=	517.67 lbs

HORIZONTAL REACTIONS:

V_{rot} (SHEAR DUE TO ECCENTRICITY):	=	14.47 lbs
V_{dir} (DIRECT SHEAR):	=	401.58 lbs
V_{MAX} (TOTAL SHEAR/ANCH. POINT):	=	415.73 lbs

SELECT ISOLATOR ⟶ RMU-EQ-SH-1

ISOLATOR CAPACITIES: V_C	=	1100.00	T_C (ADJUSTED) =	1100.00
$V_{MAX}/V_C + P_{MIN}/T_C$	=	0.85	<= 1.00	

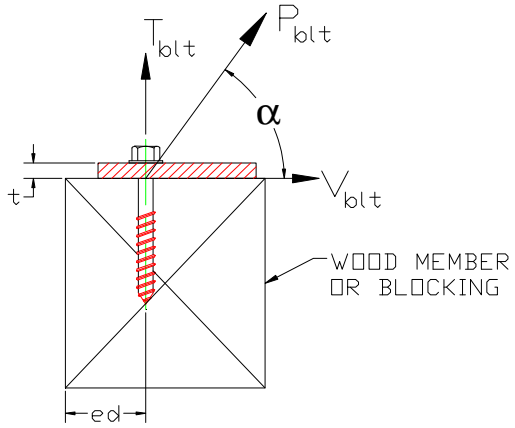
LAG BOLT FORCES

P_{MIN} (MAX UPLIFT/ANCH. POINT - IF POS.): $R_m+R_{e\ MIN}-R_{v\ MIN}$	=	**517.67 lbs**
V_{MAX} (TOTAL SHEAR/ANCH. POINT):	=	**415.73 lbs**
# OF LAG BOLTS: n	=	2
LAG BOLT TENSION DUE TO UPLIFT: T_1	=	258.83 lbs
LAG BOLT TENSION DUE TO ISO. OVERTURNING: T_2	=	225.19 lbs
COMBINED LAG BOLT TENSION: $N_{ua} = (T_1+T_2)$	=	484.02 lbs
LAG BOLT SHEAR: $V_{ua} = V_{MAX}/n$	=	207.87 lbs

LAG BOLT DIAMETER: = 1/2
LAG BOLT INTO DOUGLAS FIR WOOD. SEE THE FOLLOWING CALCULATIONS FOR DESIGN AND COMBINED LOAD CHECK PER CHAPTER 12 OF THE 2015 NDS.

JOB NAME: CAMARILLO SCHOOL	**M.W. SAUSSE' & CO., INC.**
CUST.:	PREPARED BY : TDT
MECH. ENG.: BUDLONG	DATE : 17-Mar-20
MARK: PE SUPPORT	SHEET NO. : -C1

LAG BOLT INTO WOOD CALCULATIONS - 2015 NDS - LRFD



TENSION AND SHEAR VALUES FROM SHEET: -C1

T_{blt} (lbs) =	=	484
V_{blt} (lbs) =	=	208
Resultant: $P_{blt} = (T_{blt}^2 + V_{blt}^2)^{0.5}$	=	527
Slope of resultant.: (α) = arctan (T_{blt}/V_{blt})	=	67

INPUT LAG SCREW INFO:

Nom. screw diameter: D	=	1/2
Nom. length of screw: L	=	3.0
Thickness of member to be anchored: t	=	1/2"
Spacing between screws: sp	=	10.00
Edge distance: ed	=	1.50
End distance: e	=	3.50
Length of tapered tip: E	=	5/16
Length of threaded portion of screw: T	=	2.00
Effective length of threaded portion of screw: p_t	=	1.69
Embedment in main member, less tip: p_d	=	2.19
Length of thread penetration into main member: p	=	1.69

INPUT DESIGN VALUES FROM TABLES:

Withdrawl (Tension): W	(pli)	=	378
Lateral (Shear): Z	(lbs)	=	320

MINIMUM REQUIREMENTS FOR 100% DESIGN VALUES:

Min. edge dist.: 4D	=	2.00
Min. end dist.: 7D	=	3.50
Min. spacing: 4D	=	2.00
Min. penetration: 8D	=	4.00

LOAD ADJUSTMENT FACTORS:

Time Effect Factor: λ	=	1.00
Resistance Factor: ϕ	=	0.65
Format Conversion Factor: K_F	=	3.32
Wet service factor: C_m (1 typ., 0.7 when wet)	=	1.00
Temp. factor: C_t (1 typ., 0.8 when t>100°F)	=	0.80
Group action fact.: Cg (1 typ., See Table 7.3.6C)	=	1.00
End grain factor: C_{eg} (1 typ., 0.75 @ end grain)	=	1.00

Geometry factors:

$C_{\Delta, sp}$ = actual spacing / 4D (1 typ., 0.5 min)	=	1.00
$C_{\Delta, ed}$ = actual edge dist. / 4D (1 typ., 0.5 min)	=	0.75
$C_{\Delta, e}$ = actual end dist. / 7D (1 typ., 0.5 min)	=	1.00
Penetration depth factor: $C_d = p_d/8D$ (1 typ., 0.5 Min.)	=	0.55

ALLOWABLE LAG SCREW DESIGN VALUES:

WITHDRAWAL (TENSION): (pli)

$W' = W*K_F*\lambda*\phi*C_m*C_t*C_{eg}*$ = 653

LATERAL (SHEAR): (lbs)

$Z' = Z*K_F*\lambda*\phi*C_m*C_t*C_g*C_{\Delta(s,ed\ \&\ e)}*C_d*C_{eg}$ = 227

RESULTANT @ SLOPE alpha (a): (lbs)

$Z_\alpha' = (W'*p*Z')/(W'*p*(COS\alpha)^2+Z'*(SIN\alpha)^2)$ = 688

IF Z_α' >= P_{blt}, SELECTED BOLT OK!

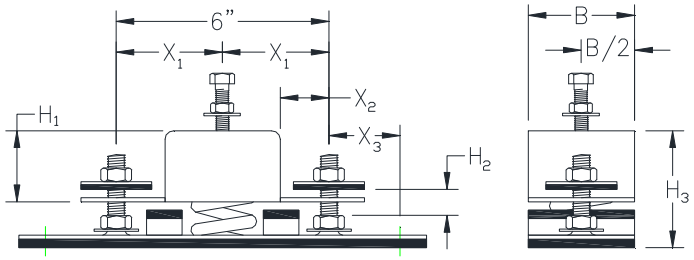
USE 1/2" DIA. LAG BOLT 3" PENETRATION W/ MIN. 1-1/2" EDGE DISTANCE & MIN. 3-1/2" END DISTANCE INTO MIN. 4X6 DOUGLAS FIR WOOD.

JOB NAME:	CAMARILLO SCHOOL	**M. W. SAUSSE' & CO., INC.**	
CUST.:		PREPARED BY :	TDT
MECH. ENG.:	BUDLONG	DATE :	17-Mar-20
MARK:	PE SUPPORT	SHEET NO. :	-C1.1

RMU-EQ-SH-1 ISOLATOR CAPACITY CHECK - LRFD DESIGN PER AISC 360-10

IMPORTANT MODELING NOTE:

RMU-EQ-SH-1 STRENGTH DEPENDS ON THE RIGIDITY OF THE ATTACHMENT POINT OF THE EQUIPMENT/FRAM ETO THE TOP OF THE ISOLATOR SINCE THE SEISMIC RESTRAINING POINTS AT THE STABILIZERS CANNOT TRANSFER A MOMENT TO THE BASEPLATE.



RMU-EQ-SH-1 MODEL

LOADS TO THE ISOLATOR

$P_{MIN} = Y =$ 518 lbs

$V_{MAX} = (X^2+Z^2)^{0.5} =$ 416 lbs

DIMENSIONS OF THE ISOLATOR

OVERALL HEIGHT:

$H_1 =$ 2.125 in (HT. OF TOP ASSEMBLY)

$H_2 =$ 0.8125 in (MAX HT. TO LOAD POINT OF STABILIZER)

$H_3 =$ 3.5 in (OVERALL IS. HT.)

$X_1 =$ 3 in (DIST. FROM LOAD PT. TO STABILIZER)

$X_2 =$ 1.375 in (DIST. FROM STABILIZER TO TOP ASSEMBLY "BOX")

$X_3 =$ 1.625 in (DIST. FROM STABILIZER TO ANCHOR BOLT)

$B =$ 3 in (WIDTH OF ISOLATOR)

$F_Y =$ 36000 psi (YIELD STRENGTH OF ISOLATOR STEEL)

$\Phi =$ 0.9 (TYP. U.N.O.)

CHECK OF EACH COMPONENT

MOUNTING STUD (AND LEVELING BOLT):

$T_1 = P_{MIN} =$ 518 lbs

$T_2 = V_{MAX}*H_1/(B/2) =$ 589.3333 lbs

$T_b = T_1 + T_2 =$ 1107.333 lbs (MAX TENSION ON STUD)

$V_b = V_{MAX} =$ 416 lbs (MAX SHEAR ON STUD)

CHECKING COMBINED LOADING...

$T_n\Phi* =$ 3310

$V_n\Phi* =$ 1650

$T_b/(T_{b,n}\Phi) + V_b/(V_{b,n}\Phi) =$ 0.59 < 1.0

$*\Phi = 0.75$ FOR BOLT SHEAR & TENSION

TOP ASSEMBLY:

$t_t =$ 0.135 in (THICKNESS)

$b_t = B =$ 3.00 in (DEPTH)

$M_{t,Y} = 0.5P_{MIN}*X_2 =$ 356.125 lb-in

$M_{t,X} = 0.5V_{MAX}*X_2 =$ 286.00 lb-in

CHECKING COMBINED MOMENTS...

$M_{t,Xn} = t_t b_t^2/4*F_Y\ \Phi =$ 9841.5 lb-in

$M_{t,Yn} = b_t t_t^2/4*F_Y\ \Phi =$ 442.8675 lb-in

$M_{t,X}/M_{t,Xn} + M_{t,Y}/M_{t,Yn} =$ 0.833195 < 1.0

TOP PLATE OKAY!

STABILIZERS:

$D_S =$ 0.5 in (DIAMETER OF STABILIZER BOLT)

$A_{NET} =$ 0.141 in^2 (NET TENSILE AREA)

$F_{Y,S} =$ 36000 psi

$M_{Su} = 0.5V_{MAX}*H_2 =$ 169 lb-in

$T_{Su} = 0.5P_{MIN} =$ 259 lbs

$V_{Su} = 0.5V_{MAX} =$ 208 lbs

CHECKING TENSION, MOMENT, AND SHEAR...

$M_{Sn} = (D_S^3/6)F_{Y,S}*\Phi =$ 675 lb-in

$T_{Sn} = A_{NET}F_{Y,S}\Phi* =$ 3807 lbs

$V_{Sn} = 0.6A_{NET}F_{Y,S}\Phi* =$ 2284.2 lbs

$*\Phi = 0.75$ FOR BOLT SHEAR & TENSION

$M_{Su}/M_{Sn} + T_{Su}/T_{Sn} + V_{Su}/V_{Sn} =$ 0.41 < 1.0

STABILIZERS OKAY!

BASEPLATE:

$t_b =$ 0.135 in (THICKNESS)

$b_b = B =$ 3.00 in (DEPTH)

$M_{b,Y} = 0.5P_{MIN}*X_3 =$ 420.88 lb-in

$M_{b,X} = 0.5V_{MAX}*X_3 =$ 338.00 lb-in

CHECKING THE MOMENT FROM BOLT/WELD TENSION...

$M_{b,Xn} = t_b b_b^2/4*F_Y\ \Phi =$ 9841.50 lb-in

$M_{b,Yn} = b_b t_b^2/4*F_Y\ \Phi =$ 442.87 lb-in

$M_{b,X}/M_{b,Xn} + M_{b,Y}/M_{b,Yn} =$ 0.98 < 1.0

BASE PLATE OKAY!

RMU-EQ-SH-1 IS ADEQUATE FOR THE SUPPORT AND SEISMIC RESTRAINT OF POWER EXHAUST

JOB NAME:	CAMARILLO SCHOOL	M. W. SAUSSE' & CO., INC.	
CUST. :		PREPARED BY :	TDT
MECH. ENGR.:	BUDLONG	DATE :	17-Mar-20
MARK:	PE SUPPORT	SHEET NO. :	-C1.2

Under-Ceiling Residential Heat Pump System

Indoor Model: RAV-SP180CT-UL
Outdoor Model: RAV-SP180AT2-UL

Carrier
turn to the experts

Submittal Data

Job Data:_____ Location:_____

Buyer:_____ Buyer P.O. #_____ Carrier # _____

Unit Number: _____ Model Number:_____

Performance Data Certified By: _____ Date:_____





Puron
the environmentally sound refrigerant

UNDER-CEILING STANDARD FEATURES

- Digital inverter compressor technology
- System can operate in cooling only mode with heating locked out
- Slim-line design
- Line lengths up to 165'
- Auto louver mode
- Quiet operation
- 3 indoor unit fan speeds
- Power saving mode
- Low-ambient cooling down to 5°F
- Filter maintenance indicator
- Indoor sound: as low as 34 decibels
- System diagnostics

CONTROL STANDARD FEATURES

- Optional wireless remote control
- Optional wired remote control

(Unless otherwise indicated, data applies to both indoor and outdoor models)

SYSTEM SIZE	18
REFRIGERANT	R-410A
PERFORMANCE	
Rated Cooling Capacity (Btuh)	17,000
Cooling Range (Btuh)	3,750-19,400
SEER/EER	17/8.6
Rated Heating Capacity (Btuh)	19,000
Heating Range (Btuh)	2,800-21,700
HSPF	10.8
CFM/Sound Pressure - dBA	
Outdoor Sound Pressure (dBA)	48/49
Indoor Cooling Airflow H / M / L (cfm)	410/360/320
Indoor Cooling at Different Speeds (dBA)	40/37/34
Indoor Heating Airflow H / M / L (cfm)	410/360/320
Indoor Heating at Different Speeds (dBA)	40/37/34
ELECTRICAL	
System Voltage	208/230 - 1 – 60
Indoor Unit	Wired from Outdoor
Wires between Indoor and Outdoor	4
MCA	17
MOCP	30
CONTROLS	
Wireless Remote	Optional
Wired Control	Optional
REFRIGERANT LINES	
Total Piping Length (ft)	165
Vertical Lift (ft)	100
Suction Line Size (in)	1/2
Liquid Line Size (in)	1/4
AMBIENT OPERATING RANGE	
Cooling DB Min ~ Max (F)	23~110 (5 with wind baffle)
Heating DB Min ~ Max (F)	-4 ~ 59
UNIT WEIGHT - Gross/Net	
Indoor unit (lbs)	36/31
Outdoor unit (lbs)	105/98

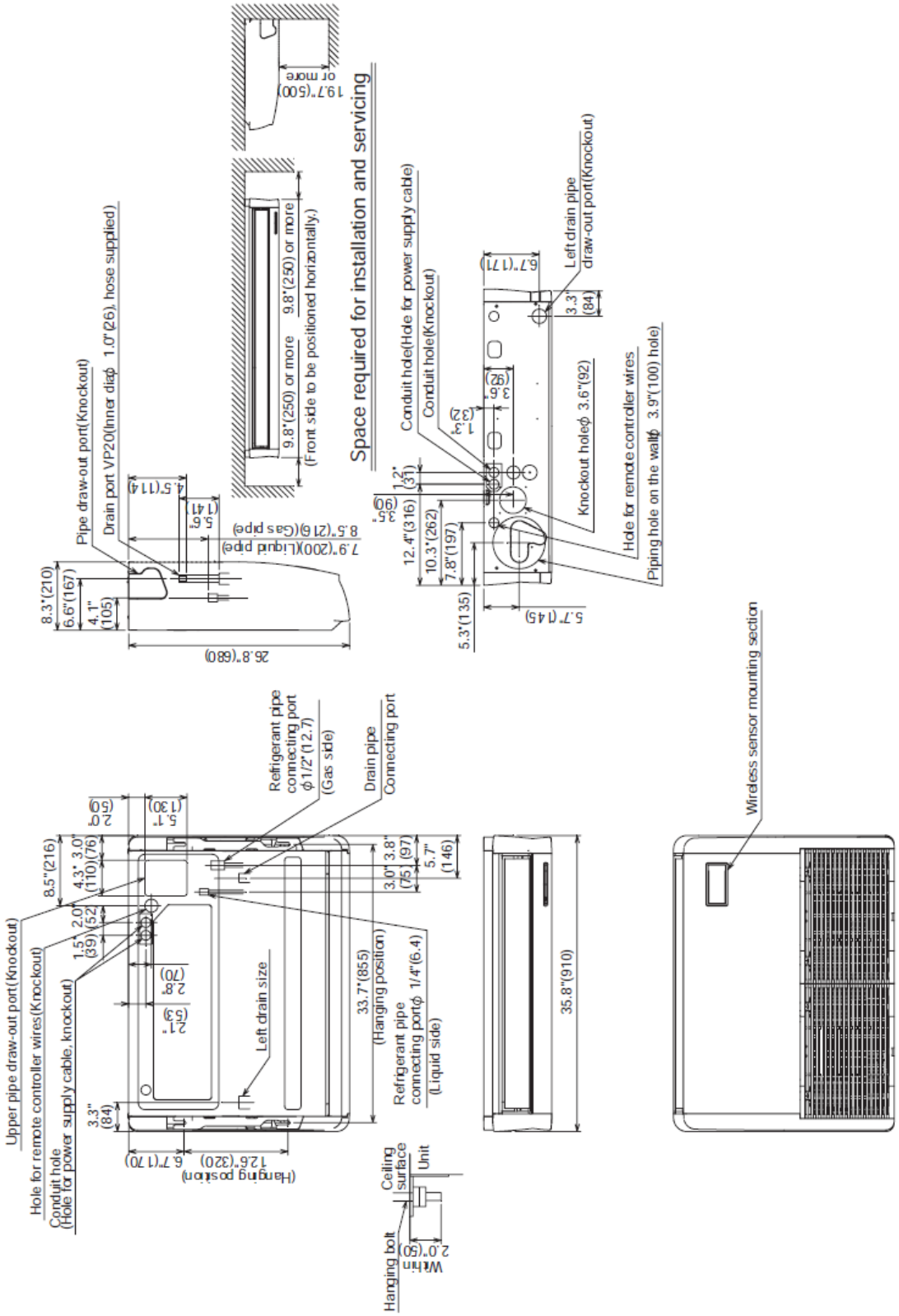
Accessories:

☐ Condensate Drain Pump Kit
☐ Elbow Piping Kit - Req. with Cond. Drain Kit
☐ Wireless Control RAV – Convertible
☐ Wired Control – RAV Convertible

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Replaces: NEW

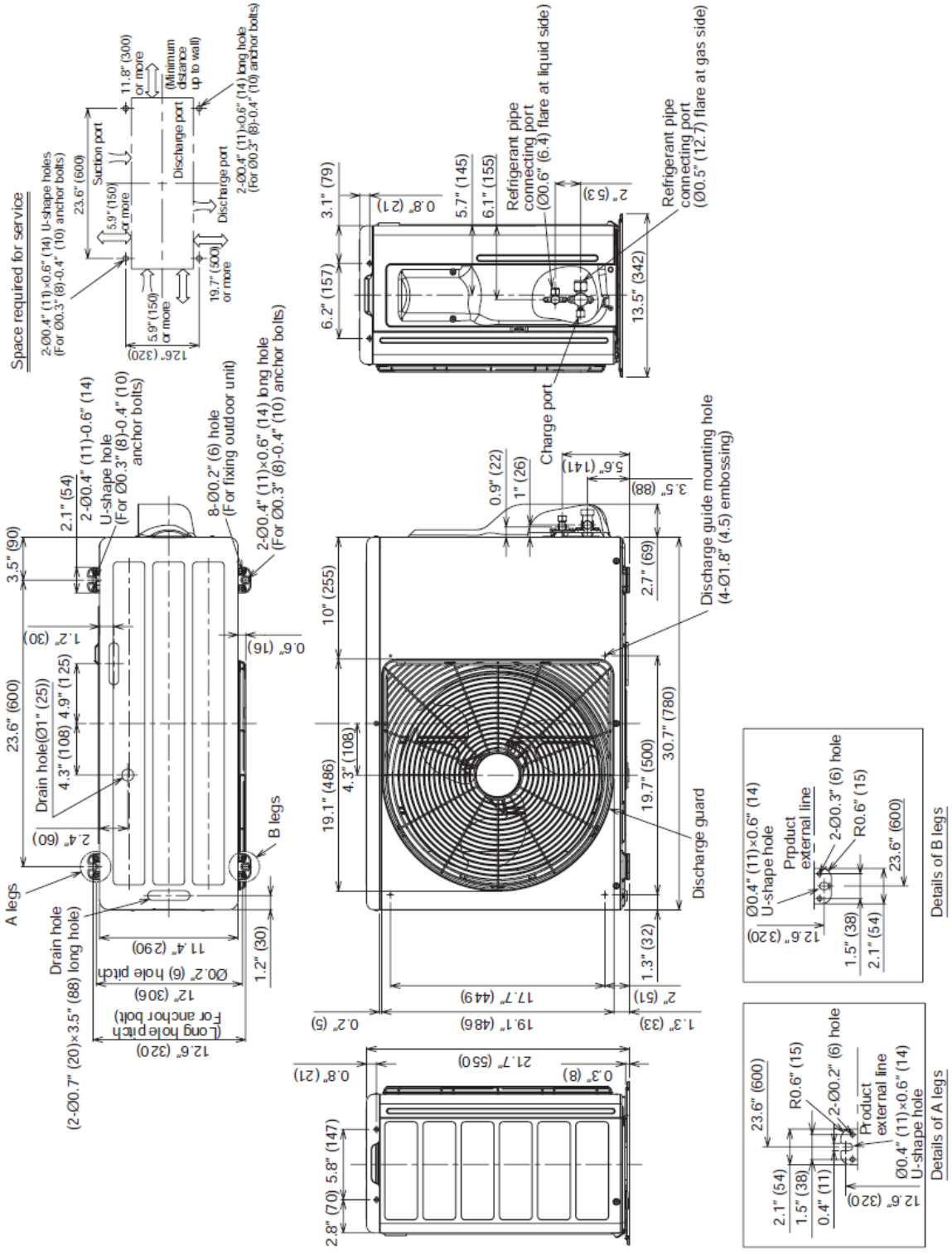
Construction View:
Indoor Unit RAV-SP180CT-UL



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Construction View:
Outdoor Unit RAV-SP180AT2-UL



AHRI CERTIFIED™ www.ahridirectory.org
Unitary Small AC
AHRI Standard 210/240
Certification applies only when the complete system is listed with AHRI.

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Replaces: NEW

Under-Ceiling Residential Heat Pump System

Indoor Model: RAV-SP240CT-UL
Outdoor Model: RAV-SP240AT2-UL

Submittal Data

Job Data: _____ Location: _____

Buyer: _____ Buyer P.O. #: _____ Carrier #: _____

Unit Number: _____ Model Number: _____

Performance Data Certified By: _____ Date: _____





UNDER-CEILING STANDARD FEATURES

- Digital inverter compressor technology
- System can operate in cooling only mode with heating locked out
- Slim-line design
- Line lengths up to 165'
- Auto louver mode
- Quiet operation
- 3 indoor unit fan speeds
- Power saving mode
- Low-ambient cooling down to 0°F
- Filter maintenance indicator
- Indoor sound: as low as 37 decibels
- System diagnostics

CONTROL STANDARD FEATURES

- Optional wireless remote control
- Optional wired remote control

(Unless otherwise indicated, data applies to both indoor and outdoor models)

SYSTEM SIZE	24
REFRIGERANT	R-410A
PERFORMANCE	
Rated Cooling Capacity (Btuh)	23,600
Cooling Range (Btuh)	4,700-26,900
SEER/EER	19.5/9.0
Rated Heating Capacity (Btuh)	28,900
Heating Range (Btuh)	3,600-32,400
HSPF	10.3
CFM/Sound Pressure - dBA	
Outdoor Sound Pressure (dBA)	49/50
Indoor Cooling Airflow H / M / L (cfm)	440/380/330
Indoor Cooling at Different Speeds (dBA)	42/40/37
Indoor Heating Airflow H / M / L (cfm)	440/380/330
Indoor Heating at Different Speeds (dBA)	42/40/37
ELECTRICAL	
System Voltage	208/230 - 1 – 60
Indoor Unit	Wired from Outdoor
Wires between Indoor and Outdoor	4
MCA	24
MOCP	40
CONTROLS	
Wireless Remote	Optional
Wired Control	Optional
REFRIGERANT LINES	
Total Piping Length (ft)	165
Vertical Lift (ft)	100
Suction Line Size (in)	5/8
Liquid Line Size (in)	3/8
AMBIENT OPERATING RANGE	
Cooling DB Min ~ Max (F)	23~110 (0 with wind baffle)
Heating DB Min ~ Max (F)	-4 ~ 59
UNIT WEIGHT - Gross/Net	
Indoor unit (lbs)	75/55
Outdoor unit (lbs)	157/144.5

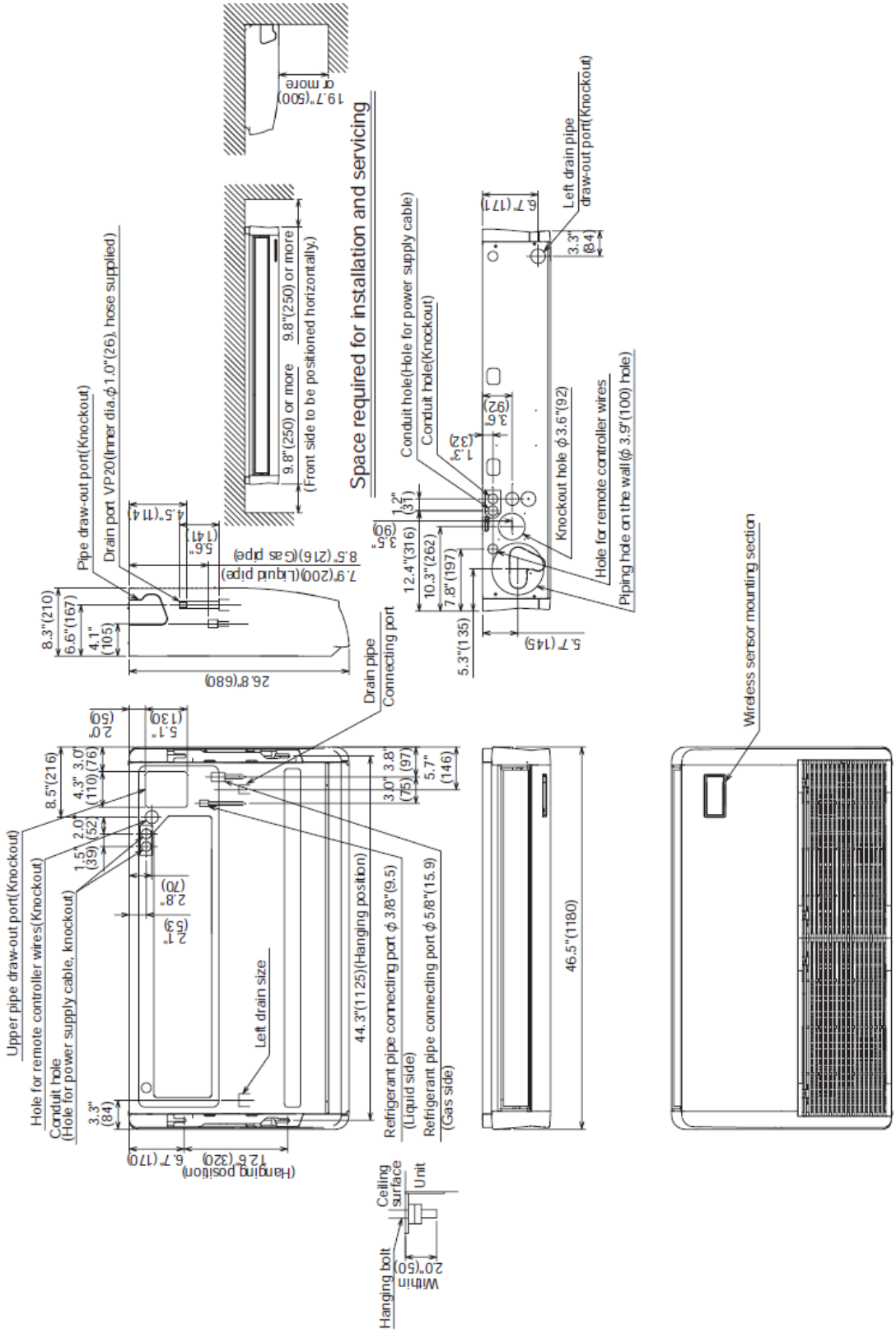
Accessories:

☐Condensate Drain Pump Kit
☐Elbow Piping Kit - Req. with Cond. Drain Kit
☐Wireless Control RAV – Convertible
☐Wired Control – RAV Convertible

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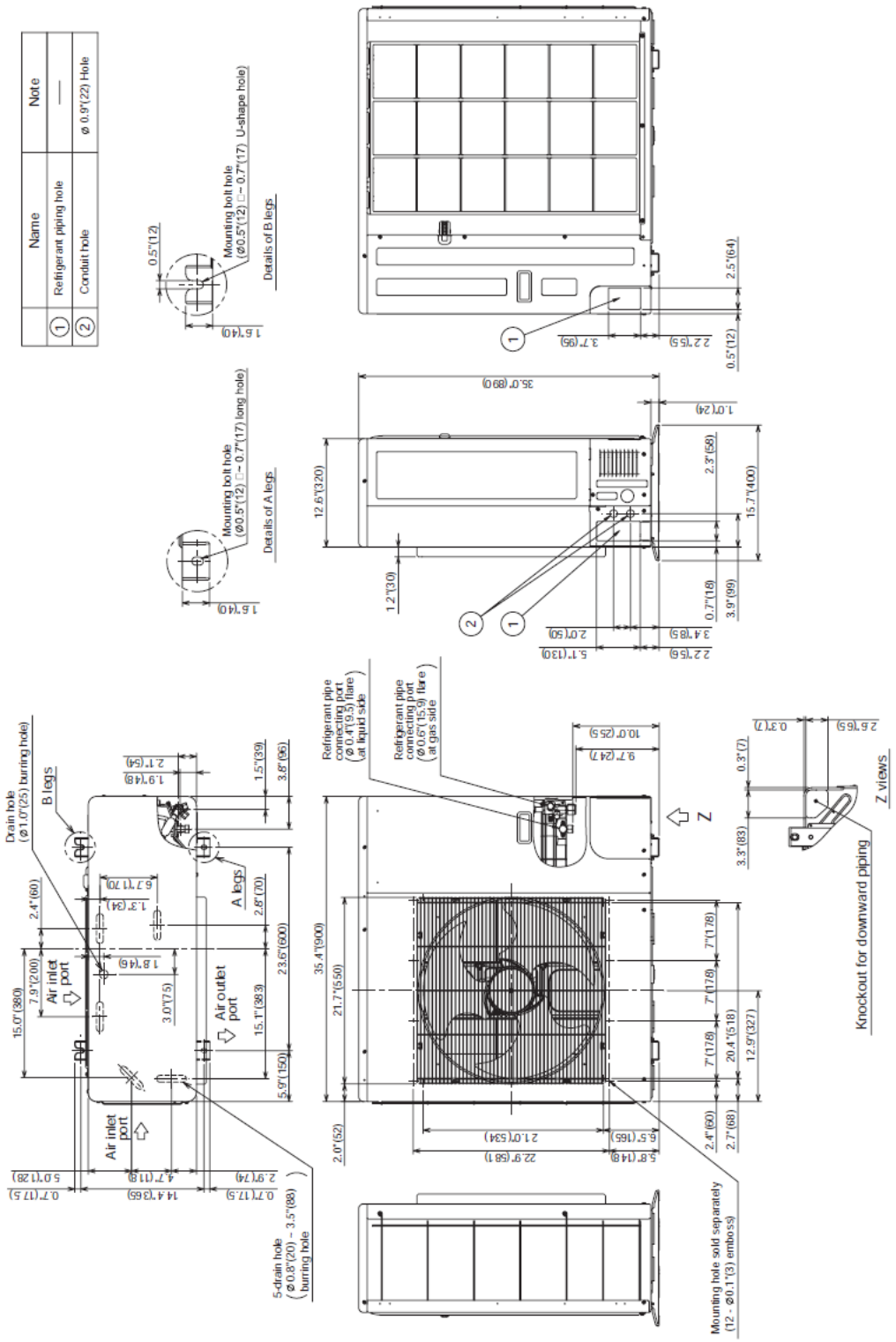
Construction View:
Indoor Unit RAV-SP240CT-UL



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Construction View:
Outdoor Unit RAV-SP240AT2-UL



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