Facilities Checksheet Response

Permit #: 13-161121-000-00-FA **Date:** 6/27/13

Customer name and phone number: GARY FRYE – (503) 415-5481

Note: *Please number each change in the '#' column. Use as many lines as necessary to describe your changes. Indicate which reviewer's checksheet you are responding to and the item your change addresses. If the item is not in response to a checksheet, write* **customer** *in the last column.*

#	Description of changes, revisions, additions, etc.	Checksheet and item #
1	DET'S/CALCS FOR SUPPORT/ANCHOR	#1
	FAN COIL UNIT.	

(For office use only)

RECEIVED
JUN 18 2013
By GF/PROP. MGMT.

INTERNATIONAL SEISMIC APPLICATION TECHNOLOGY

Submittal Documents

FCU - Suspended Equipment Anchorage Design

Calculations and Details

Project

Randal Childrens Hospital

Location

Portland, Oregon

Contractor

Total Mechanical

ISAT Project #: 13-P-0113-0

6/25/2013

REGISTERED PROFESSIONAL ENGINEER
84137PE
OREGON
MAY 11, 2010
GERRIT WAYNE WILSON
EXPIRES: 6/30/14

6/25/2013

Prepared by:
INTERNATIONAL SEISMIC APPLICATION TECHNOLOGY (ISAT)
14325 NE Airport Way, Suite 101, Portland, OR 97230

INTERNATIONAL SEISMIC APPLICATION TECHNOLOGY

14325 NE Airport Way, Suite 101
Portland, OR 97230

FCU - Anchorage Design
Calculations and Details

Project
Randal Childrens Hospital

Location
Portland, Oregon

Contractor
Total Mechanical

Table of Contents

INTERNATIONAL SEISMIC APPLICATION TECHNOLOGY

14325 NE Airport Way, Suite 101
Portland, OR 97230

FCU - Anchorage Design
Calculations and Details

Project
Randal Childrens Hospital

Location
Portland, Oregon

Contractor
Total Mechanical

Basis for Design

BUILDING CODE:

2009 EDITION OF THE INTERNATIONAL BUILDING CODE INCLUDING PROVISIONS OF THE 2010 EDITION OF THE OREGON STRUCTURAL SPECIALTY CODE SUPPLEMENTED BY THE ASCE 7-05

EQUIPMENT LOADS:

FCU-1 (MAX WEIGHT) = 182.4 LBS

MATERIAL SPECIFICATIONS:

PLATE, ANGLE, MISC. SHAPES: ASTM A36 (Fy = 36,000 PSI)
STRUT: ASTM A653 (Fy = 33,000 PSI)
28-DAY COMPRESSIVE STRENGTH OF CONCRETE ASSUMED TO BE 3,000 PSI.
SHEET METAL SCREWS SHALL CONFORM TO ICC REPORT ESR-2196
MECHANICAL CONCRETE ANCHORS SHALL CONFORM TO ICC REPORT ESR-1917

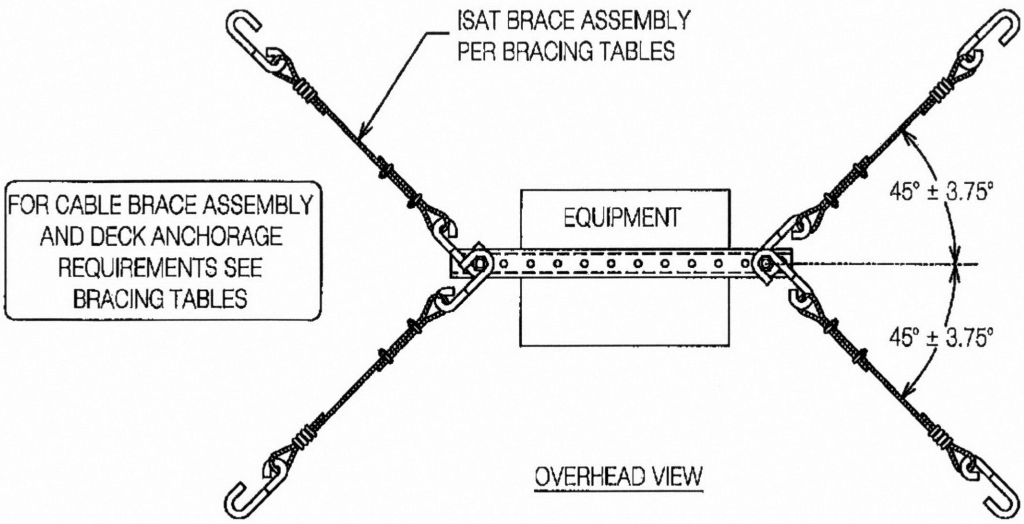
SCOPE OF WORK:

THE SUPPORTING STRUCTURE IS BEYOND THE SCOPE OF THIS SUBMITTAL. IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO SUBMIT THESE CALCULATIONS AND ASSOCIATED DOCUMENTS TO THE ENGINEER OF RECORD PRIOR TO CONSTRUCTION TO ANALYZE THE ABILITY OF THE SUPPORTING STRUCTURE TO ACCOMMODATE THE REACTIONS FROM THE CONNECTIONS SPECIFIED IN THIS SUBMITTAL. EQUIPMENT DIMENSIONS USED IN CALCULATIONS ARE BASED ON EQUIPMENT DATA SHEETS ATTACHED. EQUIPMENT WITH NO POWER RATING LISTED ASSUMED TO BE LESS THAN 10 HP. THIS SET OF CALCULATIONS IS BASED ON THE LOADS AND ASSUMPTIONS STATED WITHIN THIS SUBMITTAL. IF THE LOADS AND ASSUMPTIONS ARE NOT CORRECT THIS SUBMITTAL SHALL BE REVISED.

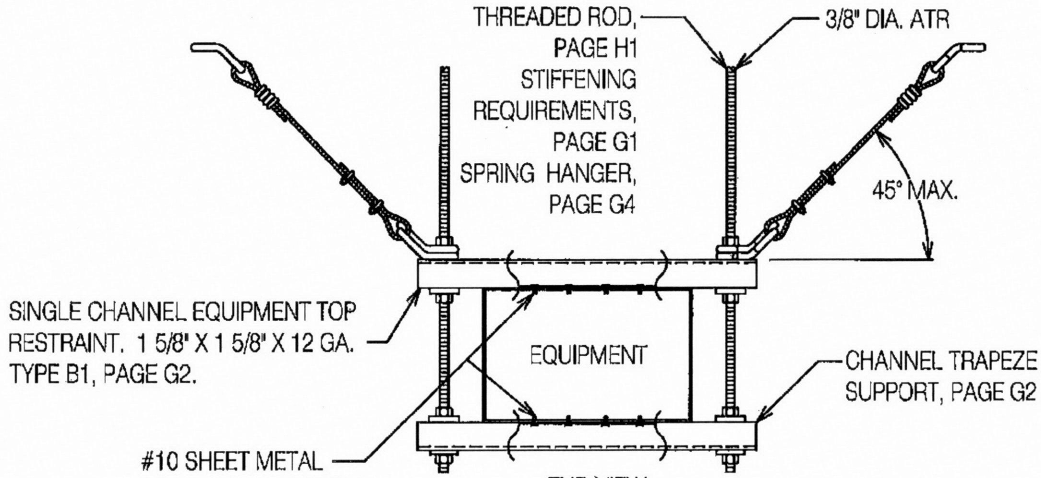
WHEN UTILIZING CABLE BRACING FOR ANYTHING OTHER THAN VIBRATION ISOLATED SYSTEMS, TENSION THE CABLE TO REMOVE SLACK WITHOUT INDUCING UPLIFT OF THE SUSPENDED ELEMENT. FOR VIBRATION ISOLATED EQUIPMENT CABLES ARE TO BE INSTALLED WITH SUFFICIENT SLACK TO ACCOMODATE, BUT NOT EXCEED, THE VIBRATION ISOLATORS CALCULATED DEFLECTION. SEE MANUFACTURER'S VIBRATION ISOLATOR SPECIFICATIONS. DO NOT TENSION CABLES TO THE EXTENT THAT THEY SUPPORT GRAVITY LOADS. CABLE INSTALLATION IS TO BE SYMMETRICAL.

INTERNATIONAL SEISMIC APPLICATION TECHNOLOGY

Suspended Equipment Calculations & Details



OVERHEAD VIEW



END VIEW

MAXIMUM UNIT LENGTH - 3 FEET
FOR UNITS EXCEEDING 3 FEET, SEE PAGE B39.4

2-ROD, SUSPENDED EQUIPMENT, S250R BRACKET
4-WAY SPLAYED TRANSVERSE-LONGITUDINAL CABLE BRACING

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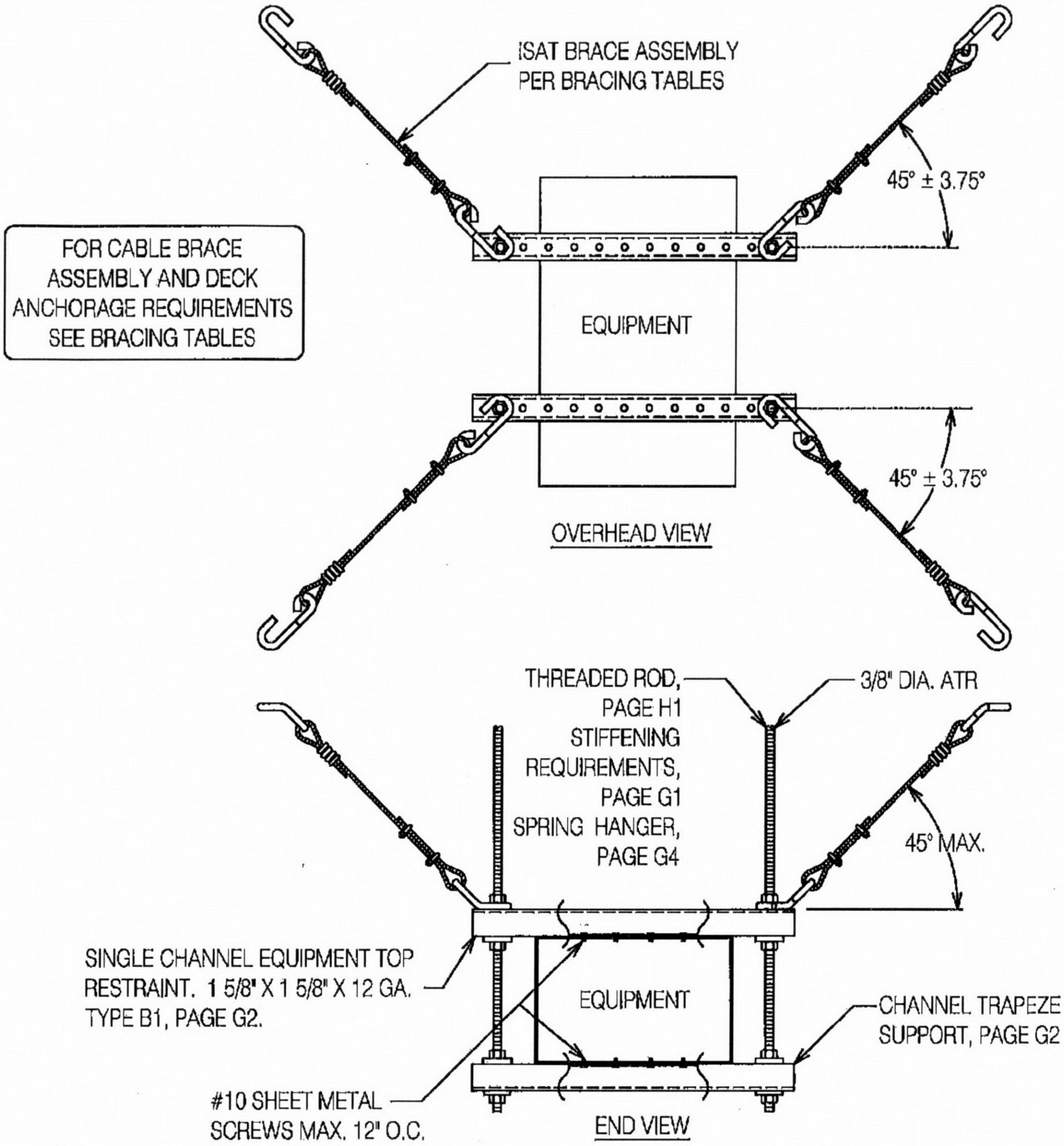
W V Jaugn
Model Law Structural Engineer
NCEES No. 20675

Rev. 1
11/01/07



4-ROD SUSPENDED EQUIPMENT, S250R SEISMIC BRACKETS
4-WAY SPLAYED TRANSVERSE-LONGITUDINAL CABLE BRACING

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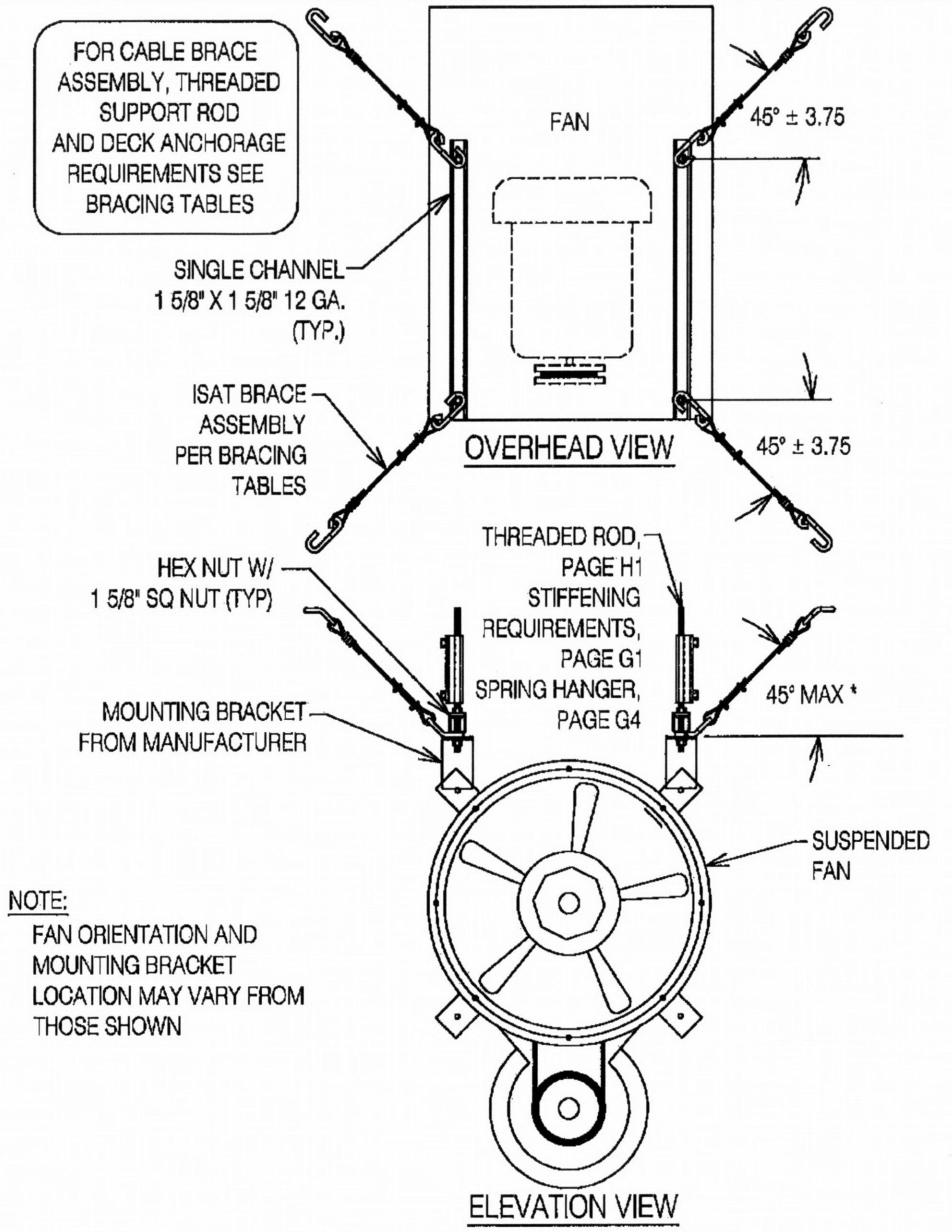

4-ROD SUSPENDED FAN
4-WAY SPLAY TRANSVERSE-LONGITUDINAL CABLE BRACING

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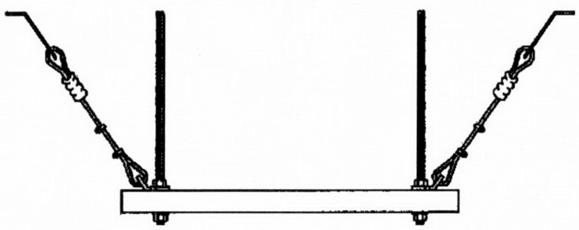
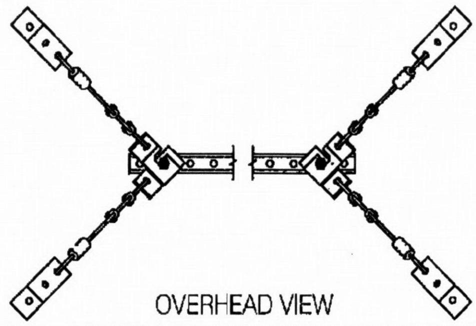
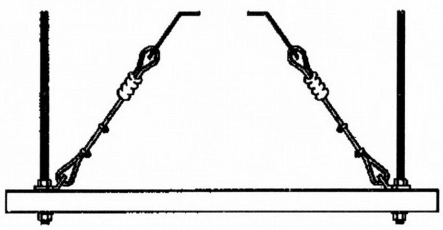
FOR USE WITH ANY "B" SERIES CABLE/WIRE BRACING DETAIL UTILIZING TRAPEZE SUPPORT.



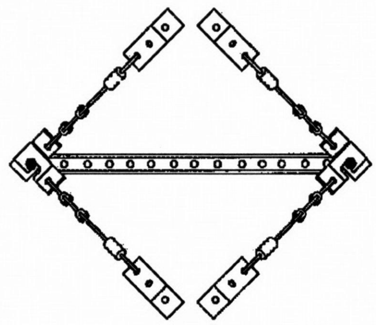
SECTION THRU TRAPEZE
STD. CABLE/WIRE TRANSVERSE BRACE PATTERN



OVERHEAD VIEW
STD. SPLAYED CABLE/WIRE BRACE PATTERN



SECTION THRU TRAPEZE
ALTERNATE CABLE/WIRE TRANSVERSE BRACE PATTERN



OVERHEAD VIEW
ALTERNATE SPLAYED CABLE/WIRE BRACE PATTERN

ALTERNATE CABLE OR WIRE BRACE ARM PATTERNS
TRAPEZE SUPPORTED SYSTEMS

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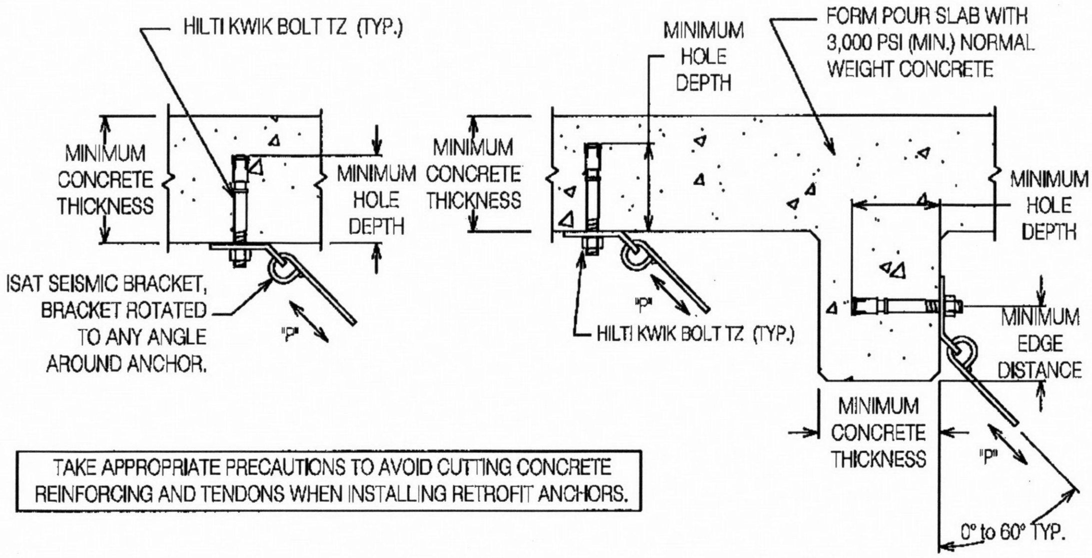

TAKE APPROPRIATE PRECAUTIONS TO AVOID CUTTING CONCRETE REINFORCING AND TENDONS WHEN INSTALLING RETROFIT ANCHORS.

SINGLE ANCHOR CONNECTION DETAILS

Form Pour Slab with Minimum Concrete Strength of 3,000 psi

2006 IBC, 2009 IBC OR 2007 CBC PROJECTS
Anchorage In Cracked Concrete
Hilti Kwik Bolt TZ Concrete Expansion Anchor
ICC Report No. ESR-1917 (Dated Sep. 1, 2009), Table 3
Special Inspection Required by Manufacturer's ICC Report

Brace Anchorage Designation	Anchor Dia. Inch	Minimum Hole Depth [1] Inch	Minimum Effective Embedment [2] Inch	Minimum Concrete Thickness Inch	Installation Torque Ft-Lbs.	Minimum Anchor Spacing Inch	Edge Distance for Pmax Inch	Maximum Brace Load Pmax Lbs.	Min. Edge Dist. Inch	Brace Load (P) at Minimum Edge Distance Lbs.
→ N5TZ3	3/8	2 5/8	2	4	25	6	6	535	3	410
N6TZ3	1/2	2 5/8	2	4	40	6	8	620	3	440
N13TZ3	1/2	4	3 1/4	6	40	9 3/4	12	1,330	5	950
N14TZ3	5/8	3 7/8	3 1/8	5	60	9 3/8	24	1,490	4 3/4	900
N19TZ3	5/8	4 3/4	4	6	60	12	18	1,960	6	1,280

1. MINIMUM HOLE DEPTH IS TO BE VERIFIED BY THE INSPEC
2. MINIMUM EFFECTIVE EMBEDMENT IS AFTER THE ANCHOR HAS BEEN
3. ANCHOR SPACING IS THE CENTER-TO-CENTER DISTANCE BETWEEN TWO ANCHORS. THE DISTANCE TO AN ADJACENT ANCHOR IS THREE TIMES THE TABULATED EDGE DISTANCE.
4. AT CONCRETE CORNERS USE THE TABULATED VALUE FOR "EDGE DISTANCE FOR PMAX" FOR ONE EDGE WHERE THE "MIN. EDGE DISTANCE" IS USED FOR THE PERPENDICULAR CONCRETE FACE.

SINGLE ANCHOR HILTI KWIK BOLT TZ FOR SEISMIC BRACE CONNECTION IN FORM POUR SLAB

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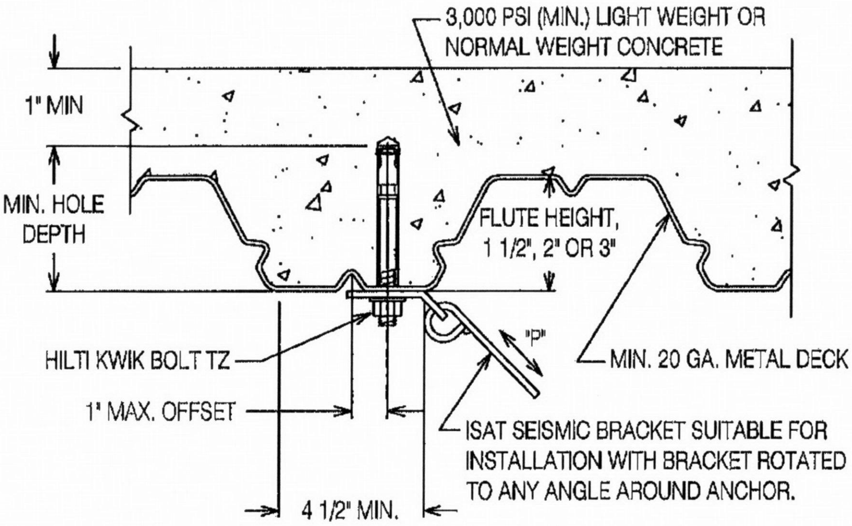


SINGLE ANCHOR CONNECTION DETAILS L4.1TZ, L4.2TZ, L8.1TZ, L12.1TZ

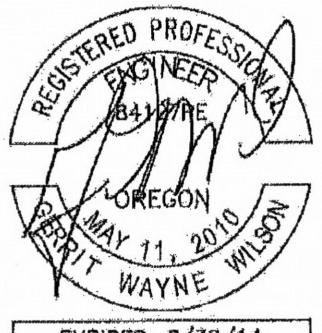
Metal Deck With Minimum 3,000 psi Light Weight or Normal Weight Concrete

2006 IBC & 2009 IBC PROJECTS
Seismically Qualified for Anchorage In Cracked Concrete
Hilti Kwik Bolt TZ Concrete Expansion Anchor
ICC Report No. ESR-1917 (Dated Nov. 2012), Table 5 and Fig. 5.
Special Inspection Required By Manufacturer's ICC Report

Brace Anchorage Designation	Anchor Quantity	Anchor Diameter Inch	Maximum Brace Load (P) Lbs.	Minimum Hole Depth [1] Inch	Minimum Effective Embedment [2] Inch	Minimum Anchor Spacing Inch	Edge Distance Inch	Installation Torque Ft-Lbs.	Min. Concrete Thickness Above Top Flute (Inch) Metal Deck Flute Height 1 1/2"	2"	3"
→ L4.1TZ	1	3/8	332	2 5/8	2	6 3/4	4 3/4	25	2 1/4	1 3/4	1 1/2
L4.2TZ	1	1/2	475	2 5/8	2	6 3/4	5 3/4	40	2 1/4	1 3/4	1 1/2
L8.1TZ	1	1/2	825	4	3 1/4	9 3/4	7 1/4	40	3 1/2	3	2
L12.1TZ	1	5/8	1,219	4 3/4	4	12	8	60	4 1/4	3 3/4	2 3/4

1. MINIMUM HOLE DEPTH IS TO BE VERIFIED BY THE INSPECTOR.
2. MINIMUM EFFECTIVE EMBEDMENT IS AFTER THE ANCHOR HAS BEEN SET.

SINGLE ANCHOR HILTI KWIK BOLT TZ SEISMIC BRACE CONNECTION IN METAL DECK SLAB



EXPIRES: 6/30/14

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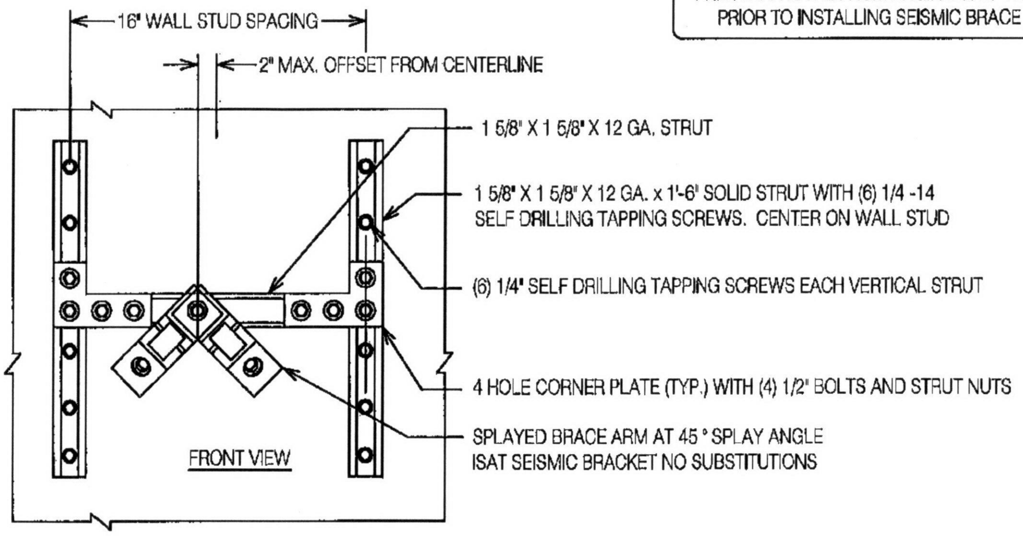
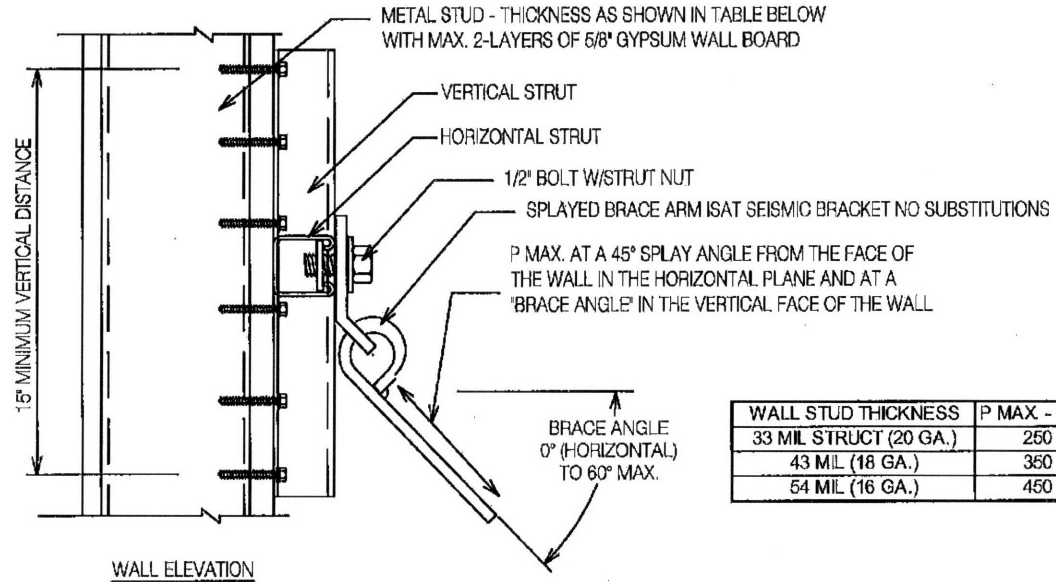
Rev. 0
03/05/13

Page
D2.1TZ-OR

PRIOR APPROVAL FROM ENGINEER OF RECORD REQUIRED
PRIOR TO INSTALLING SEISMIC BRACE CONNECTION.





WALL STUD THICKNESS	P MAX - LBS.
33 MIL STRUCT (20 GA.)	250
43 MIL (18 GA.)	350
54 MIL (16 GA.)	450

DUAL METAL WALL STUD SPLAYED SEISMIC BRACE CONNECTION

APPROVED
Fixed Equipment Anchorage
Office of Statewide Health Planning and Development
OPA-0485-07
Pre-approval Program Manager
Anthony R. Pike
(916) 440-8470

Reviewed By: Wenlin Wu — Date: 9/1/2011

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01/11/10

CABLE BRACING REQUIREMENTS

MECHANICAL EQUIPMENT, ROD HUNG — MAXIMUM HORIZONAL SEISMIC FORCE = 0.91 G's

Requires Use of ISAT Seismic Brackets. Use of Any Non-ISAT Bracket Voids Engineering — S_{DS} = 0.723

Equipment Tag	Equipment Maximum Weight (lbs)	Rod [1] Total Vertical Load (lbs)	Min [4] Vertical Support Rod Dia. (in)	4-WAY SPLAYED BRACING REQUIREMENTS: Brace [2] Reaction P (lbs)	Min. Brace Assembly Page E3	Min. Brace Anchorage [3]: Concrete Form Pour Deck	Concrete Metal Deck
	2-ROD SUPPORT			4-Way Splayed Brace Pattern (B39.0, B39.3)			
FCU-1	184.2	102	3/8	168	BC2	N5TZ3	L4.1TZ3
> 300 lbs	4-ROD SUPPORT			4-Way Splayed Brace Pattern (B39.1, B39.4, B50.3)			

1. TVL = DL + Fv + ($0.2S_{DS}/1.4 \times Wp$). All Terms are Working Loads.
2. At Max. 45 Degree Brace Inclination.
3. As an alternate, Brace Anchorage Connections To Structure May Be Employed Using Any Detail From Structural Connections Section "D" Series Details Where Assembly Design Value Meets Or Exceeds Brace Reaction.
4. Vertical Support Connections May Be Selected From The "G" Series Details Where Design Value Meets Or Exceeds Rod Total Vertical Load.

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Directory - ISAT Cable Brace Assemblies

ISAT Brace [1] Assembly	Rod Diameter Inch	*ISAT Seismic Brackets* [2] Lower Bracket Page F __	Upper Bracket Page F __	Cable Brace Arm Dia. Inch	Cable Assembly Type	Assembly Design Value (P) [3] Lbs	Brace Assembly Detail Page E4._
BC1	3/8	S250R	S250R	1/16	E4.3, Looped	160	E4.3
BC2	3/8	S250R	S250R	1/8	E4.3, Looped	300	E4.3
BC3	3/8	RCHWS38	ABHWS12	1/8	E4.1, Thru Bolt	650	E4.1
BC4	3/8	RCHWS38	ABHWS12	3/16	E4.1, Thru Bolt	950	E4.1
BC5	3/8	RCC38	ABF12	3/16	E4.2, Looped	960	E4.2
BC6.1	3/8	RCHWS38	ABHWS12	3/16	E4.2, Looped	1,060	E4.2
BC6.2	3/8	RCHWS38	ABHWS12	1/4	E4.2, Looped	1,265	E4.2
BC7	3/8	RCHWS38	ABHW12	1/4	E4.2, Looped	1,700	E4.2
BC8	3/8	RCCX38	ABF12	1/4	E4.2, Looped	1,700	E4.2
BC9	3/8	RCHW38	ABHW12	5/16	E4.2, Looped	1,850	E4.2
BC10	1/2	RCHWS12	ABHWS12	1/8	E4.1, Thru Bolt	650	E4.1
BC11	1/2	RCHWS12	ABHWS12	3/16	E4.1, Thru Bolt	950	E4.1
BC12	1/2	RCC12	ABF12	3/16	E4.2, Looped	960	E4.2
BC13	1/2	RCHWS12	ABHWS12	3/16	E4.2, Looped	1,060	E4.2
BC14	1/2	RCHWS12	ABHWS12	1/4	E4.2, Looped	1,265	E4.2
BC15	1/2	RCHWS12	ABHW12	1/4	E4.2, Looped	1,700	E4.2
BC16	1/2	RCCX12	ABF12	1/4	E4.2, Looped	1,700	E4.2
BC17	1/2	RCHW12	ABHW12	5/16	E4.2, Looped	1,960	E4.2
BC20	5/8	RCHW58	ABHWS12	3/16	E4.2, Looped	1,060	E4.2
BC21	5/8	RCHW58	ABHWS12	1/4	E4.2, Looped	1,265	E4.2
BC22	5/8	RCHW58	ABHW12	1/4	E4.2, Looped	1,700	E4.2
BC23	5/8	RCHW58	ABHW12	5/16	E4.2, Looped	1,860	E4.2
BC24	5/8	RCC58	ABF12	1/4	E4.2, Looped	1,700	E4.2
BC25	5/8	RCC58	ABF12	5/16	E4.2, Looped	1,865	E4.2
BC26	5/8	RCC58	ABF34	5/16	E4.2, Looped	1,960	E4.2
BC30	3/4	RCHW34	ABHWS12	3/16	E4.2, Looped	1,060	E4.2
BC31	3/4	RCHW34	ABHWS12	1/4	E4.2, Looped	1,265	E4.2
BC32	3/4	RCHW34	ABHW12	1/4	E4.2, Looped	1,700	E4.2
BC33	3/4	RCHW34	ABHW12	5/16	E4.2, Looped	1,860	E4.2
BC34	3/4	RCC34	ABF12	1/4	E4.2, Looped	1,700	E4.2
BC35	3/4	RCC34	ABF12	5/16	E4.2, Looped	1,865	E4.2
BC36	3/4	RCC34	ABF34	5/16	E4.2, Looped	1,960	E4.2
BC60	N/A	ABHWS12	ABHWS12	3/16	E4.1, Thru Bolt	950	E4.2
BC61	N/A	ABHWS12	ABHWS12	1/4	E4.2, Looped	1,265	E4.2
BC62	N/A	ABHW12	ABHW12	5/16	E4.2, Looped	2,400	E4.2
BC63	N/A	ABHWX	ABHWX	5/16	E4.2, Looped	2,400	E4.2
BC64	N/A	ABF34	ABF34	5/16	E4.2, Looped	2,400	E4.2

1. Typical Cable Brace Arm Assembly Details, Pages E4.1, E4.2, E4.3.
2. Use of Any Non-ISAT Bracket Voids Engineering.
3. At Nominal 45 Degree Brace Angle.

APPROVED
Fixed Equipment Anchorage
Office of Statewide Health Planning and Development

OPA-0485-07
Pre-approval Program Manager
Anthony R. Pike
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9/1/2011

Reviewed By: Wenlin Wu Date

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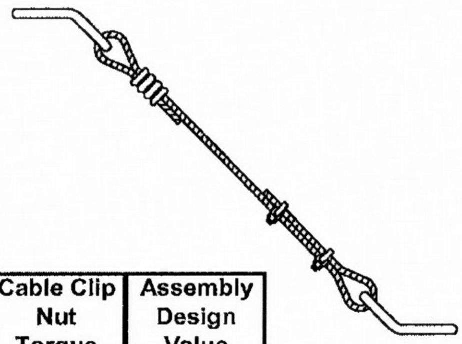
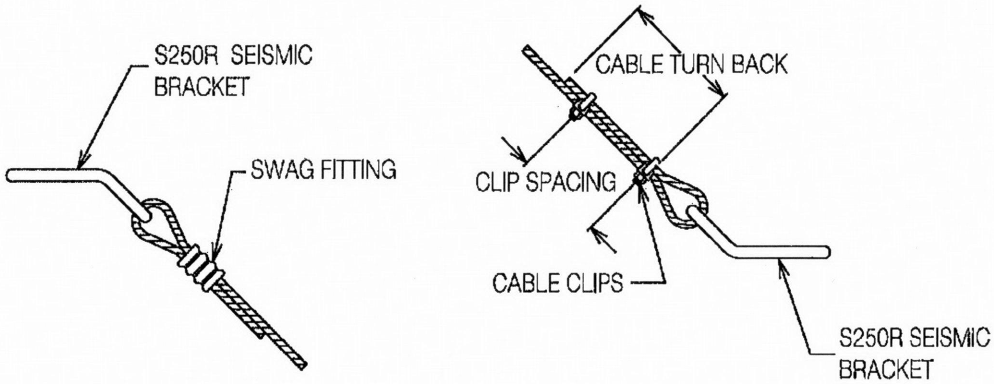
REGISTERED PROFESSIONAL ENGINEER ANTHONY A. RUBALCAVA S 4710 STRUCTURAL STATE OF CALIFORNIA

REV-8
06/20/11



S250R TO S250R

Cable Diameter Inch	Minimum Turn Back Inch	Nominal Clip Spacing Inch	Cable Clip Nut Torque Ft - Lbs	Assembly Design Value Lbs
1/16	3	2	4	160
1/8	3 1/4	2 1/4	4.5	300



S250R TO S250R CABLE ASSEMBLY

REFER TO NOTE 18, PAGE 4.2 FOR CABLE TENSIONING ON NON-VIBRATION ISOLATED INSTALLATIONS.

S250R CABLE TIE ASSEMBLY

CABLE BRACING TO BE INSTALLED IN A SYMETRICAL PATTERN PER B-SERIES INSTALLATION DETAILS.

A P P R O V E D
Fixed Equipment Anchorage
Office of Statewide Health Planning and Development

OPA-0485-07
Pre-approval Program Manager
Anthony R. Pike
(916) 440-8470

9/1/2011

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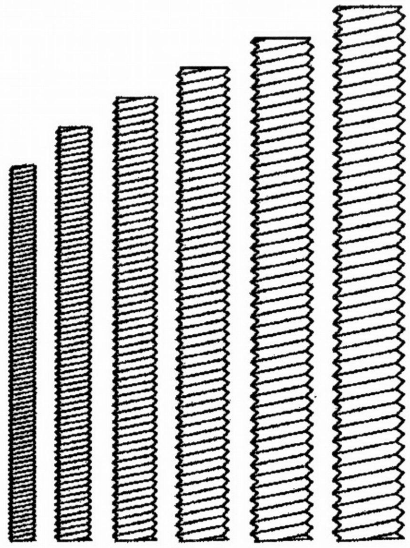

Rod Diameter Inch	Min. ASTM A36 Steel High Temperature Applications Maximum Tension Design Value Lbs	Min. ASTM A36 Steel Building Services Piping Maximum Tension Design Value Lbs
3/8	610	790
1/2	1,130	1,460
5/8	1,810	2,340
3/4	2,710	3,500
7/8	3,770	4,860
1	4,960	6,400
1-1/8	6,230	8,000
1-1/4	8,000	10,300
1-3/8	-	12,180
1-1/2	-	14,960
1-3/8	-	20,180
2	-	26,680
	ASME B31.1 Rod Temp of 650 Deg.	ASME B31.9

ALL-THREAD ROD FOR VERTICAL SUPPORTS

A P P R O V E D
Fixed Equipment Anchorage
Office of Statewide Health Planning and Development

OPA-0485-07
Pre-approval Program Manager
Anthony R. Pike
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9/1/2011

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INTERNATIONAL SEISMIC
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Appendix

ALLOWABLE SCREW SHEAR STRENGTH FOR Fu = 45 KSI (33 KSI YIELD STRENGTH) [1]										
									Ω = 3	
SCREW SIZE	SCREW DIAMETER	THICKNESS OF MEMBER IN CONTACT WITH SCREW HEAD	ALLOWABLE FASTENER STRENGTH	ALLOWABLE SHEAR STRENGTH, Pns / Ω [2] — THICKNESS OF MEMBER NOT IN CONTACT WITH SCREW HEAD						
	INCH	INCH		INCH	INCH	INCH	INCH	INCH	INCH	INCH
			Pss / Ω	0.036	0.048	0.060	0.075	0.090	0.105	0.135
			LBS.	LBS.	LBS.	LBS.	LBS.	LBS.	LBS.	LBS.
#10	0.190	0.036	405	188	277	277	277	277	277	277
		0.048	405	188	289	370	370	370	370	370
		0.060	405	188	289	403	463	463	463	463
		0.075	405	188	289	403	563	577	577	577
		0.090	405	188	289	403	563	693	693	693
		0.105	405	188	289	403	563	693	807	807
		0.135	405	188	289	403	563	693	807	1040
#12	0.216	0.036	625	200	309	315	315	315	315	315
		0.048	625	200	308	420	420	420	420	420
		0.060	625	200	308	430	523	523	523	523
		0.075	625	200	308	430	600	657	657	657
		0.090	625	200	308	430	600	787	787	787
		0.105	625	200	308	430	600	787	920	920
		0.135	625	200	308	430	600	787	920	1180
1/4 INCH	0.250	0.036	815	218	340	363	363	363	363	363
		0.048	815	218	331	467	487	487	487	487
		0.060	815	218	331	463	607	607	607	607
		0.075	815	218	331	463	647	760	760	760
		0.090	815	218	331	463	647	850	910	910
		0.105	815	218	331	463	647	850	1063	1063
		0.135	815	218	331	463	647	850	1063	1367

1. MAY BE GOVERNED BY THE ALLOWABLE SHEAR STRENGTH OF THE FASTENER. TABULATED VALUES ARE BASED ON HILTI KWIK-PRO, ESR-2196.
2. MINIMUM SPACING IS TO BE THREE TIMES THE FASTENER DIAMETER. MINIMUM EDGE DISTANCE SHALL BE 1.5 TIMES THE FASTENER DIAMETER.

SCREW SHEAR DESIGN VALUES

AISI SPECIFICATION, 2007 EDITION

ISAT

International Seismic Application Technology
14848 Northam Street, La Mirada, CA 90638
877-999-4728 (Toll Free) 714-523-0845 (fax)
www.isatsb.com

Model Law Structural Engineer
NCEES No. 20675

ALLOWABLE SCREW PULL-OUT TENSION STRENGTH FOR Fu = 45 KSI (33 KSI YIELD STRENGTH) [1]									
								Ω = 3	
SCREW SIZE	SCREW DIAMETER	ALLOWABLE FASTENER STRENGTH	ALLOWABLE PULL-OUT STRENGTH, Pnot / Ω 2						
			THICKNESS OF MEMBER NOT IN CONTACT WITH SCREW HEAD						
	INCH		INCH	INCH	INCH	INCH	INCH	INCH	INCH
		Pst / Ω	0.036	0.048	0.060	0.075	0.090	0.105	0.135
		LBS.	LBS.	LBS.	LBS.	LBS.	LBS.	LBS.	LBS.
#10-16	0.190	455	87	116	145	182	218	254	327
#12-14	0.216	775	99	126	165	207	248	289	373
1/4 INCH	0.250	1525	115	153	191	239	287	333	430

ALLOWABLE PULL-OVER TENSION STRENGTH - Fu = 45 KSI (33 KSI YIELD STRENGTH) [1]									
				HEX HEAD SCREWS				Ω [3] = 6	
SCREW SIZE	HEX HEAD DIAMETER	ALLOWABLE FASTENER STRENGTH	ALLOWABLE PULL-OVER STRENGTH, Pnov / Ω [2]						
			THICKNESS OF MEMBER IN CONTACT WITH SCREW HEAD						
	INCH		INCH	INCH	INCH	INCH	INCH	INCH	INCH
		Pst / Ω	0.036	0.048	0.060	0.075	0.090	0.105	0.135
		LBS.	LBS.	LBS.	LBS.	LBS.	LBS.	LBS.	LBS.
#10-16	0.340	455	138	183	230	287	345	402	517
#12-14	0.340	775	138	183	230	287	345	402	517
1/4 INCH	0.409	1525	166	222	277	345	413	483	622

1. MINIMUM SPACING IS TO BE THREE TIMES THE FASTENER DIAMETER. MINIMUM EDGE DISTANCE SHALL BE 1.5 TIMES THE FASTENER DIAMETER.
2. MAY BE GOVERNED BY THE ALLOWABLE TENSILE STRENGTH OF THE FASTENER. TABLE IS BASED ON HILTI KWIK-PRO, ESR-2196.
3. FOR ECCENTRICALLY LOADED CONNECTIONS THAT PRODUCE A NON-UNIFORM PULL-OVER FORCE ON THE FASTENER, THE NOMINAL PULL-OVER STRENGTH HAS BEEN TAKEN AS 50 PERCENT OF Pnov.

SCREW TENSION DESIGN VALUES

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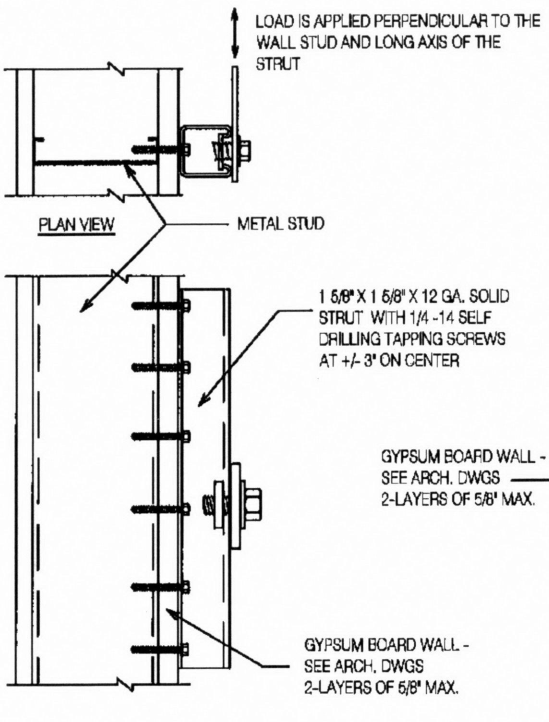
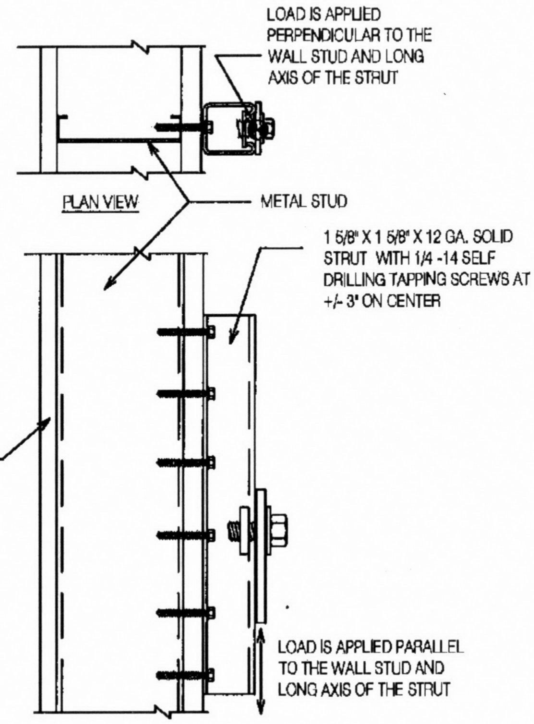


WALL ELEVATION
LOAD APPLIED PERPENDICULAR TO WALL STUD



WALL ELEVATION
LOAD APPLIED PARALLEL TO WALL STUD

ALLOWABLE SHEAR PER SCREW						
SCREW SIZE	WALL STUD THICKNESS (GAGE)	GYPSUM BOARD THICKNESS INCH	LOAD APPLIED PARALLEL LBS.	GYPSUM BOARD THICKNESS INCH	LOAD APPLIED PARALLEL LBS.	LOAD APPLIED PERPENDICULAR LBS.
#14	33 MIL (20 GA.)	5/8	150	(2) AT 5/8	110	30
	≥ 43 MIL (18 GA.)	5/8	225	(2) AT 5/8	165	45
#12	33 MIL (20 GA.)	5/8	140	(2) AT 5/8	100	25
	≥ 43 MIL (18 GA.)	5/8	210	(2) AT 5/8	150	40
#10	33 MIL (20 GA.)	5/8	130	(2) AT 5/8	90	25
	≥ 43 MIL (18 GA.)	5/8	190	(2) AT 5/8	140	40

NOTES:

1. THE PRINCIPLE OF SUPERPOSITION CAN BE USED TO COMBINE LOADS NOT PARALLEL OR PERPENDICULAR TO THE WALL SUCH A BRACE SPLAYED AT A 45° BRACE ANGLE.
2. INSPECTION SHALL INCLUDE VERIFICATION OF SCREWS BEARING AGAINST THE STRUT AND THE STRUT BEARING AGAINST THE WALL BOARD MATERIAL.

SCREW SHEAR DESIGN VALUES FOR GYPSUM WALL BOARD (BASED ON TESTING UNDER STATIC AND CYCLIC LOADING)

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Rev. 2
02/22/10

Design strength of anchors complying with the 2006 IBC and Section R301.1.3 of the 2006 IRC must be in accordance with ACI 318-05 Appendix D and this report.

Design parameters provided in Tables 3, 4, 5 and 6 of this report are based on the 2012 IBC (ACI 318-11) unless noted otherwise in Sections 4.1.1 through 4.1.12.The strength design of anchors must comply with ACI 318 D.4.1, except as required in ACI 318 D.3.3.

Strength reduction factors, ϕ, as given in ACI 318-11 D.4.3 and noted in Tables 3 and 4 of this report, must be used for load combinations calculated in accordance with Section 1605.2 of the IBC and Section 9.2 of ACI 318. Strength reduction factors, ϕ, as given in ACI 318-11 D.4.4 must be used for load combinations calculated in accordance with ACI 318 Appendix C. An example calculation in accordance with the 2012 IBC is provided in Figure 7. The value of f'_c used in the calculations must be limited to a maximum of 8,000 psi (55.2 MPa), in accordance with ACI 318-11 D.3.7.

4.1.2 Requirements for Static Steel Strength in Tension: The nominal static steel strength, N_{sa}, of a single anchor in tension must be calculated in accordance with ACI 318 D.5.1.2. The resulting N_{sa} values are provided in Tables 3 and 4 of this report. Strength reduction factors ϕ corresponding to ductile steel elements may be used.

4.1.3 Requirements for Static Concrete Breakout Strength in Tension: The nominal concrete breakout strength of a single anchor or group of anchors in tension, N_{cb} or N_{cbg}, respectively, must be calculated in accordance with ACI 318 D.5.2, with modifications as described in this section. The basic concrete breakout strength in tension, N_b, must be calculated in accordance with ACI 318 D.5.2.2, using the values of h_{ef} and k_{cr} as given in Tables 3, 4 and 6. The nominal concrete breakout strength in tension in regions where analysis indicates no cracking in accordance with ACI 318 D.5.2.6 must be calculated with k_{uncr} as given in Tables 3 and 4 and with $\Psi_{c,N}$ = 1.0.

For carbon steel KB-TZ anchors installed in the soffit of sand-lightweight or normal-weight concrete on steel deck floor and roof assemblies, as shown in Figures 5A and 5B, calculation of the concrete breakout strength is not required.

4.1.4 Requirements for Static Pullout Strength in Tension: The nominal pullout strength of a single anchor in accordance with ACI 318 D.5.3.1 and D.5.3.2 in cracked and uncracked concrete, $N_{p,cr}$ and $N_{p,uncr}$, respectively, is given in Tables 3 and 4. For all design cases $\Psi_{c,P}$ = 1.0. In accordance with ACI 318 D.5.3, the nominal pullout strength in cracked concrete may be calculated in accordance with the following equation:

$$N_{p,f'_c} = N_{p,cr}\sqrt{\frac{f'_c}{2{,}500}} \quad \text{(lb, psi)} \qquad \text{(Eq-1)}$$

$$N_{p,f'_c} = N_{p,cr}\sqrt{\frac{f'_c}{17.2}} \quad \text{(N, MPa)}$$

In regions where analysis indicates no cracking in accordance with ACI 318 D.5.3.6, the nominal pullout strength in tension may be calculated in accordance with the following equation:

$$N_{p,f'_c} = N_{p,uncr}\sqrt{\frac{f'_c}{2{,}500}} \quad \text{(lb, psi)} \qquad \text{(Eq-2)}$$

$$N_{p,f'_c} = N_{p,uncr}\sqrt{\frac{f'_c}{17.2}} \quad \text{(N, MPa)}$$

Where values for $N_{p,cr}$ or $N_{p,uncr}$ are not provided in Table 3 or Table 4, the pullout strength in tension need not be evaluated.

The nominal pullout strength in cracked concrete of the carbon steel KB-TZ installed in the soffit of sand-lightweight or normal-weight concrete on steel deck floor and roof assemblies, as shown in Figures 5A and 5B, is given in Table 5. In accordance with ACI 318 D.5.3.2, the nominal pullout strength in cracked concrete must be calculated in accordance with Eq-1, whereby the value of $N_{p,deck,cr}$ must be substituted for $N_{p,cr}$ and the value of 3,000 psi (20.7 MPa) must be substituted for the value of 2,500 psi (17.2 MPa) in the denominator. In regions where analysis indicates no cracking in accordance with ACI 318 5.3.6, the nominal strength in uncracked concrete must be calculated according to Eq-2, whereby the value of $N_{p,deck,uncr}$ must be substituted for $N_{p,uncr}$ and the value of 3,000 psi (20.7 MPa) must be substituted for the value of 2,500 psi (17.2 MPa) in the denominator. The use of stainless steel KB-TZ anchors installed in the soffit of concrete on steel deck assemblies is beyond the scope of this report.

4.1.5 Requirements for Static Steel Strength in Shear:

The nominal steel strength in shear, V_{sa}, of a single anchor in accordance with ACI 318 D.6.1.2 is given in Table 3 and Table 4 of this report and must be used in lieu of the values derived by calculation from ACI 318-11, Eq. D-29. The shear strength $V_{sa,deck}$ of the carbon-steel KB-TZ as governed by steel failure of the KB-TZ installed in the soffit of sand-lightweight or normal-weight concrete on steel deck floor and roof assemblies, as shown in Figures 5A and 5B, is given in Table 5.

4.1.6 Requirements for Static Concrete Breakout Strength in Shear: The nominal concrete breakout strength of a single anchor or group of anchors in shear, V_{cb} or V_{cbg}, respectively, must be calculated in accordance with ACI 318 D.6.2, with modifications as described in this section. The basic concrete breakout strength, V_b, must be calculated in accordance with ACI 318 D.6.2.2 based on the values provided in Tables 3 and 4. The value of ℓ_e used in ACI 318 Eq. D-24 must be taken as no greater than the lesser of h_{ef} or $8d_a$.

For carbon steel KB-TZ anchors installed in the soffit of sand-lightweight or normal-weight concrete on steel deck floor and roof assemblies, as shown in Figures 5A and 5B, calculation of the concrete breakout strength in shear is not required.

4.1.7 Requirements for Static Concrete Pryout Strength in Shear: The nominal concrete pryout strength of a single anchor or group of anchors, V_{cp} or V_{cpg}, respectively, must be calculated in accordance with ACI 318 D.6.3, modified by using the value of k_{cp} provided in Tables 3 and 4 of this report and the value of N_{cb} or N_{cbg} as calculated in Section **4**.1.3 of this report.

For carbon steel KB-TZ anchors installed in the soffit of sand-lightweight or normal-weight concrete over profile steel deck floor and roof assemblies, as shown in Figures 5A and 5B, calculation of the concrete pry-out strength in accordance with ACI 318 D.6.3 is not required.

4.1.8 Requirements for Seismic Design:

4.1.8.1 General: For load combinations including seismic, the design must be performed in accordance with ACI 318 D.3.3. For the 2012 IBC, Section 1905.1.9 shall be omitted. Modifications to ACI 318 D.3.3 shall be applied under Section 1908.1.9 of the 2009 IBC, or Section 1908.1.16 of the 2006 IBC. The nominal steel strength and the nominal concrete breakout strength for anchors in tension, and the nominal concrete breakout strength and pryout strength for anchors in shear, must be calculated in accordance with ACI 318 D.5 and D.6, respectively, taking into account the corresponding values given in Tables 3, 4 and 5 of this report. The anchors may be installed in Seismic Design Categories A through F of the IBC. The anchors comply with ACI 318 D.1 as ductile steel elements and must be designed in accordance with ACI 318-11 D.3.3.4, D.3.3.5, D.3.3.6 or D.3.3.7, ACI 318-08 D.3.3.4, D.3.3.5 or D.3.3.6, or ACI 318-05 D.3.3.4 or D.3.3.5, as applicable.

4.1.8.2 Seismic Tension: The nominal steel strength and nominal concrete breakout strength for anchors in tension must be calculated in accordance with ACI 318 D.5.1 and ACI 318 D.5.2, as described in Sections 4.1.2 and 4.1.3 of this report. In accordance with ACI 318 D.5.3.2, the appropriate pullout strength in tension for seismic loads, $N_{p,eq}$, described in Table 4 or $N_{p,deck,cr}$ described in Table 5 must be used in lieu of N_p, as applicable. The value of $N_{p,eq}$ or $N_{p,deck,cr}$ may be adjusted by calculation for concrete strength in accordance with Eq-1 and Section 4.1.4 whereby the value of $N_{p,deck,cr}$ must be substituted for $N_{p,cr}$ and the value of 3,000 psi (20.7 MPa) must be substituted for the value of 2,500 psi (17.2 MPa) in the denominator. If no values for $N_{p,eq}$ are given in Table 3 or Table 4, the static design strength values govern.

4.1.8.3 Seismic Shear: The nominal concrete breakout strength and pryout strength in shear must be calculated in accordance with ACI 318 D.6.2 and D.6.3, as described in Sections 4.1.6 and 4.1.7 of this report. In accordance with ACI 318 D.6.1.2, the appropriate value for nominal steel strength for seismic loads, $V_{sa,eq}$ described in Table 3 and Table 4 or $V_{sa,deck}$ described in Table 5 must be used in lieu of V_{sa}, as applicable.

4.1.9 Requirements for Interaction of Tensile and Shear Forces: For anchors or groups of anchors that are subject to the effects of combined tension and shear forces, the design must be performed in accordance with ACI 318 D.7.

4.1.10 Requirements for Minimum Member Thickness, Minimum Anchor Spacing and Minimum Edge Distance: In lieu of ACI 318 D.8.1 and D.8.3, values of s_{min} and c_{min} as given in Tables 3 and 4 of this report must be used. In lieu of ACI 318 D.8.5, minimum member thicknesses h_{min} as given in Tables 3 and 4 of this report must be used. Additional combinations for minimum edge distance, c_{min}, and spacing, s_{min}, may be derived by linear interpolation between the given boundary values as described in Figure 4.

For carbon steel KB-TZ anchors installed on the top of normal-weight or sand-lightweight concrete over profile steel deck floor and roof assemblies, the anchor must be installed in accordance with Table 6 and Figure 5C.

For carbon steel KB-TZ anchors installed in the soffit of sand-lightweight or normal-weight concrete over profile steel deck floor and roof assemblies, the anchors must be installed in accordance with Figure 5A or 5B and shall have an axial spacing along the flute equal to the greater of $3h_{ef}$ or 1.5 times the flute width.

4.1.11 Requirements for Critical Edge Distance: In applications where $c < c_{ac}$ and supplemental reinforcement to control splitting of the concrete is not present, the concrete breakout strength in tension for uncracked concrete, calculated in accordance with ACI 318 D.5.2, must be further multiplied by the factor $\Psi_{cp,N}$ as given by Eq-1:

$$\Psi_{cp,N} = \frac{c}{c_{ac}} \qquad \text{(Eq-3)}$$

whereby the factor $\Psi_{cp,N}$ need not be taken as less than $\frac{1.5h_{ef}}{c_{ac}}$. For all other cases, $\Psi_{cp,N}$ = 1.0. In lieu of using ACI 318 D.8.6, values of c_{ac} must comply with Table 3 or Table 4 and values of $c_{ac,deck}$ must comply with Table 6.

4.1.12 Sand-lightweight Concrete: For ACI 318-11 and 318-08, when anchors are used in sand-lightweight concrete, the modification factor λ_a or λ, respectively, for concrete breakout strength must be taken as 0.6 in lieu of ACI 318-11 D.3.6 (2012 IBC) or ACI 318-08 D.3.4 (2009 IBC). In addition the pullout strength $N_{p,cr}$, $N_{p,uncr}$ and $N_{p,eq}$ must be multiplied by 0.6, as applicable.

For ACI 318-05, the values N_b, $N_{p,cr}$, $N_{p,uncr}$, $N_{p,eq}$ and V_b determined in accordance with this report must be multiplied by 0.6, in lieu of ACI 318 D.3.4.

For carbon steel KB-TZ anchors installed in the soffit of sand-lightweight concrete-filled steel deck and floor and roof assemblies, this reduction is not required. Values are presented in Table 5 and installation details are show in Figures 5A and 5B.

4.2 Allowable Stress Design (ASD):

4.2.1 General: Design values for use with allowable stress design (working stress design) load combinations calculated in accordance with Section 1605.3 of the IBC, must be established as follows:

$$T_{allowable,ASD} = \frac{\phi N_n}{\alpha}$$

$$V_{allowable,ASD} = \frac{\phi V_n}{\alpha}$$

where:

$T_{allowable,ASD}$ = Allowable tension load (lbf or kN).

$V_{allowable,ASD}$ = Allowable shear load (lbf or kN).

ϕN_n = Lowest design strength of an anchor or anchor group in tension as determined in accordance with ACI 318 D.4.1, and 2009 IBC Section 1908.1.9 or 2006 IBC Section 1908.1.16, as applicable (lbf or N).

ϕV_n = Lowest design strength of an anchor or anchor group in shear as determined in accordance with ACI 318 D.4.1, and 2009 IBC Section 1908.1.9 or 2006 IBC Section 1908.1.16, as applicable (lbf or N).

5.15 Anchors are manufactured by Hilti AG under an approved quality control program with inspections by UL LLC (AA-668).

6.0 EVIDENCE SUBMITTED

6.1 Data in accordance with the ICC-ES Acceptance Criteria for Mechanical Anchors in Concrete Elements (AC193), dated March 2012 (ACI 355.2-07).

6.2 Quality control documentation.

7.0 IDENTIFICATION

The anchors are identified by packaging labeled with the manufacturer's name (Hilti, Inc.) and contact information, anchor name, anchor size, evaluation report number (ICC-ES ESR-1917), and the name of the inspection agency (UL LLC). The anchors have the letters KB-TZ embossed on the anchor stud and four notches embossed into the anchor head, and these are visible after installation for verification.

TABLE 1—SETTING INFORMATION (CARBON STEEL AND STAINLESS STEEL ANCHORS)

SETTING INFORMATION	Symbol	Units	Nominal anchor diameter (in.)													
			3/8			1/2				5/8				3/4		
Anchor O.D.	d_a	in.	0.375			0.5				0.625				0.75		
	(d_o)[2]	(mm)	(9.5)			(12.7)				(15.9)				(19.1)		
Nominal bit diameter	d_{bit}	in.	3/8			1/2				5/8				3/4		
Effective min. embedment	h_{ef}	in.	2			2	3-1/4			3-1/8	4			3-3/4	4-3/4	
		(mm)	(51)			(51)	(83)			(79)	(102)			(95)	(121)	
Nominal embedment	h_{nom}	in.	2-5/16			2-3/8	3-5/8			3-9/16	4-7/16			4-5/16	5-9/16	
		(mm)	(59)			(60)	(91)			(91)	(113)			(110)	(142)	
Min. hole depth	h_o	in.	2-5/8			2-5/8	4			3-3/4	4-3/4			4-1/2	5-3/4	
		(mm)	(67)			(67)	(102)			(95)	(121)			(114)	(146)	
Min. thickness of fastened part[1]	t_{min}	in.	1/4			3/4	1/4			3/8	3/4			1/8	1 5/8	
		(mm)	(6)			(19)	(6)			(9)	(19)			(3)	(41)	
Required Installation torque	T_{inst}	ft-lb	25			40				60				110		
		(Nm)	(34)			(54)				(81)				(149)		
Min. dia. of hole in fastened part	d_h	in.	7/16			9/16				11/16				13/16		
		(mm)	(11.1)			(14.3)				(17.5)				(20.6)		
Standard anchor lengths	ℓ_{anch}	in.	3	3-3/4	5	3-3/4	4-1/2	5-1/2	7	4-3/4	6	8-1/2	10	5-1/2	8	10
		(mm)	(76)	(95)	(127)	(95)	(114)	(140)	(178)	(121)	(152)	(216)	(254)	(140)	(203)	(254)
Threaded length (incl. dog point)	ℓ_{thread}	in.	7/8	1-5/8	2-7/8	1-5/8	2-3/8	3-3/8	4-7/8	1-1/2	2-3/4	5-1/4	6-3/4	1-1/2	4	6
		(mm)	(22)	(41)	(73)	(41)	(60)	(86)	(124)	(38)	(70)	(133)	(171)	(38)	(102)	(152)
Unthreaded length	ℓ_{unthr}	in.	2-1/8			2-1/8				3-1/4				4		
		(mm)	(54)			(54)				(83)				(102)		

[1]The minimum thickness of the fastened part is based on use of the anchor at minimum embedment and is controlled by the length of thread. If a thinner fastening thickness is required, increase the anchor embedment to suit.
[2]The notation in parenthesis is for the 2006 IBC.

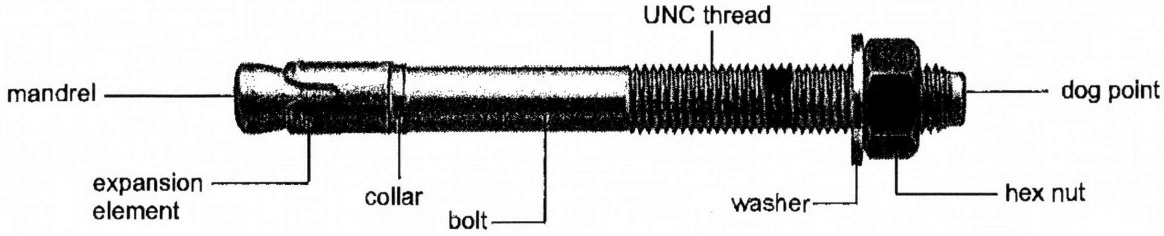


FIGURE 1—HILTI CARBON STEEL KWIK BOLT TZ (KB-TZ)

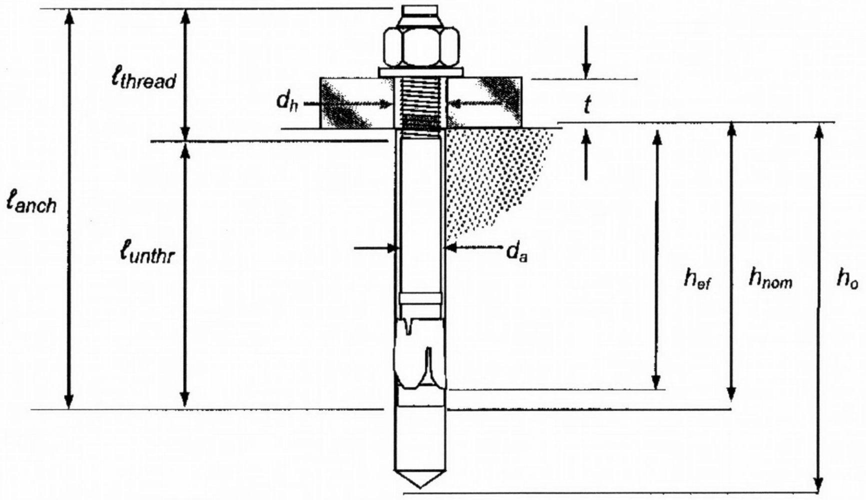


FIGURE 2—KB-TZ INSTALLED

TABLE 2—LENGTH IDENTIFICATION SYSTEM (CARBON STEEL AND STAINLESS STEEL ANCHORS)

Length ID marking on bolt head		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
Length of anchor, ℓ_{anch} (inches)	From	1 ½	2	2 ½	3	3 ½	4	4 ½	5	5 ½	6	6 ½	7	7 ½	8	8 ½	9	9 ½	10	11	12	13	14	15
	Up to but not including	2	2 ½	3	3 ½	4	4 ½	5	5 ½	6	6 ½	7	7 ½	8	8 ½	9	9 ½	10	11	12	13	14	15	16

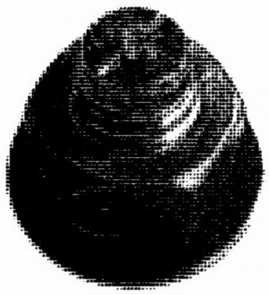


FIGURE 3—BOLT HEAD WITH LENGTH IDENTIFICATION CODE AND KB-TZ HEAD NOTCH EMBOSSMENT

TABLE 3—DESIGN INFORMATION, CARBON STEEL KB-TZ

DESIGN INFORMATION	Symbol	Units	Nominal anchor diameter											
			3/8		1/2				5/8			3/4		
Anchor O.D.	$d_a (d_o)$	in. (mm)	0.375 (9.5)		0.5 (12.7)				0.625 (15.9)			0.75 (19.1)		
Effective min. embedment[1]	h_{ef}	in. (mm)	2 (51)		2 (51)		3-1/4 (83)		3-1/8 (79)	4 (102)		3-3/4 (95)		4-3/4 (121)
Min. member thickness[2]	h_{min}	in. (mm)	4 (102)	5 (127)	4 (102)	6 (152)	6 (152)	8 (203)	5 (127)	6 (152)	8 (203)	6 (152)	8 (203)	8 (203)
Critical edge distance	c_{ac}	in. (mm)	4-3/8 (111)	4 (102)	5-1/2 (140)	4-1/2 (114)	7-1/2 (191)	6 (152)	6-1/2 (165)	8-3/4 (222)	6-3/4 (171)	10 (254)	8 (203)	9 (229)
Min. edge distance	c_{min}	in. (mm)	2-1/2 (64)		2-3/4 (70)		2-3/8 (60)		3-5/8 (92)	3-1/4 (83)		4-3/4 (121)		4-1/8 (105)
	for s ≥	in. (mm)	5 (127)		5-3/4 (146)		5-3/4 (146)		6-1/8 (156)	5-7/8 (149)		10-1/2 (267)		8-7/8 (225)
Min. anchor spacing	s_{min}	in. (mm)	2-1/2 (64)		2-3/4 (70)		2-3/8 (60)		3-1/2 (89)	3 (76)		5 (127)		4 (102)
	for c ≥	in. (mm)	3-5/8 (92)		4-1/8 (105)		3-1/2 (89)		4-3/4 (121)	4-1/4 (108)		9-1/2 (241)		7-3/4 (197)
Min. hole depth in concrete	h_o	in. (mm)	2-5/8 (67)		2-5/8 (67)		4 (102)		3-3/4 (98)	4-3/4 (121)		4-1/2 (117)		5-3/4 (146)
Min. specified yield strength	f_y	lb/in² (N/mm²)	100,000 (690)		84,800 (585)				84,800 (585)			84,800 (585)		
Min. specified ult. strength	f_{uta}	lb/in² (N/mm²)	125,000 (862)		106,000 (731)				106,000 (731)			106,000 (731)		
Effective tensile stress area	$A_{se,N}$	in² (mm²)	0.052 (33.6)		0.101 (65.0)				0.162 (104.6)			0.237 (152.8)		
Steel strength in tension	N_{sa}	lb (kN)	6,500 (28.9)		10,705 (47.6)				17,170 (76.4)			25,120 (111.8)		
Steel strength in shear	V_{sa}	lb (kN)	3,595 (16.0)		5,495 (24.4)				8,090 (36.0)			13,675 (60.8)		
Steel strength in shear, seismic[3]	$V_{sa,eq}$	lb (kN)	2,255 (10.0)		5,495 (24.4)				7,600 (33.8)			11,745 (52.2)		
Pullout strength uncracked concrete[4]	$N_{p,uncr}$	lb (kN)	2,515 (11.2)		NA		5,515 (24.5)		NA	9,145 (40.7)		8,280 (36.8)		10,680 (47.5)
Pullout strength cracked concrete[4]	$N_{p,cr}$	lb (kN)	2,270 (10.1)		NA		4,915 (21.9)		NA	NA		NA		NA
Anchor category[5]			1											
Effectiveness factor k_{uncr} uncracked concrete			24											
Effectiveness factor k_{cr} cracked concrete[6]			17											
$\Psi_{c,N} = k_{uncr}/k_{cr}$ [7]			1.0											
Coefficient for pryout strength, k_{cp}			1.0				2.0							
Strength reduction factor ϕ for tension, steel failure modes[8]			0.75											
Strength reduction factor ϕ for shear, steel failure modes[8]			0.65											
Strength reduction ϕ factor for tension, concrete failure modes or pullout, Condition B[9]			0.65											
Strength reduction ϕ factor for shear, concrete failure modes, Condition B[9]			0.70											
Axial stiffness in service load range[10]	β_{uncr}	lb/in.	700,000											
	β_{cr}	lb/in.	500,000											

For **SI:** 1 inch = 25.4 mm, 1 lbf = 4.45 N, 1 psi = 0.006895 MPa. For pound-inch units: 1 mm = 0.03937 inches.

[1]See Fig. 2.
[2]For sand-lightweight concrete over metal deck, see Figures 5A, 5B and 5C and Table 6.
[3]See Section 4.1.8 of this report.
[4]For all design cases $\Psi_{c,P}$ =1.0. NA (not applicable) denotes that this value does not control for design. See Section 4.1.4 of this report.
[5]See ACI 318-11 D.4.3.
[6]See ACI 318 D.5.2.2.
[7]For all design cases $\Psi_{c,N}$ =1.0. The appropriate effectiveness factor for cracked concrete (k_{cr}) or uncracked concrete (k_{uncr}) must be used.
[8]The KB-TZ is a ductile steel element as defined by ACI 318 D.1.
[9]For use with the load combinations of ACI 318 Section 9.2. Condition B applies where supplementary reinforcement in conformance with ACI 318-11 D.4.3 is not provided, or where pullout or pryout strength governs. For cases where the presence of supplementary reinforcement can be verified, the strength reduction factors associated with Condition **A** may be used.
[10]Mean values shown, actual stiffness may vary considerably depending on concrete strength, loading and geometry of application.

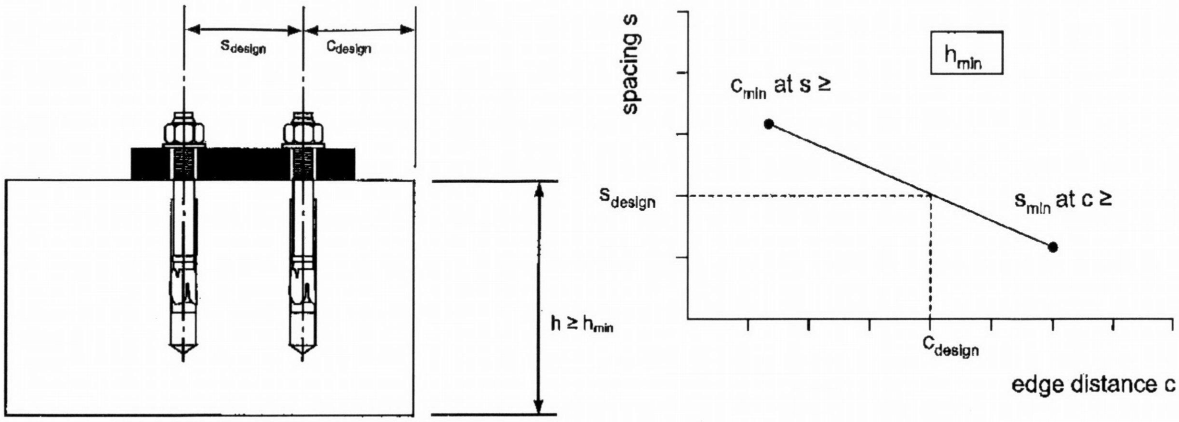


FIGURE 4—INTERPOLATION OF MINIMUM EDGE DISTANCE AND ANCHOR SPACING

TABLE 5—HILTI KWIK BOLT TZ (KB-TZ) CARBON STEEL ANCHORS TENSION AND SHEAR DESIGN DATA FOR INSTALLATION IN THE UNDERSIDE OF CONCRETE-FILLED PROFILE STEEL DECK ASSEMBLIES[1,6,7,8]

DESIGN INFORMATION	Symbol	Units	Loads According to Figure 5A					Loads According to Figure 5B			
			Anchor Diameter					Anchor Diameter			
			3/8	1/2		5/8		3/8	1/2		5/8
Effective Embedment Depth	h_{ef}	in.	2	2	3-1/4	3-1/8	4	2	2	3-1/4	3-1/8
Minimum Hole Depth	h_o	in.	2-5/8	2-5/8	4	3-3/4	4-3/4	2-5/8	2-5/8	4	3-3/4
Pullout Resistance, (uncracked concrete)[2]	$N_{p,deck,uncr}$	lb.	2,060	2,060	3,695	2,825	6,555	1,845	1,865	3,375	4,065
Pullout Resistance (cracked concrete)[3]	$N_{p,deck,cr}$	lb.	1,460	1,460	2,620	2,000	4,645	1,660	1,325	3,005	2,885
Steel Strength in Shear[4]	$V_{sa,deck}$	lb.	2,130	3,000	4,945	4,600	6,040	2,845	2,585	3,945	4,705
Steel Strength in Shear, Seismic[5]	$V_{sa,deck,eq}$	lb.	1,340	3,000	4,945	4,320	5,675	1,790	2,585	3,945	4,420

[1]Installation must comply with Sections 4.1.10 and 4.3 and Figure 5A and 5B of this report.
[2]The values listed must be used in accordance with Section 4.1.4 of this report.
[3]The values listed must be used in accordance with Section 4.1.4 and 4.1.8.2 of this report.
[4]The values listed must be used in accordance with Section 4.1.5 of this report.
[5]The values listed must be used in accordance with 4.1.8.3 of this report. Values are applicable to both static and seismic load combinations.
[6]The values for ϕ_p in tension and the values for ϕ_{sa} in shear can be found in Table 3 of this report.
[7]The characteristic pullout resistance for concrete compressive strengths greater than 3,000 psi may be increased by multiplying the value in the table by $(f'_c/3,000)^{1/2}$ for psi or $(f'_c/20.7)^{1/2}$ for MPa.
[8]Evaluation of concrete breakout capacity in accordance with ACI 318 D.5.2, D.6.2, and D.6.3 is not required for anchors installed in the deck soffit.

TABLE 6—HILTI KWIK BOLT TZ (KB-TZ) CARBON STEEL ANCHORS SETTING INFORMATION FOR INSTALLATION ON THE TOP OF CONCRETE-FILLED PROFILE STEEL DECK ASSEMBLIES ACCORDING TO FIGURE 5C[1,2,3,4]

DESIGN INFORMATION	Symbol	Units	Nominal anchor diameter	
			3/8	1/2
Effective Embedment Depth	h_{ef}	in.	2	2
Minimum concrete thickness[5]	$h_{min,deck}$	in.	3-1/4	3-1/4
Critical edge distance	$c_{ac,deck,top}$	in.	9	9
Minimum edge distance	$c_{min,deck,top}$	in.	3	4-1/2
Minimum spacing	$s_{min,deck,top}$	in.	4	6-1/2

[1]Installation must comply with Sections 4.1.10 and 4.3 and Figure 5C of this report.
[2]For all other anchor diameters and embedment depths refer to Table 3 and 4 for applicable values of h_{min}, c_{min}, and s_{min}.
[3]Design capacity shall be based on calculations according to values in Table 3 and 4 of this report.
[4]Applicable for $3^1/_4$-in $\leq h_{min,deck} <$ 4-in. For $h_{min,deck} \geq$ 4-inch use setting information in Table 3 of this report.
[5]Minimum concrete thickness refers to concrete thickness above upper flute. See Figure 5C.

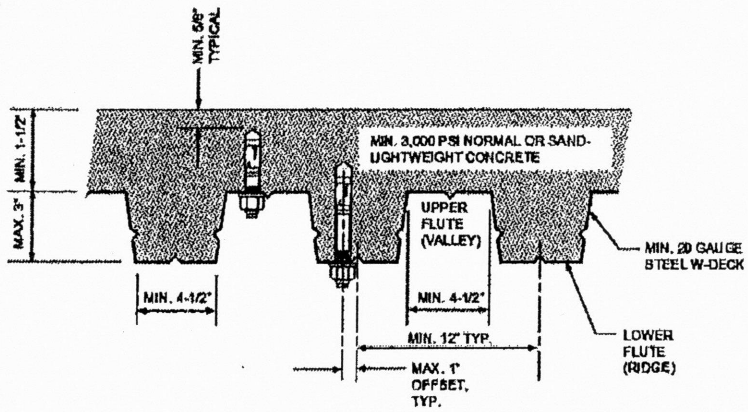


FIGURE 5A—INSTALLATION IN THE SOFFIT OF CONCRETE OVER METAL DECK FLOOR AND ROOF ASSEMBLIES[1]

[1]Anchors may be placed in the upper or lower flute of the steel deck profile provided the minimum hole clearance is satisfied. Anchors in the lower flute may be installed with a maximum 1-inch offset in either direction from the center of the flute.

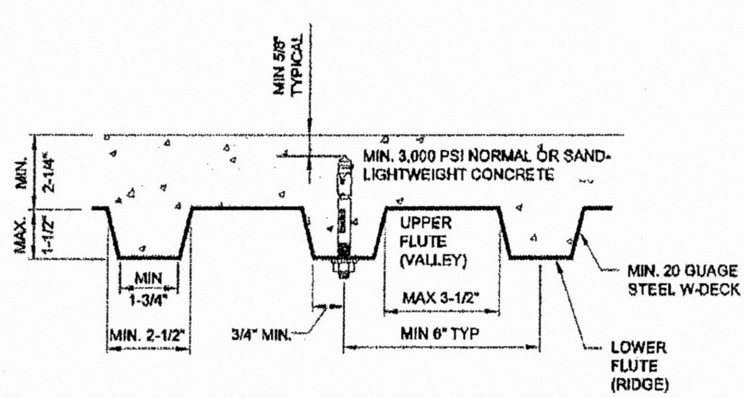


FIGURE 5B—INSTALLATION IN THE SOFFIT OF CONCRETE OVER METAL DECK FLOOR AND ROOF ASSEMBLIES – B DECK[1,2]

[1]Anchors may be placed in the upper or lower flute of the steel deck profile provided the minimum hole clearance is satisfied. Anchors in the lower flute may be installed with a maximum $^1/_8$-inch offset in either direction from the center of the flute. The offset distance may be increased proportionally for profiles with lower flute widths greater than those shown provided the minimum lower flute edge distance is also satisfied.
[2]Anchors may be placed in the upper flute of the steel deck profiles in accordance with Figure 5B provided the concrete thickness above the upper flute is minimum $3^1/_4$-inch and the minimum hole clearance of $^5/_8$-inch is satisfied.

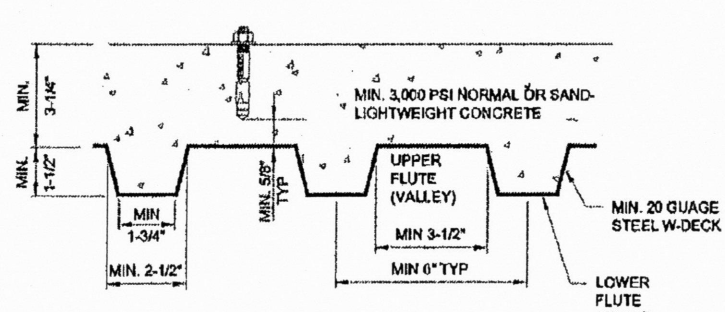


FIGURE 5C—INSTALLATION ON THE TOP OF CONCRETE OVER METAL DECK FLOOR AND ROOF ASSEMBLIES[1,2]

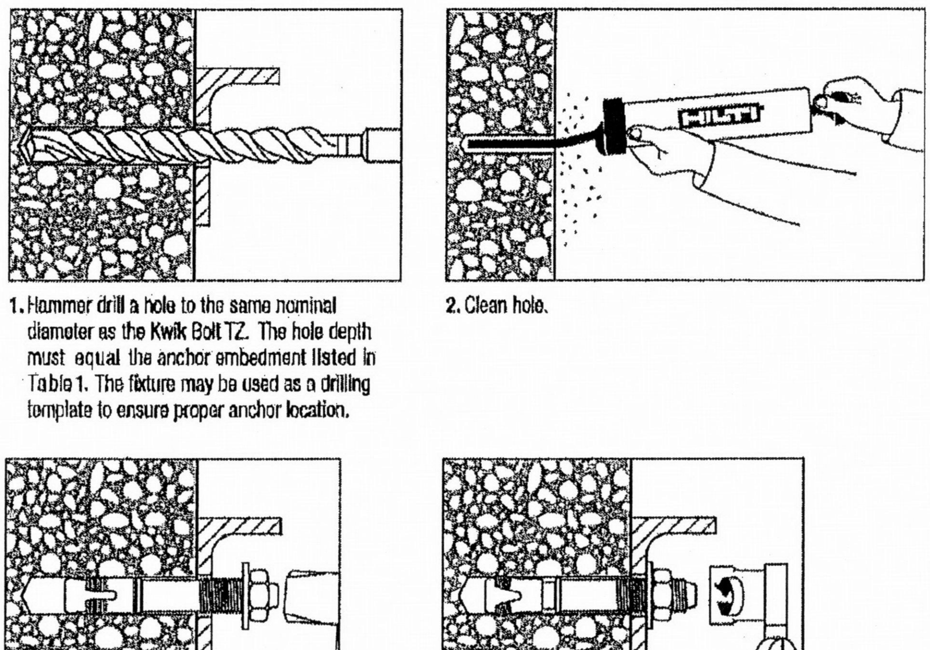
[1]Refer to Table 6 for setting information for anchors in to the top of concrete over metal deck.
[2]Applicable for 3-1/4-in ≤ h_{min} < 4-in. For h_{min} ≥ 4-inch use setting information in Table 3 of this report.

TABLE 7—EXAMPLE ALLOWABLE STRESS DESIGN VALUES FOR ILLUSTRATIVE PURPOSES

Nominal Anchor diameter (in.)	Embedment depth (in.)	Allowable tension (lbf)	
		Carbon Steel	Stainless Steel
		f'c = 2500 psi	
		Carbon Steel	Stainless Steel
3/8	2	1105	1155
1/2	2	1490	1260
	3-1/4	2420	2530
5/8	3-1/8	2910	2910
	4	4015	4215
3/4	3-3/4	3635	3825
	4-3/4	4690	5290

For SI: 1 lbf = 4.45 N, 1 psi = 0.00689 MPa 1 psi = 0.00689 MPa. 1 inch = 25.4 mm.

[1]Single anchors with static tension load only.
[2]Concrete determined to remain uncracked for the life of the anchorage.
[3]Load combinations from ACI 318 Section 9.2 (no seismic loading).
[4]30% dead load and 70% live load, controlling load combination 1.2D + 1.6 L.
[5]Calculation of the weighted average for $\alpha = 0.3*1.2 + 0.7*1.6 = 1.48$.
[6]f'_c = 2,500 psi (normal weight concrete).
[7]$c_{a1} = c_{a2} \geq c_{ac}$
[8]$h \geq h_{min}$
[9]Values are for Condition B where supplementary reinforcement in accordance with ACI 318-11 D.4.3 is not provided



1. Hammer drill a hole to the same nominal diameter as the Kwik Bolt TZ. The hole depth must equal the anchor embedment listed in Table 1. The fixture may be used as a drilling template to ensure proper anchor location.

2. Clean hole.

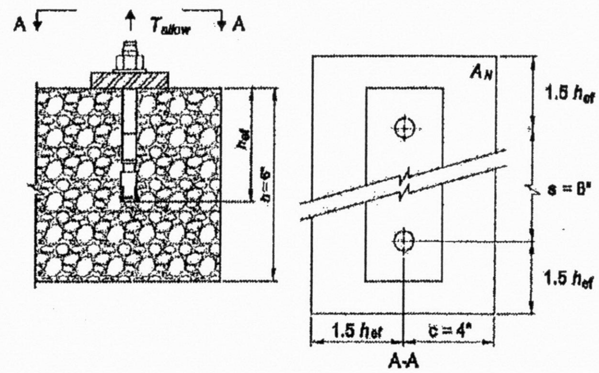
3. Drive the Kwik Bolt TZ into the hole using a hammer. The anchor must be driven until the nominal embedment is achieved.

4. Tighten the nut to the required installation torque.

FIGURE 6—INSTALLATION INSTRUCTIONS

Given:
Two 1/2-inch carbon steel KB-TZ anchors under static tension load as shown.
h_{ef} = 3.25 in.
Normal weight concrete, f'_c = 3,000 psi
No supplementary reinforcement (Condition B per ACI 318-11 D.4.3 c)
Assume cracked concrete since no other information is available.

Needed: Using Allowable Stress Design (ASD) calculate the allowable tension load for this configuration.



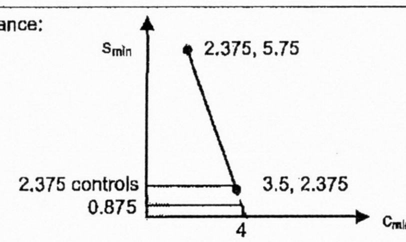
Calculation per ACI 318-11 Appendix D and this report.	Code Ref.	Report Ref.
Step 1. Calculate steel capacity: $\phi N_s = \phi n A_{se} f_{ut} = 0.75 \times 2 \times 0.101 \times 106{,}000 = 16{,}059 \text{lb}$ Check whether f_{uta} is not greater than $1.9f_{ya}$ and 125,000 psi.	D.5.1.2 D.4.3 a	§4.1.2 Table 3
Step 2. Calculate concrete breakout strength of anchor in tension: $N_{cbg} = \frac{A_{Nc}}{A_{Nco}} \psi_{ec,N} \psi_{ed,N} \psi_{c,N} \psi_{cp,N} N_b$	D.5.2.1	§ 4.1.3
Step 2a. Verify minimum member thickness, spacing and edge distance: h_{min} = 6 in. ≤ 6 in. ∴ ok slope = $\frac{2.375 - 5.75}{3.5 - 2.375}$ = -3.0 For $c_{min} = 4 \text{in} \Rightarrow$ $s_{min} = 5.75 - [(2.375 - 4.0)(-3.0)] = 0.875 < 2.375 \text{in} < 6 \text{in} \therefore$ ok  	D.8	Table 3 Fig. 4
Step 2b. For A_N check $1.5h_{ef} = 1.5(3.25) = 4.88 \text{ in} > c$ $\quad 3.0h_{ef} = 3(3.25) = 9.75 \text{ in} > s$	D.5.2.1	Table 3
Step 2c. Calculate A_{Nco} and A_{Nc} for the anchorage: $A_{Nco} = 9h_{ef}^2 = 9 \times (3.25)^2 = 95.1 in.^2$ $A_{Nc} = (1.5h_{ef} + c)(3h_{ef} + s) = [1.5 \times (3.25) + 4][3 \times (3.25) + 6] = 139.8 in.^2 < 2A_{Nco} \therefore ok$	D.5.2.1	Table 3
Step 2d. Determine $\psi_{ec,N}$: $e'_N = 0 \therefore \psi_{ec,N} = 1.0$	D.5.2.4	-
Step 2e. Calculate N_b: $N_b = k_{cr} \lambda_a \sqrt{f'_c} h_{ef}^{1.5} = 17 \times 1.0 \times \sqrt{3{,}000} \times 3.25^{1.5} = 5{,}456 \ lb$	D.5.2.2	Table 3
Step 2f. Calculate modification factor for edge distance: $\psi_{ed,N} = 0.7 + 0.3 \frac{4}{1.5(3.25)} = 0.95$	D.5.2.5	Table 3
Step 2g. Calculate modification factor for cracked concrete: $\psi_{c,N}$ =1.00 (cracked concrete)	D.5.2.6	Table 3
Step 2h. Calculate modification factor for splitting: $\psi_{cp,N}$ =1.00 (cracked concrete)	-	§ 4.1.10 Table 3
Step 2i. Calculate ϕN_{cbg} : $\phi N_{cbg} = 0.65 \times \frac{139.8}{95.1} \times 1.00 \times 0.95 \times 1.00 \times 5{,}456 = 4{,}952$ lb	D.5.2.1 D.4.3 c)	§ 4.1.3 Table 3
Step 3. Check pullout strength: Table 3, $\phi n N_{pn,f'c} = 0.65 \times 2 \times 5{,}515 \text{ lb} \times \sqrt{\frac{3{,}000}{2{,}500}} = 7{,}852 \text{ lb} > 4{,}952 \therefore$ OK	D.5.3.2 D.4.3 c)	§ 4.1.4 Table 3
Step 4. Controlling strength: $\phi N_{cbg} = 4{,}952 \text{ lb} < \phi n N_{pn} < \phi N_s \therefore \phi N_{cbg}$ controls	D.4.1.2	Table 3
Step 5. To convert to ASD, assume U = 1.2D + 1.6L: $T_{allow} = \frac{4{,}952}{1.48} = 3{,}346$ lb.	-	§ 4.2

FIGURE 7—EXAMPLE CALCULATION

SECTION 230548 - VIBRATION AND SEISMIC CONTROLS FOR MECHANICAL PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. This Section includes vibration isolators, vibration isolation bases, vibration isolation roof curbs.
2. This Section includes seismic restraint requirements for suspended pipes, ducts, and mechanical equipment with and without vibration isolation.

1.3 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

C. OSHPD: Office of Statewide Health Planning and Development for the State of California.

D. SEI/ASCE 7: American Society of Civil Engineers; Minimum Design Loads for Buildings and Other Structures.

1.4 PERFORMANCE REQUIREMENTS

A. Design seismic and vibration isolation systems, including drawings, calculations, and material specifications prepared according to current IBC and SEI/ASCE 7 (2005) for obtaining approval from authorities having jurisdiction. Seismic and vibration systems shall be selected for the approved Project equipment, piping and ductwork components.

B. Wind-Restraint Loading:

1. Basic Wind Speed: 100 MPH.
2. Minimum 10 lb/sq. ft.multiplied by the maximum area of the HVAC component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

C. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC: D.
2. Assigned Seismic Use Group as Defined in the IBC: III.

   a. For Seismic Use Group III: us the following:

1) Component Importance Factor: 1.5 for all life safety systems and equipments required to function after an earthquake and all systems, and equipment, needed for continued operation of the facility or whose failure could impair the continued operation of the facility.

3. Component Response Modification Factor (Rp) and Component Amplification Factor (Ap): From SEI/ASCE 7 (2005), Table 13.6-1, Seismic Coefficients for Mechanical and Electrical Components.
4. Seismic Design Category: A.

D. Reports and Certificates: Equipment manufacturers, provide submittals of the following:

1. Mechanical Seismic Qualification Certificates: For all required equipment specified in Divisions 21, 22, and 23, accessories, and components from manufacturer.

a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

1) For Seismic User Group III: The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

2. Field quality-control reports.

1.5 SUBMITTALS

A. General: See Section 230500 for general requirements of Product Data, Shop Drawings, Reports and Certificates, and Operation and Maintenance data submittals.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by OSHPD.
b. Annotate to indicate application of each product submitted and compliance with requirements.

3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Product Data: Provide submittals of the following:

1. Vibration isolators.
2. Anchor Bolts, Washers, and Bushings
3. Restrained Vibration Isolation Roof Curb Rails.
4. Seismic Restraint Devices
5. Vibration Isolation Equipment Bases.

1.6 QUALITY ASSURANCE

A. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in the jurisdiction where the Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of vibration isolation bases and seismic restraints that are similar to those indicated for this Project in material, design, and extent. This professional engineer shall develop a Quality Assurance Plan.

B. Testing Agency Qualifications (Owner will engage): An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

C. Comply with seismic-restraint requirements in the Oregon Structural Specialty Code unless requirements in this Section are more stringent.

D. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

E. Any device that provides seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, showing maximum seismic-restraint ratings. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

1.7 FIELD QUALITY CONTROL

A. Provide a Quality Assurance Plan that complies with SEI/ASCE 7, Appendix 11A for the following mechanical systems or equipment.

1. Flammable, combustible, or highly toxic piping systems and their associated mechanical units in Seismic Design Categories C, D, E, or F.
2. Installation of HVAC ductwork that will contain hazardous materials in Seismic Design Categories C, D, E, or F.
3. Installation of vibration isolation systems where the maximum clearance (air gap) between the equipment support frame and restraint is less than or equal to 1/4-inch.
4. Installation of seismic restraint systems for Seismic Use Group II and III.

B. The Contractor shall submit a written Contractor's statement of responsibility to the regulatory authority having jurisdiction and the Owner prior to the commencement of work. The Contractor's statement of responsibility shall contain the following:

1. Acknowledgement of awareness of the special requirements contained in the Quality Assurance Plan.
2. Acknowledgement that control will be exercised to obtain conformance with the design documents approved by the authority having jurisdiction.
3. Procedure for exercising control within the Contractor's organization, the method and frequency of reporting, and the distribution of the reports.
4. Identification and qualifications of the person exercising such control and their position in the organization.

C. The Owner shall employ a special inspector to observe the construction of all seismic systems in accordance with the Quality Assurance Plan.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Vibration Isolation: Subject to compliance with requirements, provide products by the manufacturers specified.

1. Amber/Booth Company, Inc.
2. Kinetics Noise Control, Inc.
3. Korfund/Vibration Mountings and Controls, Inc.
4. Mason Industries, Inc.

B. Seismic Restraint for Suspended Elements: Subject to compliance with requirements, provide products by the manufacturers specified.

1. International Seismic Application Technology (ISAT).
2. Kinetics Noise Control, Inc.
3. Korfund/Vibration Mountings and Controls, Inc.
4. Mason Industries, Inc.Tolco.

2.2 VIBRATION ISOLATORS

A. Type V-1, Elastomeric Isolator Pads: Oil- and water-resistant neoprene or natural rubber, molded with a nonslip, ribbed or waffle-pattern steel load distribution plates of sufficient stiffness for uniform loading over pad area, factory cut to sizes that match requirements of supported equipment.

1. Basis of Design: Mason Models W and WM.
2. Material: Standard neoprene.
3. Durometer Rating: 40.
4. Thickness: 5/16 inch thick.
5. Isolator shall be loaded to limit surface pressure to a maximum of 50 psi.

B. Type V-2, Elastomeric Isolator Pads: Oil- and water-resistant neoprene or natural rubbermolded with a nonslip, ribbed or waffle-pattern steel load distribution plates of sufficient stiffness for uniform loading over pad area factory cut to sizes that match requirements of supported equipment.

1. Basis of Design: Mason Model Super W and Super WM.
2. Material: Standard neoprene.
3. Durometer Rating: 50.
4. Thickness: 3/4-inch thick.
5. Isolator shall be loaded to limit surface pressure to a maximum of 50 psi.

C. Type V-3, Elastomeric Mounts: Double-deflection type, with molded, oil-resistant rubber or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.

1. Basis of Design: Mason Model ND.
2. Durometer Rating: 40 to 50, unless a higher or lower rating is necessary to meet the load and deflection requirements.

D. Type V-4, Restrained Elastomeric Mounts: All-directional elastomeric mountings with seismic restraint. Color-code to identify capacity range.

1. Basis of Design: Mason Models RBA and RCA.
2. Materials: Steel housing containing two separate and opposing, molded, bridge-bearing neoprene elements that prevent central threaded sleeve and attachment bolt from contacting the casting during normal operation.
3. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO, M251.
4. Durometer Rating: 30 to 60, as required to meet load requirements.

E. Type V-5, Spring Isolators: Freestanding, laterally stable, open-spring isolators.

1. Basis of Design: Mason Model SLF or SLFH.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- thick, neoprene isolator pad attached to baseplate underside. Baseplates shall limit floor load to 100 psi. Provide resilient isolation washers and bushings at baseplate anchor bolts.
7. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

F. Type V-6, Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.

1. Basis of Design: Mason Model SLR/SLRS.
2. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

G. Type V-7, Housed Spring Mounts: Housed spring isolator with integral seismic snubbers.

1. Basis of Design: Mason Model SSLFH.
2. Housing: Steel housing to provide all-directional seismic restraint.
3. Base: Factory drilled for bolting to structure with 1/4-inch thick neoprene pad attached to baseplate.
4. Snubbers: Vertically adjustable to allow a maximum of 1/4-inch travel before contacting a resilient collar. Snubbing in all modes with adjustment to limit upward, downward, and horizontal travel to a maximum rating of 1.0g.
5. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
6. Minimum Additional Travel: 50 percent of the required deflection at rated load.
7. Isolator to be equipped with leveling bolts that must be rigidly bolted to the equipment with height-saving brackets.
8. Isolator to be installed with neoprene washers and bushings at baseplate anchor bolts.

H. Type V-8, Elastomeric Hangers: Double-deflection type, with molded, oil-resistant rubber or neoprene isolator elements with steel housings for hanger rods. Molded element shall include a neoprene bushing to prevent rod from contacting the hanger box. Color-code or otherwise identify to indicate capacity range.

1. Basis of Design: Mason Model HD.
2. Durometer Rating: 40 to 50, unless a higher or lower rating is necessary to meet the load and deflection requirements.

I. Type V-9, Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.

1. Basis of Design: Mason Model 30N.
2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Elements: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

J. Type V-10, Spring Hangers with Vertical-Limit Stop: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop and deflection scale.

1. Basis of Design: Mason Model PC30N.
2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Elements: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
7. Adjustable Vertical Stop: Steel washer encapsulated in a molded neoprene rebound washer on lower threaded rod.
8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

K. Type TR-1, Thrust Restraint: Combination coil spring and elastomeric insert with spring and insert in compression and with a load stop. Include rod and angle-iron brackets for attaching to equipment.

1. Basis of Design: Mason Models WBI and WBD.
2. Frame: Steel, fabricated for connection to threaded rods.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

L. Pipe Riser Resilient Support: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch- thick, 60 durometer neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psi and for equal resistance in all directions.

1. Basis of Design: Mason Model ADA.

M. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes separated by a minimum of 1/2-inch-thick, 60-durometer neoprene. Factory set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

1. Basis of Design: Mason Model VSG.

2.3 ANCHOR BOLTS, WASHERS, AND BUSHINGS

A. Resilient Isolation Washers and Bushings: 1-piece, molded, bridge-bearing neoprene complying with AASHTO M 251 and having a durometer rating of 50 with a flat washer face.

1. Basis of Design: Mason Model HG.
2. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.
3. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

B. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

1. Basis of Design: Hilti Kwik Bolt TZ Mechanical Anchor for seismic restraints.
2. Basis of Design: Hilti Undercut HDA anchors for direct attachment to equipment 10 hp and greater.

2.4 SEISMIC-RESTRAINT DEVICES

A. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in OSHPD pre-approval.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

B. Type S-1, Seismic Snubbers: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Basis of Design: Mason Model Z-1011.
2. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and female-wedge or stud-wedge type.
3. Resilient Isolation Washers and Bushings: 1-piece, molded, bridge-bearing neoprene complying with AASHTO M 251 and having a durometer rating of 50.

C. Type S-2, Suspended Elements:

1. Design Requirements: Seismic restraint hardware to be furnished in manufacturer's pre-assembled "kits" labeled for installer cross reference with manufacturer's layout performed on

contractor shop drawings. Kits to be labeled as to "kit number," "trade" and "floor." Kits to include:

a. All required seismic bracketry correctly sized for attachment to vertical support rods.
b. Rod stiffeners as required based on rod diameter and length.
c. Correct anchorage hardware for connection to concrete deck, structural steel, or wood structural members.
d. Complete installation instructions.

2. Rigid seismic restraint brace arm assemblies: Designed for strut nut attachment to minimum 12 gage steel channel with pregalvanized zinc finish per ASTM A525, solid, punched or short slot per engineering calculations.

a. Basis of Design: Pre-engineered brackets with OSHPD pre-approval. Hinged seismic brackets.
b. Assembly: Brackets to be provided from manufacturer with integral 1/2" hex bolts and strut nuts.

3. Cable seismic restraint brace arm assemblies: Minimum 7 x 19 pre-stretched galvanized steel aircraft cable appropriately sized for the system load.

a. Basis of Design: Pre engineered brackets with OSHPD pre-approval.
b. Design Requirements: Hinged seismic brackets.
c. Assembly: Brackets factory pre-tied to made-to-length aircraft cable, with integral method for length adjustment by installer.

4. Cast-In Place Deck Inserts: For vertical supports and seismic restraint anchorage.

a. Basis of Design: Pre-engineered inserts with OSHPD pre-approval.
b. Design Requirements: For form pour slabs, for metal decks with concrete, internally threaded to accept threaded rod diameters, with an OSHPD approval or other enforcement agency approval. Coordinate installation locations with manufacturer's lay out of seismic restraint locations on contractor's shop drawings.

2.5 VIBRATION ISOLATION EQUIPMENT BASES

A. Type B-1, Steel Base: Factory-fabricated, welded, structural-steel bases with pre-drilled anchor bolt holes.

1. Basis of Design: Mason Model WF.
2. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails. Bases shall be sized to accommodate supports for suction and discharge elbows.
3. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
4. Height Saving Brackets: Factory-welded steel L brackets on frame for outrigger isolation mountings.
5. Frame to be manufactured of beams or channels of minimum section depth equal to 10-percent of the longest span between support isolators, as indicated on the drawings.
6. Frame to provide a rigid, distortion free mounting base for supported equipment, which allows no excessive differential motion between driving or driven equipment components.
7. Isolation materials manufacturer to coordinate the isolator locations for each piece of equipment as required.

B. Type B-2, Inertia Base: Factory-fabricated, bolted steel bases ready for field-applied, cast-in-place concrete.

1. Basis of Design: Mason Model BMK.
2. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor rails. Include supports for suction and discharge elbows for pumps.
3. Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
4. Height Saving Brackets: Factory-welded steel corners bolted to frame for isolation mountings.
5. Frame to be manufactured with a minimum section depth equal to 8-percent of the longest span between support isolators, as indicated on the drawings.
6. Steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete.
7. Base to be equipped with equipment anchor bolts fixed into position and housed in a steel bolt sleeve, allowing minor bolt location adjustment.
8. Base to include reinforced concrete with 1/2 inch reinforcing bars at a maximum of 8 inches on center.
9. Weight of base to be not less than twice that of all the equipment it supports.

2.6 FACTORY FINISHES

A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

1. Epoxy Powder coating or electro-galvanized isolation on springs and housings. Zinc plate all bolts, nuts and washers.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-and wind-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by OSHPD.

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Comply with requirements in Division 07 Section "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

B. Equipment Restraints:

1. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
3. Install seismic-restraint devices using methods approved by OSHPD.

C. Piping Restraints:

1. Comply with requirements in MSS SP-127.
2. Space lateral braces a maximum of 40 feet o.c., and longitudinal braces a maximum of 80 feet o.c.
3. Brace a change of direction longer than 2 feet .

D. Ductwork Restraints:

1. Comply with requirements of SMACNA "Seismic Restraint Manual Guidelines for Mechanical Systems."
2. Use Seismic Hazard Level A.

E. Attachments to Structure:

1. Install cables so they do not bend across edges of adjacent equipment or building structure.
2. Install seismic-restraint devices using anchor bolts that meet building code requirements for testing and approval.
3. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and oversize mounting hole.
4. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
5. If specific attachment to structure is not indicated, anchor bracing to structure at flanges of beams at upper chords of bar joists, or at concrete members. Obtain approval of the structural engineer prior to installation.

F. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid pre-stressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install V or U Type flexible loops in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment as indicated on the drawings. Comply with requirements in Division 23 Section "Hydronic Piping" for piping flexible connections.

3.5 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust active height of spring isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.

3.6 HVAC VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE SCHEDULE

EQUIPMENT DESCRIPTION	MARK	VIBRATION ISOLATOR TYPE	MINIMUM DEFLECTION (INCHES)	BASE/ CURB TYPE	SEISMIC RESTRAINT DEVICE TYPE	NOTES
HYDRONIC AND PLUMBING PUMPS						
HYDRONIC AND PLUMBING PUMPS	HRP	V-5	0.75	B-2	S-1	
AIR AND VACUUM EQUIPMENT						
AIR AND VACUUM EQUIPMENT	MAC/ MVP	V-5	0.75	B-2	S-1	
FAN-COIL UNITS	FCU-X	V-9	1.0	N/A	S-2	
UNIT HEATERS AND CABINET HEATERS						
UNIT HEATERS AND CABINET HEATERS	UH/CH	V-9	0.75	N/A	S-2	
AIR TERMINALS						
AIR TERMINALS	TU	N/A	N/A	N/A	N/A	
FANS						
ROOFTOP EXHAUST FAN	FE	V-2	0.11	N/A	N/A	
INLINE FANS	FS	V-9	0.75	N/A	S-2	
AIR HANDLING UNITS						
AIR HANDLING UNITS	FS/FE	V-5	1.5	B-1	S-1	

A. Vibration Isolator and Seismic Restraint Schedule Notes:

1. Seismic restraints are required for all systems and equipment. Seismic restraints for equipment without scheduled seismic snubbers shall be provided by the anchor bolts, vibration isolators, or devices as specified for suspended elements.
2. Provide vibration isolators and seismic restraints for all equipment as specified, including, but not limited to, the specific equipment marks listed above. Where a piece of equipment is included on the project but is not listed above, provide vibration isolators and seismic restraints as specified and as described for similar equipment.
3. Internal vibration isolators, snubbers, and bases for custom air handling units and custom exhaust fans shall be provided and installed at the fan manufacturer's factory, except concrete for inertia bases will be field installed as specified in this section.
4. Provide vibration isolators as indicated for suspended piping attached to any piece of vibrating equipment 5 horsepower or larger within mechanical rooms or within 50 feet of equipment, whichever provides the greater length. For piping supported from the floor, provide isolators similar to those used on the equipment. Applicable vibrating equipment includes items that are not internally isolated such as chillers, pumps, and air compressors.
5. The indicated equipment will be provided with internal vibration isolators.

END OF SECTION 230548