EQUIPMENT SEISMIC ANCHORAGE – THERMOFISHER SCIENTIFIC FREEZERS

2015-932-DC-001
REV. 0

PREPARED FOR:

THERMOFISHER SCIENTIFIC
CONTACT: JOSHUA LEWIS
275 AIKEN ROAD, ASHEVILLE, NC 28804
828-658-2862

PREPARED BY:

TOBOLSKI|WATKINS ENGINEERING, INC.
PROJECT MANAGER: MATTHEW TOBOLSKI, PHD, SE
4125 SORRENTO VALLEY BLVD, SUITE B
SAN DIEGO, CA 92121
858-381-5843

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TOBOLSKI WATKINS ENGINEERING

AUTHORIZATION FOR RELEASE OF CALCULATION

Calculation Title:

Equipment Seismic Anchorage – ThermoFisher Scientific Freezers

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Analyzed System: ThermoFisher Scientific Freezers	
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Initial Issue

ORIGINATOR

James Linjun Yan, PhD, PE — Signature — 07/13/2015

Print Name — Signature — Date

REVIEWER

Matthew Tobolski, PhD, SE — Signature — 07/13/2015

Print Name — Signature — Date

INDEPENDENT REVIEWER (if required)

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FINAL APPROVER

Matthew Tobolski, PhD, SE — Signature — 07/13/2015

Print Name — Signature — Date

Document History

Rev.	Date	Reason for Revision	Revised by
0	7/13/2015	Initial Issue	James Linjun Yan, PhD, PE

List of Effective Pages

Section	Pages	Revision
Body	269	0
Attachment A	15	0

Executive Summary

TWEI has been retained to develop a series of anchorage design details and calculations for seismic restraint of a series of freezer products by ThermoFisher Scientific. These anchor details are designed using an off-the-shelf system provided by QuakeHOLD! Industrial for use with systems in California or other seismic regions.

A total of 15 different freezers (as defined by cut sheets in Appendix A) were covered by this study. For each freezer, a kit for seismic restraint (per TWEI drawing 2015-0932-DD-001) will be provided, including the following essential components:

- A frame of unistrut installed against the freezer's base on all four sides to resist seismic shear.
- A strap with pretension force wrapping around the freezer from side to side, which is tied down to the unistrut frame to resist the unit overturning due to seismic force.
- Post-installed anchors (Powers Power-Stud+ SD2 & SD4 anchors per ICC-ES ESR 2502) for the connection of the unistrut frame to supporting concrete slab by others, to resist seismic shear and uplift force due to overturning.

A systematical check of each system was performed to ensure a complete load path can be established to provide the expected seismic restraint mechanism. The detailed calculations are documented in this report and the main design considerations are summarized below:

- Code standards: IBC 2012 and ASCE 7-10.
- Design seismic force for each freezer is developed per ASCE 7-10 Chapter 13 for nonstructural components, with the following seismic parameters:
  - Component amplification factor, $a_p = 2.5$
  - Component response modification factor, $R_p = 6$
  - Component important factor, $I_p = 1.0$ or 1.5
  - Component attachment height within building, $z/h = 0$ or 1
- Consideration of Center Gravity (C.G.):
  - Maximum height of C.G. is 2/3 of overall unit height.
  - Maximum 10% eccentricity of C.G. each horizontal direction.
- The supporting structure provided by others is a normal weight concrete slab of minimum 6in thickness and minimum compression strength, f_c'=4000psi.
- Maximum site demands (in terms of short period spectral acceleration, S_{DS}) considered for each freezer of different installation heights are summarized in the table on next page.

Please note that this study is only limited to ensure structural adequacy of the seismic restraint system provided for each freezer, which does not include structural integrity check of freezer itself.

CONFIGURATION NO.	UNIT NAME	UNIT BASE			CASTER	MAX. OPERATION WEIGHT	MAX. HEIGHT OF CENTER OF GRAVITY	MAX. S_{DS}				REFERENCED DRAWING
		HEIGHT H	WIDTH B	DEPTH D	OUT-TO-OUT DEPTH Dc			I_p=1		I_p=1.5		
								z/h=0	z/h=1	z/h=0	z/h=1	
		in	in	in	in	lbf	in	g	g	g	g	
1	LRF12	73.62	24.00	26.20	21.30	550	49.08	2.50	2.50	2.50	2.00	S101
2	LRF23	79.23	28.00	33.00	26.50	800	52.82	2.50	2.05	2.30	1.35	S102
3	LRF30	79.23	34.00	33.00	26.50	1000	52.82	2.50	1.65	1.80	1.10	S103
4A	LRF45	79.23	56.50	31.50	23.20	1100	52.82	2.50	1.50	1.65	1.00	S104A
4B	LRF50	79.23	56.50	33.00	26.50	1250	52.82	2.20	1.30	1.45	0.85	S104B
5	LRF75	79.23	85.00	33.00	26.50	1600	52.82	1.70	1.00	1.15	0.65	S105A&B
6	ULT13	77.90	33.30	29.50	24.30	1350	51.93	2.00	1.20	1.35	0.80	S106
7	ULT300	78.00	23.00	35.90	30.30	1300	52.00	2.10	1.25	1.40	0.85	S107
8	ULT400	78.00	28.40	35.90	30.30	1600	52.00	1.70	1.00	1.15	0.65	S108
9A	ULT500	78.00	34.00	35.90	30.30	1850	52.00	1.45	0.85	0.95	0.55	S109A
9B	ULT17	77.90	33.30	35.75	30.50	1500	51.93	1.80	1.10	1.20	0.70	S109B
10A	ULT600	78.00	39.60	35.90	30.30	2100	52.00	1.30	0.75	0.85	0.50	S110A
10B	ULT23	77.90	40.70	35.75	30.50	1650	51.93	1.65	1.00	1.10	0.65	S110B
11A	ULT700	78.00	45.30	35.90	30.30	2500	52.00	1.10	0.65	0.70	0.40	S111A
11B	ULT28	77.90	46.70	35.75	30.50	1800	51.93	1.50	0.90	1.00	0.60	S111B

S_{DS}: SHORT PERIOD SPECTRAL ACCELERATION.
z : HEIGHT IN BUILDING OF UNIT INSTALLATION WITH RESPECT TO THE BUILDING BASE.
h : AVERAGE ROOF HEIGHT OF BUILDING WITH RESPECT TO THE BUILDING BASE.
I_p= 1.5, SHOWN IN THIS TABLE FOR ANCHORAGE DESIGN ONLY, NOT FOR CONSIDERATION OF SPECIAL SEISMIC CERTIFICATION.

Table of Contents

Section 1. Seismic Restraint Design of Freezers for I_p =1 & z/h=0

Summary of Anchor Force

Configuration	Unit	Demand	Case 1	Case 2		Case 3	Case 4	Strap Pretension
	Name	S_{DS}	T_{u1}	V_{u2}	$T_{u2,prying}$	T_{u3}	V_{u4}	Force
			(lbf)	(lbf)		(lbf)	(lbf)	lbf
1	LRF 12	2.50	1810.82	515.63	2300.48	2122.94	257.81	798.26
2	LRF 23	2.50	2456.36	750.00	3346.15	2694.61	375.00	1004.37
3	LRF 30	2.50	2541.23	937.50	4182.69	3368.27	468.75	1255.47
4a	LRF 45	2.50	1664.60	1031.25	4600.96	4224.20	515.63	1591.18
4b	LRF 50	2.20	1610.01	1031.25	4600.96	3653.43	515.63	1329.35
5	LRF 75	1.70	868.62	1020.00	4550.77	3488.34	510.00	1189.61
6	ULT 13	2.00	2652.42	1012.50	4517.31	3795.82	506.25	1361.91
7	ULT 300	2.10	3898.93	1023.75	4567.50	3093.17	511.88	1405.98
8	ULT 400	1.70	3053.20	1020.00	4550.77	2975.54	510.00	1001.69
9a	ULT 500	1.45	2396.96	1005.94	4488.03	2839.63	502.97	873.44
9b	ULT 17	1.80	2597.43	1012.50	4517.31	2958.76	506.25	994.59
10a	ULT 600	1.30	1975.54	1023.75	4567.50	2814.14	511.88	813.14
10b	ULT 23	1.65	2065.68	1020.94	4554.95	2935.31	510.47	954.77
11a	ULT 700	1.10	1548.56	1031.25	4600.96	2700.60	515.63	684.94
11b	ULT 28	1.50	1694.34	1012.50	4517.31	2853.81	506.25	889.63
Max			**3898.93**	**1031.25**	**4600.96**	**4224.20**	**515.63**	**1591.18**

z/h =	0
I_p =	1

Note:
- Case 1: Tension load to middle anchor group due to side to side seismic loading
- Case 2: Shear load & tension load by prying action to end anchor due to side to side seismic loading
- Case 3: Tension load to middle anchor group due to front to back seismic loading
- Case 4: Shear loading to end anchor due to front and back seismic loading

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 12
Configuratoin No.: 1

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	550	lbf	per unit cut sheet
Unit width	B	24	in	per unit cut sheet
Unit depth	D	26.2	in	per unit cut sheet
Unit height	H	73.62	in	per unit cut sheet
Caster out to out distance	D_c	21.3	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	26.63	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	22.93	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	49.08	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	2.40	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	2.62	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	2.50		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	0		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1		
Seismic design force	F_p	229.17	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	2200.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	412.50	lbf	Eq. 13.3-3
Final seismic design force	F_p	412.50	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

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3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	20245.50	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	2400.75	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	17844.75	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	670.23	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	20245.50	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	1945.35	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	18300.15	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	798.26	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	798.26	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.38	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

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Notes:
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3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	670.23	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.11	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	798.26	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.13	O.K.	$DCR = M_{u1}/ØM_n$

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Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	495.00	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	25.00	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.08	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	1810.82	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	515.63	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	2300.48	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	2122.94	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	257.81	lbf	$V_{u4} = Ω*F_p/4$

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Item: LRF 23
Configuratoin No.: 2

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Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	800	lbf	per unit cut sheet
Unit width	B	28	in	per unit cut sheet
Unit depth	D	33	in	per unit cut sheet
Unit height	H	79.23	in	per unit cut sheet
Caster out to out distance	D_c	26.5	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	30.63	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	28.13	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.82	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	2.80	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.30	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	2.50		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	0		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1		
Seismic design force	F_p	333.33	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	3200.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	600.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	600.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

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2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	31692.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	4004.00	lbf-in	$M_{R.grav} = (0.9\text{-}0.2*S_{DS})W_p*(S_{ss}/2\text{-}e_{ss})$
Resisting moment by strap	$M_{R.strap}$	27688.00	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	904.10	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	31692.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	3444.00	lbf-in	$M_{R.grav} = (0.9\text{-}0.2*S_{DS})W_p*(S_{fb}/2\text{-}e_{fb})$
Resisting moment by strap	$M_{R.strap}$	28248.00	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	1004.37	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	1004.37	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.48	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

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3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	904.10	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.15	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1004.37	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.17	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 23
Configuratoin No.: 2

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	840.00	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	29.00	in	L = B+1"
Capcity reduction factor	f	0.96		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5791.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.15	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	2456.36	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	750.00	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	3346.15	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	2694.61	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	375.00	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 30
Configuratoin No.: 3

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1000	lbf	per unit cut sheet
Unit width	B	34	in	per unit cut sheet
Unit depth	D	33	in	per unit cut sheet
Unit height	H	79.23	in	per unit cut sheet
Caster out to out distance	D_c	26.5	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	36.63	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	28.13	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.82	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	3.40	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.30	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	2.5		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	0		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1		
Seismic design force	F_p	416.67	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	4000.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	750.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	750.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 30
Configuratoin No.: 3

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	39615.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	5965.00	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	33650.00	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	918.77	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	39615.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	4305.00	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	35310.00	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	1255.47	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	1255.47	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.60	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 30
Configuratoin No.: 3

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	918.77	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.15	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1255.47	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.21	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific) **Cal. No.:** 2015-0932-DC-001, r0
Project No.: 0932 **Originator:** JY
Item: LRF 30 **Reviewer:** MT
Configuratoin No.: 3 **Date:** 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1275.00	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	35.00	in	L = B+1"
Capcity reduction factor	f	0.94		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5671.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.22	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	2541.23	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	937.50	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4182.69	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	3368.27	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	468.75	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 45
Configuratoin No.: 4a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1100	lbf	per unit cut sheet
Unit width	B	56.5	in	per unit cut sheet
Unit depth	D	31.5	in	per unit cut sheet
Unit height	H	79.23	in	per unit cut sheet
Caster out to out distance	D_c	23.2	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	59.13	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	24.83	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.82	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	5.65	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.15	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	2.50		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	0		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1		
Seismic design force	F_p	458.33	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	4400.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	825.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	825.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 45
Configuratoin No.: 4a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	43576.50	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	10521.50	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	33055.00	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	559.07	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	43576.50	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	4075.50	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	39501.00	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	1591.18	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	1591.18	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.76	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 45
Configuratoin No.: 4a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	559.07	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.09	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1591.18	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.26	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific) **Cal. No.:** 2015-0932-DC-001, r0
Project No.: 0932 **Originator:** JY
Item: LRF 45 **Reviewer:** MT
Configuratoin No.: 4a **Date:** 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	2330.63	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	57.50	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.39	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	1664.60	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1031.25	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4600.96	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	4224.20	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	515.63	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 50
Configuratoin No.: 4b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1250	lbf	per unit cut sheet
Unit width	B	56.5	in	per unit cut sheet
Unit depth	D	33	in	per unit cut sheet
Unit height	H	79.23	in	per unit cut sheet
Caster out to out distance	D_c	26.5	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	59.13	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	28.13	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.82	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	5.65	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.30	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	2.20		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	0		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1		
Seismic design force	F_p	458.33	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	4400.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	825.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	825.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 50
Configuratoin No.: 4b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
3. Load Combinations				
		$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
		$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
		$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
		$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir
4. Check of Strap				
4.1 Side to Side Direction				
Overturning moment due to seismic foce	M_{OT}	43576.50	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	13749.69	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	29826.81	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	504.47	lbf	$F_{ss} = M_{R.strap}/S_{ss}$
4.2 Front to Back Direction				
Overturning moment due to seismic foce	M_{OT}	43576.50	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	6188.44	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	37388.06	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	1329.35	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$
4.3 Check of Strap				
Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	1329.35	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.63	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 50
Configuratoin No.: 4b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	504.47	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.08	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1329.35	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.22	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific) **Cal. No.:** 2015-0932-DC-001, r0
Project No.: 0932 **Originator:** JY
Item: LRF 50 **Reviewer:** MT
Configuratoin No.: 4b **Date:** 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	2330.63	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	57.50	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.39	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	1610.01	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1031.25	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4600.96	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	3653.43	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	515.63	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 75
Configuratoin No.: 5

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1600	lbf	per unit cut sheet
Unit width	B	85	in	per unit cut sheet
Unit depth	D	33	in	per unit cut sheet
Unit height	H	79.23	in	per unit cut sheet
Caster out to out distance	D_c	26.5	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	87.63	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	28.13	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.82	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	8.50	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.30	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	1.70		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	0		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1		
Seismic design force	F_p	453.33	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	4352.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	816.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	816.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 75
Configuratoin No.: 5

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	43101.12	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	31640.00	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	11461.12	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	130.80	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	43101.12	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	9643.20	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	33457.92	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	1189.61	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	1189.61	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.57	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 75
Configuratoin No.: 5

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	130.80	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.02	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1189.61	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.20	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 75
Configuratoin No.: 5

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	3468.00	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	86.00	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.58	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	868.62	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1020.00	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4550.77	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	3488.34	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	510.00	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 13
Configuratoin No.: 6

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1350	lbf	per unit cut sheet
Unit width	B	33.3	in	per unit cut sheet
Unit depth	D	29.5	in	per unit cut sheet
Unit height	H	77.9	in	per unit cut sheet
Caster out to out distance	D_c	24.3	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	35.93	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	25.93	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	51.93	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	3.33	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	2.95	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	2.00		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	0		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1		
Seismic design force	F_p	450.00	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	4320.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	810.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	810.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 13
Configuratoin No.: 6

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	42066.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	9876.94	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	32189.06	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	896.01	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	42066.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	6758.44	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	35307.56	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	1361.91	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	1361.91	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.65	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific) **Cal. No.:** 2015-0932-DC-001, r0
Project No.: 0932 **Originator:** JY
Item: ULT 13 **Reviewer:** MT
Configuratoin No.: 6 **Date:** 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	896.01	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.15	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1361.91	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.23	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1348.65	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	34.30	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.23	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 13
Configuratoin No.: 6

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	2652.42	lbf	$T_{u1} = (\Omega * M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1012.50	lbf	$V_{u2} = \Omega * F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4517.31	lbf	$T_{u2,prying} = V_{u2} * h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	3795.82	lbf	$T_{u3} = (\Omega * M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	506.25	lbf	$V_{u4} = \Omega * F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 300
Configuratoin No.: 7

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1300	lbf	per unit cut sheet
Unit width	B	23	in	per unit cut sheet
Unit depth	D	35.9	in	per unit cut sheet
Unit height	H	78	in	per unit cut sheet
Caster out to out distance	D_c	30.3	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	25.63	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	31.93	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.00	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	2.30	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.59	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	2.10		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	0		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1		
Seismic design force	F_p	455.00	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	4368.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	819.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	819.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 300
Configuratoin No.: 7

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	42588.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	6559.80	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	36028.20	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	1405.98	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	42588.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	7720.44	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	34867.56	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	1092.17	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	1405.98	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.67	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 300
Configuratoin No.: 7

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1405.98	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.23	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1092.17	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.18	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific) **Cal. No.:** 2015-0932-DC-001, r0
Project No.: 0932 **Originator:** JY
Item: ULT 300 **Reviewer:** MT
Configuratoin No.: 7 **Date:** 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	941.85	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	24.00	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.16	O.K.	$DCR = M_{u2}/ØM_n$

6. Calculation of Post Installed Anchor Force

6.1 Side to Side Direction

Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	3898.93	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1023.75	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4567.50	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$

6.2 Front to Back Direction

Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	3093.17	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	511.88	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 400
Configuratoin No.: 8

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1600	lbf	per unit cut sheet
Unit width	B	28.4	in	per unit cut sheet
Unit depth	D	35.9	in	per unit cut sheet
Unit height	H	78	in	per unit cut sheet
Caster out to out distance	D_c	30.3	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	31.03	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	31.93	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.00	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	2.84	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.59	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	1.70		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	0		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1		
Seismic design force	F_p	453.33	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	4352.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	816.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	816.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 400
Configuratoin No.: 8

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	42432.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	11354.56	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	31077.44	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	1001.69	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	42432.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	11085.76	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	31346.24	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	981.87	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	1001.69	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.48	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 400
Configuratoin No.: 8

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1001.69	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.17	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	981.87	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.16	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific) **Cal. No.:** 2015-0932-DC-001, r0
Project No.: 0932 **Originator:** JY
Item: ULT 400 **Reviewer:** MT
Configuratoin No.: 8 **Date:** 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1158.72	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	29.40	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.19	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	3053.20	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1020.00	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4550.77	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	2975.54	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	510.00	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 500
Configuratoin No.: 9a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1850	lbf	per unit cut sheet
Unit width	B	34	in	per unit cut sheet
Unit depth	D	35.9	in	per unit cut sheet
Unit height	H	78	in	per unit cut sheet
Caster out to out distance	D_c	30.3	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	36.63	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	31.93	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.00	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	3.40	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.59	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	1.45		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	0		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1		
Seismic design force	F_p	447.08	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	4292.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	804.75	lbf	Eq. 13.3-3
Final seismic design force	F_p	804.75	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 500
Configuratoin No.: 9a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	41847.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	16828.76	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	25018.24	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	683.09	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	41847.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	13962.37	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	27884.63	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	873.44	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	873.44	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.42	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 500
Configuratoin No.: 9a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	683.09	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.11	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	873.44	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.14	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 500
Configuratoin No.: 9a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1368.08	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	35.00	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.23	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	2396.96	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1005.94	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4488.03	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	2839.63	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	502.97	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 17
Configuratoin No.: 9b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1500	lbf	per unit cut sheet
Unit width	B	33.3	in	per unit cut sheet
Unit depth	D	35.75	in	per unit cut sheet
Unit height	H	77.9	in	per unit cut sheet
Caster out to out distance	D_c	30.5	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	35.93	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	32.13	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	51.93	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	3.33	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.58	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	1.80		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	0		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1		
Seismic design force	F_p	450.00	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	4320.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	810.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	810.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 17
Configuratoin No.: 9b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	42066.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	11852.33	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	30213.68	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	841.02	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	42066.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	10114.88	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	31951.13	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	994.59	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	994.59	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.47	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 17
Configuratoin No.: 9b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	841.02	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.14	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	994.59	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.16	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific) **Cal. No.:** 2015-0932-DC-001, r0
Project No.: 0932 **Originator:** JY
Item: ULT 17 **Reviewer:** MT
Configuratoin No.: 9b **Date:** 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1348.65	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	34.30	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.23	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	2597.43	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1012.50	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4517.31	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	2958.76	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	506.25	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 600
Configuratoin No.: 10a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	2100	lbf	per unit cut sheet
Unit width	B	39.6	in	per unit cut sheet
Unit depth	D	35.9	in	per unit cut sheet
Unit height	H	78	in	per unit cut sheet
Caster out to out distance	D_c	30.3	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	42.23	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	31.93	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.00	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	3.96	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.59	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	1.30		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	0		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1		
Seismic design force	F_p	455.00	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	4368.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	819.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	819.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 600
Configuratoin No.: 10a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
3. Load Combinations				
		$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
		$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
		$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
		$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir
4. Check of Strap				
4.1 Side to Side Direction				
Overturning moment due to seismic foce	M_{OT}	42588.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	23052.96	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	19535.04	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	462.64	lbf	$F_{ss} = M_{R.strap}/S_{ss}$
4.2 Front to Back Direction				
Overturning moment due to seismic foce	M_{OT}	42588.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	16628.64	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	25959.36	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	813.14	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$
4.3 Check of Strap				
Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	813.14	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.39	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific) **Cal. No.:** 2015-0932-DC-001, r0
Project No.: 0932 **Originator:** JY
Item: ULT 600 **Reviewer:** MT
Configuratoin No.: 10a **Date:** 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	462.64	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.08	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	813.14	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.13	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific) **Cal. No.:** 2015-0932-DC-001, r0
Project No.: 0932 **Originator:** JY
Item: ULT 600 **Reviewer:** MT
Configuratoin No.: 10a **Date:** 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1621.62	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	40.60	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.27	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	1975.54	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1023.75	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4567.50	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	2814.14	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	511.88	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 23
Configuratoin No.: 10b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1650	lbf	per unit cut sheet
Unit width	B	40.7	in	per unit cut sheet
Unit depth	D	35.75	in	per unit cut sheet
Unit height	H	77.9	in	per unit cut sheet
Caster out to out distance	D_c	30.5	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	43.33	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	32.13	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	51.93	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	4.07	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.58	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	1.65		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	0		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1		
Seismic design force	F_p	453.75	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	4356.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	816.75	lbf	Eq. 13.3-3
Final seismic design force	F_p	816.75	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

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Cal. No.: 2015-0932-DC-001, r0
Originator: JY
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Sesimic Restraints of Freezers

Notes:
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2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	42416.55	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	16545.75	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	25870.80	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	597.13	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	42416.55	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	11744.49	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	30672.06	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	954.77	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	954.77	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.45	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
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Configuratoin No.: 10b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	597.13	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.10	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	954.77	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.16	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 23
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Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1662.09	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	41.70	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.28	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	2065.68	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1020.94	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4554.95	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	2935.31	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	510.47	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 700
Configuratoin No.: 11a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	2500	lbf	per unit cut sheet
Unit width	B	45.3	in	per unit cut sheet
Unit depth	D	35.9	in	per unit cut sheet
Unit height	H	78	in	per unit cut sheet
Caster out to out distance	D_c	30.3	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	47.93	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	31.93	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.00	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	4.53	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.59	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	1.10		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	0		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1		
Seismic design force	F_p	458.33	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	4400.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	825.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	825.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
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Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
3. Load Combinations				
		$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
		$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
		$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
		$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir
4. Check of Strap				
4.1 Side to Side Direction				
Overturning moment due to seismic foce	M_{OT}	42900.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	33035.25	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	9864.75	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	205.84	lbf	$F_{ss} = M_{R.strap}/S_{ss}$
4.2 Front to Back Direction				
Overturning moment due to seismic foce	M_{OT}	42900.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	21033.25	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	21866.75	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	684.94	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$
4.3 Check of Strap				
Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	684.94	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.33	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
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Cal. No.: 2015-0932-DC-001, r0
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Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	205.84	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.03	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	684.94	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.11	O.K.	$DCR = M_{u1}/ØM_n$

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Sesimic Restraints of Freezers

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3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1868.63	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	46.30	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.31	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	1548.56	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1031.25	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4600.96	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	2700.60	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	515.63	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 28
Configuratoin No.: 11b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1800	lbf	per unit cut sheet
Unit width	B	46.7	in	per unit cut sheet
Unit depth	D	35.75	in	per unit cut sheet
Unit height	H	77.9	in	per unit cut sheet
Caster out to out distance	D_c	30.5	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	49.33	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	32.13	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	51.93	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	4.67	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.58	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	1.50		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	0		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1		
Seismic design force	F_p	450.00	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	4320.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	810.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	810.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

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Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	42066.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	21591.90	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	20474.10	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	415.09	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	42066.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	13486.50	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	28579.50	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	889.63	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	889.63	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.42	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 28
Configuratoin No.: 11b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	415.09	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.07	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	889.63	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.15	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific) **Cal. No.:** 2015-0932-DC-001, r0
Project No.: 0932 **Originator:** JY
Item: ULT 28 **Reviewer:** MT
Configuratoin No.: 11b **Date:** 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1891.35	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	47.70	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.32	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	1694.34	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1012.50	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4517.31	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	2853.81	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	506.25	lbf	$V_{u4} = Ω*F_p/4$

Section 2. Seismic Restraint Design of Freezers for I_p =1 & z/h=1

Summary of Anchor Force

Configuration	Unit	Demand	Case 1	Case 2		Case 3	Case 4	Strap Pretension
	Name	S_{DS}	T_{u1}	V_{u2}	$T_{u2,prying}$	T_{u3}	V_{u4}	Force
			(lbf)	(lbf)		(lbf)	(lbf)	lbf
1	LRF 12	2.50	3078.14	859.38	3834.13	3594.80	429.69	1387.01
2	LRF 23	2.05	3375.55	1025.00	4573.08	3699.99	512.50	1389.99
3	LRF 30	1.65	2742.42	1031.25	4600.96	3655.35	515.63	1331.27
4a	LRF 45	1.50	1575.63	1031.25	4600.96	4142.11	515.63	1509.09
4b	LRF 50	1.30	1491.09	1015.63	4531.25	3508.64	507.81	1219.78
5	LRF 75	1.00	754.24	1000.00	4461.54	3327.50	500.00	1073.85
6	ULT 13	1.20	2564.44	1012.50	4517.31	3712.40	506.25	1278.49
7	ULT 300	1.25	3775.30	1015.63	4531.25	2981.06	507.81	1302.12
8	ULT 400	1.00	2894.66	1000.00	4461.54	2823.58	500.00	883.38
9a	ULT 500	0.85	2240.91	982.81	4384.86	2678.26	491.41	757.27
9b	ULT 17	1.10	2566.11	1031.25	4600.96	2937.75	515.63	937.21
10a	ULT 600	0.75	1784.72	984.38	4391.83	2596.34	492.19	672.30
10b	ULT 23	1.00	2003.30	1031.25	4600.96	2885.27	515.63	884.73
11a	ULT 700	0.65	1423.42	1015.63	4531.25	2562.50	507.81	577.38
11b	ULT 28	0.90	1606.79	1012.50	4517.31	2769.84	506.25	805.67
Max			**3775.30**	**1031.25**	**4600.96**	**4142.11**	**515.63**	**1509.09**

z/h =	1
I_p =	1

Note:

Case 1	Tension load to middle anchor group due to side to side seismic loading
Case 2	Shear load & tension load by prying action to end anchor due to side to side seismic loading
Case 3	Tension load to middle anchor group due to front to back seismic loading
Case 4	Shear loading to end anchor due to front and back seismic loading

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 12
Configuratoin No.: 1

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	550	lbf	per unit cut sheet
Unit width	B	24	in	per unit cut sheet
Unit depth	D	26.2	in	per unit cut sheet
Unit height	H	73.62	in	per unit cut sheet
Caster out to out distance	D_c	21.3	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	26.63	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	22.93	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	49.08	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	2.40	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	2.62	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	2.50		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	1		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1		
Seismic design force	F_p	687.50	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	2200.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	412.50	lbf	Eq. 13.3-3
Final seismic design force	F_p	687.50	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 12
Configuratoin No.: 1

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	33742.50	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	2400.75	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	31341.75	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	1177.15	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	33742.50	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	1945.35	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	31797.15	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	1387.01	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	1387.01	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.66	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 12
Configuratoin No.: 1

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1177.15	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.20	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1387.01	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.23	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 12
Configuratoin No.: 1

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	825.00	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	25.00	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.14	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	3078.14	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	859.38	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	3834.13	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	3594.80	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	429.69	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 23
Configuratoin No.: 2

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	800	lbf	per unit cut sheet
Unit width	B	28	in	per unit cut sheet
Unit depth	D	33	in	per unit cut sheet
Unit height	H	79.23	in	per unit cut sheet
Caster out to out distance	D_c	26.5	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	30.63	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	28.13	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.82	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	2.80	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.30	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	2.05		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	1		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1		
Seismic design force	F_p	820.00	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	2624.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	492.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	820.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 23
Configuratoin No.: 2

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	43312.40	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	4904.90	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	38407.50	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	1254.12	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	43312.40	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	4218.90	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	39093.50	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	1389.99	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	1389.99	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.66	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 23
Configuratoin No.: 2

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1254.12	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.21	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1389.99	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.23	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 23
Configuratoin No.: 2

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1148.00	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	29.00	in	L = B+1"
Capcity reduction factor	f	0.96		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5791.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.20	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	3375.55	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1025.00	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4573.08	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	3699.99	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	512.50	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 30
Configuratoin No.: 3

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1000	lbf	per unit cut sheet
Unit width	B	34	in	per unit cut sheet
Unit depth	D	33	in	per unit cut sheet
Unit height	H	79.23	in	per unit cut sheet
Caster out to out distance	D_c	26.5	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	36.63	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	28.13	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.82	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	3.40	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.30	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	1.65		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	1		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1		
Seismic design force	F_p	825.00	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	2640.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	495.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	825.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 30
Configuratoin No.: 3

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	43576.50	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	8500.13	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	35076.38	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	957.72	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	43576.50	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	6134.63	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	37441.88	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	1331.27	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	1331.27	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.63	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 30
Configuratoin No.: 3

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	957.72	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.16	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1331.27	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.22	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 30
Configuratoin No.: 3

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1402.50	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	35.00	in	L = B+1"
Capcity reduction factor	f	0.94		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5671.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.25	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	2742.42	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1031.25	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4600.96	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	3655.35	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	515.63	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 45
Configuratoin No.: 4a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1100	lbf	per unit cut sheet
Unit width	B	56.5	in	per unit cut sheet
Unit depth	D	31.5	in	per unit cut sheet
Unit height	H	79.23	in	per unit cut sheet
Caster out to out distance	D_c	23.2	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	59.13	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	24.83	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.82	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	5.65	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.15	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	1.50		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	1		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1		
Seismic design force	F_p	825.00	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	2640.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	495.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	825.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 45
Configuratoin No.: 4a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	43576.50	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	15782.25	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	27794.25	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	470.09	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	43576.50	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	6113.25	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	37463.25	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	1509.09	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	1509.09	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.72	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 45
Configuratoin No.: 4a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	470.09	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.08	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1509.09	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.25	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 45
Configuratoin No.: 4a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	2330.63	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	57.50	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.39	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	1575.63	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1031.25	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4600.96	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	4142.11	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	515.63	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 50
Configuratoin No.: 4b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1250	lbf	per unit cut sheet
Unit width	B	56.5	in	per unit cut sheet
Unit depth	D	33	in	per unit cut sheet
Unit height	H	79.23	in	per unit cut sheet
Caster out to out distance	D_c	26.5	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	59.13	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	28.13	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.82	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	5.65	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.30	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	1.30		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	1		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1		
Seismic design force	F_p	812.50	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	2600.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	487.50	lbf	Eq. 13.3-3
Final seismic design force	F_p	812.50	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 50
Configuratoin No.: 4b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	42916.25	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	19130.00	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	23786.25	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	402.30	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	42916.25	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	8610.00	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	34306.25	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	1219.78	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	1219.78	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.58	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 50
Configuratoin No.: 4b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	402.30	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.07	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1219.78	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.20	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 50
Configuratoin No.: 4b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	2295.31	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	57.50	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.38	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	1491.09	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1015.63	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4531.25	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	3508.64	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	507.81	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 75
Configuratoin No.: 5

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1600	lbf	per unit cut sheet
Unit width	B	85	in	per unit cut sheet
Unit depth	D	33	in	per unit cut sheet
Unit height	H	79.23	in	per unit cut sheet
Caster out to out distance	D_c	26.5	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	87.63	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	28.13	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.82	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	8.50	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.30	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	1.00		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	1		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1		
Seismic design force	F_p	800.00	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	2560.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	480.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	800.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 75
Configuratoin No.: 5

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	42256.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	39550.00	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	2706.00	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	30.88	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	42256.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	12054.00	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	30202.00	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	1073.85	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	1073.85	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.51	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 75
Configuratoin No.: 5

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	30.88	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.01	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1073.85	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.18	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 75
Configuratoin No.: 5

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	3400.00	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	86.00	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.57	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	754.24	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1000.00	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4461.54	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	3327.50	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	500.00	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 13
Configuratoin No.: 6

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1350	lbf	per unit cut sheet
Unit width	B	33.3	in	per unit cut sheet
Unit depth	D	29.5	in	per unit cut sheet
Unit height	H	77.9	in	per unit cut sheet
Caster out to out distance	D_c	24.3	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	35.93	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	25.93	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	51.93	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	3.33	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	2.95	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	1.20		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	1		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1		
Seismic design force	F_p	810.00	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	2592.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	486.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	810.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 13
Configuratoin No.: 6

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	42066.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	13037.56	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	29028.44	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	808.03	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	42066.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	8921.14	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	33144.86	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	1278.49	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	1278.49	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.61	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 13
Configuratoin No.: 6

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	808.03	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.13	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1278.49	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.21	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 13
Configuratoin No.: 6

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1348.65	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	34.30	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.23	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	2564.44	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1012.50	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4517.31	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	3712.40	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	506.25	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 300
Configuratoin No.: 7

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1300	lbf	per unit cut sheet
Unit width	B	23	in	per unit cut sheet
Unit depth	D	35.9	in	per unit cut sheet
Unit height	H	78	in	per unit cut sheet
Caster out to out distance	D_c	30.3	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	25.63	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	31.93	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.00	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	2.30	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.59	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	1.25		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	1		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1		
Seismic design force	F_p	812.50	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	2600.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	487.50	lbf	Eq. 13.3-3
Final seismic design force	F_p	812.50	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
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Item: ULT 300
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Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	42250.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	8883.06	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	33366.94	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	1302.12	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	42250.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	10454.76	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	31795.24	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	995.94	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	1302.12	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.62	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
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Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1302.12	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.22	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	995.94	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.17	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
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Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	934.38	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	24.00	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.16	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	3775.30	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1015.63	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4531.25	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	2981.06	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	507.81	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 400
Configuratoin No.: 8

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1600	lbf	per unit cut sheet
Unit width	B	28.4	in	per unit cut sheet
Unit depth	D	35.9	in	per unit cut sheet
Unit height	H	78	in	per unit cut sheet
Caster out to out distance	D_c	30.3	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	31.03	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	31.93	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.00	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	2.84	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.59	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	1.00		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	1		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1		
Seismic design force	F_p	800.00	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	2560.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	480.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	800.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 400
Configuratoin No.: 8

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	41600.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	14193.20	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	27406.80	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	883.38	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	41600.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	13857.20	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	27742.80	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	869.00	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	883.38	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.42	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 400
Configuratoin No.: 8

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	883.38	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.15	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	869.00	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.14	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 400
Configuratoin No.: 8

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1136.00	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	29.40	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.19	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	2894.66	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1000.00	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4461.54	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	2823.58	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	500.00	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 500
Configuratoin No.: 9a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1850	lbf	per unit cut sheet
Unit width	B	34	in	per unit cut sheet
Unit depth	D	35.9	in	per unit cut sheet
Unit height	H	78	in	per unit cut sheet
Caster out to out distance	D_c	30.3	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	36.63	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	31.93	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.00	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	3.40	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.59	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	0.85		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	1		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1		
Seismic design force	F_p	786.25	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	2516.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	471.75	lbf	Eq. 13.3-3
Final seismic design force	F_p	786.25	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 500
Configuratoin No.: 9a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	40885.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	20139.33	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	20745.67	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	566.43	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	40885.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	16709.06	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	24175.94	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	757.27	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	757.27	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.36	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 500
Configuratoin No.: 9a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	566.43	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.09	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	757.27	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.13	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 500
Configuratoin No.: 9a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1336.63	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	35.00	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.22	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	2240.91	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	982.81	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4384.86	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	2678.26	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	491.41	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 17
Configuratoin No.: 9b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1500	lbf	per unit cut sheet
Unit width	B	33.3	in	per unit cut sheet
Unit depth	D	35.75	in	per unit cut sheet
Unit height	H	77.9	in	per unit cut sheet
Caster out to out distance	D_c	30.5	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	35.93	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	32.13	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	51.93	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	3.33	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.58	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	1.10		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	1		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1		
Seismic design force	F_p	825.00	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	2640.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	495.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	825.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 17
Configuratoin No.: 9b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	42845.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	14925.15	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	27919.85	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	777.17	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	42845.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	12737.25	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	30107.75	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	937.21	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	937.21	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.45	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 17
Configuratoin No.: 9b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	777.17	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.13	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	937.21	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.16	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 17
Configuratoin No.: 9b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1373.63	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	34.30	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.23	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	2566.11	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1031.25	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4600.96	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	2937.75	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	515.63	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 600
Configuratoin No.: 10a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	2100	lbf	per unit cut sheet
Unit width	B	39.6	in	per unit cut sheet
Unit depth	D	35.9	in	per unit cut sheet
Unit height	H	78	in	per unit cut sheet
Caster out to out distance	D_c	30.3	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	42.23	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	31.93	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.00	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	3.96	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.59	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	0.75		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	1		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1		
Seismic design force	F_p	787.50	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	2520.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	472.50	lbf	Eq. 13.3-3
Final seismic design force	F_p	787.50	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 600
Configuratoin No.: 10a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	40950.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	27015.19	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	13934.81	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	330.01	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	40950.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	19486.69	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	21463.31	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	672.30	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	672.30	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.32	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 600
Configuratoin No.: 10a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	330.01	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.05	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	672.30	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.11	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 600
Configuratoin No.: 10a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1559.25	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	40.60	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.26	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	1784.72	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	984.38	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4391.83	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	2596.34	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	492.19	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 23
Configuratoin No.: 10b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1650	lbf	per unit cut sheet
Unit width	B	40.7	in	per unit cut sheet
Unit depth	D	35.75	in	per unit cut sheet
Unit height	H	77.9	in	per unit cut sheet
Caster out to out distance	D_c	30.5	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	43.33	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	32.13	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	51.93	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	4.07	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.58	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	1.00		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	1		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1		
Seismic design force	F_p	825.00	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	2640.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	495.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	825.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 23
Configuratoin No.: 10b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	42845.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	20319.34	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	22525.66	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	519.92	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	42845.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	14423.06	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	28421.94	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	884.73	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	884.73	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.42	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 23
Configuratoin No.: 10b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	519.92	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.09	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	884.73	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.15	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 23
Configuratoin No.: 10b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1678.88	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	41.70	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.28	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	2003.30	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1031.25	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4600.96	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	2885.27	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	515.63	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 700
Configuratoin No.: 11a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	2500	lbf	per unit cut sheet
Unit width	B	45.3	in	per unit cut sheet
Unit depth	D	35.9	in	per unit cut sheet
Unit height	H	78	in	per unit cut sheet
Caster out to out distance	D_c	30.3	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	47.93	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	31.93	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.00	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	4.53	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.59	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	0.65		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	1		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1		
Seismic design force	F_p	812.50	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	2600.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	487.50	lbf	Eq. 13.3-3
Final seismic design force	F_p	812.50	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 700
Configuratoin No.: 11a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	42250.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	37407.56	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	4842.44	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	101.04	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	42250.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	23817.06	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	18432.94	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	577.38	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	577.38	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.27	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
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Item: ULT 700
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Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
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Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	101.04	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.02	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	577.38	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.10	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
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Configuratoin No.: 11a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1840.31	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	46.30	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.31	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	1423.42	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1015.63	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4531.25	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	2562.50	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	507.81	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 28
Configuratoin No.: 11b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1800	lbf	per unit cut sheet
Unit width	B	46.7	in	per unit cut sheet
Unit depth	D	35.75	in	per unit cut sheet
Unit height	H	77.9	in	per unit cut sheet
Caster out to out distance	D_c	30.5	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	49.33	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	32.13	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	51.93	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	4.67	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.58	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	0.90		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	1		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1		
Seismic design force	F_p	810.00	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	2592.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	486.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	810.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
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Item: ULT 28
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Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	42066.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	25910.28	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	16155.72	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	327.54	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	42066.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	16183.80	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	25882.20	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	805.67	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	805.67	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.38	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 28
Configuratoin No.: 11b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	327.54	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.05	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	805.67	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.13	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 28
Configuratoin No.: 11b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1891.35	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	47.70	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.32	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	1606.79	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1012.50	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4517.31	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	2769.84	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	506.25	lbf	$V_{u4} = Ω*F_p/4$

Section 3. Seismic Restraint Design of Freezers for I_p =1.5 & z/h=0

Summary of Anchor Force

Configuration	Unit	Demand	Case 1	Case 2		Case 3	Case 4	Strap Pretension
	Name	S_{DS}	T_{u1}	V_{u2}	$T_{u2,prying}$	T_{u3}	V_{u4}	Force
			(lbf)	(lbf)		(lbf)	(lbf)	lbf
1	LRF 12	2.50	2761.31	773.44	3450.72	3226.84	386.72	1239.82
2	LRF 23	2.30	3426.38	1035.00	4617.69	3752.85	517.50	1420.32
3	LRF 30	1.80	2700.55	1012.50	4517.31	3596.40	506.25	1314.58
4a	LRF 45	1.65	1570.55	1020.94	4554.95	4110.54	510.47	1503.85
4b	LRF 50	1.45	1513.23	1019.53	4548.68	3537.67	509.77	1240.00
5	LRF 75	1.15	815.78	1035.00	4617.69	3477.33	517.50	1144.80
6	ULT 13	1.35	2617.53	1025.16	4573.77	3778.74	512.58	1314.41
7	ULT 300	1.40	3824.27	1023.75	4567.50	3022.64	511.88	1331.31
8	ULT 400	1.15	3031.59	1035.00	4617.69	2956.20	517.50	949.91
9a	ULT 500	0.95	2272.39	988.59	4410.65	2711.43	494.30	779.15
9b	ULT 17	1.20	2524.11	1012.50	4517.31	2888.79	506.25	924.62
10a	ULT 600	0.85	1850.27	1004.06	4479.66	2676.76	502.03	714.24
10b	ULT 23	1.10	1991.98	1020.94	4554.95	2864.76	510.47	884.22
11a	ULT 700	0.70	1365.74	984.38	4391.83	2470.39	492.19	546.35
11b	ULT 28	1.00	1621.38	1012.50	4517.31	2783.84	506.25	819.67
Max			**3824.27**	**1035.00**	**4617.69**	**4110.54**	**517.50**	**1503.85**

z/h =	0
I_p =	1.5

Note:

Case 1	Tension load to middle anchor group due to side to side seismic loading
Case 2	Shear load & tension load by prying action to end anchor due to side to side seismic loading
Case 3	Tension load to middle anchor group due to front to back seismic loading
Case 4	Shear loading to end anchor due to front and back seismic loading

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 12
Configuratoin No.: 1

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	550	lbf	per unit cut sheet
Unit width	B	24	in	per unit cut sheet
Unit depth	D	26.2	in	per unit cut sheet
Unit height	H	73.62	in	per unit cut sheet
Caster out to out distance	D_c	21.3	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	26.63	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	22.93	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	49.08	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	2.40	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	2.62	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	2.50		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	0		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1.5		
Seismic design force	F_p	343.75	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	3300.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	618.75	lbf	Eq. 13.3-3
Final seismic design force	F_p	618.75	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
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Sesimic Restraints of Freezers

Notes:
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2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	30368.25	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	2400.75	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	27967.50	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	1050.42	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	30368.25	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	1945.35	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	28422.90	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	1239.82	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	1239.82	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.59	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
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Item: LRF 12
Configuratoin No.: 1

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1050.42	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.17	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1239.82	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.21	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
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Configuratoin No.: 1

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	742.50	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	25.00	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.12	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	2761.31	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	773.44	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	3450.72	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	3226.84	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	386.72	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 23
Configuratoin No.: 2

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	800	lbf	per unit cut sheet
Unit width	B	28	in	per unit cut sheet
Unit depth	D	33	in	per unit cut sheet
Unit height	H	79.23	in	per unit cut sheet
Caster out to out distance	D_c	26.5	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	30.63	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	28.13	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.82	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	2.80	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.30	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	2.30		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	0		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1.5		
Seismic design force	F_p	460.00	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	4416.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	828.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	828.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
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Cal. No.: 2015-0932-DC-001, r0
Originator: JY
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Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	43734.96	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	4404.40	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	39330.56	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	1284.26	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	43734.96	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	3788.40	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	39946.56	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	1420.32	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	1420.32	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.68	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 23
Configuratoin No.: 2

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
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Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1284.26	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.21	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1420.32	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.24	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 23
Configuratoin No.: 2

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1159.20	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	29.00	in	L = B+1"
Capcity reduction factor	f	0.96		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5791.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.20	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	3426.38	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1035.00	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4617.69	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	3752.85	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	517.50	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 30
Configuratoin No.: 3

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1000	lbf	per unit cut sheet
Unit width	B	34	in	per unit cut sheet
Unit depth	D	33	in	per unit cut sheet
Unit height	H	79.23	in	per unit cut sheet
Caster out to out distance	D_c	26.5	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	36.63	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	28.13	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.82	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	3.40	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.30	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	1.80		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	0		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1.5		
Seismic design force	F_p	450.00	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	4320.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	810.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	810.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 30
Configuratoin No.: 3

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	42784.20	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	8052.75	lbf-in	$M_{R.grav} = (0.9\text{-}0.2*S_{DS})W_p*(S_{ss}/2\text{-}e_{ss})$
Resisting moment by strap	$M_{R.strap}$	34731.45	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	948.30	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	42784.20	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	5811.75	lbf-in	$M_{R.grav} = (0.9\text{-}0.2*S_{DS})W_p*(S_{fb}/2\text{-}e_{fb})$
Resisting moment by strap	$M_{R.strap}$	36972.45	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	1314.58	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	1314.58	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.63	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 30
Configuratoin No.: 3

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	948.30	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.16	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1314.58	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.22	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 30
Configuratoin No.: 3

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1377.00	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	35.00	in	L = B+1"
Capcity reduction factor	f	0.94		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5671.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.24	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	2700.55	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1012.50	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4517.31	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	3596.40	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	506.25	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 45
Configuratoin No.: 4a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1100	lbf	per unit cut sheet
Unit width	B	56.5	in	per unit cut sheet
Unit depth	D	31.5	in	per unit cut sheet
Unit height	H	79.23	in	per unit cut sheet
Caster out to out distance	D_c	23.2	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	59.13	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	24.83	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.82	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	5.65	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.15	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	1.65		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	0		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1.5		
Seismic design force	F_p	453.75	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	4356.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	816.75	lbf	Eq. 13.3-3
Final seismic design force	F_p	816.75	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 45
Configuratoin No.: 4a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	43140.74	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	14993.14	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	28147.60	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	476.07	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	43140.74	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	5807.59	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	37333.15	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	1503.85	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	1503.85	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.72	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 45
Configuratoin No.: 4a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	476.07	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.08	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1503.85	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.25	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 45
Configuratoin No.: 4a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	2307.32	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	57.50	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.39	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	1570.55	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1020.94	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4554.95	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	4110.54	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	510.47	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 50
Configuratoin No.: 4b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1250	lbf	per unit cut sheet
Unit width	B	56.5	in	per unit cut sheet
Unit depth	D	33	in	per unit cut sheet
Unit height	H	79.23	in	per unit cut sheet
Caster out to out distance	D_c	26.5	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	59.13	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	28.13	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.82	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	5.65	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.30	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	1.45		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	0		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1.5		
Seismic design force	F_p	453.13	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	4350.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	815.63	lbf	Eq. 13.3-3
Final seismic design force	F_p	815.63	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 50
Configuratoin No.: 4b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	43081.31	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	18233.28	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	24848.03	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	420.26	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	43081.31	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	8206.41	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	34874.91	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	1240.00	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	1240.00	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.59	O.K.	DCR = $F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 50
Configuratoin No.: 4b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	420.26	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.07	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1240.00	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.21	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 50
Configuratoin No.: 4b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	2304.14	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	57.50	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.39	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	1513.23	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1019.53	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4548.68	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	3537.67	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	509.77	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 75
Configuratoin No.: 5

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1600	lbf	per unit cut sheet
Unit width	B	85	in	per unit cut sheet
Unit depth	D	33	in	per unit cut sheet
Unit height	H	79.23	in	per unit cut sheet
Caster out to out distance	D_c	26.5	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	87.63	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	28.13	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.82	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	8.50	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.30	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	1.15		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	0		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1.5		
Seismic design force	F_p	460.00	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	4416.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	828.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	828.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 75
Configuratoin No.: 5

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
3. Load Combinations				
		$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
		$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
		$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
		$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir
4. Check of Strap				
4.1 Side to Side Direction				
Overturning moment due to seismic foce	M_{OT}	43734.96	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	37855.00	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	5879.96	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	67.10	lbf	$F_{ss} = M_{R.strap}/S_{ss}$
4.2 Front to Back Direction				
Overturning moment due to seismic foce	M_{OT}	43734.96	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	11537.40	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	32197.56	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	1144.80	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$
4.3 Check of Strap				
Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	1144.80	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.55	O.K.	DCR = $F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 75
Configuratoin No.: 5

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	67.10	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.01	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1144.80	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.19	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 75
Configuratoin No.: 5

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	3519.00	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	86.00	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.59	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	815.78	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1035.00	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4617.69	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	3477.33	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	517.50	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 13
Configuratoin No.: 6

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1350	lbf	per unit cut sheet
Unit width	B	33.3	in	per unit cut sheet
Unit depth	D	29.5	in	per unit cut sheet
Unit height	H	77.9	in	per unit cut sheet
Caster out to out distance	D_c	24.3	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	35.93	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	25.93	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	51.93	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	3.33	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	2.95	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	1.35		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	0		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1.5		
Seismic design force	F_p	455.63	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	4374.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	820.13	lbf	Eq. 13.3-3
Final seismic design force	F_p	820.13	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 13
Configuratoin No.: 6

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	42591.83	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	12444.94	lbf-in	$M_{R.grav} = (0.9\text{-}0.2*S_{DS})W_p*(S_{ss}/2\text{-}e_{ss})$
Resisting moment by strap	$M_{R.strap}$	30146.88	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	839.16	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	42591.83	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	8515.63	lbf-in	$M_{R.grav} = (0.9\text{-}0.2*S_{DS})W_p*(S_{fb}/2\text{-}e_{fb})$
Resisting moment by strap	$M_{R.strap}$	34076.19	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	1314.41	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	1314.41	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.63	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 13
Configuratoin No.: 6

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	839.16	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.14	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1314.41	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.22	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 13
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Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
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Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1365.51	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	34.30	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.23	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	2617.53	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1025.16	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4573.77	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	3778.74	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	512.58	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 300
Configuratoin No.: 7

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1300	lbf	per unit cut sheet
Unit width	B	23	in	per unit cut sheet
Unit depth	D	35.9	in	per unit cut sheet
Unit height	H	78	in	per unit cut sheet
Caster out to out distance	D_c	30.3	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	25.63	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	31.93	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.00	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	2.30	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.59	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	1.40		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	0		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1.5		
Seismic design force	F_p	455.00	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	4368.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	819.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	819.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
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Item: ULT 300
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Cal. No.: 2015-0932-DC-001, r0
Originator: JY
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Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	42588.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	8473.08	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	34114.93	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	1331.31	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	42588.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	9972.24	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	32615.77	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	1021.64	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	1331.31	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.63	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
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Item: ULT 300
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Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1331.31	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.22	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1021.64	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.17	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
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Cal. No.: 2015-0932-DC-001, r0
Originator: JY
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Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	941.85	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	24.00	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.16	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	3824.27	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1023.75	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4567.50	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	3022.64	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	511.88	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 400
Configuratoin No.: 8

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1600	lbf	per unit cut sheet
Unit width	B	28.4	in	per unit cut sheet
Unit depth	D	35.9	in	per unit cut sheet
Unit height	H	78	in	per unit cut sheet
Caster out to out distance	D_c	30.3	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	31.03	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	31.93	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.00	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	2.84	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.59	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	1.15		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	0		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1.5		
Seismic design force	F_p	460.00	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	4416.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	828.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	828.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 400
Configuratoin No.: 8

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	43056.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	13584.92	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	29471.08	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	949.91	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	43056.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	13263.32	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	29792.68	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	933.21	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	949.91	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.45	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
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Item: ULT 400
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Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	949.91	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.16	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	933.21	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.15	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 400
Configuratoin No.: 8

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
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2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1175.76	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	29.40	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.20	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	3031.59	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1035.00	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4617.69	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	2956.20	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	517.50	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 500
Configuratoin No.: 9a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1850	lbf	per unit cut sheet
Unit width	B	34	in	per unit cut sheet
Unit depth	D	35.9	in	per unit cut sheet
Unit height	H	78	in	per unit cut sheet
Caster out to out distance	D_c	30.3	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	36.63	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	31.93	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.00	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	3.40	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.59	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	0.95		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	0		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1.5		
Seismic design force	F_p	439.38	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	4218.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	790.88	lbf	Eq. 13.3-3
Final seismic design force	F_p	790.88	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 500
Configuratoin No.: 9a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
3. Load Combinations				
		$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
		$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
		$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
		$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir
4. Check of Strap				
4.1 Side to Side Direction				
Overturning moment due to seismic foce	M_{OT}	41125.50	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	19587.57	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	21537.93	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	588.07	lbf	$F_{ss} = M_{R.strap}/S_{ss}$
4.2 Front to Back Direction				
Overturning moment due to seismic foce	M_{OT}	41125.50	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	16251.28	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	24874.22	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	779.15	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$
4.3 Check of Strap				
Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	779.15	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.37	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 500
Configuratoin No.: 9a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	588.07	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.10	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	779.15	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.13	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 500
Configuratoin No.: 9a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1344.49	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	35.00	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.23	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	2272.39	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	988.59	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4410.65	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	2711.43	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	494.30	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 17
Configuratoin No.: 9b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1500	lbf	per unit cut sheet
Unit width	B	33.3	in	per unit cut sheet
Unit depth	D	35.75	in	per unit cut sheet
Unit height	H	77.9	in	per unit cut sheet
Caster out to out distance	D_c	30.5	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	35.93	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	32.13	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	51.93	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	3.33	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.58	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	1.20		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	0		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1.5		
Seismic design force	F_p	450.00	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	4320.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	810.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	810.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 17
Configuratoin No.: 9b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	42066.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	14486.18	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	27579.83	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	767.71	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	42066.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	12362.63	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	29703.38	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	924.62	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	924.62	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.44	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 17
Configuratoin No.: 9b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	767.71	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.13	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	924.62	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.15	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 17
Configuratoin No.: 9b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1348.65	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	34.30	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.23	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	2524.11	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1012.50	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4517.31	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	2888.79	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	506.25	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 600
Configuratoin No.: 10a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	2100	lbf	per unit cut sheet
Unit width	B	39.6	in	per unit cut sheet
Unit depth	D	35.9	in	per unit cut sheet
Unit height	H	78	in	per unit cut sheet
Caster out to out distance	D_c	30.3	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	42.23	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	31.93	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.00	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	3.96	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.59	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	0.85		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	0		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1.5		
Seismic design force	F_p	446.25	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	4284.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	803.25	lbf	Eq. 13.3-3
Final seismic design force	F_p	803.25	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 600
Configuratoin No.: 10a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	41769.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	26294.78	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	15474.22	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	366.47	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	41769.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	18967.04	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	22801.96	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	714.24	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	714.24	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.34	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 600
Configuratoin No.: 10a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	366.47	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.06	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	714.24	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.12	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 600
Configuratoin No.: 10a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1590.44	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	40.60	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.27	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	1850.27	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1004.06	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4479.66	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	2676.76	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	502.03	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 23
Configuratoin No.: 10b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1650	lbf	per unit cut sheet
Unit width	B	40.7	in	per unit cut sheet
Unit depth	D	35.75	in	per unit cut sheet
Unit height	H	77.9	in	per unit cut sheet
Caster out to out distance	D_c	30.5	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	43.33	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	32.13	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	51.93	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	4.07	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.58	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	1.10		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	0		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1.5		
Seismic design force	F_p	453.75	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	4356.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	816.75	lbf	Eq. 13.3-3
Final seismic design force	F_p	816.75	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
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Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
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Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
3. Load Combinations				
		$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
		$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
		$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
		$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir
4. Check of Strap				
4.1 Side to Side Direction				
Overturning moment due to seismic foce	M_{OT}	42416.55	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	19738.79	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	22677.77	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	523.43	lbf	$F_{ss} = M_{R.strap}/S_{ss}$
4.2 Front to Back Direction				
Overturning moment due to seismic foce	M_{OT}	42416.55	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	14010.98	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	28405.58	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	884.22	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$
4.3 Check of Strap				
Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	884.22	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.42	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 23
Configuratoin No.: 10b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	523.43	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.09	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	884.22	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.15	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
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Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1662.09	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	41.70	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.28	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	1991.98	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1020.94	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4554.95	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	2864.76	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	510.47	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 700
Configuratoin No.: 11a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	2500	lbf	per unit cut sheet
Unit width	B	45.3	in	per unit cut sheet
Unit depth	D	35.9	in	per unit cut sheet
Unit height	H	78	in	per unit cut sheet
Caster out to out distance	D_c	30.3	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	47.93	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	31.93	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.00	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	4.53	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.59	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	0.70		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	0		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1.5		
Seismic design force	F_p	437.50	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	4200.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	787.50	lbf	Eq. 13.3-3
Final seismic design force	F_p	787.50	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
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Item: ULT 700
Configuratoin No.: 11a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
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3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	40950.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	36921.75	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	4028.25	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	84.05	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	40950.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	23507.75	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	17442.25	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	546.35	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	546.35	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.26	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
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Cal. No.: 2015-0932-DC-001, r0
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Sesimic Restraints of Freezers

Notes:
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2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	84.05	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.01	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	546.35	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.09	O.K.	$DCR = M_{u1}/ØM_n$

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Sesimic Restraints of Freezers

Notes:
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3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1783.69	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	46.30	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.30	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	1365.74	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	984.38	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4391.83	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	2470.39	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	492.19	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 28
Configuratoin No.: 11b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1800	lbf	per unit cut sheet
Unit width	B	46.7	in	per unit cut sheet
Unit depth	D	35.75	in	per unit cut sheet
Unit height	H	77.9	in	per unit cut sheet
Caster out to out distance	D_c	30.5	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	49.33	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	32.13	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	51.93	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	4.67	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.58	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	1.00		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	0		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1.5		
Seismic design force	F_p	450.00	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	4320.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	810.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	810.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

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Sesimic Restraints of Freezers

Notes:
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2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	42066.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	25190.55	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	16875.45	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	342.13	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	42066.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	15734.25	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	26331.75	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	819.67	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	819.67	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.39	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 28
Configuratoin No.: 11b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	342.13	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.06	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	819.67	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.14	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 28
Configuratoin No.: 11b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1891.35	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	47.70	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.32	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	1621.38	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1012.50	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4517.31	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	2783.84	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	506.25	lbf	$V_{u4} = Ω*F_p/4$

Section 4. Seismic Restraint Design of Freezers for I_p =1.5 & z/h=1

Summary of Anchor Force

Configuration	Unit	Demand	Case 1	Case 2		Case 3	Case 4	Strap Pretension
	Name	S_{DS}	T_{u1}	V_{u2}	$T_{u2,prying}$	T_{u3}	V_{u4}	Force
			(lbf)	(lbf)		(lbf)	(lbf)	lbf
1	LRF 12	2.00	3689.26	1031.25	4600.96	4309.52	515.63	1660.17
2	LRF 23	1.35	3286.67	1012.50	4517.31	3610.18	506.25	1328.35
3	LRF 30	1.10	2697.63	1031.25	4600.96	3613.25	515.63	1289.17
4a	LRF 45	1.00	1531.14	1031.25	4600.96	4101.07	515.63	1468.05
4b	LRF 50	0.85	1410.69	996.09	4444.11	3392.23	498.05	1147.38
5	LRF 75	0.65	678.96	975.00	4350.00	3190.74	487.50	993.43
6	ULT 13	0.80	2520.45	1012.50	4517.31	3670.69	506.25	1236.78
7	ULT 300	0.85	3815.07	1035.94	4621.88	3006.92	517.97	1292.43
8	ULT 400	0.65	2765.11	975.00	4350.00	2698.73	487.50	804.11
9a	ULT 500	0.55	2113.63	953.91	4255.89	2541.08	476.95	676.59
9b	ULT 17	0.70	2381.70	984.38	4391.83	2739.55	492.19	829.94
10a	ULT 600	0.50	1742.07	984.38	4391.83	2555.65	492.19	631.61
10b	ULT 23	0.65	1894.60	1005.47	4485.94	2757.02	502.73	806.49
11a	ULT 700	0.40	1203.20	937.50	4182.69	2259.56	468.75	427.14
11b	ULT 28	0.60	1563.01	1012.50	4517.31	2727.86	506.25	763.69
Max			**3815.07**	**1035.94**	**4621.88**	**4309.52**	**517.97**	**1660.17**

z/h =	1
I_p =	1.5

Note:

Case 1	Tension load to middle anchor group due to side to side seismic loading
Case 2	Shear load & tension load by prying action to end anchor due to side to side seismic loading
Case 3	Tension load to middle anchor group due to front to back seismic loading
Case 4	Shear loading to end anchor due to front and back seismic loading

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 12
Configuratoin No.: 1

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	550	lbf	per unit cut sheet
Unit width	B	24	in	per unit cut sheet
Unit depth	D	26.2	in	per unit cut sheet
Unit height	H	73.62	in	per unit cut sheet
Caster out to out distance	D_c	21.3	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	26.63	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	22.93	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	49.08	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	2.40	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	2.62	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	2.00		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	1		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1.5		
Seismic design force	F_p	825.00	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	2640.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	495.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	825.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
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Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	40491.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	3000.94	lbf-in	$M_{R.grav} = (0.9\text{-}0.2*S_{DS})W_p*(S_{ss}/2\text{-}e_{ss})$
Resisting moment by strap	$M_{R.strap}$	37490.06	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	1408.08	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	40491.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	2431.69	lbf-in	$M_{R.grav} = (0.9\text{-}0.2*S_{DS})W_p*(S_{fb}/2\text{-}e_{fb})$
Resisting moment by strap	$M_{R.strap}$	38059.31	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	1660.17	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	1660.17	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.79	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
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Item: LRF 12
Configuratoin No.: 1

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1408.08	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.23	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1660.17	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.28	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
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Configuratoin No.: 1

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	990.00	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	25.00	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.17	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	3689.26	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1031.25	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4600.96	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	4309.52	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	515.63	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 23
Configuratoin No.: 2

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	800	lbf	per unit cut sheet
Unit width	B	28	in	per unit cut sheet
Unit depth	D	33	in	per unit cut sheet
Unit height	H	79.23	in	per unit cut sheet
Caster out to out distance	D_c	26.5	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	30.63	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	28.13	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.82	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	2.80	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.30	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	1.35		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	1		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1.5		
Seismic design force	F_p	810.00	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	2592.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	486.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	810.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
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Item: LRF 23
Configuratoin No.: 2

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	42784.20	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	6306.30	lbf-in	$M_{R.grav} = (0.9\text{-}0.2*S_{DS})W_p*(S_{ss}/2\text{-}e_{ss})$
Resisting moment by strap	$M_{R.strap}$	36477.90	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	1191.12	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	42784.20	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	5424.30	lbf-in	$M_{R.grav} = (0.9\text{-}0.2*S_{DS})W_p*(S_{fb}/2\text{-}e_{fb})$
Resisting moment by strap	$M_{R.strap}$	37359.90	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	1328.35	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	1328.35	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.63	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 23
Configuratoin No.: 2

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1191.12	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.20	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1328.35	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.22	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 23
Configuratoin No.: 2

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1134.00	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	29.00	in	L = B+1"
Capcity reduction factor	f	0.96		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5791.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.20	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	3286.67	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1012.50	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4517.31	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	3610.18	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	506.25	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 30
Configuratoin No.: 3

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1000	lbf	per unit cut sheet
Unit width	B	34	in	per unit cut sheet
Unit depth	D	33	in	per unit cut sheet
Unit height	H	79.23	in	per unit cut sheet
Caster out to out distance	D_c	26.5	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	36.63	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	28.13	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.82	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	3.40	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.30	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	1.10		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	1		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1.5		
Seismic design force	F_p	825.00	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	2640.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	495.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	825.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 30
Configuratoin No.: 3

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	43576.50	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	10140.50	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	33436.00	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	912.93	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	43576.50	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	7318.50	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	36258.00	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	1289.17	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	1289.17	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.61	O.K.	DCR = $F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 30
Configuratoin No.: 3

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	912.93	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.15	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1289.17	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.21	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 30
Configuratoin No.: 3

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1402.50	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	35.00	in	L = B+1"
Capcity reduction factor	f	0.94		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5671.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.25	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	2697.63	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1031.25	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4600.96	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	3613.25	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	515.63	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 45
Configuratoin No.: 4a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1100	lbf	per unit cut sheet
Unit width	B	56.5	in	per unit cut sheet
Unit depth	D	31.5	in	per unit cut sheet
Unit height	H	79.23	in	per unit cut sheet
Caster out to out distance	D_c	23.2	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	59.13	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	24.83	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.82	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	5.65	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.15	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	1.00		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	1		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1.5		
Seismic design force	F_p	825.00	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	2640.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	495.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	825.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 45
Configuratoin No.: 4a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	43576.50	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	18412.63	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	25163.88	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	425.60	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	43576.50	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	7132.13	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	36444.38	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	1468.05	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	1468.05	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.70	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 45
Configuratoin No.: 4a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	425.60	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.07	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1468.05	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.24	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 45
Configuratoin No.: 4a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	2330.63	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	57.50	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.39	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	1531.14	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1031.25	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4600.96	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	4101.07	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	515.63	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 50
Configuratoin No.: 4b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1250	lbf	per unit cut sheet
Unit width	B	56.5	in	per unit cut sheet
Unit depth	D	33	in	per unit cut sheet
Unit height	H	79.23	in	per unit cut sheet
Caster out to out distance	D_c	26.5	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	59.13	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	28.13	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.82	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	5.65	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.30	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	0.85		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	1		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1.5		
Seismic design force	F_p	796.88	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	2550.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	478.13	lbf	Eq. 13.3-3
Final seismic design force	F_p	796.88	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 50
Configuratoin No.: 4b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
3. Load Combinations				
		$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
		$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
		$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
		$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir
4. Check of Strap				
4.1 Side to Side Direction				
Overturning moment due to seismic foce	M_{OT}	42090.94	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	21820.16	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	20270.78	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	342.85	lbf	$F_{ss} = M_{R.strap}/S_{ss}$
4.2 Front to Back Direction				
Overturning moment due to seismic foce	M_{OT}	42090.94	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	9820.78	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	32270.16	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	1147.38	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$
4.3 Check of Strap				
Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	1147.38	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.55	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 50
Configuratoin No.: 4b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	342.85	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.06	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1147.38	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.19	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 50
Configuratoin No.: 4b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	2251.17	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	57.50	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.38	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	1410.69	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	996.09	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4444.11	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	3392.23	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	498.05	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 75
Configuratoin No.: 5

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1600	lbf	per unit cut sheet
Unit width	B	85	in	per unit cut sheet
Unit depth	D	33	in	per unit cut sheet
Unit height	H	79.23	in	per unit cut sheet
Caster out to out distance	D_c	26.5	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	87.63	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	28.13	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.82	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	8.50	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.30	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	0.65		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	1		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1.5		
Seismic design force	F_p	780.00	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	2496.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	468.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	780.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 75
Configuratoin No.: 5

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
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Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	41199.60	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	43505.00	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	-2305.40	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	-26.31	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	41199.60	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	13259.40	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	27940.20	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	993.43	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	993.43	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.47	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 75
Configuratoin No.: 5

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	-26.31	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.00	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	993.43	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.16	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: LRF 75
Configuratoin No.: 5

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	3315.00	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	86.00	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.56	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	678.96	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	975.00	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4350.00	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	3190.74	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	487.50	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 13
Configuratoin No.: 6

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1350	lbf	per unit cut sheet
Unit width	B	33.3	in	per unit cut sheet
Unit depth	D	29.5	in	per unit cut sheet
Unit height	H	77.9	in	per unit cut sheet
Caster out to out distance	D_c	24.3	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	35.93	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	25.93	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	51.93	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	3.33	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	2.95	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	0.80		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	1		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1.5		
Seismic design force	F_p	810.00	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	2592.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	486.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	810.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 13
Configuratoin No.: 6

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	42066.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	14617.87	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	27448.13	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	764.04	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	42066.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	10002.49	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	32063.51	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	1236.78	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	1236.78	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.59	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 13
Configuratoin No.: 6

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	764.04	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.13	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1236.78	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.20	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 13
Configuratoin No.: 6

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1348.65	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	34.30	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.23	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	2520.45	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1012.50	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4517.31	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	3670.69	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	506.25	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 300
Configuratoin No.: 7

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1300	lbf	per unit cut sheet
Unit width	B	23	in	per unit cut sheet
Unit depth	D	35.9	in	per unit cut sheet
Unit height	H	78	in	per unit cut sheet
Caster out to out distance	D_c	30.3	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	25.63	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	31.93	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.00	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	2.30	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.59	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	0.85		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	1		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1.5		
Seismic design force	F_p	828.75	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	2652.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	497.25	lbf	Eq. 13.3-3
Final seismic design force	F_p	828.75	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
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Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
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Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	43095.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	9976.36	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	33118.64	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	1292.43	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	43095.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	11741.50	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	31353.50	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	982.10	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	1292.43	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.62	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
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Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	1292.43	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.21	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	982.10	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.16	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
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Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	953.06	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	24.00	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.16	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	3815.07	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1035.94	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4621.88	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	3006.92	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	517.97	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 400
Configuratoin No.: 8

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1600	lbf	per unit cut sheet
Unit width	B	28.4	in	per unit cut sheet
Unit depth	D	35.9	in	per unit cut sheet
Unit height	H	78	in	per unit cut sheet
Caster out to out distance	D_c	30.3	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	31.03	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	31.93	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.00	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	2.84	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.59	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	0.65		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	1		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1.5		
Seismic design force	F_p	780.00	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	2496.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	468.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	780.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
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Configuratoin No.: 8

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	40560.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	15612.52	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	24947.48	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	804.11	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	40560.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	15242.92	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	25317.08	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	793.02	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	804.11	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.38	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
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Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	804.11	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.13	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	793.02	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.13	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 400
Configuratoin No.: 8

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1107.60	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	29.40	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.19	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	2765.11	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	975.00	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4350.00	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	2698.73	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	487.50	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 500
Configuratoin No.: 9a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1850	lbf	per unit cut sheet
Unit width	B	34	in	per unit cut sheet
Unit depth	D	35.9	in	per unit cut sheet
Unit height	H	78	in	per unit cut sheet
Caster out to out distance	D_c	30.3	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	36.63	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	31.93	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.00	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	3.40	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.59	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	0.55		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	1		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1.5		
Seismic design force	F_p	763.13	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	2442.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	457.88	lbf	Eq. 13.3-3
Final seismic design force	F_p	763.13	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 500
Configuratoin No.: 9a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
3. Load Combinations				
		$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
		$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
		$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
		$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir
4. Check of Strap				
4.1 Side to Side Direction				
Overturning moment due to seismic foce	M_{OT}	39682.50	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	21794.62	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	17887.88	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	488.41	lbf	$F_{ss} = M_{R.strap}/S_{ss}$
4.2 Front to Back Direction				
Overturning moment due to seismic foce	M_{OT}	39682.50	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	18082.41	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	21600.09	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	676.59	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$
4.3 Check of Strap				
Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	676.59	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.32	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 500
Configuratoin No.: 9a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	488.41	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.08	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	676.59	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.11	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 500
Configuratoin No.: 9a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1297.31	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	35.00	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.22	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	2113.63	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	953.91	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4255.89	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	2541.08	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	476.95	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 17
Configuratoin No.: 9b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1500	lbf	per unit cut sheet
Unit width	B	33.3	in	per unit cut sheet
Unit depth	D	35.75	in	per unit cut sheet
Unit height	H	77.9	in	per unit cut sheet
Caster out to out distance	D_c	30.5	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	35.93	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	32.13	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	51.93	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	3.33	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.58	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	0.70		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	1		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1.5		
Seismic design force	F_p	787.50	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	2520.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	472.50	lbf	Eq. 13.3-3
Final seismic design force	F_p	787.50	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 17
Configuratoin No.: 9b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	40897.50	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	16681.05	lbf-in	$M_{R.grav} = (0.9\text{-}0.2*S_{DS})W_p*(S_{ss}/2\text{-}e_{ss})$
Resisting moment by strap	$M_{R.strap}$	24216.45	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	674.08	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	40897.50	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	14235.75	lbf-in	$M_{R.grav} = (0.9\text{-}0.2*S_{DS})W_p*(S_{fb}/2\text{-}e_{fb})$
Resisting moment by strap	$M_{R.strap}$	26661.75	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	829.94	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	829.94	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.40	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 17
Configuratoin No.: 9b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	674.08	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.11	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	829.94	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.14	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 17
Configuratoin No.: 9b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1311.19	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	34.30	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.22	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	2381.70	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	984.38	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4391.83	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	2739.55	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	492.19	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 600
Configuratoin No.: 10a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	2100	lbf	per unit cut sheet
Unit width	B	39.6	in	per unit cut sheet
Unit depth	D	35.9	in	per unit cut sheet
Unit height	H	78	in	per unit cut sheet
Caster out to out distance	D_c	30.3	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	42.23	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	31.93	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.00	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	3.96	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.59	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	0.50		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	1		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1.5		
Seismic design force	F_p	787.50	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	2520.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	472.50	lbf	Eq. 13.3-3
Final seismic design force	F_p	787.50	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 600
Configuratoin No.: 10a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	40950.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	28816.20	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	12133.80	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	287.36	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	40950.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	20785.80	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	20164.20	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	631.61	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	631.61	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.30	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 600
Configuratoin No.: 10a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	287.36	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.05	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	631.61	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.10	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 600
Configuratoin No.: 10a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1559.25	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	40.60	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.26	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	1742.07	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	984.38	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4391.83	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	2555.65	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	492.19	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 23
Configuratoin No.: 10b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1650	lbf	per unit cut sheet
Unit width	B	40.7	in	per unit cut sheet
Unit depth	D	35.75	in	per unit cut sheet
Unit height	H	77.9	in	per unit cut sheet
Caster out to out distance	D_c	30.5	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	43.33	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	32.13	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	51.93	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	4.07	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.58	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	0.65		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	1		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1.5		
Seismic design force	F_p	804.38	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	2574.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	482.63	lbf	Eq. 13.3-3
Final seismic design force	F_p	804.38	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
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Cal. No.: 2015-0932-DC-001, r0
Originator: JY
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Sesimic Restraints of Freezers

Notes:
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2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	41773.88	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	22351.27	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	19422.60	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	448.30	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	41773.88	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	15865.37	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	25908.51	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	806.49	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	806.49	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.38	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 23
Configuratoin No.: 10b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	448.30	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.07	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	806.49	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.13	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 23
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Cal. No.: 2015-0932-DC-001, r0
Originator: JY
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Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1636.90	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	41.70	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.27	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	1894.60	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1005.47	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4485.94	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	2757.02	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	502.73	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 700
Configuratoin No.: 11a

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	2500	lbf	per unit cut sheet
Unit width	B	45.3	in	per unit cut sheet
Unit depth	D	35.9	in	per unit cut sheet
Unit height	H	78	in	per unit cut sheet
Caster out to out distance	D_c	30.3	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	47.93	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	31.93	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	52.00	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	4.53	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.59	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	0.40		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	1		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1.5		
Seismic design force	F_p	750.00	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	2400.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	450.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	750.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
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Item: ULT 700
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Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	39000.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	39836.63	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	-836.62	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	-17.46	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	39000.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	25363.63	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	13636.38	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	427.14	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	427.14	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.20	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
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Originator: JY
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Sesimic Restraints of Freezers

Notes:
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2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	-17.46	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.00	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	427.14	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.07	O.K.	$DCR = M_{u1}/ØM_n$

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Sesimic Restraints of Freezers

Notes:
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3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1698.75	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	46.30	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.28	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	1203.20	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	937.50	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4182.69	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	2259.56	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	468.75	lbf	$V_{u4} = Ω*F_p/4$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 28
Configuratoin No.: 11b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
1. Unit Basic Information				
Unit weight	W_p	1800	lbf	per unit cut sheet
Unit width	B	46.7	in	per unit cut sheet
Unit depth	D	35.75	in	per unit cut sheet
Unit height	H	77.9	in	per unit cut sheet
Caster out to out distance	D_c	30.5	in	per unit cut sheet
Unistrut spacing in side to side direction	S_{ss}	49.33	in	S_{ss} = B+1"+1 5/8"
Unistrut spacing in front to back direction	S_{fb}	32.13	in	S_{fb} = D_c+1 5/8"
CG location	H_{cg}	51.93	in	H_{cg} = H*2/3
CG eccentricity in side to side direction	e_{ss}	4.67	in	e_{ss} = 0.1B
CG eccentricity in front to back direction	e_{fb}	3.58	in	e_{fb} = 0.1D
Height of unistrut plus angle short leg	$h_{unistrut}$	3.63	in	per unistrut catalogue
Depth of unistrut	$d_{unistrut}$	1.63	in	per unistrut catalogue
2. Seismic Force Calculation				
Short period spectral response acceleration	S_{DS}	0.60		
Average roof height of structure	h	1		normalized height
Height in structure of component attachment	z	1		normalized height
Component repsonse amplication factor	a_p	2.5		
Component repsonse modification factor	R_p	6		
Overstrength factor	Ω	2.5		
Component important factor	I_p	1.5		
Seismic design force	F_p	810.00	lbf	Eq. 13.3-1
Max seismic design force	$F_{p,max}$	2592.00	lbf	Eq. 13.3-2
Min seismic design force	$F_{p,min}$	486.00	lbf	Eq. 13.3-3
Final seismic design force	F_p	810.00	lbf	min($F_{p,max}$, max(F_p, $F_{p,min}$))

Tobolski Watkins Engineering, Inc.

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Sesimic Restraints of Freezers

Notes:
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3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference

3. Load Combinations

$(1.2 + 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 5 for x dir
$(1.2 + 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 5 for y dir
$(0.9 - 0.2S_{DS})D + \Omega E_x$		Section 12.4.3.2 basic load comb 7 for x dir
$(0.9 - 0.2S_{DS})D + \Omega E_y$		Section 12.4.3.2 basic load comb 7 for y dir

4. Check of Strap

4.1 Side to Side Direction

Overturning moment due to seismic foce	M_{OT}	42066.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	28069.47	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{ss}/2-e_{ss})$
Resisting moment by strap	$M_{R.strap}$	13996.53	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for side to side direction	F_{ss}	283.76	lbf	$F_{ss} = M_{R.strap}/S_{ss}$

4.2 Front to Back Direction

Overturning moment due to seismic foce	M_{OT}	42066.00	lbf-in	$M_{OT} = F_p * H_{cg}$
Resisting moment by gravity	$M_{R.grav}$	17532.45	lbf-in	$M_{R.grav} = (0.9-0.2*S_{DS})W_p*(S_{fb}/2-e_{fb})$
Resisting moment by strap	$M_{R.strap}$	24533.55	lbf-in	$M_{R.strap} = M_{OT} - M_{R.grav}$
Required strap froce for front to back direction	F_{fb}	763.69	lbf	$F_{fb} = M_{R.strap}/(S_{fb}/2)/2$

4.3 Check of Strap

Tested allowable capacity of strap	T_a	1500	lbf	per information of QuakHold Part No. 44627-11 with 2" Strap
Max strap force	F_{max}	763.69	lbf	$F_{max} = \max(F_{ss}, F_{fb})$
Demand capacity ratio	DCR	0.36	O.K.	$DCR = F_{max}/(1.4T_a)$, O.K. if DCR < 1.

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 28
Configuratoin No.: 11b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
5. Check of Unistrut				
Unistrut allowable bending capacity for any dir. bending	M_a	5070	lbf-in	for 1 5/8in unistrut P1000 12GA
Modified bending capacity for HS/T Section	M_a	4309.5	lbf-in	for 1 5/8in unistrut P1000T 12GA
Max spacing of anchors next to strap	S_{anchor}	4	in	
Max distance of end anchors to the end of unistrut	D_{anchor}	6.5	in	
5.1 Side to Side Direction				
Unistrut on one side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	283.76	lbf-in	$M_{u1} = F_{ss}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.05	O.K.	$DCR = M_{u1}/ØM_n$
Unistrut on the other side resisting seismic shear by anchor shear				
5.2 Front to Back Direction				
Unistrut on each side resisting strap force by bending in vertical direction				
Ultimate moment in unistrut due to strap force	M_{u1}	763.69	lbf-in	$M_{u1} = F_{fb}*S_{anchor}/4$
Unbraced length	L	4	in	
Capcity reduction factor	f	1		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	6033.30	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.13	O.K.	$DCR = M_{u1}/ØM_n$

Tobolski Watkins Engineering, Inc.

Project Name: Freezers (Thermo Fisher Scientific)
Project No.: 0932
Item: ULT 28
Configuratoin No.: 11b

Cal. No.: 2015-0932-DC-001, r0
Originator: JY
Reviewer: MT
Date: 4/10/2015

Sesimic Restraints of Freezers

Notes:
1. Seismic force is determined per Section 13.3 of ASCE 7.
2. Strap is tied down by eye bolt to unistrut, which is anchored to slab below by (2) post installed anchors of max 4in spacing.
3. In addition, for unistrut on the side, one post installed anchor is provided at max 6.5in from each end.

Description	Variable	Value	Units	Equation / Reference
Unistrut on front and back sides resisting seismic shear by sideway bending				
Ultimate moment in unistrut due to seismic shear	M_{u2}	1891.35	lbf-in	$M_{u2} = F_p/2*0.1*B$
Unbraced length	L	47.70	in	L = B+1"
Capcity reduction factor	f	0.99		per unistruct catalog page 56 for P1000 beam.
Unistrut ultimate bending capacity	$ØM_n$	5972.97	lbf-in	$ØM_n = f*1.4*M_a$
Demand capacity ratio	DCR	0.32	O.K.	$DCR = M_{u2}/ØM_n$
6. Calculation of Post Installed Anchor Force				
6.1 Side to Side Direction				
Anchor bolts of unistrut on one side resisting tension only (Case 1 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u1}	1563.01	lbf	$T_{u1} = (Ω*M_{OT} - M_{R.grav})/S_{ss}$
End anchor bolts of unistrut on the other side resisting shear only with prying action (Case 2 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u2}	1012.50	lbf	$V_{u2} = Ω*F_p/2$
Ultimate prying tension force on anchor due to shear	$T_{u2,prying}$	4517.31	lbf	$T_{u2,prying} = V_{u2}*h_{unistrut}/(d_{unistrut}/2)$
6.2 Front to Back Direction				
Anchor bolts of unistruts on both sides resisting tension and shear (Case 3 for anchor check for an anchor group)				
Ultimate tension force on anchor group due to overturning	T_{u3}	2727.86	lbf	$T_{u3} = (Ω*M_{OT} - M_{R.grav})/(S_{fb}/2)/2$
Anchor bolts of unistruts on both sides resisting shear (Case 4 for anchor check for individual anchor)				
Ultimate shear force on anchor	V_{u4}	506.25	lbf	$V_{u4} = Ω*F_p/4$

Section 5. Check of Middle Anchor

PDA Powers Design Assist	Company name:		
	Project:	Date:	7/14/2015
Version: 2.2.5543.30490	Project number:	Page:	1/5

PROJECT DATA:

Company name:

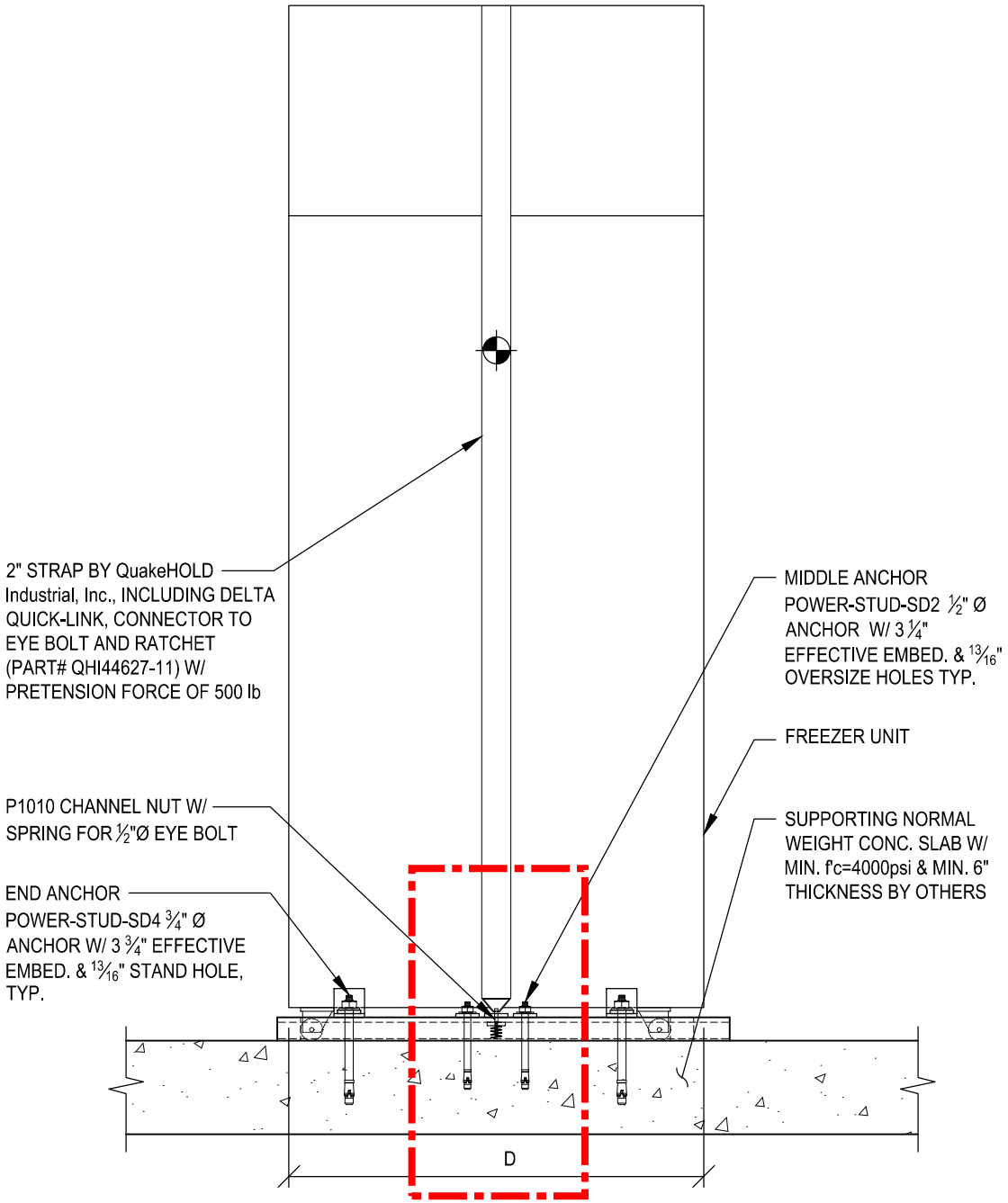
Project engineer:

Project name:

Subject/Topic: Middle Anchor Capacity Check

Description:

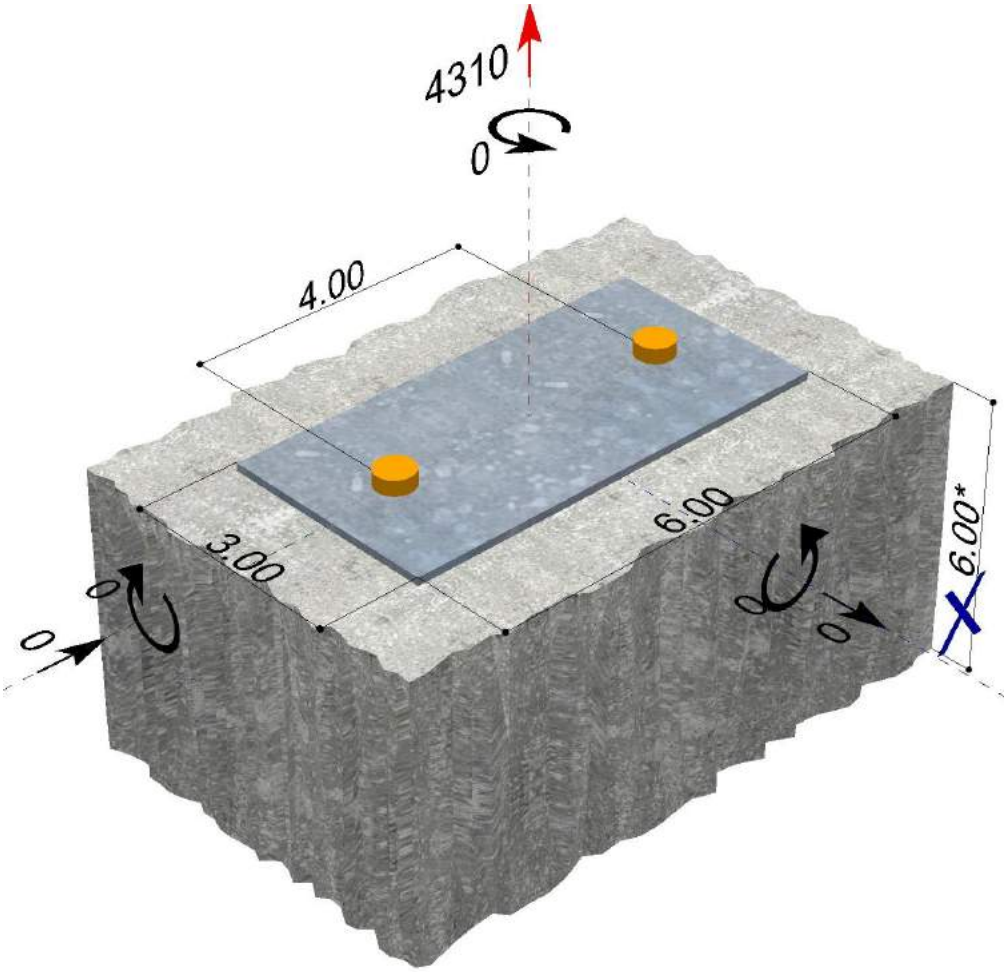
Notes/Remarks:



3 SIDE ELEVATION VIEW

PDA Powers Design Assist	Company name:		
	Project:	Date:	7/14/2015
Version: 2.2.5543.30490	Project number:	Page:	2/5

GEOMETRY:



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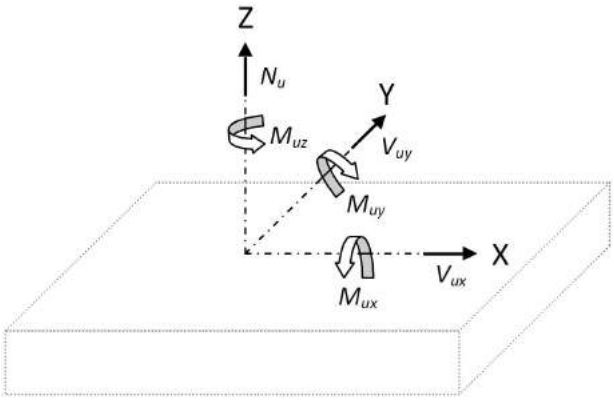


Design loads / actions		
N_u	4310	lb
V_{ux}	0	lb
V_{uy}	0	lb
M_{ux}	0	ft-lb
M_{uy}	0	ft-lb
M_{uz}	0	ft-lb

Eccentric profile		
e_x = 0.00 inch; e_y = 0.00 inch		
Load reversal X-direction	100	%
Load reversal Y-direction	100	%

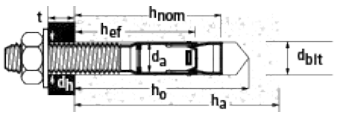
PDA Powers Design Assist	Company name:		
	Project:	Date:	7/14/2015
Version: 2.2.5543.30490	Project number:	Page:	3/5

SUMMARY:

Selected anchor: Power-Stud+ SD2
1/2" Ø; hnom 3-3/4" (95mm), Grade 2

Effective embedment depth: h_{ef} = 3.250 inch

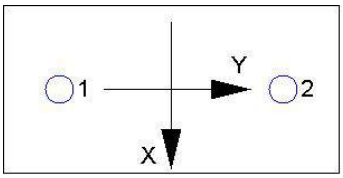
Approval: ESR-2502
Issued: 5/1/2014



Basic principles of Design:

Design method:	ACI 318-11 (Appendix D)							
Concrete:	Normal weight concrete			cracked concrete		f'_c = 4000	psi	
Load combination:	taken from Section 9.2							
	Factored loads							
	Ω = User enters load							
Anchor Parameters:	c_{min} = 2.75	inch	s_{min} = 4.00	inch	h_{min} = 5.75	inch		
	c_{ac} = 10.00	inch	s_{cr} = 9.75	inch	Anchor Ductility:	Yes		
Reinforcement:	none edge reinforcement or < #4 bar							
	Tension:	Condition B		Shear:	Condition B			
Stand-off:	not existent							
Seismic Loads:	Yes							
	Tension load	Yes (D.3.3.4.3(d))						
	Shear load	Yes (D.3.3.5.3(c))						

Resulting anchor forces / load distribution::



Anchor No.	Tension load	Shear load
#1	2155 lb	0 lb
#2	2155 lb	0 lb
Maximum	2155 lb	0 lb

Max. concrete compression strain:	0.00	‰
Max. concrete compression stress:	0	psi
Resulting tension force:	4310	lb
Resulting compression force:	0	lb

Calculations:	Design proof:	Demand		Capacity		Status	
	Tension load	4310	lb	4331	lb	1.00 ≤ 1.0	OK
	Shear load	-	-	-	-	-	
	Interaction	-	-	-	-	-	

Anchor plate:

Material:	f_{yk} = 36000 psi			
Length x width:	3.00	inch	x 6.00	inch
Actual plate thickness:	0.000	inch		
Calculated plate thickness:	-	inch	not calculated	

Profile: none selected

PDA Powers Design Assist	Company name:		
	Project:	Date:	7/14/2015
Version: 2.2.5543.30490	Project number:	Page:	4/5

DESIGN PROOF TENSION LOADING: Reference

Steel strength:

N_{sa}	= 10445 lb		D.5.1
$\Phi * N_{sa}$	= $\Phi * N_{sa}$		D.5.1.2
	= 0.75 * 10445 lb = 7834 lb		
N_{ua}	= 2155 lb		
Design proof:	$N_{ua} / (\Phi * N_{sa})$ = 2155 lb / 7834 lb = 0.28 ≤ 1.00		

Concrete Breakout Strength:

h_{ef}	= 3.250	inch	
k_c	= 17.0		
N_b	= $k_c * f'_c{}^{0.5} * \lambda_a * h_{ef}{}^{1.5}$		D.5.2.2
	= 17.0 * 63.25 * 1.00 * 5.859 = 6299 lb		
A_{Nc0}	= 95.06	inch²	
A_{Nc}	= 134.06	inch²	
$\Psi_{ec,N,x}$	= 1.000		D.5.2.4
$\Psi_{ec,N,y}$	= 1.000		D.5.2.4
$\Psi_{ed,N}$	= 1.000		D.5.2.5
$\Psi_{c,N}$	= 1.00		D.5.2.6
c_{ac}	= 10.00	inch	
$\Psi_{cp,N}$	= 1.000		D.5.2.7
$\Phi * N_{cbg}$	= $\Phi_{seis} * \Phi * (A_{Nc} / A_{Nc0}) * \Psi_{ec,N,x} * \Psi_{ec,N,y} * \Psi_{ed,N} * \Psi_{c,N} * \Psi_{cp,N} * N_b$		D.5.2.1
	= 0.75 * 0.65 * (134.06 / 95.06) * 1.000 * 1.000 * 1.000 * 1.00 * 1.000 * 6299 lb		
	= 4331	lb	
N_{ua}	= 4310	lb	
Design proof:	$N_{ua} / (\Phi * N_{cbg})$ = 4310 lb / 4331 lb = 1.00 ≤ 1.00		

Pullout / Bond strength:

$N_{p,eq}$	= 4375	lb	D.5.3.2
$\Phi * N_{pn}$	= $\Phi_{seis} * \Phi * (f'_c / 2500)^{n} * N_{p,eq}$		
	= 0.75 * 0.65 * (4000 / 2500) ^ 0.50 * 4375 = 2698 lb		
N_{ua}	= 2155	lb	
Design proof:	$N_{ua} / (\Phi * N_{pn})$ = 2155 lb / 2698 lb = 0.80 ≤ 1.00		

Fastening ok!

WARNINGS / REMARKS:

Calculations including seismic design requirements in accordance with ACI 318 D.3.3 are required for anchors in structures assigned to seismic design categories C, D, E and F. Under these seismic conditions, the direction of shear may not be predictable. As default and in accordance with ACI 318 D.3.3 the full shear force is assumed also in reverse direction for a safe design. This may influence the direction of the controlling concrete breakout strength.

D.3.3.4.3 (c) Selected:
Anchor or anchor group shall be designed for the max design load combinations that include E, with E increased by Ωo. The anchor design tensile strength shall satisfy the tensile strength requirements of D.3.3.4.4.

Per ACI 318-11, Part D.3.3.4.3(b) the anchor or group of anchors shall be designed fo the maximum tension that can be transmitted to the anchor or group of anchors based on the development of a ductile yield mechanism in the attachment in flexure, shear, or bearing, or a combination of those conditions, and considering both material overstrength and strain hardening effects for the attachement. The anchor desgn tensile strength shall be calculated from D.3.3.4.4. Per ACI 318-11, Part D.3.3.4.3(c) the anchor or group of anchors shall be designed for the maximum tension that can be transmitted to the anchors by a non-yielding attachment. The anchor desgn tensile strength shall be calculated from D.3.3.4.4. Per ACI 318-11, Part D.3.3.4.3(d) The anchor or group of anchors shall be designed for the maximum tension obtained from design load combinations that include E, with E increased by Ωo. The anchor design tensile strength shall satisfy the tensile strength requirements of D.4.1.1.

Section 6. Check of End Anchors & Angle Brackets

PDA Powers Design Assist	Company name:		
	Project:	Date:	7/14/2015
Version: 2.2.5543.30490	Project number:	Page:	1/6

PROJECT DATA:

Company name:

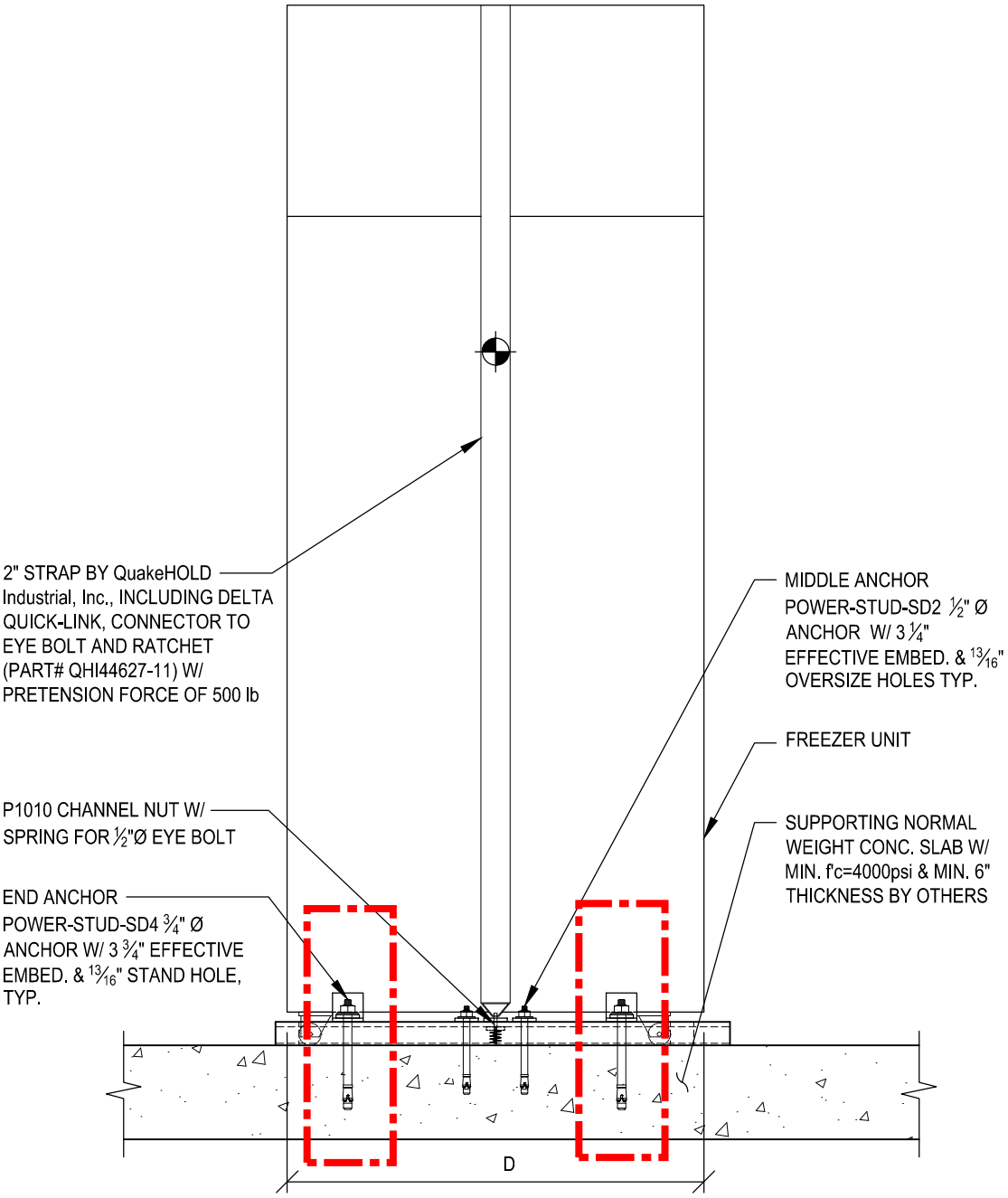
Project engineer:

Project name:

Subject/Topic: End Anchor Capacity Check

Description:

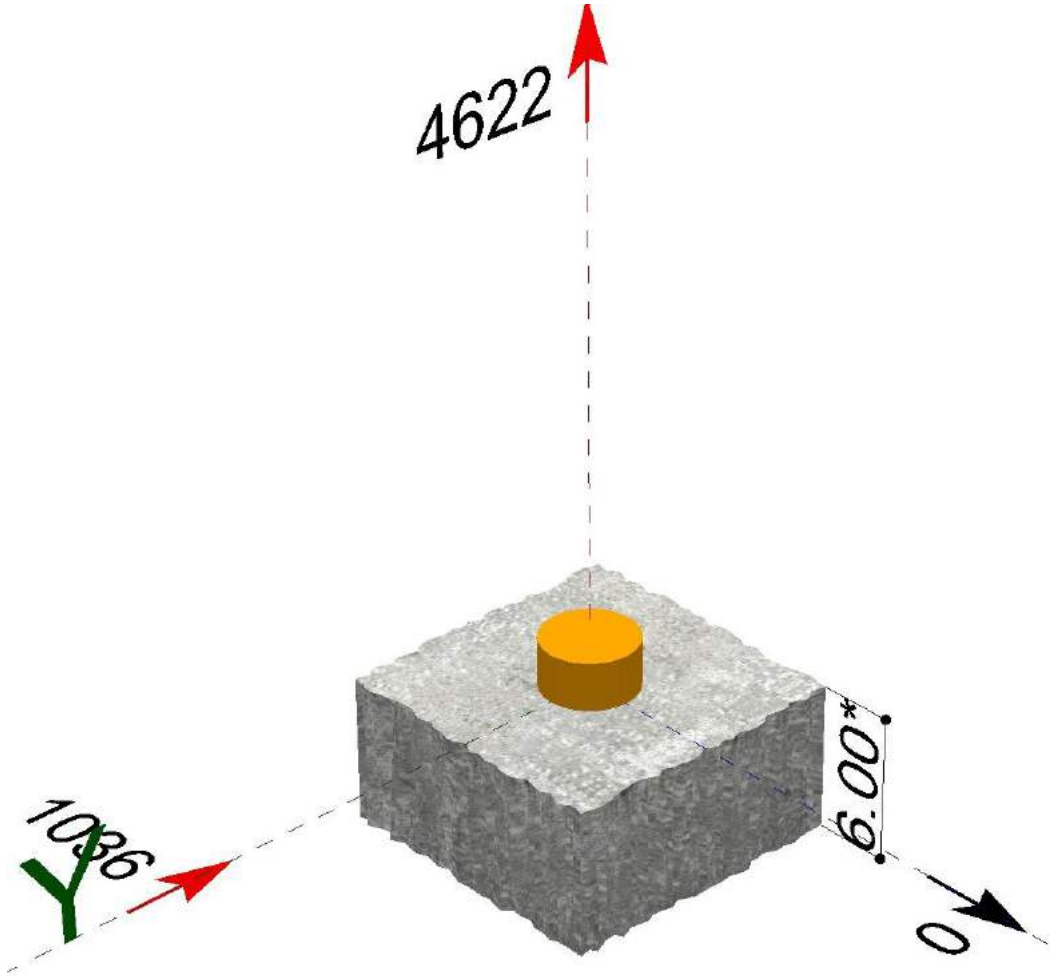
Notes/Remarks:



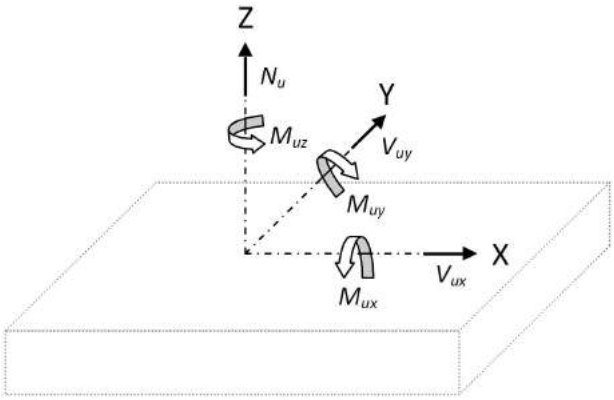
3 SIDE ELEVATION VIEW

PDA Powers Design Assist	Company name:		
	Project:	Date:	7/14/2015
Version: 2.2.5543.30490	Project number:	Page:	2/6

GEOMETRY:



LOAD ACTIONS: [lb], [ft-lb]



Design loads / actions		
N_u	4622	lb
V_{ux}	0	lb
V_{uy}	1036	lb
M_{ux}	0	ft-lb
M_{uy}	0	ft-lb
M_{uz}	0	ft-lb

Load reversal X-direction	100	%
Load reversal Y-direction	100	%

PDA Powers Design Assist	Company name:		
	Project:	Date:	7/14/2015
Version: 2.2.5543.30490	Project number:	Page:	3/6

SUMMARY:

Selected anchor: Power-Stud+ SD4
3/4" Ø; hnom 4-1/2" (114mm), Grade 304 (stainless)

Effective embedment depth: h_{ef} = 3.750 inch
Approval: ESR-2502
Issued: 5/1/2014

Basic principles of Design:

Design method:	ACI 318-11 (Appendix D)								
Concrete:	Normal weight concrete			cracked concrete			f'_c = 4000	psi	
Load combination:	taken from Section 9.2								
	Factored loads								
	Ω =	User enters load							
Anchor Parameters:	c_{min} =	5.00	inch	s_{min} =	9.00	inch	h_{min} =	6.00	inch
	c_{ac} =	9.00	inch	s_{cr} =	11.25	inch	Anchor Ductility:		Yes
Reinforcement:	none edge reinforcement or < #4 bar								
	Tension:	Condition B			Shear:		Condition B		
Stand-off:	not existent								
Seismic Loads:	Yes								
	Tension load	Yes (D.3.3.4.3(d))							
	Shear load	Yes (D.3.3.5.3(c))							

Resulting anchor forces / load distribution::

Anchor No.	Tension load	Shear load
#1	4622 lb	1036 lb
Maximum	4622 lb	1036 lb

Max. concrete compression strain:	0.00	‰
Max. concrete compression stress:	0	psi
Resulting tension force:	4622	lb
Resulting compression force:	0	lb

Calculations:	Design proof:	Demand		Capacity		Status	
	Tension load	4622	lb	4702	lb	0.98 ≤ 1.0	OK
	Shear load	1036	lb	5034	lb	0.21 ≤ 1.0	
	Interaction	-	-	-	-	0.99 ≤ 1.0	

DESIGN PROOF TENSION LOADING:

Reference

Steel strength:

N_{sa}	= 21380 lb	D.5.1
$\Phi * N_{sa}$	$= \Phi * N_{sa}$	D.5.1.2
	= 0.75 * 21380 lb = 16035 lb	
N_{ua}	= 4622 lb	
Design proof:	$N_{ua} / (\Phi * N_{sa})$ = 4622 lb / 16035 lb = 0.29 ≤ 1.00	

Concrete Breakout Strength:

h_{ef}	= 3.750	inch	
k_c	= 21.0		
N_b	$= k_c * f'_c{}^{0.5} * \lambda_a * h_{ef}{}^{1.5}$		D.5.2.2
	= 21.0 * 63.25 * 1.00 * 7.262 = 9645 lb		
A_{Nc0}	= 126.56	inch²	
A_{Nc}	= 126.56	inch²	
$\Psi_{ed,N}$	= 1.000		D.5.2.5
$\Psi_{c,N}$	= 1.00		D.5.2.6
c_{ac}	= 9.00	inch	
$\Psi_{cp,N}$	= 1.000		D.5.2.7
$\Phi * N_{cb}$	$= \Phi_{seis} * \Phi * (A_{Nc} / A_{Nc0}) * \Psi_{ed,N} * \Psi_{c,N} * \Psi_{cp,N} * N_b$		D.5.2.1
	= 0.75 * 0.65 * (126.56 / 126.56) * 1.000 * 1.00 * 1.000 * 9645 lb		
	= 4702	lb	
N_{ua}	= 4622	lb	
Design proof:	$N_{ua} / (\Phi * N_{cb})$ = 4622 lb / 4702 lb = 0.98 ≤ 1.00		

DESIGN PROOF SHEAR LOADING:

Reference

Steel strength (without lever arm):

$V_{sa,eq}$	= 7745	lb	D.6.1
$\Phi * V_{sa,eq}$	$= \Phi * V_{sa,eq}$		D.6.1.2
	= 0.65 * 7745 lb = 5034 lb		
V_{ua}	= 1036	lb	
Design proof:	$V_{ua} / (\Phi * V_{sa,eq})$ = 1036 lb / 5034 lb = 0.21 ≤ 1.00		

Pryout strength:

h_{ef}	= 3.750	inch	
k_c	= 21.0		
N_b	$= k_c * f'_c{}^{0.5} * \lambda_a * h_{ef}{}^{1.5}$		D.5.2.2
	$= 21.0 * 4000^{0.5} * 1.00 * 3.750^{1.5} =$ 9645 lb		
A_{Nc}	= 126.56	inch²	
A_{Nc0}	= 126.56	inch²	
$\psi_{ed,N}$	= 1.000		D.5.2.5
$\psi_{cp,N}$	= 1.000		D.5.2.7
$\psi_{c,N}$	= 1.000		D.5.2.6
k_{cp}	= 2.0		D.6.3.1
$\Phi * V_{cp}$	$= \Phi_{seis} * \Phi * (A_{Nc} / A_{Nc0}) * \psi_{ed,N} * \psi_{cp,N} * \psi_{c,N} * N_b * k_{cp}$		
	= 1.0 * 0.70 * (126.56 / 126.56) * 1.000 * 1.000 * 1.000 * 9645 lb * 2.0		
	= 13503	lb	
V_{ua}	= 1036	lb	
Design proof:	$V_{ua} / (\Phi * V_{cp}) =$ 1036 lb / 13503 lb = 0.08 ≤ 1.00		

COMBINATION TENSION / SHEAR LOAD: **Reference**

Interaction:

Design proof:	$= N_u / (\Phi * N_n) + V_u / (\Phi * V_n) / 1.2$	D.7.3
	= (0.98 + 0.21) / 1.2 = 0.99 ≤ 1.0	

Fastening ok!

WARNINGS / REMARKS:

Calculations including seismic design requirements in accordance with ACI 318 D.3.3 are required for anchors in structures assigned to seismic design categories C, D, E and F. Under these seismic conditions, the direction of shear may not be predictable. As default and in accordance with ACI 318 D.3.3 the full shear force is assumed also in reverse direction for a safe design. This may influence the direction of the controlling concrete breakout strength.

D.3.3.4.3 (c) Selected:
Anchor or anchor group shall be designed for the max design load combinations that include E, with E increased by Ωo. The anchor design tensile strength shall satisfy the tensile strength requirements of D.3.3.4.4.

Per ACI 318-11, Part D.3.3.4.3(b) the anchor or group of anchors shall be designed fo the maximum tension that can be transmitted to the anchor or group of anchors based on the development of a ductile yield mechanism in the attachment in flexure, shear, or bearing, or a combination of those conditions, and considering both material overstrength and strain hardening effects for the attachement. The anchor desgn tensile strength shall be calculated from D.3.3.4.4. Per ACI 318-11, Part D.3.3.4.3(c) the anchor or group of anchors shall be designed for the maximum tension that can be transmitted to the anchors by a non-yielding attachment. The anchor desgn tensile strength shall be calculated from D.3.3.4.4. Per ACI 318-11, Part D.3.3.4.3(d) The anchor or group of anchors shall be designed for the maximum tension obtained from design load combinations that include E, with E increased by Ωo. The anchor design tensile strength shall satisfy the tensile strength requirements of D.4.1.1.

Per ACI 318-11, Part D.3.3.5.3(a) the anchor or group of anchors shall be designed fo the maximum shear that can be transmitted to the anchor or group of anchors based on the development of a ductile yield mechanism in the attachment in flexure, shear, or bearing, or a combination of those conditions, and considering both material overstrength and strain hardening effects for the attachement. Per ACI 318-11, Part D.3.3.5.3(b) the anchor or group of anchors shall be designed for the maximum shear that can be transmitted to the anchors by a non-yielding attachment. Per ACI 318-11, Part D.3.3.5.3(c) the anchor or group of anchors shall be designed for the maximum shear obtained from design load combinations that include E, with E increased by Ωo. The anchor design shear strength shall satisfy the shear strength requirements of D.4.1.1.

Project: Lab Freezer Restraints (Thermo Fisher)
Project No.: 0932
Subject: Angle Bracket for Shear Stop

Designer: JY
Date: 7/14/2015

Check of Angle Bracket

Max shear force to single L2-1/2x2x1/4 $V_{max} := 1036lbf$

For L2-1/2x2x1/4 $k := 0.5in$

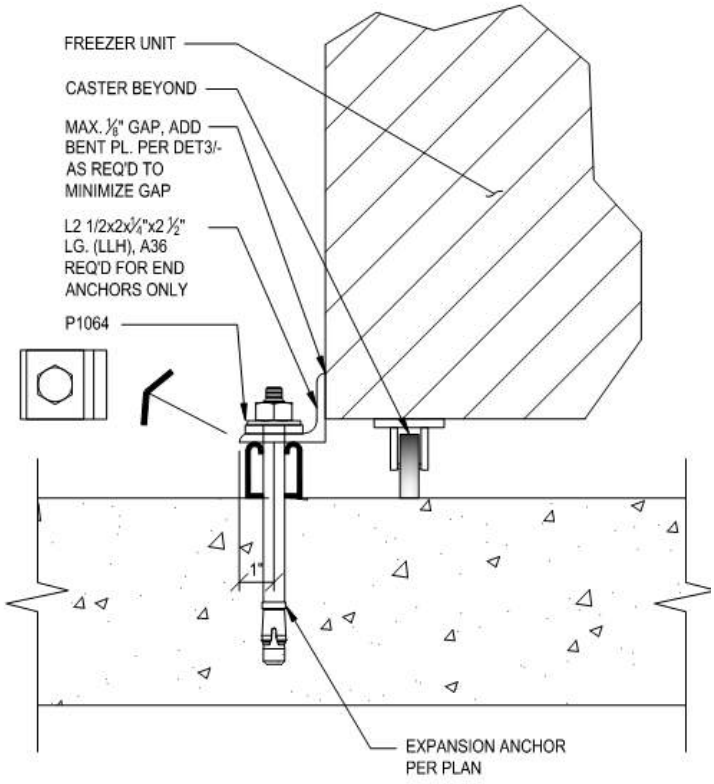
Assumnig height of bearing area to be 0.75 in $h := 0.75in$

$$M_u := V_{max} \cdot \left(2in - k - \frac{h}{2}\right) = 1.165 \cdot kip \cdot in$$

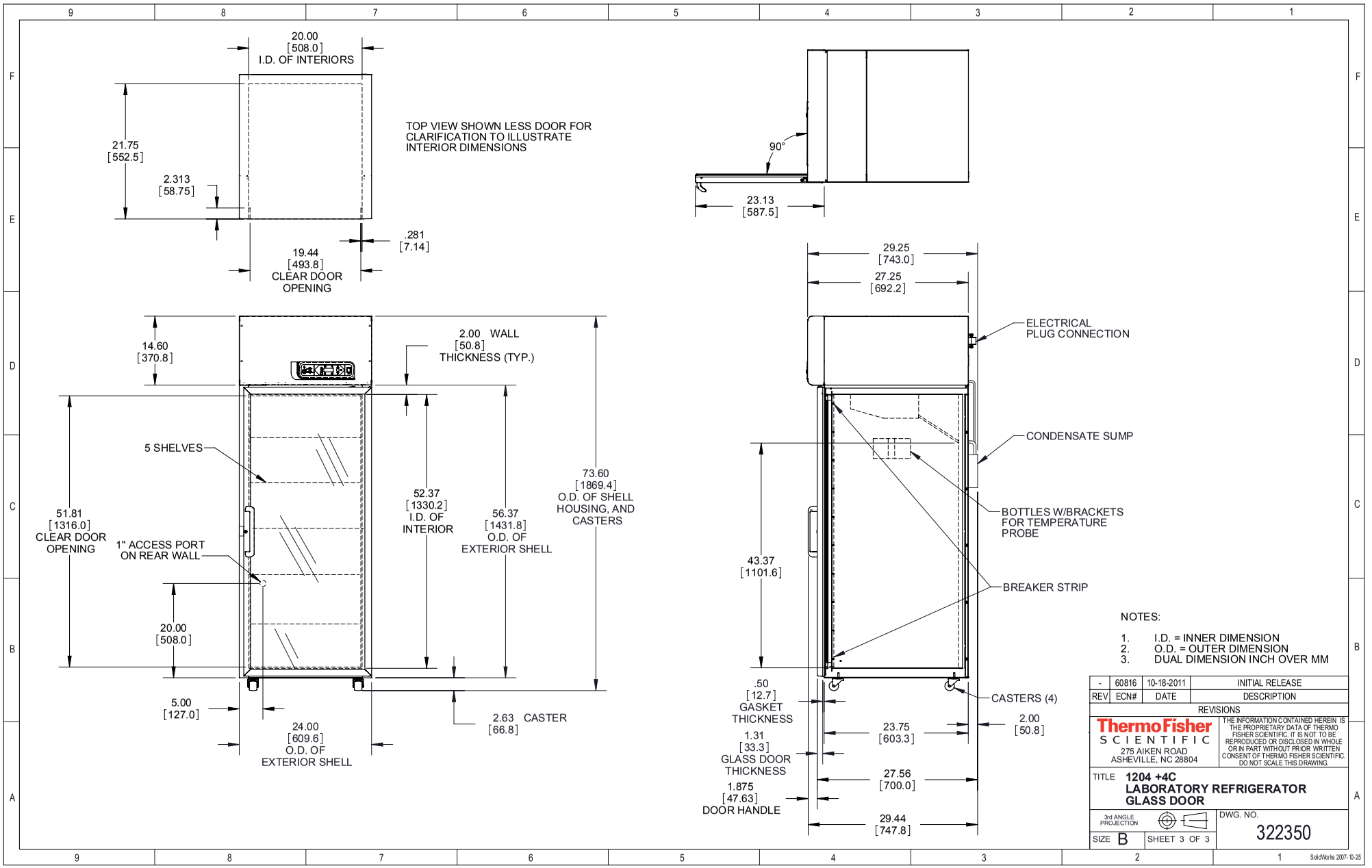
$$\phi M_n := 0.9 \cdot 36ksi \cdot 2.5in \cdot \frac{(0.25in)^2}{4} = 1.266 \cdot kip \cdot in$$

$$DCR := \frac{M_u}{\phi M_n} = 0.921$$

$$Check := if(DCR < 1, "O.K.", "N.G.") = "O.K."$$



Appendix A. Cut Sheets of ThermoFisher Scientific Freezers



NOTES:

1. I.D. = INNER DIMENSION
2. O.D. = OUTER DIMENSION
3. DUAL DIMENSION INCH OVER MM

REV	ECN#	DATE	DESCRIPTION
-	60816	10-18-2011	INITIAL RELEASE

REVISIONS

ThermoFisher SCIENTIFIC
275 AIKEN ROAD
ASHEVILLE, NC 28804

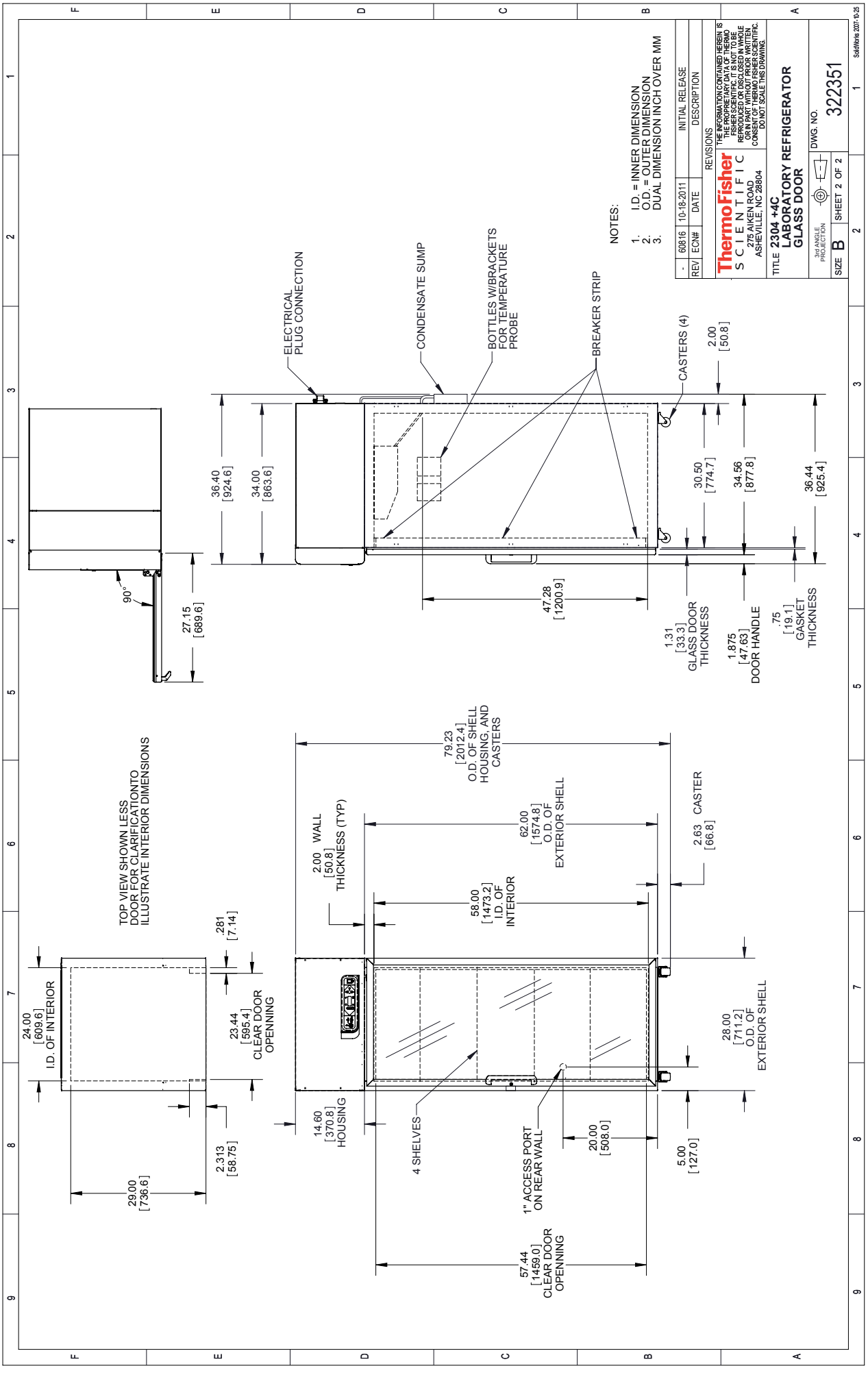
TITLE **1204 +4C**
LABORATORY REFRIGERATOR
GLASS DOOR

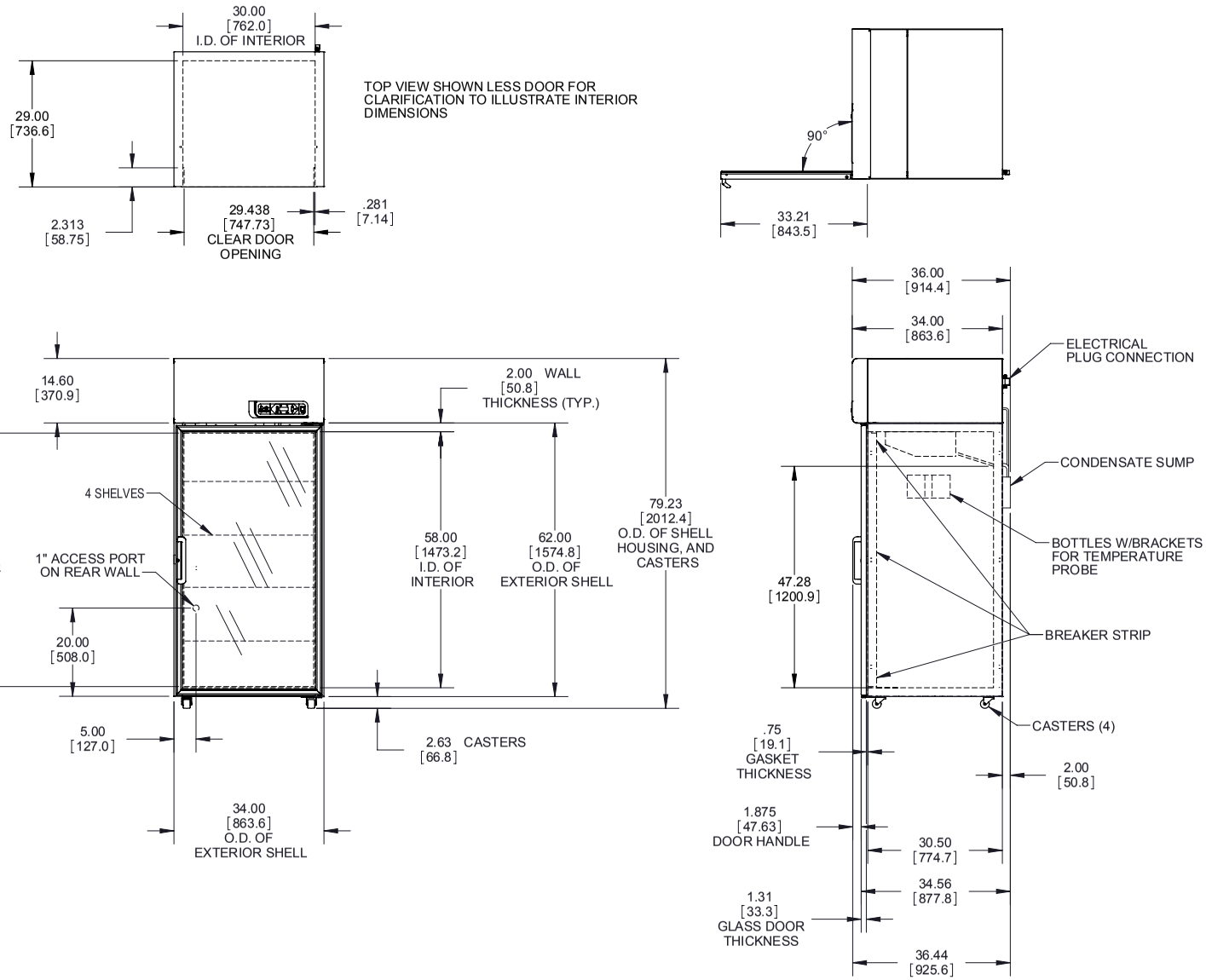
3rd ANGLE PROJECTION

DWG. NO. 322350

SIZE B SHEET 3 OF 3

SolidWorks 2007-10-25


NOTES:
1. I.D. = INNER DIMENSION
2. O.D. = OUTER DIMENSION
3. DUAL DIMENSION INCH OVER MM
ELECTRICAL PLUG CONNECTION
CONDENSATE SUMP
BOTTLES W/BRACKETS FOR TEMPERATURE PROBE
BREAKER STRIP
CASTERS (4)
2.00 [50.8]
36.40 [924.6]
34.00 [863.6]
30.50 [774.7]
34.56 [877.8]
36.44 [925.4]
90°
27.15 [689.6]
47.28 [1200.9]
1.31 [33.3] GLASS DOOR THICKNESS
1.875 [47.63] DOOR HANDLE
.75 [19.1] GASKET THICKNESS
TOP VIEW SHOWN LESS DOOR FOR CLARIFICATIONTO ILLUSTRATE INTERIOR DIMENSIONS
.281 [7.14]
24.00 [609.6] I.D. OF INTERIOR
23.44 [595.4] CLEAR DOOR OPENNING
29.00 [736.6]
2.313 [58.75]
79.23 [2012.4] O.D. OF SHELL HOUSING, AND CASTERS
2.00 WALL [50.8] THICKNESS (TYP)
62.00 [1574.8] O.D. OF EXTERIOR SHELL
58.00 [1473.2] I.D. OF INTERIOR
2.63 CASTER [66.8]
28.00 [711.2] O.D. OF EXTERIOR SHELL
14.60 [370.8] HOUSING
4 SHELVES
1" ACCESS PORT ON REAR WALL
20.00 [508.0]
5.00 [127.0]
57.44 [1459.0] CLEAR DOOR OPENNING
REV | ECN# | DATE | DESCRIPTION
- | 60816 | 10-18-2011 | INITIAL RELEASE
REVISIONS
ThermoFisher SCIENTIFIC
275 AIKEN ROAD
ASHEVILLE, NC 28804
THE INFORMATION CONTAINED HEREIN IS THE PROPRIETARY DATA OF THERMO FISHER SCIENTIFIC. IT IS NOT TO BE REPRODUCED OR DISCLOSED IN WHOLE OR IN PART WITHOUT PRIOR WRITTEN CONSENT OF THERMO FISHER SCIENTIFIC. DO NOT SCALE THIS DRAWING.
TITLE 2304 +4C LABORATORY REFRIGERATOR GLASS DOOR
3rd ANGLE PROJECTION
DWG. NO. 322351
SIZE B | SHEET 2 OF 2
SolidWorks 2007-10-25



NOTES:

1. I.D. = INNER DIMENSION
2. O.D. = OUTER DIMENSION
3. DUAL DIMENSION INCH OVER MM

REV	ECN#	DATE	DESCRIPTION
-	60816	10-18-2011	INITIAL RELEASE

REVISIONS

ThermoFisher SCIENTIFIC
275 AIKEN ROAD
ASHEVILLE, NC 28804

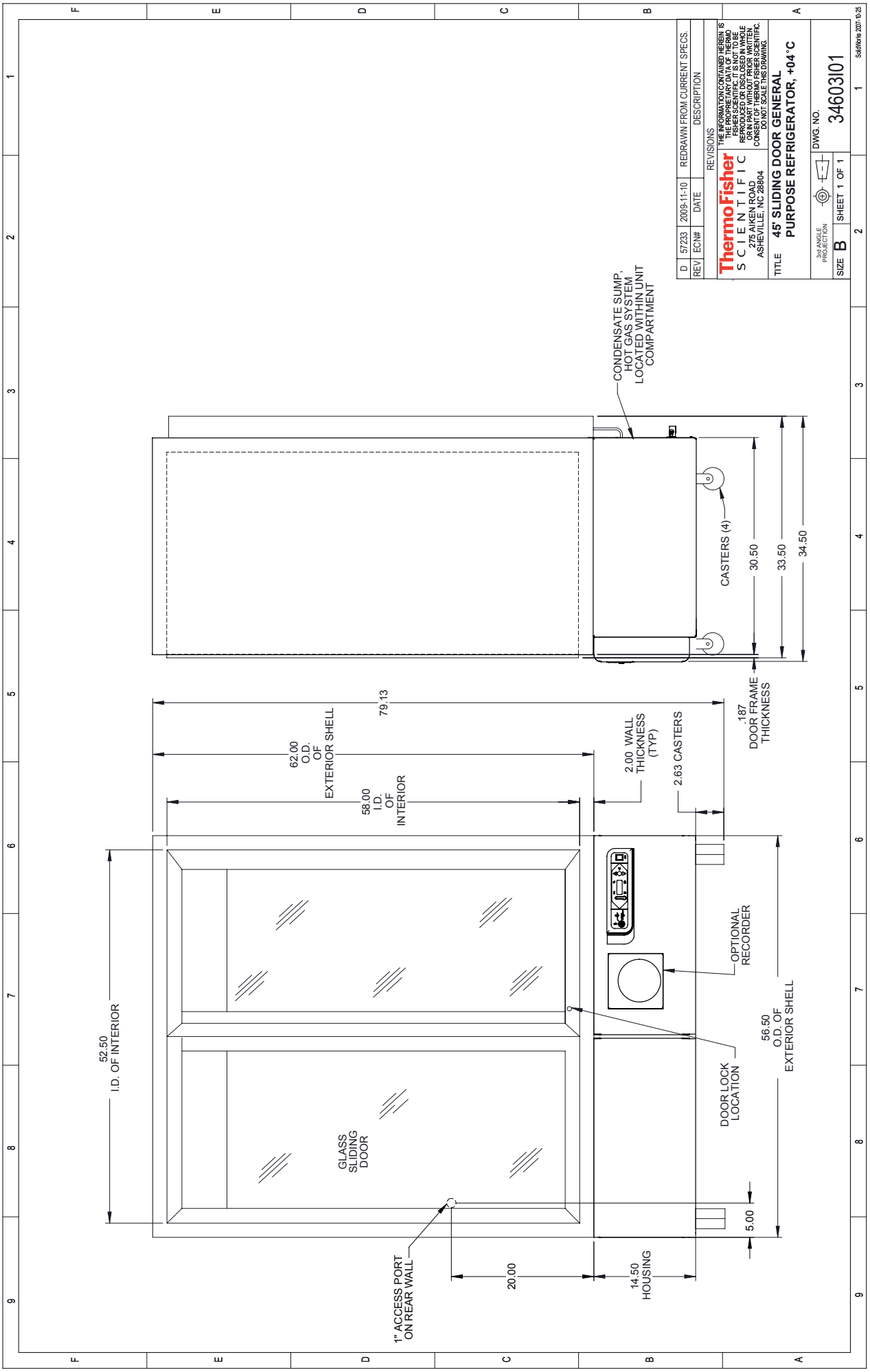
TITLE **3004 +4C**
LABORATORY REFRIGERATOR
GLASS DOOR

3rd ANGLE PROJECTION

DWG. NO. 322352

SIZE B SHEET 2 OF 2

SolidWorks 2007-10-25



REV	ECN#	DATE	DESCRIPTION
D	57233	2009-11-10	REDRAWN FROM CURRENT SPECS.

REVISIONS

ThermoFisher SCIENTIFIC
275 AIKEN ROAD
ASHEVILLE, NC 28804

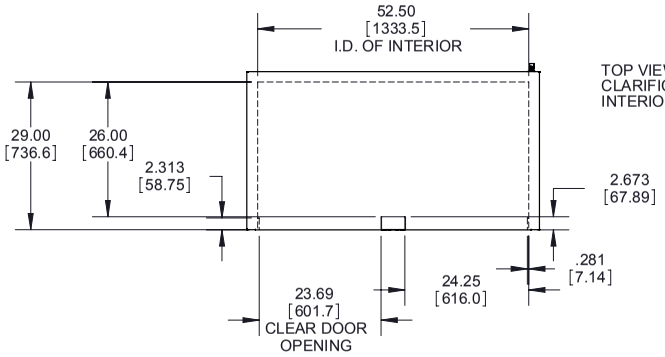
TITLE **45' SLIDING DOOR GENERAL PURPOSE REFRIGERATOR, +04 °C**

3rd ANGLE PROJECTION

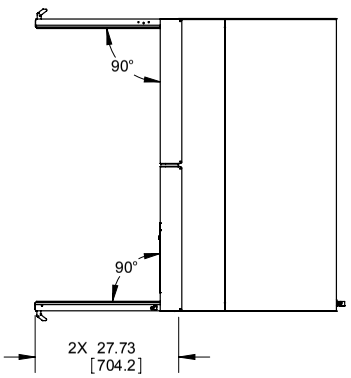
SIZE B | SHEET 1 OF 1

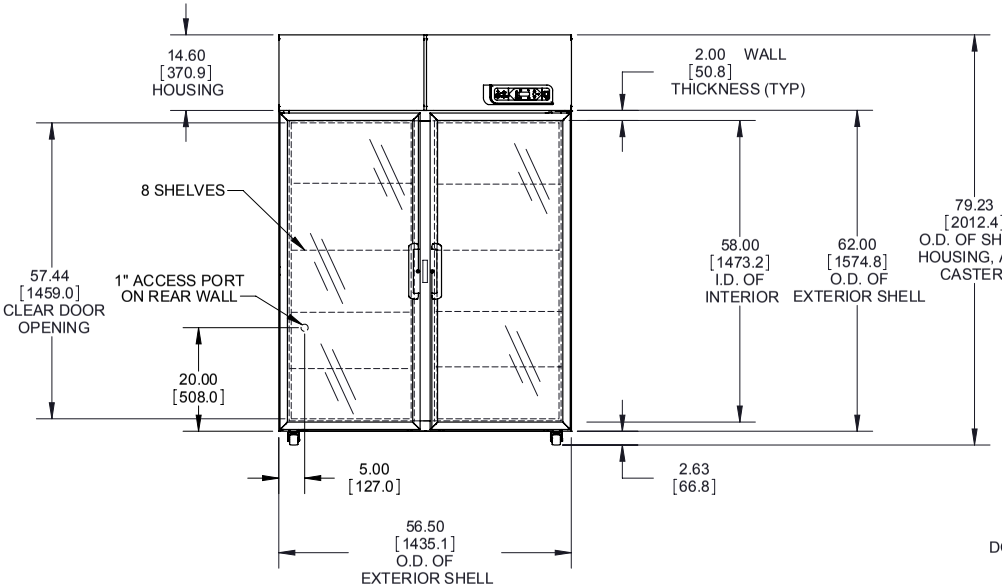
DWG. NO. 34603101

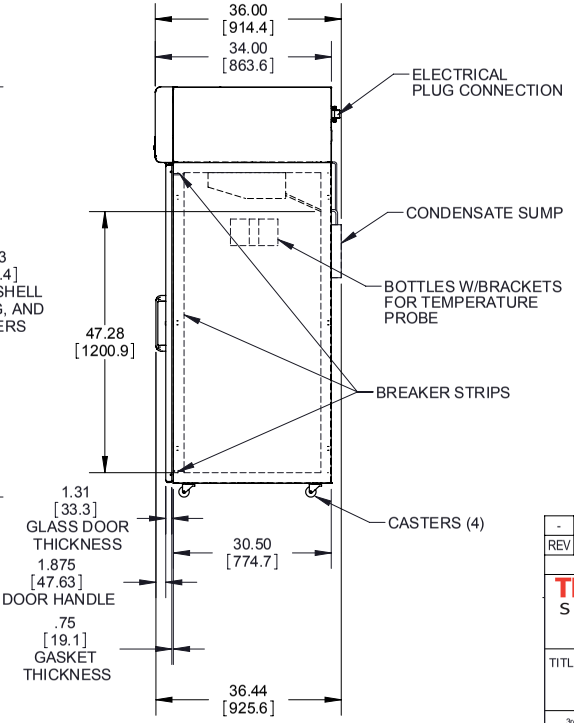
SolidWorks 2007-10-25



TOP VIEW SHOWN LESS DOOR FOR CLARIFICATION TO ILLUSTRATE INTERIOR DIMENSIONS







NOTES:

1. I.D. = INNEER DIMENSION
2. O.D. = OUTER DIMENSION
3. DUAL DIMENSION IS INCH OVER MM

REV	ECN#	DATE	DESCRIPTION
-	60816	10-18-2011	INITIAL RELEASE

REVISIONS

ThermoFisher SCIENTIFIC
275 AIKEN ROAD
ASHEVILLE, NC 28804

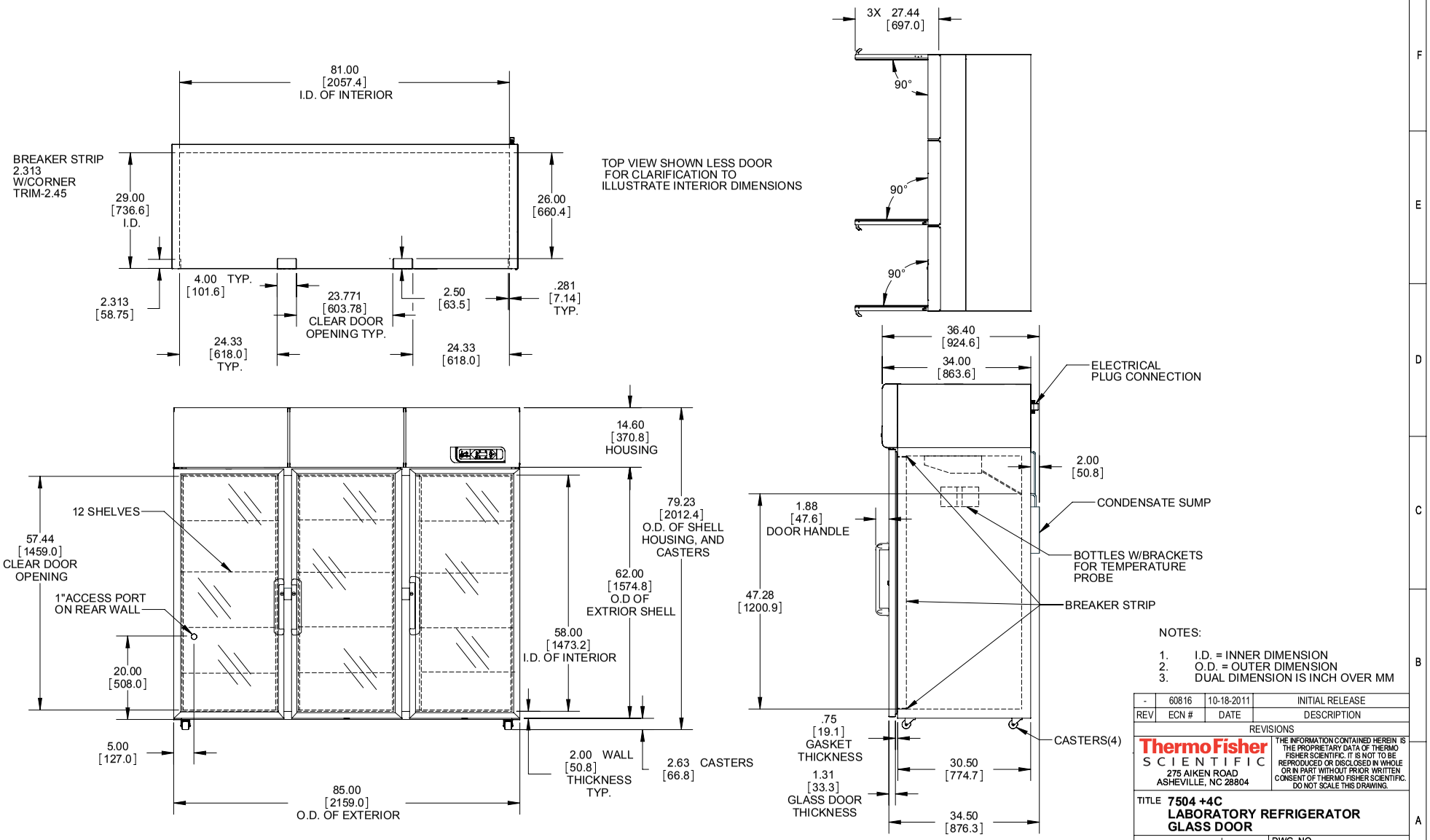
TITLE **5004 +4C**
LABORATORY REFRIGERATOR
GLASS DOOR

3rd ANGLE PROJECTION

DWG. NO. 322353

SIZE B | SHEET 2 OF 2

SolidWorks 2007-10-25



NOTES:

1. I.D. = INNER DIMENSION
2. O.D. = OUTER DIMENSION
3. DUAL DIMENSION IS INCH OVER MM

REV	ECN #	DATE	DESCRIPTION
-	60816	10-18-2011	INITIAL RELEASE

REVISIONS

ThermoFisher SCIENTIFIC
275 AIKEN ROAD
ASHEVILLE, NC 28804

TITLE **7504 +4C**
LABORATORY REFRIGERATOR
GLASS DOOR

3rd ANGLE PROJECTION

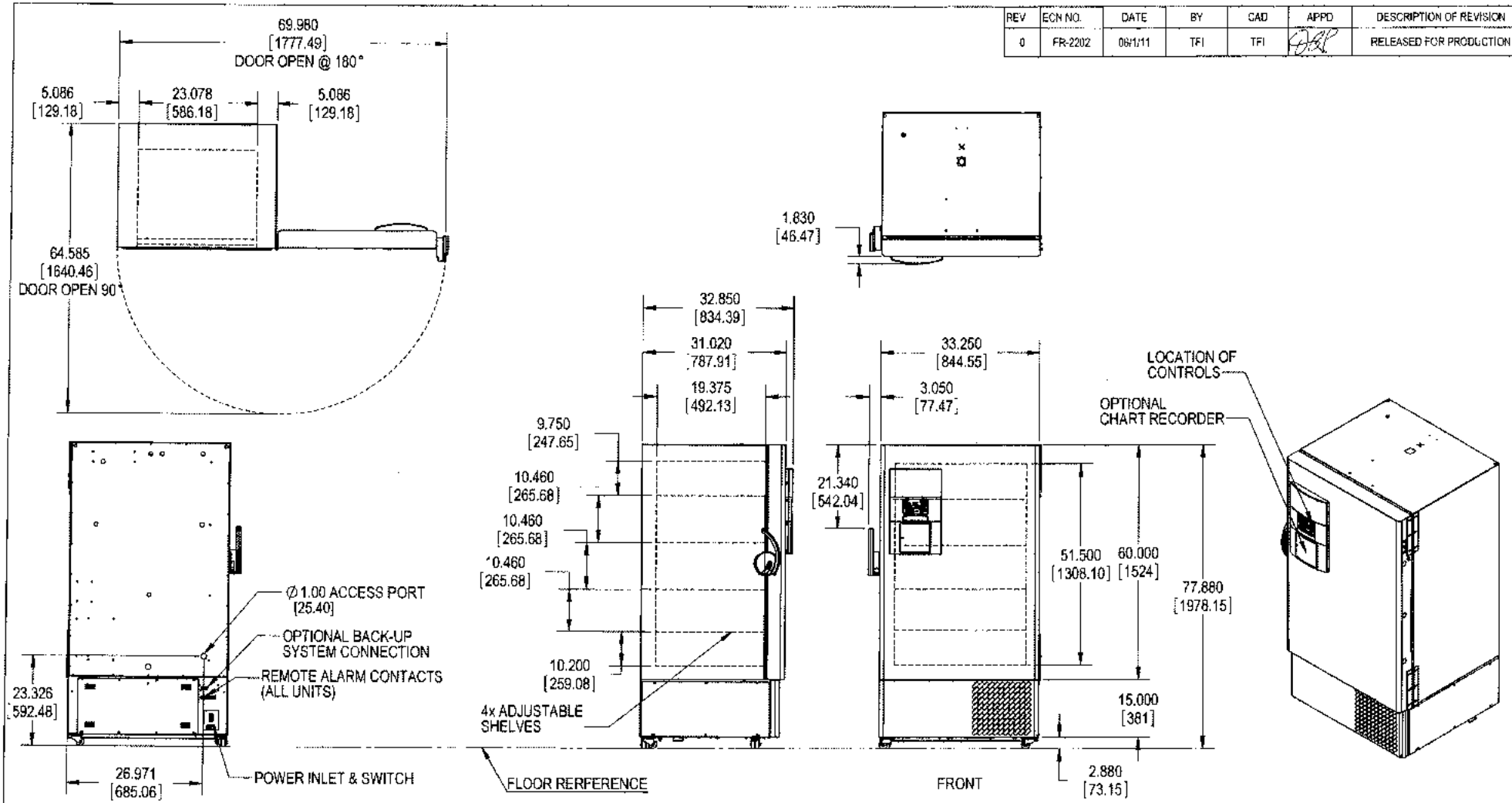
DWG. NO. 322354

SIZE B | SHEET 3 OF 3

SolidWorks 2007-10-25

DRAWING NUMBER: **8920-00-1**

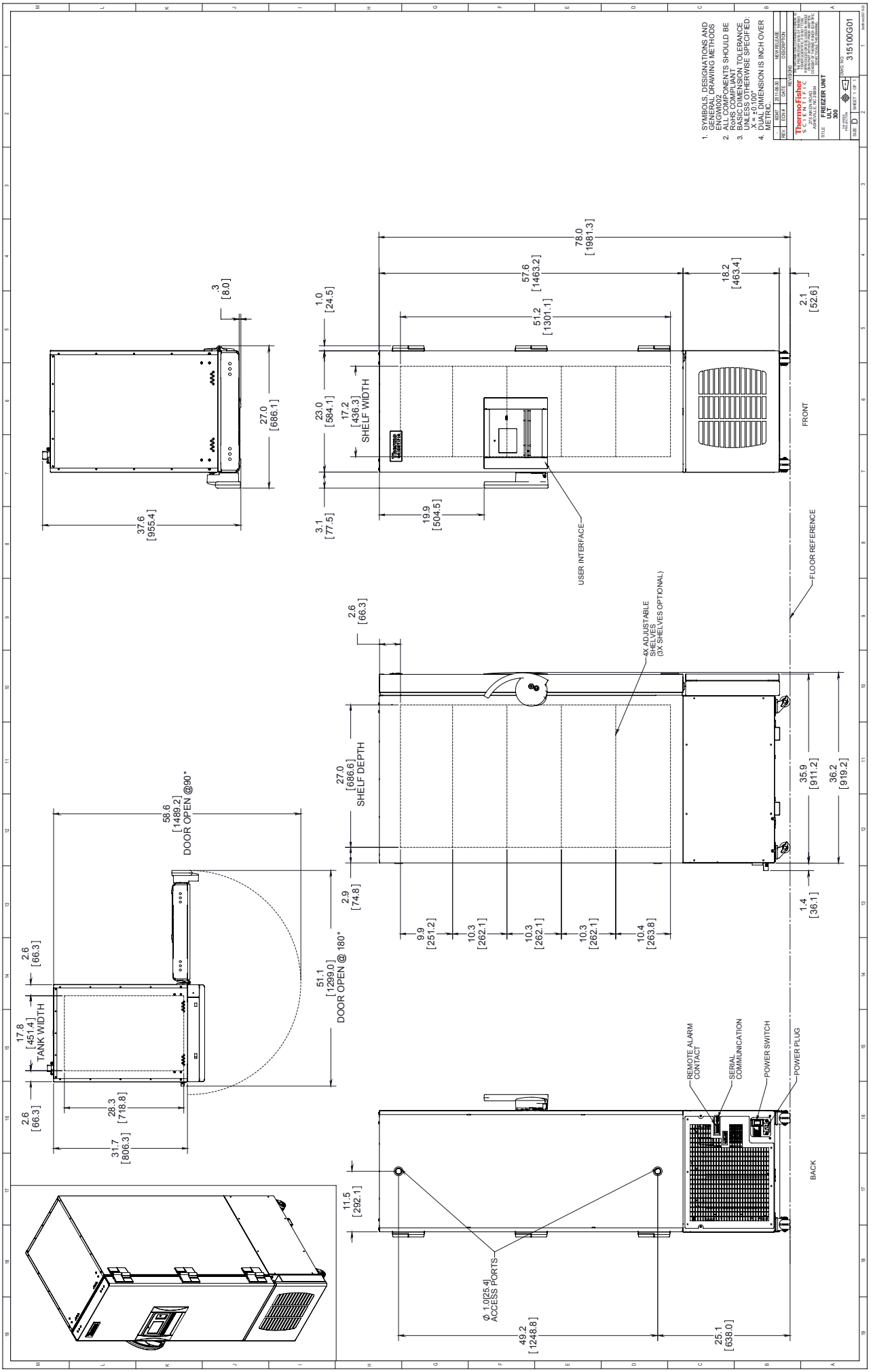
REV	ECN NO.	DATE	BY	CAD	APPD	DESCRIPTION OF REVISION
0	FR-2202	06/1/11	TFI	TFI		RELEASED FOR PRODUCTION

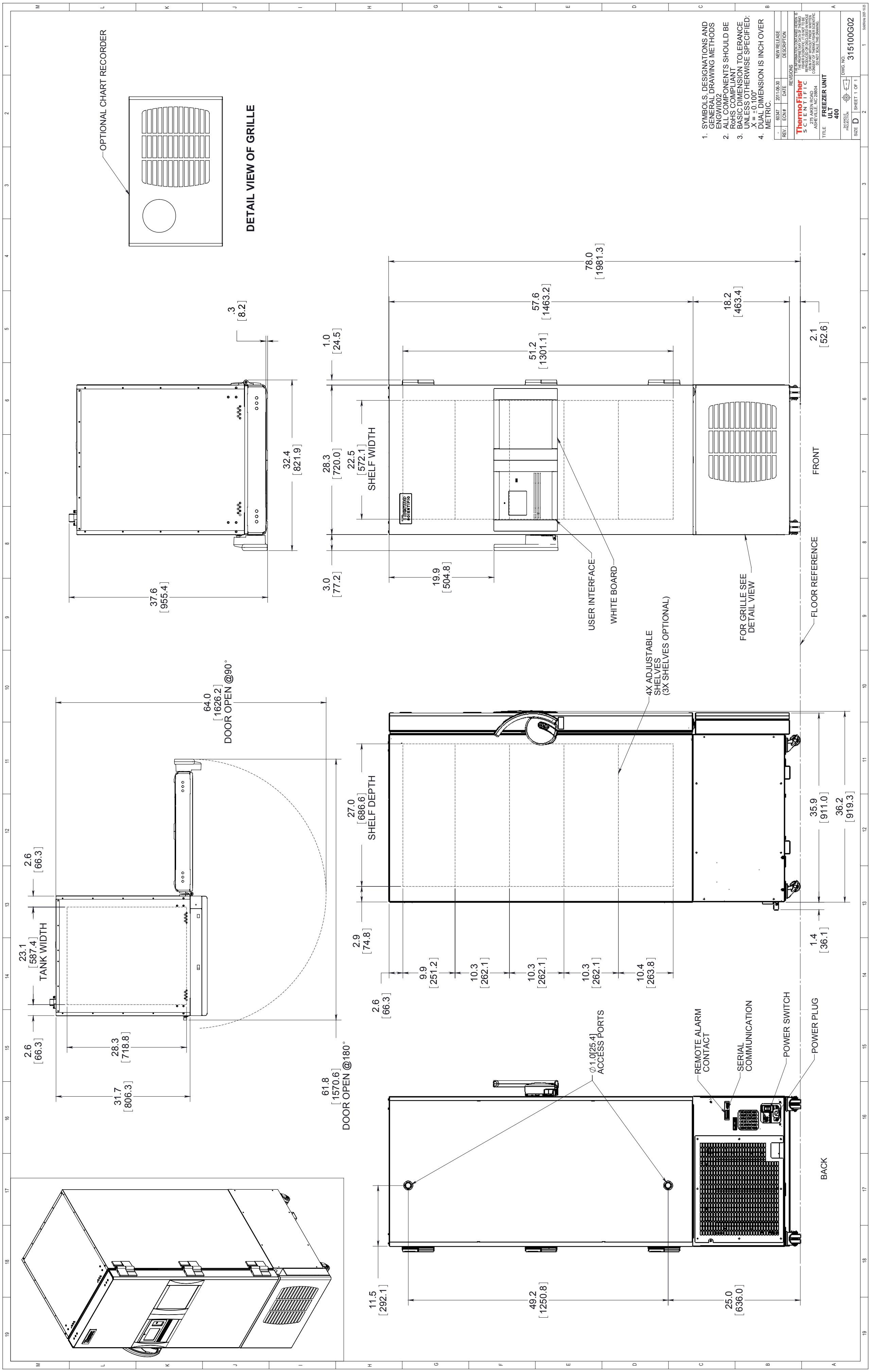


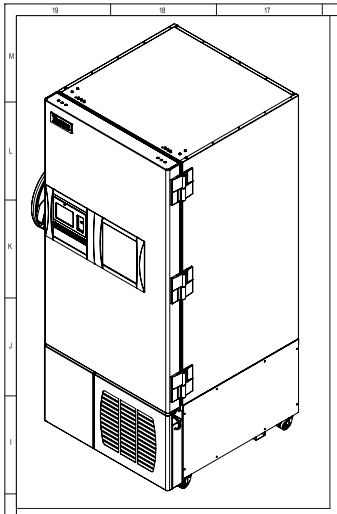
NOTE: DUAL DIMENSION IS INCH OVER METRIC.

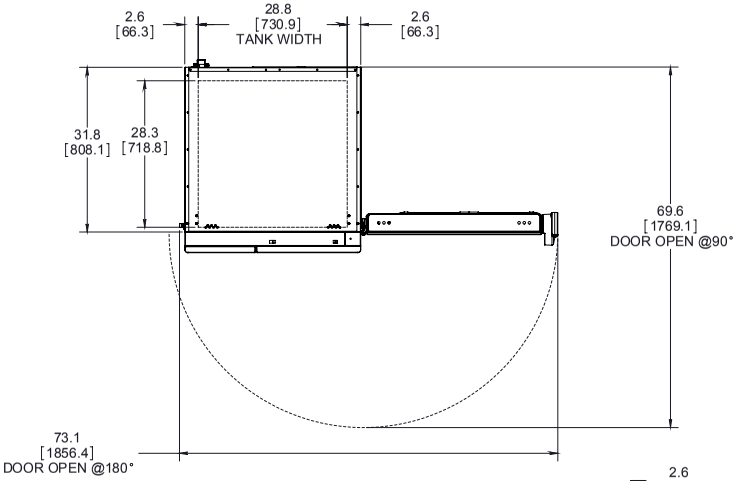
MODEL/PART NAME: 13 CU FT, -86°C UPRIGHT FREEZERS				
DWG TITLE: GENERAL DIMENSION DRAWING ULT				
DWN: TFI	CAD: TFI	APPD: SSK	DATE: 06/1/2011	SCALE: N/A
MATERIAL: N/A				
PAINT COLOR: N/A				
TOLERANCE UNLESS OTHERWISE SPECIFIED ANGLES: DECIMAL: XX=±.06 XXX=±.030			DRAWING NUMBER: 8920-00-1	SIZE: B

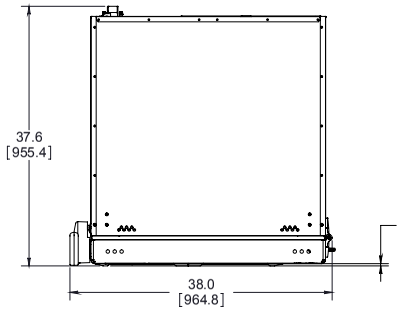
ThermoFisher SCIENTIFIC
BOX 649, MARIETTA, OHIO 45750

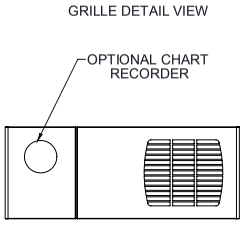

1. SYMBOLS, DESIGNATIONS AND GENERAL DRAWING METHODS ENGW002
2. ALL COMPONENTS SHOULD BE REACH COMPLIANT.
3. BASIC DIMENSION, TOLERANCE UNLESS OTHERWISE SPECIFIED: .X ± 0.1 [.X ± 2.5] .XX ± 0.05 [.XX ± 1.3]
4. DUAL DIMENSION IS INCH OVER METRIC.
REV RELEASE
DESCRIPTION
DATE
BY
ThermoFisher SCIENTIFIC
TITLE FREEZER UNIT ULT 300
SIZE D
SHEET 1 OF 1
315100G01
.3 [8.0]
27.0 [686.1]
37.6 [955.4]
78.0 [1981.3]
57.6 [1463.2]
18.2 [463.4]
1.0 [24.5]
2.1 [52.6]
51.2 [1301.1]
23.0 [584.1]
17.2 [436.3] SHELF WIDTH
3.1 [77.5]
19.9 [504.5]
USER INTERFACE
FRONT
FLOOR REFERENCE
2.6 [66.3]
4X ADJUSTABLE SHELVES (3X SHELVES OPTIONAL)
27.0 [686.6] SHELF DEPTH
35.9 [911.2]
36.2 [919.2]
9.9 [251.2]
10.3 [262.1]
10.3 [262.1]
10.3 [262.1]
10.4 [263.8]
1.4 [36.1]
58.6 [1489.2] DOOR OPEN @90°
51.1 [1299.0] DOOR OPEN @ 180°
2.9 [74.8]
17.8 [451.4] TANK WIDTH
2.6 [66.3]
28.3 [718.8]
31.7 [806.3]
REMOTE ALARM CONTACT
SERIAL COMMUNICATION
POWER SWITCH
POWER PLUG
BACK
11.5 [292.1]
Ø 1.0 [25.4] ACCESS PORTS
49.2 [1248.8]
25.1 [638.0]

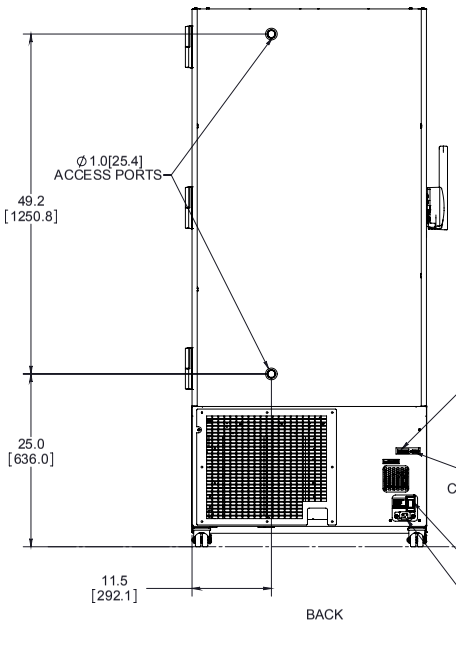

OPTIONAL CHART RECORDER
DETAIL VIEW OF GRILLE
1. SYMBOLS, DESIGNATIONS AND GENERAL DRAWING METHODS ENGW1002
2. ALL COMPONENTS SHOULD BE RoHS COMPLIANT
3. BASIC DIMENSION TOLERANCE UNLESS OTHERWISE SPECIFIED: X = ±0.100"
4. DUAL DIMENSION IS INCH OVER METRIC.
NEW RELEASE
ThermoFisher SCIENTIFIC
FREEZER UNIT
ULT
400
315100G02
USER INTERFACE
WHITE BOARD
FOR GRILLE SEE DETAIL VIEW
FLOOR REFERENCE
FRONT
4X ADJUSTABLE SHELVES (3X SHELVES OPTIONAL)
SHELF WIDTH
SHELF DEPTH
TANK WIDTH
DOOR OPEN @90°
DOOR OPEN @180°
Ø1.0[25.4] ACCESS PORTS
REMOTE ALARM CONTACT
SERIAL COMMUNICATION
POWER SWITCH
POWER PLUG
BACK
78.0 [1981.3]
57.6 [1463.2]
51.2 [1301.1]
18.2 [463.4]
2.1 [52.6]
1.0 [24.5]
.3 [8.2]
32.4 [821.9]
28.3 [720.0]
22.5 [572.1]
3.0 [77.2]
19.9 [504.8]
37.6 [955.4]
64.0 [1626.2]
27.0 [686.6]
35.9 [911.0]
36.2 [919.3]
1.4 [36.1]
2.9 [74.8]
9.9 [251.2]
10.3 [262.1]
10.4 [263.8]
2.6 [66.3]
23.1 [587.4]
28.3 [718.8]
31.7 [806.3]
61.8 [1570.6]
11.5 [292.1]
49.2 [1250.8]
25.0 [636.0]

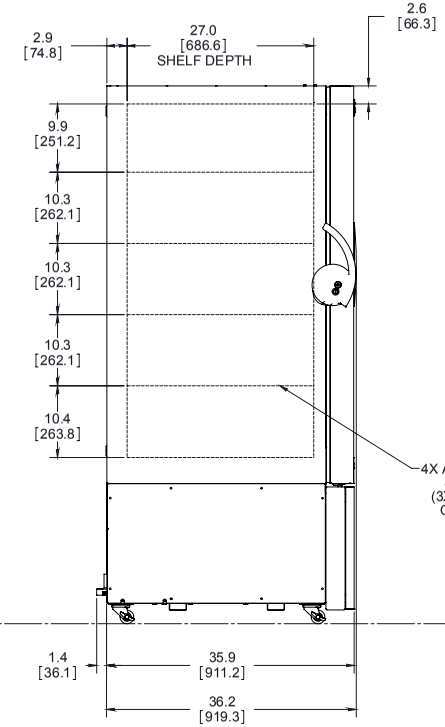


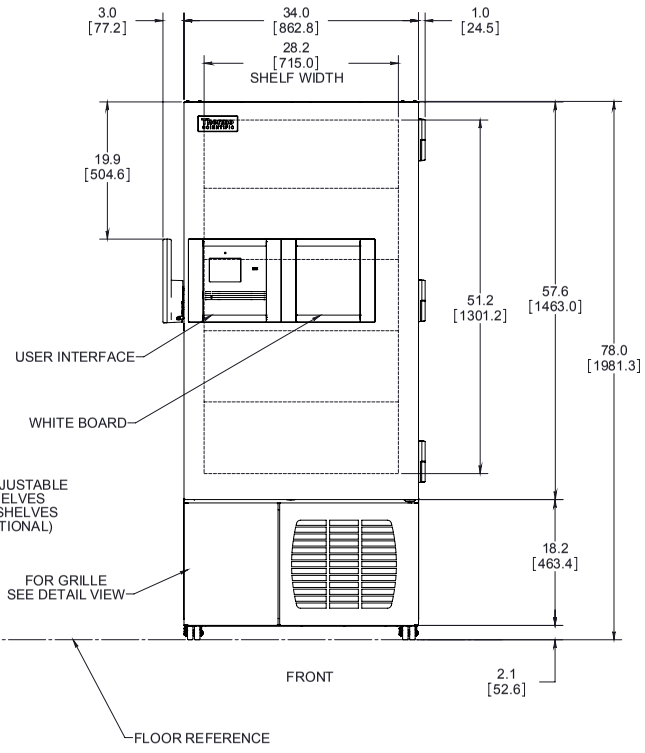












1. SYMBOLS, DESIGNATIONS AND GENERAL DRAWING METHODS ENGWI002
2. ALL COMPONENTS SHOULD BE RoHS COMPLIANT
3. BASIC DIMENSION TOLERANCE UNLESS OTHERWISE SPECIFIED. .X = ±0.100"
4. DUAL DIMENSION IS INCH OVER METRIC.

-	60347	2011-06-30	NEW RELEASE
REV.	ECN #	DATE	DESCRIPTION

REVISIONS

ThermoFisher SCIENTIFIC
275 AIKEN ROAD
ASHEVILLE, NC 28804

TITLE: **FREEZER UNIT**
ULT
500

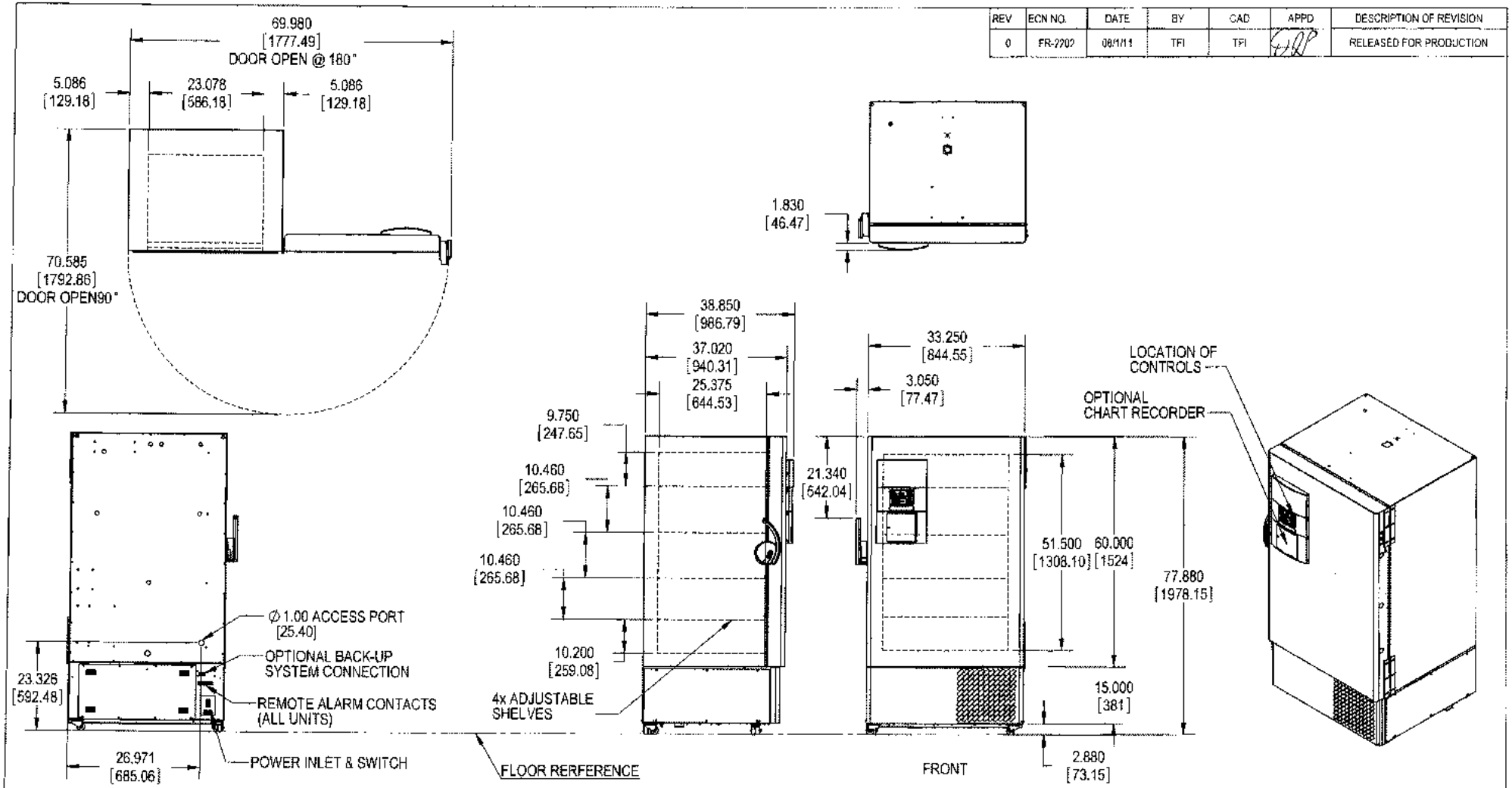
1st ANGLE PROJECTION

DWG. NO.: **315100G03**

SIZE: D SHEET 1 OF 1

DRAWING NUMBER: **8924-00-1**

REV	ECN NO.	DATE	BY	CAD	APPD	DESCRIPTION OF REVISION
0	FR-2202	08/1/11	TFI	TFI	[illegible]	RELEASED FOR PRODUCTION



NOTE: DUAL DIMENSION IS INCH OVER METRIC.

MODEL/PART NAME: 17 CU FT, -86°C UPRIGHT FREEZERS

DWG TITLE: GENERAL DIMENSION DRAWING U.T

DWN: TFI | CAD: TFI | APPD: SSK | DATE: 08/1/2011 | SCALE: N/A

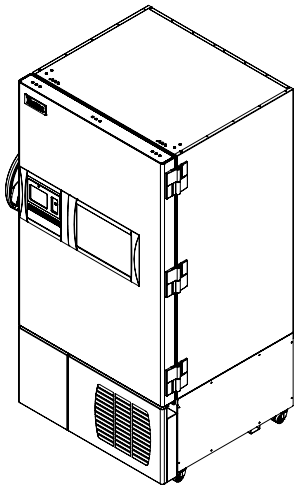
MATERIAL: N/A

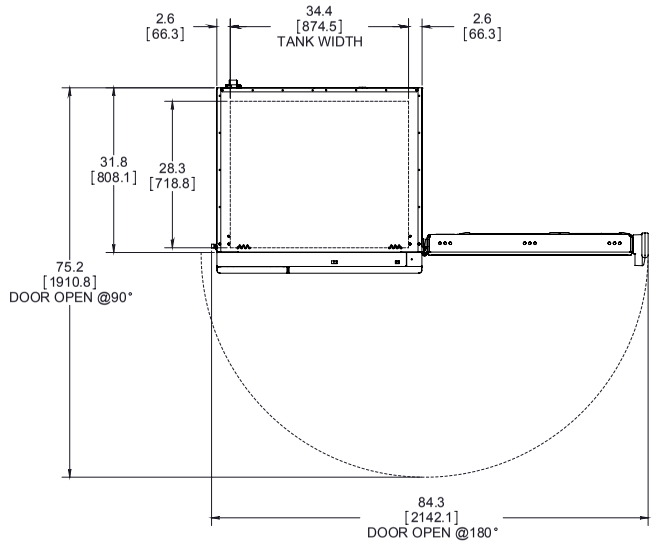
PAINT COLOR: N/A

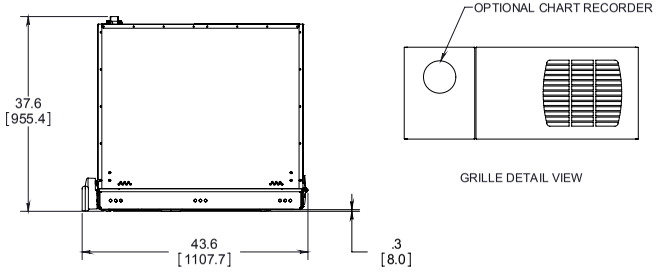
TOLERANCE UNLESS OTHERWISE SPECIFIED: ANGLES: DECIMAL: .XX=±.06 .XXX=±.030

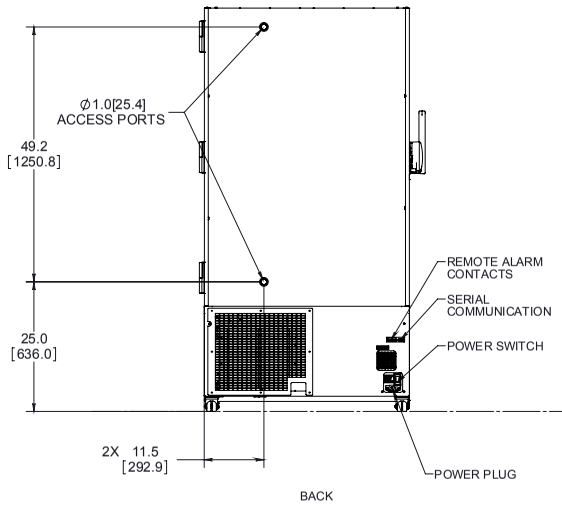
DRAWING NUMBER: **8924-00-1** | SIZE: B

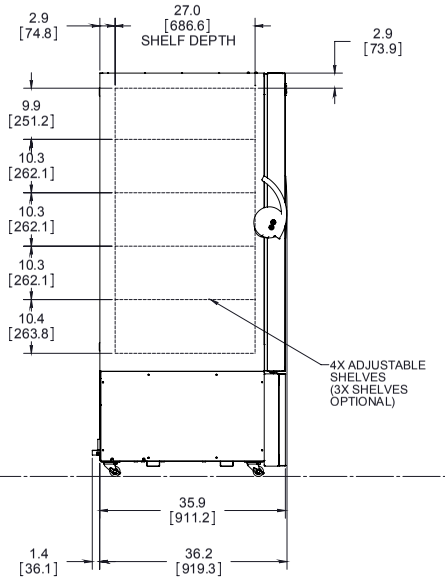
ThermoFisher SCIENTIFIC
BOX 649, MARIETTA, OHIO 45750

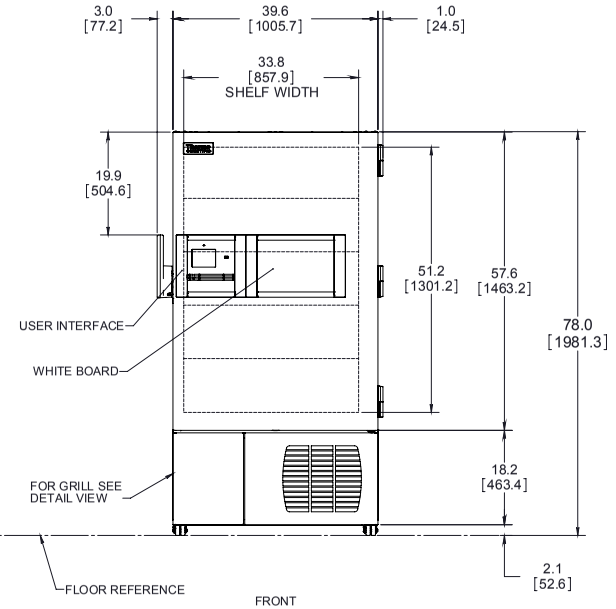












1. SYMBOLS, DESIGNATIONS AND GENERAL DRAWING METHODS ENGWI002
2. ALL COMPONENTS SHOULD BE RoHS COMPLIANT
3. DUAL DIMENSION IS INCH OVER METRIC
4. BASIC DIMENSION TOLERANCE UNLESS OTHERWISE SPECIFIED: .X = ±.100"

REV	ECN#	DATE	DESCRIPTION
-	60347	2011-06-30	NEW RELEASE

REVISIONS

ThermoFisher SCIENTIFIC
275 AIKEN ROAD
ASHEVILLE, NC 28804

TITLE: **FREEZER UNIT**
ULT
600

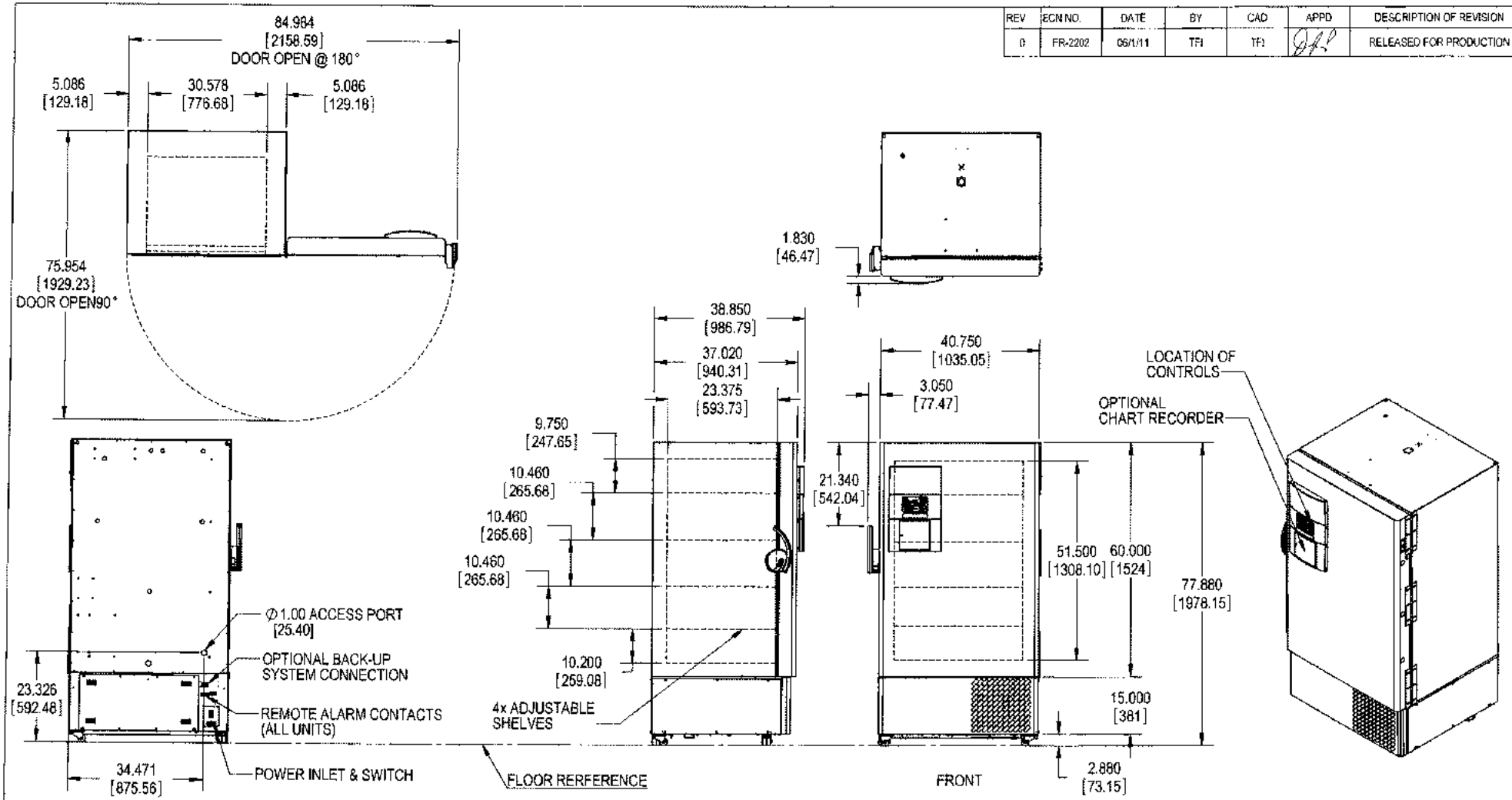
1st ANGLE PROJECTION

DWG. NO. **315100G04**

SIZE: D SHEET 1 OF 1

DRAWING NUMBER: **8926-00-1**

REV	ECN NO.	DATE	BY	CAD	APPD	DESCRIPTION OF REVISION
0	FR-2202	06/1/11	TFI	TFI		RELEASED FOR PRODUCTION

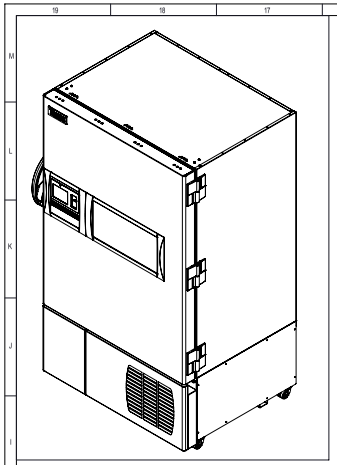


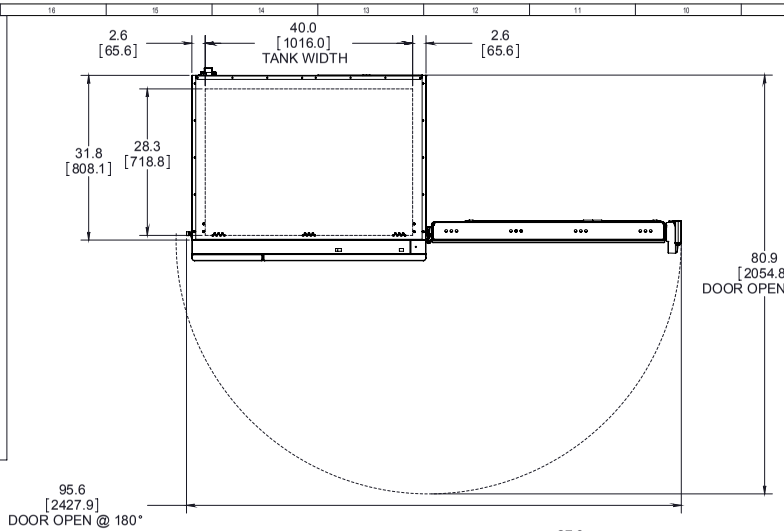
NOTE: DUAL DIMENSION IS INCH OVER METRIC.

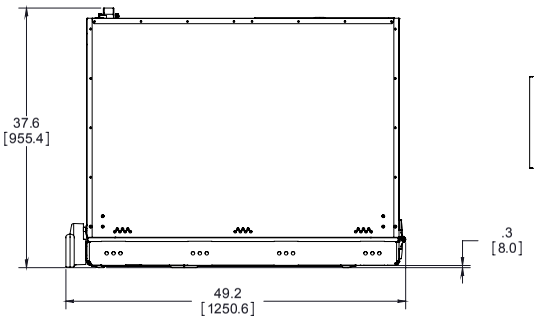
MODEL/PART NAME: 23 CU FT, -86°C UPRIGHT FREEZERS				
DWG TITLE: GENERAL DIMENSION DRAWING ULT				
DWN: TFI	CAD: TFI	APPD: SSK	DATE: 06/1/2011	SCALE: N/A
MATERIAL: N/A				
PAINT COLOR: N/A				
TOLERANCE UNLESS OTHERWISE SPECIFIED ANGLES: DECIMAL: .XX=±.06 .XXX=±.030			DRAWING NUMBER 8926-00-1	SIZE B

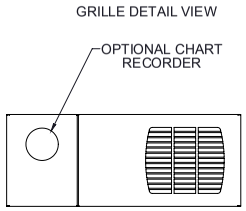
ThermoFisher SCIENTIFIC
BOX 649, MARIETTA, OHIO 45750

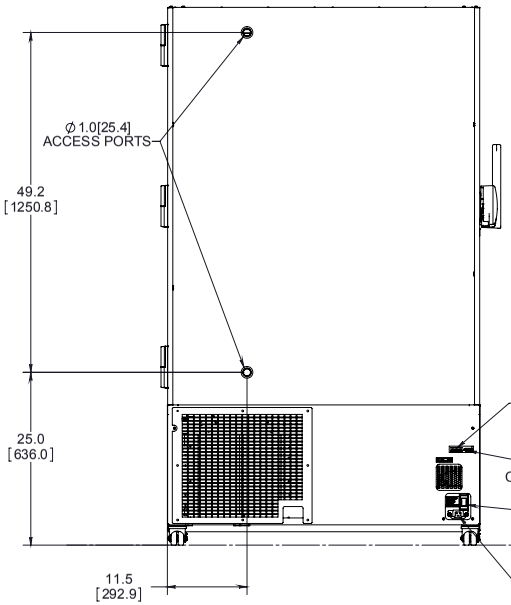
SolidWorks 2010-11-23

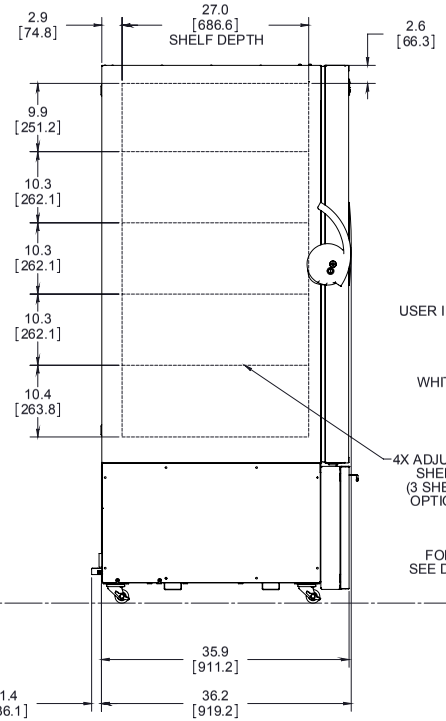


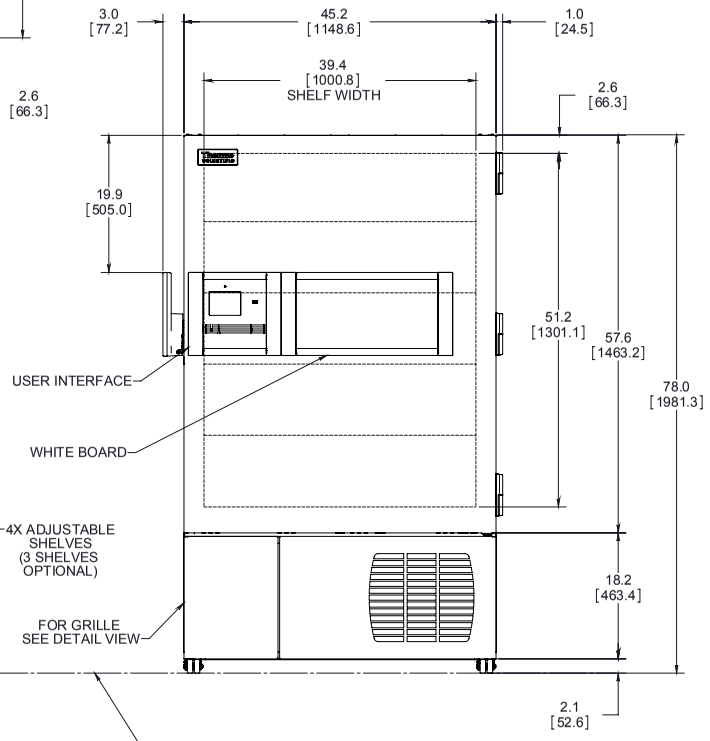












1. SYMBOLS, DESIGNATIONS AND GENERAL DRAWING METHODS ENGWI002
2. ALL COMPONENTS SHOULD BE RoHS COMPLIANT
3. BASIC DIMENSION TOLERANCE UNLESS OTHERWISE SPECIFIED: .X= ±0.100"
4. DUAL DIMENSION IS INCH OVER METRIC.

-	60347	2011-09-30	NEW RELEASE
REV.	ECN #	DATE	DESCRIPTION

REVISIONS

ThermoFisher SCIENTIFIC
275 AIKEN ROAD
ASHEVILLE, NC 28804

TITLE: **FREEZER UNIT**
ULT
700

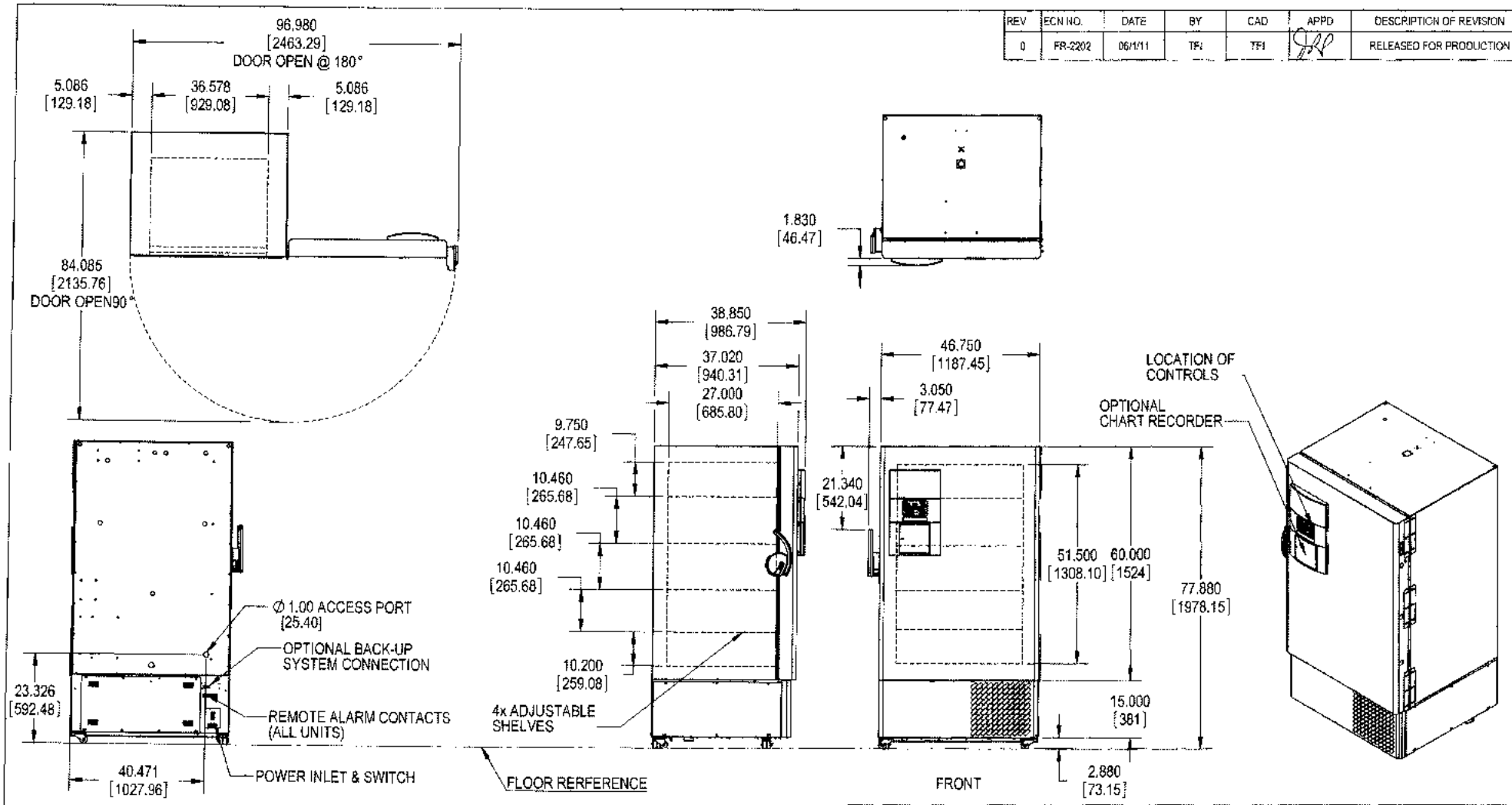
1st ANGLE PROJECTION

DWG. NO.
315100G05

SIZE: D SHEET 1 OF 1

DRAWING NUMBER: **8930-00-1**

REV	ECN NO.	DATE	BY	CAD	APPD	DESCRIPTION OF REVISION
0	FR-2202	06/1/11	TFI	TFI		RELEASED FOR PRODUCTION



NOTE: DUAL DIMENSION IS INCH OVER METRIC.

MODEL/PART NAME:	28 CU FT, -86°C UPRIGHT FREEZERS				
DWG TITLE:	GENERAL DIMENSION DRAWING ULT				
DWN: TFI	CAD: TFI	APPD: SSK	DATE: 06/1/2011	SCALE: N/A	
MATERIAL: N/A					
PAINT COLOR: N/A					
TOLERANCE UNLESS OTHERWISE SPECIFIED ANGLES	DECIMAL: .XX=±.06 .XXX=±.030	DRAWING NUMBER: 8930-00-1	SIZE: B		

ThermoFisher SCIENTIFIC
BOX 649, MARIETTA, OHIO 45750