	Alfa Laval Inc. 5400 International Trade Dr. Richmond, VA 23231	
	Date: 8/12/2015	Rev.: 1
Title: Data Book Index	**Doc. No.: 85480-4-DBI**	Page 1 of 1

Customer:	Virdia B2X, LLC	SU Order No:	85480-40
Model :	TS6-MFG	Serial No:	30116-93128
Customer PO:	148	Item No:	HE-2853

PLATE HEAT EXCHANGER DATABOOK

Section 1: GA Drawing / Plate Hanging List / Technical Specification Sheet

Section 2: ASME Data Report / Code Plate Copy / Certificate of Conformance

Section 3: Pressure Part Material Certificates

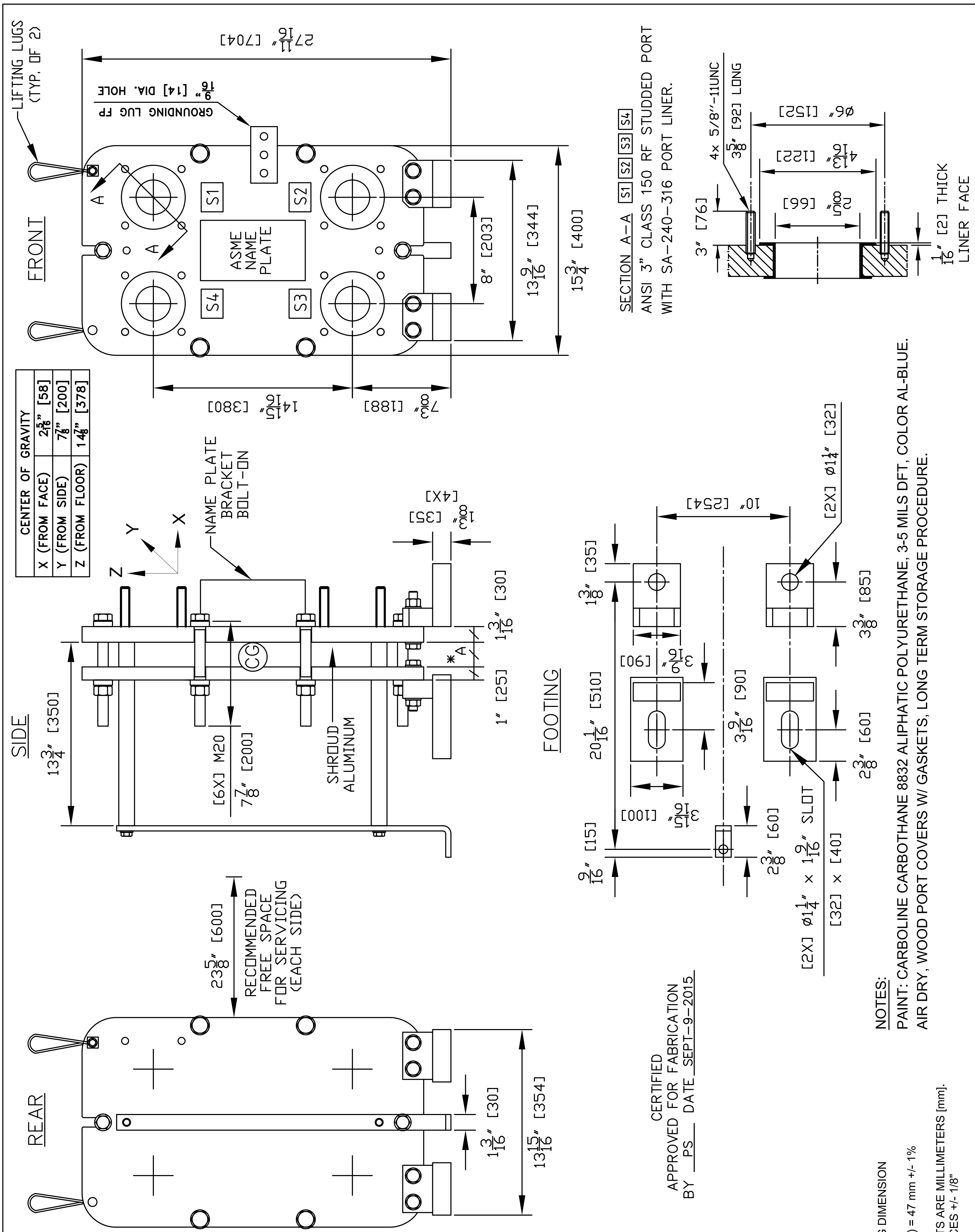
- Frame and Pressure Plate MTR
- Channel Plate MTR
- Tightening Bolt and Nut (Representative MTR)

Section 4: Standard Hydrostatic Test Certificate

Section 5: Calculations

- Stress Calculations
- Lifting Device Calculations

Prepared By: Peter Scholtes	Approved By: Peter Scholtes
Rev1: Revised for change in design	



SIDE	MEDIA	CONNECTIONS	LINER MATERIAL	INLET	TEMPERATURE	OUTLET	TEMPERATURE	FLOW RATE	PRESSURE DROP	LIQUID VOLUME
1	WATER-STEAM	ANSI 3" CLASS 150 RF	SA-240-316	S4	250.0 °F	S3	250.0 °F	514 LB/H	0.42 PSI	0.07 FT³
2	WATER	ANSI 3" CLASS 150 RF	SA-240-316	S2	100.0 °F	S1	150.0 °F	10000 LB/H	0.49 PSI	0.09 FT³

REMARKS:	SIDE 1	SIDE 2
DESIGN PRESSURE	150 PSIG	150 PSIG
MAWP	150 PSIG	150 PSIG
TEST PRESSURE	195 PSIG	195 PSIG
DESIGN TEMPERATURE	300 °F	300 °F
MDMT	-20 °F	-20 °F

GASKET	EPDMP CLIP-ON
PLATE MATERIAL	SA-240-316
PLATE THICKNESS	0.60 mm
HEATING SURFACE	7.4 FT²
PLATE GROUPING	1*4H / 1*5H = 10 PLATES (14 MAX)
OPERATING WEIGHT	368 LBS
NET WEIGHT	357 LBS

SUPPLIER: ALFA LAVAL INC. RE: 1828203	ORDER NO. 85480-40		PLATE HEAT EXCHANGER
CUSTOMER VIRDIA B2X, LLC	CUSTOMER P.O. NO. 148		
ITEM NO. HE-2853	ITEM DESCRIPTION DESORBENT WATER FEED HEATER		SERIAL NO. 30116-93128
DRAWN BY DMN	CHECKED BY PSS	DATE 8-12-2015	REV NO. 0

TS6-MFG

ASME

Designed constructed and stamped in accordance with 2013 ASME Code and latest Addendum.

Alfa Laval, Plate Heat Exchanger
Channel Plate Installation Description

2015-08-12

Customer:	Virdia B2X, LLC	SU Order No:	85480-40
Model :	TS6-MFG	Serial No:	30116-93128
Customer PO:	148	Item No:	HE-2853

Plate material and Thickness: SA-240-316 0.60 mm

A Dimension: 47 mm

	Hot side	**Cold side**
Grouping:	1*4H	1*5H
Sealing material:	EPDMP CLIP-ON	EPDMP CLIP-ON
Port Locations:	S4 -> S3	S2 -> S1
Connection material:	SA-240-316	SA-240-316

Port hole with flow on the gasketed side: U
Port hole sealed with O-ring: O
Plates are assembled with the gasket side facing the frame plate.

Plate no.	Plate code no.	Plate Pattern		Punched corner of the plate: upper left		lower left	lower right		upper right	Flow direction on the gasket side of the plate
				S1		S2	S3		S4	
	FRAME PLATE			=<=		=>=	=>=		=<=	
	1640917 01			O		O	O		O	
1	39505285 83	TS6 M2	A	O		O	O		O	
2	39505285 03	TS6 M2	B	U	--<---	U	O		O	Up
3	39505285 03	TS6 M2	A	O		O	U	--<---	U	Down
4	39505285 03	TS6 M2	B	U	--<---	U	O		O	Up
5	39505285 03	TS6 M2	A	O		O	U	--<---	U	Down
6	39505285 03	TS6 M2	B	U	--<---	U	O		O	Up
7	39505285 03	TS6 M2	A	O		O	U	--<---	U	Down
8	39505285 03	TS6 M2	B	U	--<---	U	O		O	Up
9	39505285 03	TS6 M2	A	O		O	U	--<---	U	Down
10	39505285 76	TS6 M2	B		--<---					Up
	PRESSURE PLATE									
				T1		T2	T3		T4	

Article No:	Quantity:
1640917 01	1
39505285 83	1
39505285 03	8
39505285 76	1
	11

Alfa Laval, Plate Heat Exchanger
Technical Specification

2015-08-12

Customer:	Virdia B2X, LLC	SU Order No:	85480-40
Model :	TS6-MFG	Serial No:	30116-93128
Customer PO:	148	Item No:	HE-2853

Fluid		**Water-Steam**	**Water**
Mass flow rate	lb/h	513.7	10000
Fluid Condensed/Vapourized	lb/h	513.7	0.000
Inlet temperature	°F	250.0	100.0
Outlet temperature (vapor/liquid)	°F	249.2/224.5	150.0
Operating pressure (In/Out)	psia	29.8/29.4	
Pressure drop (Perm/Calculate)	psi	14.5/0.424	14.5/0.494
Velocity Connection (In/Out)	ft/s	54.3/0.0658	1.22/1.23
Heat Exchanged	kBtu/h	498.5	
Mean Temperature Difference	°F	124.4	
Heat transfer area	ft²	495.1	
O.H.T.C	Btu/ft²,h,°F	544.6	
Relative directions of fluids		Countercurrent	
Number of plates		10	
Number of passes		1	1
Extension capacity			4
Plate material/ Thickness		SA-240-316 / 0.60 mm	
Sealing material		EPDMP CLIP-ON	EPDMP CLIP-ON
Connection material		SA-240-316	SA-240-316
Connection diameter		3”	3”
Nozzle orientation		S4 -> S3	S1 <- S2
Pressure vessel code		ASME	
Flange rating		ASME 150#	
Design pressure	psig	150.0	150.0
Test pressure	psig	195.0	195.0
Design temperature	°F	300.0	300.0
Overall length x width x height	in	22 x 16 x 28	
Liquid volume	ft³	0.07	0.09
Net Weight Empty / Operating	lbs	357 / 368	

Performance is conditioned on the accuracy of customers data and customers ability to supply equipment

FORM U-1 MANUFACTURER'S DATA REPORT FOR PRESSURE VESSELS

As Required by the Provisions of the ASME Code Rules, Section VIII, Division 1

1. Manufactured and certified by Alfa Laval Inc., 5400 International Trade Drive, Richmond, Virginia, 23231
(Name and address of Manufacturer)

2. Manufactured for Virdia B2X, LLC, 1319 HWY 182, Raceland, LA, 70394
(Name and address of Purchaser)

3. Location of installation Unknown
(Name and address)

4. Type **Vertical** (Horiz., vert., or sphere) **Plate Heat Exchanger** (Tank, separator, jkt. vessel, heat exh., etc.) **30116-93128** (Mfg's serial No.)

N/A (CRN) **30116-93128.0** (Drawing No.) **36557** (Nat'l. Bd. No.) 2015 (Year built)

5. ASME Code, Section VIII, Div. 1 2013/ N/A (Edition and Addenda (date)) 2523, 2766 (Code Case No.) N/A (Special Service per UG-120(d))

Items 6-11 incl. to be completed for single wall vessels, jackets of jacketed vessels, shell of heat exchangers, or chamber of multichamber vessels.

6. Shell (a) No. of course(s): 0 (b) Overall length: 0'

Course(s)			Material	Thickness		Long. Joint (Cat. A)			Circum. Joint (Cat. A, B, & C)			Heat Treatment	
No.	Diameter	Length	Spec./Grade or Type	Nom.	Corr.	Type	Full, Spot, None	Eff.	Type	Full, Spot, None	Eff.	Temp.	Time
	N/A	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**

7. Heads: (a) SA-516-70 (Mat'l Spec. No., Grade or Type) (H.T. - Time & Temp.) (b) SA-516-70 (Mat'l Spec. No., Grade or Type) (H.T. - Time & Temp.)

	Location (Top, Bottom, Ends)	Thickness		Radius		Elliptical Ratio	Conical Apex Angle	Hemispherical Radius	Flat Diameter	Side to Pressure		Category A		
		Min.	Corr.	Crown	Knuckle					Convex	Concave	Type	Full, Spot, None	Eff.
(a)	**Fixed**	**1.18"**	**0"**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**26" X 16"**			**N/A**	**N/A**	**N/A**
(b)	**Movable**	**1"**	**0"**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**26" X 16"**			**N/A**	**N/A**	**N/A**

If removable, bolts used (describe other fastening) **SA193-B7 (6) 0.787" (M20 actual) BOLTS**
(Mat'l, Spec. No., Grade, Size, No.)

8. Type of jacket **N/A** Jacket closure **N/A**
(Describe as ogee & weld, bar, etc.)

If bar, give dimensions **N/A** If bolted, describe or sketch.

9. MAWP **150 psi** (internal) **N/A** (external) at max. temp. **300 °F** (internal) **N/A** (external) Min. design metal temp. **-20 °F** at **150 psi**

10. Impact test NO (Impact Exemption UCS-66(a), (b), UHA-51, UNF-65, as applicable) at test temperature of **N/A**
(Indicate yes or no and the component(s) impact tested)

11. Hydro., pneu., or comb. test press. **HYDRO at 195 psi** Proof test **N/A**

Items 12 and 13 to be completed for tube sections.

12. Tubesheet: **N/A** Stationary (Mat'l Spec. No.) **N/A** Dia., (subject to press.) **N/A** Nom. thk. **N/A** Corr. Allow. **N/A** Attachment (welded or bolted)

N/A Floating (Mat'l Spec. No.) **N/A** Dia. **N/A** Nom. thk. **N/A** Corr. Allow. **N/A** Attachment

13. Tubes: **N/A** Mat'l Spec. No., Grade or Type **N/A** O. D. **N/A** (Nom. thk.) **N/A** Number **N/A** Type (Straight or U)

Items 14-18 incl. to be completed for inner chambers of jacketed vessels or channels of heat exchangers.

14. Shell (a) No. of course(s): 0 (b) Overall length: N/A

Course(s)			Material	Thickness		Long. Joint (Cat. A)			Circum. Joint (Cat. A, B, & C)			Heat Treatment	
No.	Diameter	Length	Spec./Grade or Type	Nom.	Corr.	Type	Full, Spot, None	Eff.	Type	Full, Spot, None	Eff.	Temp.	Time
	N/A	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**

15. Heads: (a) N/A (Mat'l Spec. No., Grade or Type) (H.T. - Time & Temp.) (b) N/A (Mat'l Spec. No., Grade or Type) (H.T. - Time & Temp.)

	Location (Top, Bottom, Ends)	Thickness		Radius		Elliptical Ratio	Conical Apex Angle	Hemispherical Radius	Flat Diameter	Side to Pressure		Category A		
		Min.	Corr.	Crown	Knuckle					Convex	Concave	Type	Full, Spot, None	Eff.
N/A	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**			**N/A**	**N/A**	**N/A**

If removable, bolts used (describe other fastening) **N/A**
(Mat'l, Spec. No., Grade, Size, No.)

NB Number 36557

16. MAWP N/A (internal) N/A (external) at max. temp. N/A (internal) N/A (external) Min. design metal temp. N/A at N/A

17. Impact test N/A (Indicate yes or no and the component(s) impact tested) at test temperature of N/A

18. Hydro., pneu., or comb. test press. N/A Proof test N/A

19. Nozzles, inspection, and safety valve openings:

Purpose (Inlet, Outlet, Drain, etc.)	No.	Diameter or Size	Flange Type	Material		Nozzle Thickness		Reinforcement Material	How Attached		Location (Insp. Open.)
				Nozzle	Flange	Nom.	Corr.		Nozzle	Flange	
Outlet	**2**	**3"**	**STUDS**	**SA193-B7**		**5/8"**					
Inlet	**2**	**3"**	**STUDS**	**SA193-B7**		**5/8"**					

20. Supports: Skirt ______ (Yes or no) Lugs N/A (No.) Legs N/A (No.) Others FEET (Describe) Attached BOLTED (Where and how)

21. Manufacturer's Partial Data Reports properly identified and signed by Commissioned Inspectors have been furnished for the following items of the report:

N/A

(List the name of part, item number, mfg's. name and identifying number)

22. Remarks:

Actual Plates (10) SA-240-316 (ALLOY 316) 0.6 mm (13) Plates Maximum; Distance between Heads = 47 mm; Customer PO#: 148; Tag #: Desorbent Water Feed Heater HE-2853; Owner to supply Safety Valve/Noncorrosive Service Only;

CERTIFICATE OF SHOP COMPLIANCE

We certify that the statements made in this report are correct and that all details of design, material, construction, and workmanship of this vessel conform to the ASME Code for Pressure Vessels, Section VIII, Division 1. U Certificate of Authorization No. 25017 Expires July 5, 2016

Date 10/02/2015 Name **Alfa Laval Inc.** (Manufacturer) Signed [signature] (Representative)

CERTIFICATE OF SHOP INSPECTION

I, the undersigned, holding a valid commission issued by The National Board of Boiler and Pressure Vessel Inspectors and/or the State or Province of VA and employed by OneCIS Insurance Company, of Lynn, MA have inspected the pressure vessel described in this Manufacturer's Data Report on October 2, 2015, and state that, to the best of my knowledge and belief, the Manufacturer has constructed this pressure vessel in accordance with ASME Code, Section VIII, Division 1. By signing this certificate neither the Inspector nor his employer makes any warranty, expressed or implied, concerning the pressure vessel described in this Manufacturer's Data Report. Furthermore, neither the Inspector nor his employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

Date 10/14/2015 Signed [signature] (Authorized Inspector) Commissions **10803A, VA951R** (Nat'l Board incl. endorsements, State, Province and No.)

CERTIFICATE OF FIELD ASSEMBLY COMPLIANCE

We certify that the statements made in this report are correct and that the field assembly construction of all parts of this vessel conforms with the requirements of ASME Code, Section VIII, Division 1. U Certificate of Authorization No. ______ Expires ______

Date ______ Name ______ (Assembler) Signed ______ (Representative)

CERTIFICATE OF FIELD ASSEMBLY INSPECTION

I, the undersigned, holding a valid commission issued by The National Board of Boiler and Pressure Vessel Inspectors and/or the State or Province of ______ and employed by ______ of ______, have compared the statements in this Manufacturer's Data Report with the described pressure vessel and state that parts referred to as data items ______, not included in the certificate of shop inspection, have been inspected by me and to the best of my knowledge and belief, the Manufacturer has constructed and assembled this pressure vessel in accordance with the ASME Code, Section VIII, Division 1. The described vessel was inspected and subjected to a hydrostatic test of ______ psi. By signing this certificate neither the Inspector nor his employer makes any warranty, expressed or implied, concerning the pressure vessel described in this Manufacturer's Data Report. Furthermore, neither the Inspector nor his employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

Date ______ Signed ______ (Authorized Inspector) Commissions ______ (Nat'l Board incl. endorsements, State, Province and No.)

36557

Certified by

Alfa Laval - Richmond, VA

U

Single ratings apply to all chambers
Multiple ratings are listed as Hot/Cold

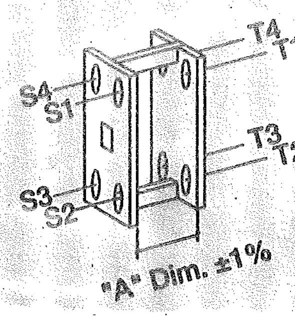
MAWP	150 PSIG AT 300 °F		
MDMT	-20 °F AT 150 PSIG		
S/N	30116-93128	Year	2015
Model	TS6-MFG		
Area	7.4 SQ.FT.		
A-Dim	47mm w/10 0.6mm PLTS		
Order	1828203		

VIRDIA PO 148
ITEM NO HE-2853
DUTY 498,500 BTU/HR
OHTC 544.6 BTU/FT2,H,F
MAX NO OF 316 SS PLATES: 14

Customer Service

866-ALFALAVAL WWW.ALFALAVAL.COM

WARNING
READ INSTRUCTION MANUAL
BEFORE INSTALLATION,
OPERATION AND MAINTENANCE
TO AVOID INJURIES
OR DAMAGE.



October 7, 2015

Alfa Laval Inc.
5400 International Trade Drive
Richmond, VA 23232
USA
Tel: +1 804-222-5300
www.alfalaval.com

Reference:	Alfa Laval Order:	85480 / 1828203
	Serial Number:	30116-93128
	Customer Reference Number:	148
	Customer Item No:	HE-2853

CERTIFICATE OF CONFORMANCE

Alfa Laval herby states that the methods and materials used to fabricate the plate heat exchanger(s) referenced above conform to the applicable requirements of Alfa Laval Richmond's ISO 9001-2008 Quality Management System requirements. Additionally, if an ASME code stamp has been applied to the equipment, we hereby state that it meets the applicable requirements of ASME Section VIII, Div.1.

Sincerely,
Michael J. Gunnoe

Michael J. Gunnoe – Quality Technician, Quality Assurance
Alfa Laval Inc – USA, VA

MISSION STATEMENT: To optimize the performance of our customer's processes.
Time and time again.

FRAME & PRESSURE PLATES

NUCOR
PLATE MILL

P.O.Box 279
Winton, NC 27986
(252) 356-3700

Mill Test Report

Page 1

NUCOR It's our Nature.

Issuing Date : 04/23/2013 **B/L No. :** 355310 **Load No. :** 358178 **Our Order No. :** 110890/6 **Cust. Order No. :** 2518100 OP

Vehicle No: NOKL 725387

Specification : 1.0000" x 96.000" x 240.000"
ASTM A516 70-10/ASME SA516 70 SA516-485 PVQ 2011 Addenda
NACE MR0175 Annex 2.1.2, MR0103 Section 2.1.2 Compliant

Sold To : ONEAL STEEL INC
P O BOX 98
BIRMINGHAM,AL 35201

Ship To : ONEAL MANUFACTURING SERVICES
PITTSBURGH - DIST 261
DISTRICT 261
STATION: PITTSBURGH 43RD STREET
PITTSBURGH,PA 15202

Marking : 808958

Heat No	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Al(tot)	V	Nb	Ti	N	Ca	B	Sn	CEQ	PCM
3503059	0.19	1.02	0.020	0.001	0.21	0.12	0.04	0.08	0.01	0.034	0.004	0.003	0.002		0.0011	0.0003	0.006	0.39	0.26

Tensile Test

Plate Serial No	Pieces	Tons	Dir.	(psi) Yield	(psi) Tensile	Elongation % in 2"	Elongation % in 8"
3503059-02	13	42.47	T	44,200	70,200		24.0

Charpy Impacts

Dir.	1	(%) shear	2	(%) shear	3	(%) shear	Ave.	(%) shear	Size	Temp	Min Ave.

herbert.wathan
@alfalaval.com

Digitally signed by
herbert.wathan@alfalaval.com
DN: cn=herbert.wathan@alfalaval.com
Date: 2015.10.06 09:05:34 -04'00'

Manufactured to fully killed fine grain practice by Electric Arc Furnace. Welding or weld repair was not performed on this material. Mercury has not been used in the direct manufacturing of this material. Produced as continuous cast discrete plate as-rolled, unless otherwise noted in Specification.
Yield by 0.5EUL method unless otherwise specified. Ceq = C+(Mn/6)+((Cr+Mo+V)/5)+((Cu+Ni)/15)
Pcm = C+(Si/30)+(Mn/20)+(Cu/20)+(Ni/60)+(Cr/20)+(Mo/15)+(V/10)+5B
Melted and manufactured in the USA. ISO 9001:2008 certified (#008083) by SRI Quality System Registrar (#0985-09). PED 97/23/EC 7/2 Annex 1, Para. 4.3 Compliant.
DIN 50049 3.1.B/EN 10204 3.1B(2004), DIN EN 10204 3.1(2005) compliant. For ABS grades only, Quality Assurance certificate 09-MMPQA-546

We hereby certify that the contents of this report are accurate and correct. All test results and operations performed by the material manufacturer are in compliance with the applicable specifications, including customer specifications.

T. A. Depretis

T. A. Depretis, Metallurgist

04/25/2013 8:31:24 AM

NUCOR PLATE MILL

P.O.Box 279
Winton, NC 27986
(252) 356-3700

Mill Test Report

NUCOR

Issuing Date :	05/27/2015	B/L No. : 416925	Load No. : 422523	Our Order No. : 127883/1	Cust. Order No. : 4500684520
Vehicle No:	10451		Sold To:	RYERSON PROCUREMENT CORP PO BOX 91601 LUBBOCK,TX 79490	Ship To: JOSEPH T RYERSON AND SON INC - FAIRLESS HILLS 20 STEEL RD S MORRISVILLE,PA 19067
Specification:	1.1811" x 96.000" x 240.000" ASTM A516 70-10/ASME SA516 70 SA516-485 PVQ 2011 Addenda, 2013 NACE MR0175 Annex 2.1.2, MR0103 Section 2.1.2 Compliant				
Marking :	300041821				

Heat No	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Al(tot)	V	Nb	Ti	N	Ca	B	Sn	Ceq	Pcm
5502764	0.20	1.06	0.013	0.003	0.21	0.21	0.08	0.11	0.02	0.027	0.004	0.001	0.005		0.0027	0.0003	0.009	0.42	0.27

Tensile Test								Charpy Impacts											
Plate Serial No	Pieces	Tons	Dir.	(psi) Yield	(psi) Tensile	Elongation % in 2"	Elongation % in 8"	Dir.	1	(%) shear	2	(%) shear	3	(%) shear	Ave.	(%) shear	Size	Temp	Min Ave.
5502764-01	1	3.85	T	43,600	74,200		18.0												

herbert.wathan
@alfalaval.com

Digitally signed by
herbert.wathan@alfalaval.com
DN:
cn=herbert.wathan@alfalaval.com
Date: 2015.07.13 14:56:52 -04'00'

Manufactured to fully killed fine grain practice by Electric Arc Furnace. Welding or weld repair was not performed on this material. Mercury has not been used in the direct manufacturing of this material. Produced as continuous cast discrete plate as-rolled, unless otherwise noted in Specification. For Mexico shipments: nhc-SalesMX@Nucor.com
Yield by 0.5EUL method unless otherwise specified. Ceq = C+(Mn/6)+((Cr+Mo+V)/5)+((Cu+Ni)/15)
Pcm = C+(Si/30)+(Mn/20)+(Cu/20)+(Ni/60)+(Cr/20)+(Mo/15)+(V/10)+5B
Melted and Manufactured in the USA. ISO 9001:2008 certified (#010940) by SRI Quality System Registrar (#0985-09). PED 97/23/EC 7/2 Annex 1, Para. 4.3 Compliant. DIN 50049 3.1.B/EN 10204 3.1B(2004), DIN EN 10204 3.1(2005) compliant. For ABS grades only, Quality Assurance certificate 14-MMPQA-723

We hereby certify that the contents of this report are accurate and correct. All test results and operations performed by the material manufacturer are in compliance with the applicable specifications, including customer specifications.

T. A. Depretis

T. A. Depretis, Metallurgist

5/27/2015 11:25:57 AM

CHANNEL PLATES

aperam

Aperam - Stainless France
Aperam Gueugnon
71130 Gueugnon
FRANCE

MILL CERTIFICATE BS EN 10204/3.1
CERTIFICAT DE RECEPTION NF EN 10204/3.1
ABNAHMEPRUEFZEUGNIS DIN EN 10204/3.1

ISO 9001 V2008 - ISO TS 16949 V2009 - ISO 14001 V 2004

N-Nr-N **15G0339755-01 V01**

A04 A02 A03 A01 Z05

Manufacturer's works order number
N° de la commande usine productrice
Werksauftragsnummer
80251884 /01-60770/1 A08

Z03

Purchaser and/or consignee
Client et/ou destinataire
Besteller und/oder Empfaenger

Alfa Laval Lund AB
Rudeboksvägen 1

221 00 LUND
SUEDE A06

Purchaser's order number
N° de commande client
Kundenbestellnummer
OMCP-133699 A07

Product - Produit - Erzeugnis
COLD-ROLLED COIL
BOBINE LAMINEE A FROID
KALTGEWALZTES BAND B01

Customer article number
N.article client
Artikelnummer des Kunden A09

Steel designation B02
Désignation de l'acier
Stahlbezeichnung

Steel designation	Finish / Présentation / Ausfuehrung
ASTM A 240 / 14 - TYPE 316L - TYPE 316	2B
ASME SA 240 / 13 - TYPE 316L - TYPE 316	2B
EN 10028-7 / 08 - 1.4404 - 1.4401	2B
EN 10088-2 / 14 - 1.4404 - 1.4401	2B

Steelmaking process C70
Mode d'élaboration de l'acier - Stahlherstellungverfahren
Prod.proces: Electric arc furnace - VOD/AOD - Continuous casting
Proc.fabric.: Four à arc - VOD/AOD - Coulée continue
Fertigungsablauf: Elektro-Ofen - VOD/AOD - Stranggussanlage

Any supplementary requirements B03
Prescriptions supplémentaires - Zusätzliche Anforderungen
AL1112359-63/5-AL1112349-

Product delivery condition
Etat de livraison du produit - Lieferzustand

Solution treated
Hypertrempe : **1040-1110 C**
Loesungsgegl+abgeschreckt

Forced Air
Air forcé Geblaese Luft B04

NACE MR 0103 / ATTESTATION PED 97/23/EC PAR TUV SUD / CORROSIONTEST:ASTM A 262-E :OK / NACE MR 0175/ISO 15156-1 /ISO 15156-3 / / Z06

Identification of the product B07
Identification du produit - Identifizierung des Erzeugnisses
MELTED IN BELGIUM, MADE IN FRANCE

Coil n. / N.Bobine - Band Nr.	Heat n. / N.Coulée - Schmelz Nr.	Thickness / Epaisseur - Staerke (B09)	Width / Largeur - Breite (B10)	Length / Longueur - Laenge (B11)
731306	507025	0,600 mm	333,00 mm	

Number of pieces / Nb de pièces - Stueckzahl (B08): **1**
Net weight / Poids net - netto Gewicht (B13): **1314 KGS**

CHEMICAL ANALYSIS - ANALYSE CHIMIQUE - CHEMISCHE ZUSAMMENSETZUNG

	C	Si	Mn	Ni	Cr	Mo	Ti	N	S	P						
Required -Exigé %mini				10,00	16,50	2,000										
Anforderung. %maxi	0,030	0,75	2,00	13,00	18,00	2,500		0,100	0,0150	0,045						
Cast Analysis / Analyse coulée / Analyse Schmelze	0,026	0,37	1,25	10,03	16,56	2,020		0,040	0,0018	0,031						
	C71	C72	C73	C74	C75	C76	C77	C78	C79	C80	C81	C82	C83	C84	C85	C86

Positive material identification carried out : OK
Tests de vérification de la conformité de la nuance fournie : OK
Verwechslungpruefung wurde durchgefuehrt : OK C04

C93 D52

MECHANICAL PROPERTIES - PROPRIETES MECANIQUES - MECHANISCHE WERTE C20

Room temperature - Température ambiante - Raumtemperatur | Test temperature (°C) : C03

Location (1)	Direction (2)		Yield or proof strength / Limite d'élasticité / Dehngrenze MPa Rp0.2%	Rp1%	Tensile Strength / Résistance à la traction / Zugfestigkeit MPa Rm	Elongation after fracture / Allongement après rupt. / Bruchdehnung % 80mm	50mm	Hardness / Dureté / Haerte HB (C30)	Yield or proof strength / Limite d'élasticité / Dehngrenze MPa Rp0.2%	Rp1%	Tensile str. / Résist. MPa / Zugfestigkeit Rm	Elongation % / Allongement. / Bruchdehnung
		Required Exigé Anforderung mini	240	270	530	45	45	130				
		maxi			680			180				
1	T	**Obtained** Obtenu Ergebnisse	285	330	592	62	62	154				
2	T							155				
			C11	C14	C12	C13	C15	C31	C16	C17	C18	C19

Impact strength test / Essai de résilience / Kerbschlagzaehigkeitstest	Corrosion test / Test de corrosion / Korrosionstest	GRAIN ASTM E 112						
C40 t(°c) C44		8,4						
C42	D51	C50	C51	C52	C53	C54	C55	C05

Internal cleanliness: A: B: C: D: C57

Location of the sample (1)
Emplacement de l'échantillon
Lage des Probenabschnittes
1. Front - Début - Anfang
2. Back - Fin - Ende
3. Middle - Milieu - Mitte C01

The delivery is in accordance with the order
La fourniture est conforme aux exigences de la commande
Die lieferung entspricht den Bestellbedingungen Z01

Packing list
Avis d'expédition **150311G01724-101132**
LieferscheinNummer A10

Organisation inspection
Organisme et/ou service contrôle
Ueberwachungsabteilung A05

Customer Quality

11/03/2015 Romain GERARD

Direction of the test pieces (2)
Orientation des éprouvettes
Probenrichtung
T. Transverse - Travers - Quer
L. Longitudinal - Long - Laengs C02

Marking, inspection and measurement : without objection
Contrôle de marquage, d'aspect et de dimensions : satisfaisants
Pruefung der Stempelung, des Oberflaechenaspekts und der
Abmessungen : ohne Beanstandung D01

The inspector
Le responsable
Der Werkssachverstaendige Z02

TIGHTENING BOLTS/NUTS

Date	09/04/2015
Folio	1/2
Author	APLATTEEUW
Office	QC Technician

Beck-Crespel
A Beck Industries Company

Certificat d'essais / Test Certificate NFEN 10204.3.1

NR 15026/26 - 1260/99 - 61698

ALFA LAVAL INC

5400 INTERNATIONAL TRADE DRIVE
RICHMOND, VIRGINIA 23231 U.S.A.

VOTRE/YOUR REF N° US-158897

Poste/item 1
Qte/Qty 400

VIS M20X200/150 ENISO 898-1 CL8.8
SA193/B7 ADW7
COAT : ZN
Plan 32324-1402-01 REV.9

- **VIS M20X200/150**
  Coulée : B09102

Normes/Standard : **ASME SA193 GRADE B7- EN ISO 898-1 CL 8.8 ADW7**

ANALYSE/HEAT ANALYSIS

C	Mn	Si	S	P	Cr	Mo	
0.41	0.83	0.22	0.008	0.01	0.86	0.16	

CARACTERISTIQUES MECANIQUES/MECHANICAL TEST

TEST n°85326

Rm 300°C MPa	Rp0.2% 300° MPa	A% 5d 300°C	Z% 300°C				
899	656	26.4	71				

TEST n°85327

Rm MPa	Rp0.2% MPa	A% 4D	A% 5d	Z%	REV. T° C	HB	
947	861	21.5	18.2	63	640	287	

TEST n°85329

Rm MPa	Rp0.2% MPa	A% 4D	A% 5d	Z%	REV. T° C	HB	
961	878	21.3	18.4	61	640	317	

TEST n°85330

KV +20°C Joules							
129/129/122							

TEST n°85331

Rm MPa	Rp0.2% MPa	A% 4D	A% 5d	Z%	REV. T° C	HB	
950	864	20.6	18.1	62	640	287	

TEST n°85332

KV +20°C Joules							
123/120/120							

TEST n°85333

Rm MPa	Rp0.2% MPa	A% 4D	A% 5d	Z%	REV. T° C	HB	
965	879	21.3	18.7	61	640	317	

Goods are in conformity to: EN ISO 898-1 CLASSE 8.8 ADW7-ASME SA193 GRADE B7 EDITION 2010 + ADDENDAS 2011
Material in conformity To PED 97/23/EC
Delivery state : Quenched and Tempered
Superficial hardness : HV 0.3 : Conform
Decarburation Test : Conform
Proof load Test : Conform
Proof load Test with wedge : Conform
Visual and dimensional control : conform
Macroetch Examination :Conform
Marks on tightbolt : BC - B7 - 8.8
V X PS <= 5000
MIT ZUSTIMMUNG DES TÜV RHEINLAND WE 208 VOM 15.01.85 UND VERZICHT AUF GEGENZEICHNUNG VOM 15.10.99

Beck-Crespel
A Beck Industries Company

Date	09/04/2015
Folio	2/2
Author	APLATTEEUW
Office	QC Technician

Certificat d'essais / Test Certificate NFEN 10204.3.1

NR 15026/26 - 1260/99 - 61698

ALFA LAVAL INC

5400 INTERNATIONAL TRADE DRIVE
RICHMOND, VIRGINIA 23231 U.S.A.

VOTRE/YOUR REF N° US-158897

We the undersigned, BECK CRESPEL, hereby certify that the supplied products are fully in accordance with the requirments of the order.
This test certificate applies only the items, designation and quantities as described above.

CUSTOMER	Virdia B2X, LLC
P.O. NO.	148
ALFA LAVAL NO.	85480 / 1828203
SERIAL NO.	30116-93128
ITEM NO. or MODEL TYPE	HE-2853

ASME Hydrostatic Test No.	Revision No.
WI 25001	9

	Test Pressure	Holding Time	Test Gauges	Gauge Due Date	A.I. Witness or Test Operator
Single	195 PSIG / 150 PSIG	2 min / 10 min	620	3/9/2016	Herb Wathan (A.I.)
Single	195 PSIG / 150 PSIG	2 min / 10 min	620	3/9/2016	Herb Wathan (A.I.)

C.I. Hydrostatic Test No.	Revision No.
N/A	N/A

	Test Pressure	Holding Time	Test Gauges	Gauge Due Date	Customer Witness
Single	N/A	N/A	N/A	N/A	N/A
Single	N/A	N/A	N/A	N/A	N/A

This hydrostatic pressure test was performed successfully with no visible internal or external leakage from the heat exchanger. Testing was witnessed as noted above.

APPROVED BY: *Michael J. Gunnoe* (Quality Technician)

DATE OF ASME CODE TEST: 10/2/2015

DATE OF CUSTOMER WITNESS: Waived per Jim Biasca 9/22/2015

Customer:	Virdia B2X, LLC	SU Order No:	85480-40
Model :	TS6-MFG	Serial No:	30116-93128
Customer PO:	148	Item No:	HE-2853

Design Verification of Plate Heat Exchangers (PHE) exposed to External Loads

ASME Section III, Division 1
Edition and Addenda according to doc. PPD 0406-07

Order number 85480-40
Document registration number 30116-93128
Revision 0

0	External Load Analysis: Seismic Accelerations per ASCE 7-10		
Rev. no.	Description of revision		
Prepared Randy Neagle		Date 8/21/2015	Signature Randy Neagle
Approved Dean Middleton		Date 8/21/2015	Signature Dean Middleton

Calculation of External Loads

Seismic Loads (ASCE 7-10)
Order Number: 85480
Serial Numbers: 30116-93125
30116-93126
30116-93128
30116-93129
30116-93130
30116-93131

Site location:	Raceland, LA		
Risk Category:	II		Based on Table 1.5-1 (Assumed)
Importance Factor:	$I := 1.00$		Based on Description in Section 11.5 and Table 1.5-2
Site Classification:	E		Based on Description in Section 11.4.2 & Chapter 20 and Supplied Inputs
Mapped spectral acceleration at short periods as determined in Section 11.4:	$S_S := 0.125$		Based on Customer Inputs and Supplied Site Information
Mapped spectral acceleration at a period of 1-second as determined in Section 11.4:	$S_1 := 0.073$		Based on Customer Inputs and Supplied Site Information
Site coefficient defined in Table 11.4-1:	$F_a := 2.5$		Based on Customer Inputs and Supplied Site Information
Site coefficient defined in Table 11.4-2:	$F_v := 3.5$		Based on Customer Inputs and Supplied Site Information
Max. considered earthquake spectral response acceleration for short periods:	$S_{MS} := F_a \cdot S_S$	$S_{MS} = 0.313$	(ASCE Eq. 11.4-1)
Max. considered earthquake spectral response acceleration at 1 second:	$S_{M1} := F_v \cdot S_1$	$S_{M1} = 0.256$	(ASCE Eq. 11.4-2)
Design spectral response acceleration at short periods	$S_{DS} := \frac{2 \cdot S_{MS}}{3}$	$S_{DS} = 0.208$	(ASCE Eq. 11.4-3)
Design spectral response acceleration at 1 second:	$S_{D1} := \frac{2 \cdot S_{M1}}{3}$	$S_{D1} = 0.17$	(ASCE Eq. 11.4-4)

Component Amplification Factor	$a_p := 1.0$	Based on Tables 13.5-1 and 13.6-1
Component Response Modification Factor	$R_P := 2.5$	Based on Tables 13.5-1 and 13.6-1
Height in Structure Point of Attachment with Respect to the Base	$z := 0$	Heat exchanger assumed to be mounted at base.
Height of Structure	$h := 0$	Heat exchanger assumed to be mounted at base.
Seismic Design Acceleration (Horizontal):	$a_{horizontal} := \frac{(0.4 \cdot a_p \cdot S_{DS})}{\left(\frac{R_P}{I}\right)} \left[1 + 2 \cdot \left(\frac{z}{h}\right)\right]$ $a_{horizontal} = 0.033$	(ASCE Eq. 13.3-1)
Horizontal acceleration is not required to be taken as greater than:	$a_{horizontal} := 1.6 \cdot S_{DS} \cdot I$ $a_{horizontal} = 0.333$	(ASCE Eq. 13.3-2)
Horizontal acceleration shall not be taken as less than:	$a_{horizontal} := 0.3 \cdot S_{DS} \cdot I$ $a_{horizontal} = 0.063$	(ASCE Eq. 13.3-3)
Seismic Design Acceleration (Vertical):	$a_{vertical} := (0.2 \cdot S_{DS})$ $a_{vertical} = 0.042$	Based on Section 13.3

Design Maps Detailed Report

2012 International Building Code (38.54484°N, 82.76962°W)

Site Class E – “Soft Clay Soil”, Risk Category I/II/III

Section 1613.3.1 — Mapped acceleration parameters

Note: Ground motion values provided below are for the direction of maximum horizontal spectral response acceleration. They have been converted from corresponding geometric mean ground motions computed by the USGS by applying factors of 1.1 (to obtain S_S) and 1.3 (to obtain S_1). Maps in the 2012 International Building Code are provided for Site Class B. Adjustments for other Site Classes are made, as needed, in Section 1613.3.3.

From Figure 1613.3.1(1) [1]	$S_S = 0.152$ g
From Figure 1613.3.1(2) [2]	$S_1 = 0.073$ g

Section 1613.3.2 — Site class definitions

The authority having jurisdiction (not the USGS), site-specific geotechnical data, and/or the default has classified the site as Site Class E, based on the site soil properties in accordance with Section 1613.

2010 ASCE-7 Standard – Table 20.3-1
SITE CLASS DEFINITIONS

Site Class	$\bar{v}_s$	$\bar{N}$ or $\bar{N}_{ch}$	$\bar{s}_u$
A. Hard Rock	>5,000 ft/s	N/A	N/A
B. Rock	2,500 to 5,000 ft/s	N/A	N/A
C. Very dense soil and soft rock	1,200 to 2,500 ft/s	>50	>2,000 psf
D. Stiff Soil	600 to 1,200 ft/s	15 to 50	1,000 to 2,000 psf
E. Soft clay soil	<600 ft/s	<15	<1,000 psf
	Any profile with more than 10 ft of soil having the characteristics: • Plasticity index *PI* > 20, • Moisture content $w \geq 40\%$, and • Undrained shear strength $\bar{s}_u < 500$ psf		
F. Soils requiring site response analysis in accordance with Section 21.1	See Section 20.3.1		

For SI: 1ft/s = 0.3048 m/s 1lb/ft² = 0.0479 kN/m²

Section 1613.3.3 — Site coefficients and adjusted maximum considered earthquake spectral response acceleration parameters

TABLE 1613.3.3(1)
VALUES OF SITE COEFFICIENT F_a

Site Class	Mapped Spectral Response Acceleration at Short Period				
	$S_S \leq 0.25$	$S_S = 0.50$	$S_S = 0.75$	$S_S = 1.00$	$S_S \geq 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7 of ASCE 7				

Note: Use straight–line interpolation for intermediate values of S_S

For Site Class = E and S_S = 0.152 g, F_a = 2.500

TABLE 1613.3.3(2)
VALUES OF SITE COEFFICIENT F_v

Site Class	Mapped Spectral Response Acceleration at 1–s Period				
	$S_1 \leq 0.10$	$S_1 = 0.20$	$S_1 = 0.30$	$S_1 = 0.40$	$S_1 \geq 0.50$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	See Section 11.4.7 of ASCE 7				

Note: Use straight–line interpolation for intermediate values of S_1

For Site Class = E and S_1 = 0.073 g, F_v = 3.500

Equation (16-37): $S_{MS} = F_aS_S = 2.500 \times 0.152 = 0.380$ g

Equation (16-38): $S_{M1} = F_vS_1 = 3.500 \times 0.073 = 0.256$ g

Section 1613.3.4 — Design spectral response acceleration parameters

Equation (16-39): $S_{DS} = ⅔ S_{MS} = ⅔ \times 0.380 = 0.253$ g

Equation (16-40): $S_{D1} = ⅔ S_{M1} = ⅔ \times 0.256 = 0.171$ g

Section 1613.3.5 — Determination of seismic design category

TABLE 1613.3.5(1)
SEISMIC DESIGN CATEGORY BASED ON SHORT-PERIOD (0.2 second) RESPONSE ACCELERATION

VALUE OF S_{DS}	RISK CATEGORY		
	I or II	III	IV
$S_{DS} < 0.167g$	A	A	A
$0.167g \leq S_{DS} < 0.33g$	B	B	C
$0.33g \leq S_{DS} < 0.50g$	C	C	D
$0.50g \leq S_{DS}$	D	D	D

For Risk Category = I and S_{DS} = 0.253 g, Seismic Design Category = B

TABLE 1613.3.5(2)
SEISMIC DESIGN CATEGORY BASED ON 1-SECOND PERIOD RESPONSE ACCELERATION

VALUE OF S_{D1}	RISK CATEGORY		
	I or II	III	IV
$S_{D1} < 0.067g$	A	A	A
$0.067g \leq S_{D1} < 0.133g$	B	B	C
$0.133g \leq S_{D1} < 0.20g$	C	C	D
$0.20g \leq S_{D1}$	D	D	D

For Risk Category = I and S_{D1} = 0.171 g, Seismic Design Category = C

Note: When S_1 is greater than or equal to 0.75g, the Seismic Design Category is **E** for buildings in Risk Categories I, II, and III, and **F** for those in Risk Category IV, irrespective of the above.

Seismic Design Category ≡ "the more severe design category in accordance with Table 1613.3.5(1) or 1613.3.5(2)" = C

Note: See Section 1613.3.5.1 for alternative approaches to calculating Seismic Design Category.

References

1. *Figure 1613.3.1(1)*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/IBC-2012-Fig1613p3p1(1).pdf
2. *Figure 1613.3.1(2)*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/IBC-2012-Fig1613p3p1(2).pdf

GLOBAL DEFINITIONS

SCHEMATIC PICTURES

Plate heat exchanger parts

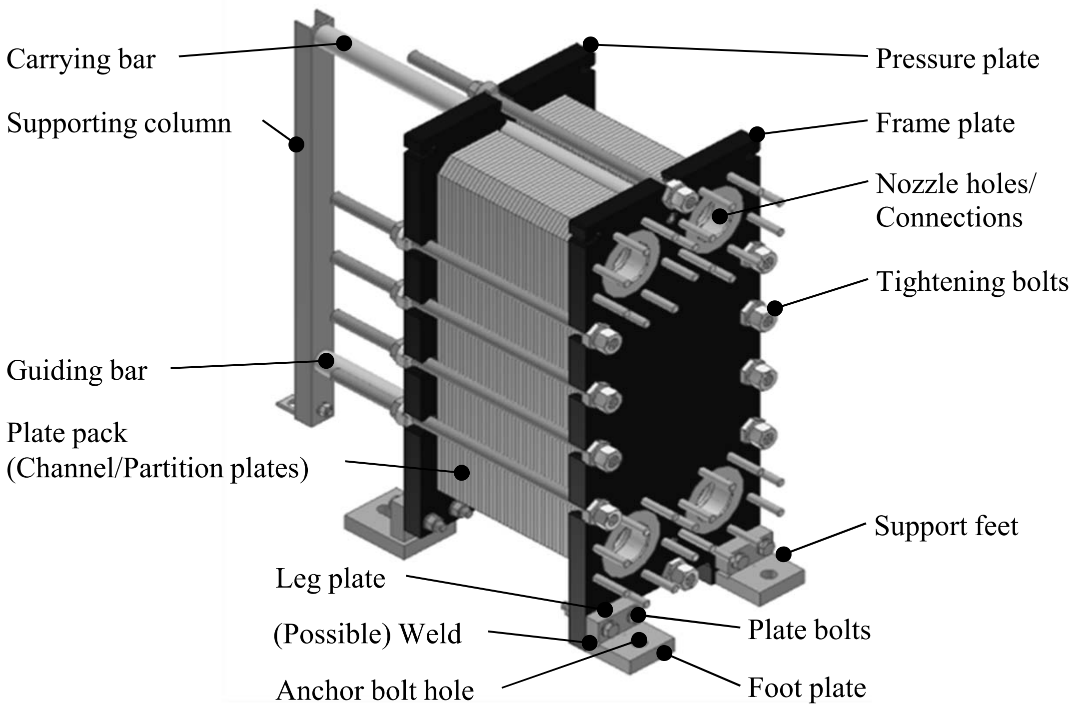
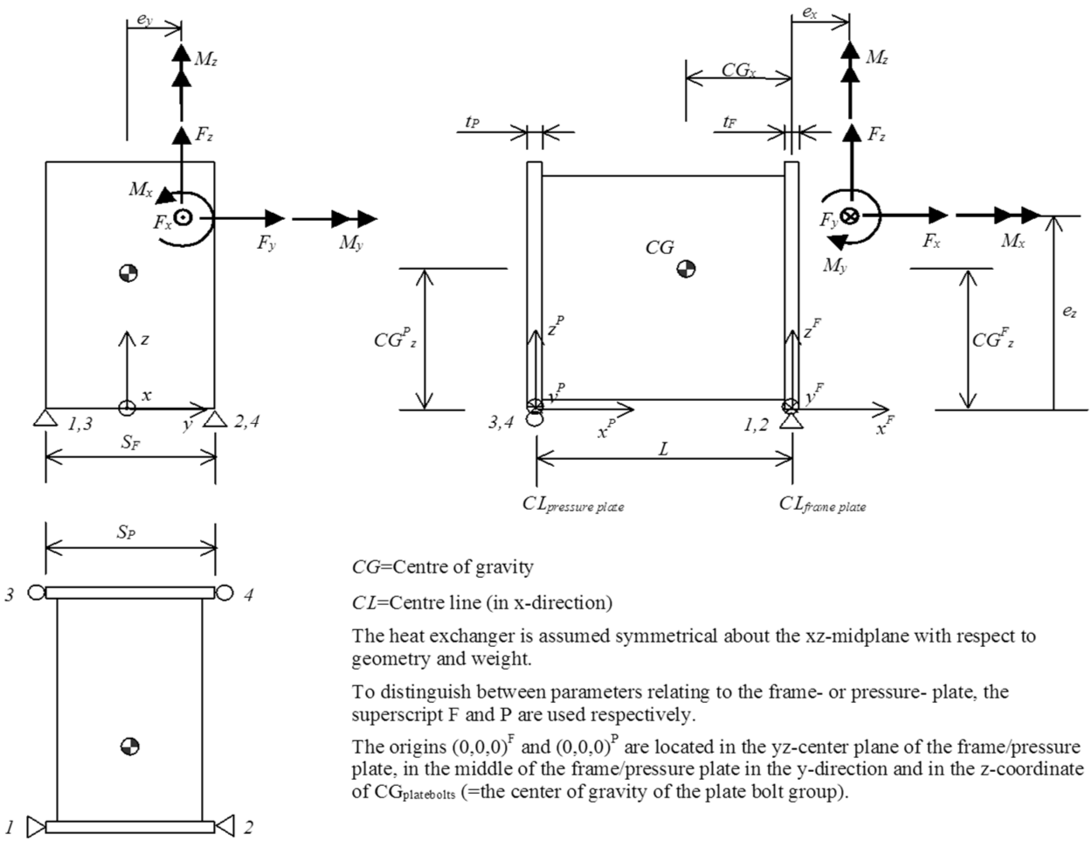


Plate heat exchanger model



CG=Centre of gravity

CL=Centre line (in x-direction)

The heat exchanger is assumed symmetrical about the xz-midplane with respect to geometry and weight.

To distinguish between parameters relating to the frame- or pressure- plate, the superscript F and P are used respectively.

The origins $(0,0,0)^F$ and $(0,0,0)^P$ are located in the yz-center plane of the frame/pressure plate, in the middle of the frame/pressure plate in the y-direction and in the z-coordinate of $CG_{platebolts}$ (=the center of gravity of the plate bolt group).

COMPLEMENTARY DATA

GEOMETRY

Dimensions

Distance in the x-direction between the center lines of the frame and pressure plates

$L =$ 74,5 [mm]

Frame plate width, height, thickness and distance between the feet/foot pairs

$B_F =$ 400 [mm] $t_F =$ 30 [mm]

$H_F =$ 652 [mm] $S_F =$ 254 [mm]

Pressure plate width, height, thickness and distance between the feet/foot pairs

$B_P =$ 400 [mm] $t_P =$ 25 [mm]

$H_P =$ 652 [mm] $S_P =$ 254 [mm]

Height from frame and pressure plate bottom edge respectively to the lower tightening bolts category I

$h_{tbF} =$ 225 [mm] $h_{tbP} =$ 225 [mm]

Height from frame and pressure plate bottom edge respectively to the lowest plate bolt holes

$h_{Fpb} =$ 20 [mm] $h_{Ppb} =$ 20 [mm]

Center of gravity

Distance in the –x- and +z- directions from $(0,0,0)^F$ to center of gravity

For the PHE

$CG_{x0} =$ +43 [mm] $CG^F_{z0} =$ 378 [mm]

For the additional mass

$CG_{xa} =$ [mm] $CG_{za} =$ [mm]

MASS

Mean density of the heat transfer media

$\rho =$ 1000 [kg/m^3]

Mass of PHE with content

$m_s =$ 170 [kg]

Additional mass

$m_a =$ 0 [kg]

LOAD SPECIFICATION - Load analysis

Design/Operating temperature	Code Class	Service Level
$T_G =$ +149 [°C]	3	B

Each load component is categorized as (i) static with known sign, (ii) static with unknown sign or dynamic and correlated (linearly summed) and (iii) dynamic and uncorrelated (SRSS-summed). Loads of types (i), (ii) and (iii) are specified in the 1:st, 2:nd and 3:rd row respectively. The e_z-values are normally conservatively simplified to relate to the bottom edge of the frame/pressure plate.

NOZZLE LOADS AND POINTS OF ACTION

	S1	S2	S3	S4	S5	T1	T2	T3	T4	T5	
	0	0	0	0	0	0	0	0	0	0	
F_x	0	0	0	0	0	0	0	0	0	0	[N]
	±0	±0	±0	±0	±0	±0	±0	±0	±0	±0	
	0	0	0	0	0	0	0	0	0	0	
F_y	0	0	0	0	0	0	0	0	0	0	[N]
	±0	±0	±0	±0	±0	±0	±0	±0	±0	±0	
	0	0	0	0	0	0	0	0	0	0	
F_z	0	0	0	0	0	0	0	0	0	0	[N]
	±0	±0	±0	±0	±0	±0	±0	±0	±0	±0	
	0	0	0	0	0	0	0	0	0	0	
M_x	0	0	0	0	0	0	0	0	0	0	[Nm]
	±0	±0	±0	±0	±0	±0	±0	±0	±0	±0	
	0	0	0	0	0	0	0	0	0	0	
M_y	0	0	0	0	0	0	0	0	0	0	[Nm]
	±0	±0	±0	±0	±0	±0	±0	±0	±0	±0	
	0	0	0	0	0	0	0	0	0	0	
M_z	0	0	0	0	0	0	0	0	0	0	[Nm]
	±0	±0	±0	±0	±0	±0	±0	±0	±0	±0	
e_x	0	0	0	0	0	0	0	0	0	0	[mm]
e_y	0	0	0	0	0	0	0	0	0	0	[mm]
e_z	0	0	0	0	0	0	0	0	0	0	[mm]

INERTIA LOADS

g 9,81 [m/s^2]

Gravity load	g_x	0 [g]	g_y	0 [g]	g_z	-1 [g]
Acceleration loads		0 [g]		0 [g]		0 [g]
	a_x	0 [g]	a_y	0 [g]	a_z	0 [g]
		±0,063 [g]		±0,063 [g]		±0,042 [g]

EXTERNAL PRESSURE LOADS

Wind		0 [m/s]		0 [m/s]		0 [m/s]
	v_x	0 [m/s]	v_y	0 [m/s]	v_z	0 [m/s]
		±0 [m/s]		±0 [m/s]		±0 [m/s]
Pressure difference		0 [bar]		0 [bar]		0 [bar]
	q_x	0 [bar]	q_y	0 [bar]	q_z	0 [bar]
		±0 [bar]		±0 [bar]		±0 [bar]

SINGLE SUPPORT FOOT C ON THE FRAME PLATE

INPUT

Dimensions

PLATE BOLTS

Nominal diameter and thread pitch

d_{pb} = 16 [mm]

z_{pb} = 2 [mm]

Type of bolt
- (●) Metric
- ( ) Inch

Tensile stress, root, nominal and shear stress areas

$$A_{spb} = \begin{cases} \frac{\pi}{4}\cdot\left(d_{pb} - 0.9382\cdot z_{pb}\right)^2 & \text{metric screws} \\ \frac{\pi}{4}\cdot\left(d_{pb} - 0.9743\cdot z_{pb}\right)^2 & \text{unified inch screws} \end{cases} = 156{,}668\ [\text{mm}^2]$$

$$A_{rpb} = \frac{\pi}{4}\cdot\left(d_{pb} - 1.2990\cdot z_{pb}\right)^2 = 141{,}068\ [\text{mm}^2]$$

$$A_{npb} = \frac{\pi}{4}\cdot d_{pb}^{\ 2} = 201{,}062\ [\text{mm}^2]$$

Type of shear planes
- ( ) Threads not excluded from shear planes $\Rightarrow A_{vpb} = A_{rpb}$
- (●) Threads excluded from shear planes $\Rightarrow A_{vpb} = A_{npb}$

$\Rightarrow A_{vpb}$ = 201,062 [mm^2]

LEG PLATE

h_l = 57 [mm] d_{bhl} = 18 [mm] h_{pb} = 54,5 [mm]

b_l = 90 [mm] s_{ypb} = 50 [mm]

t_l = 35 [mm] h_{Fpb}, h_{Ppb} = 20 [mm]

$$h_{le} = h_l - h_{pb} + \frac{t_f}{2} = 20\ [\text{mm}]$$

$$h_e = h_{pb} - (h_{Fpb}\quad or \quad h_{Ppb}) = 34{,}5\ [\text{mm}]$$

$$h_c = h_{pb} = 54{,}5\ [\text{mm}]$$

$$b_e = \frac{b_l - s_{ypb}}{2} = 20\ [\text{mm}]$$

Distance from the center of the plate bolt holes to the nearest leg plate edge

$$L_{bhl1} = L_{bhl2} = \min[b_e, h_{le}, (h_{pb} - \frac{t_f}{2})] = 20\ [\text{mm}]$$

Shortest distance between the centers of the plate bolt holes

$L_{sbhl} = s_{ypb} =$ 50 [mm]

FOOT PLATE

$l_{fa} =$ 67,5 [mm]	$N_{ab} =$ 1 [-]	$L_{bhf} =$ 35 [mm]
$l_{fe} =$ 35 [mm]	$d_{bhf} =$ 32 [mm]	$L_{sbhf} =$ [mm]
$b_f =$ 90 [mm]		
$t_f =$ 35 [mm]		

ANCHOR BOLTS

Nominal diameter and thread pitch

$d_{ab} =$ 24 [mm]

$z_{ab} =$ 3 [mm]

Type of bolt
- (●) Metric
- ( ) Inch

Tensile stress and root areas

$$A_{sab} = \begin{cases} \frac{\pi}{4} \cdot \left(d_{ab} - 0.9382 \cdot z_{ab}\right)^2 & \text{metric screws} \\ \frac{\pi}{4} \cdot \left(d_{ab} - 0.9743 \cdot z_{ab}\right)^2 & \text{unified inch screws} \end{cases} = 352{,}503 \ [\text{mm}^2]$$

$$A_{rab} = \frac{\pi}{4} \cdot \left(d_{ab} - 1.2990 \cdot z_{ab}\right)^2 = 317{,}403 \ [\text{mm}^2]$$

Component loads

Component specific temperature $T_C =$ +149 [°C] (equal to T_G if blank)

Reaction forces

R^{high}	x	y	z	
1	+52,533	+22,212	+627,58	[N]
2	+52,533	+22,212	+627,58	[N]

R^{low}	x	y	z	
1	-52,5326	-22,2117	+77,551	[N]
2	-52,5326	-22,2117	+77,551	[N]

Material data

S_y =yield strength at temperature
S_u =ultimate tensile strength at temperature
S =maximum allowable stress value at temperature (used for code class 2 and 3)
S_m =design stress intensity value at temperature (used for code class 1)

PLATE BOLTS

Type of material

- (●) Ferritic steel
- ( ) Austenitic steel

Material ISO Grade 8,8

S_{ypb} = 634
S_{upb} = 827
[N/mm²]

LEG PLATE

Material SA36

S_{yl} = 219
S_{ul} = 400
S_{l} = 115
S_{ml} = 133
[N/mm²]

FOOT PLATE

Material SA36

S_{yf} = 219
S_{uf} = 400
S_{f} = 115
S_{mf} = 133
[N/mm²]

ANCHOR BOLTS

Type of material

- (●) Ferritic steel
- ( ) Austenitic steel

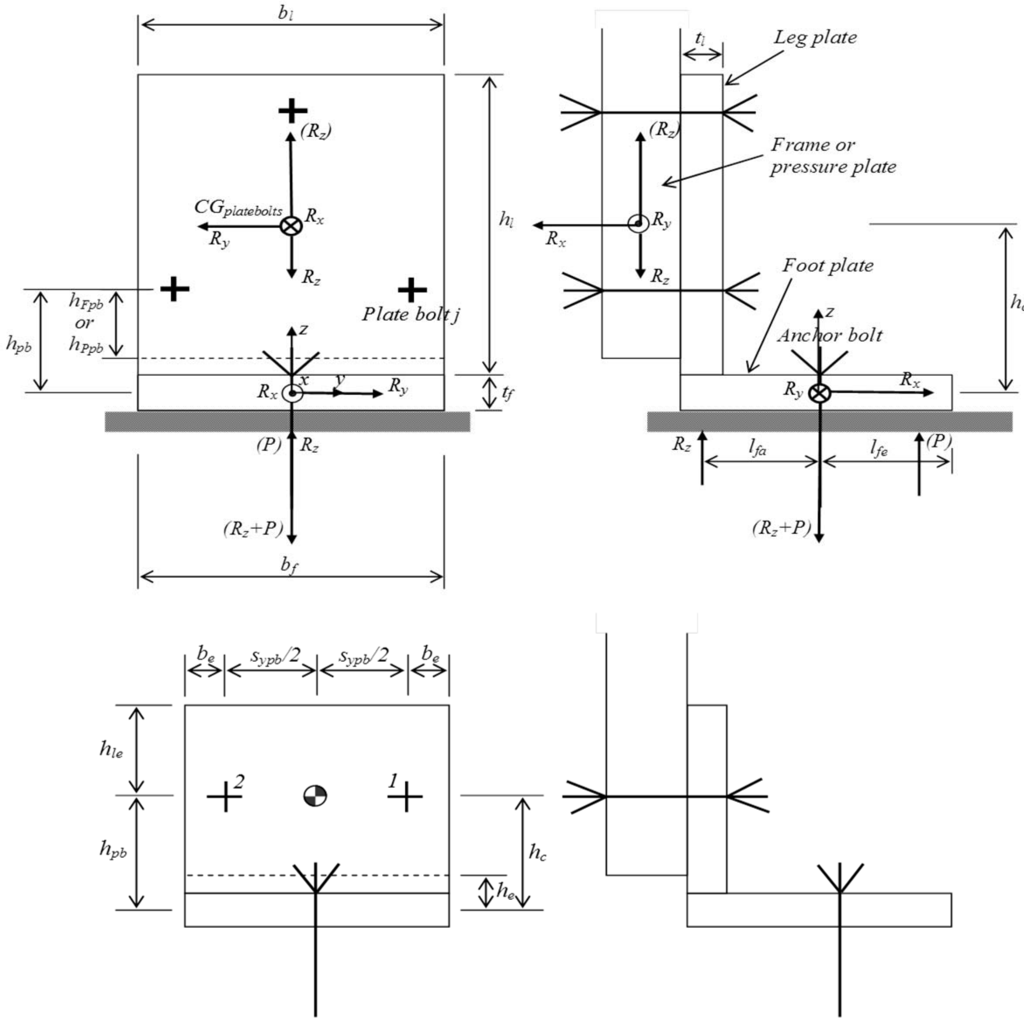
Material ISO Grade 8,8

S_{yab} = 634
S_{uab} = 827
[N/mm²]

SINGLE SUPPORT FOOT C ON THE FRAME PLATE

INPUT

Schematic pictures



Loads relating to negative R_z are in parenthesis. Thus R_z and (R_z) are not acting simultaneously.

$CG_{platebolts}$ =rotational center of gravity for the plate bolt group

The numbering of the plate bolts is related to a foot placed on the outside of the frame plate or on the inside of the pressure plate.

The foot is symmetrical about the xz-midplane.

All the bolts within the plate or anchor bolt group are identical.

Definitions

d_{bhl} =diameter of the plate bolt hole
N_{ab} =number of anchor bolts per foot
d_{bhf} =diameter of the anchor bolt hole
L_{bhf} =distance from the center of an anchor bolt hole to the nearest foot plate edge
L_{sbhf} =shortest distance between the centers of any two anchor bolt holes on a foot

SINGLE SUPPORT FOOT C ON THE FRAME PLATE

CRITERIA

S below is only applicable to Code Class 2 and 3 components. For analysis of Class 1 components, the value of S should be replaced by S_m in all equations below.

Plate bolts / Leg plate

STRESS CRITERION FOR THE PLATE BOLTS

Allowable tensile stress

$$F_{tpb} = \begin{cases} \dfrac{S_{upb}}{2} & \text{ferritic steel} \\ \dfrac{S_{upb}}{3.33} & \text{austenitic steel} \end{cases} = \quad 413{,}5 \ [\text{N/mm}^2]$$

Allowable shear stress

$$F_{vpb} = \begin{cases} \dfrac{0.62 S_{upb}}{3} & \text{ferritic steel} \\ \dfrac{0.62 S_{upb}}{5} & \text{austenitic steel} \end{cases} = \quad 170{,}913 \ [\text{N/mm}^2]$$

Combined tensile and shear stress

$$\left(\frac{f_{tpbj}}{\kappa_{tpb} \cdot F_{tpb}}\right)^2 + \left(\frac{f_{vpbj}}{\kappa_{vpb} \cdot F_{vpb}}\right)^2 \le 1$$

	Foot position 1	Foot position 2			
j=1	5,6E-05	5,6E-05	≤ 1	OK!	OK!
j=2	7,6E-05	7,6E-05		OK!	OK!

Usage ratio

$$u_{pb} = \max\left\{\sqrt{\left(\frac{f_{tpbj}}{\kappa_{tpb} \cdot F_{tpb}}\right)^2 + \left(\frac{f_{vpbj}}{\kappa_{vpb} \cdot F_{vpb}}\right)^2}\right\} =$$

Foot position 1	Foot position 2
0,0087	0,0087

STRESS CRITERIA FOR THE LEG PLATE

$$\sigma_{eml} \le \kappa_l \cdot S_l$$

Foot position					
1	0,37865	≤	152,95	[N/mm²]	OK!
2	0,37865	≤	152,95	[N/mm²]	OK!

$\sigma_{embl} \leq 1.5\kappa_l \cdot S_l$

Foot position					
1	0,65562	≤	229,425	[N/mm²]	OK!
2	0,65562	≤	229,425	[N/mm²]	OK!

BEARING STRESS CRITERION

$$f_{ppbj} \leq \min\left(\frac{L_{bhlj}}{2d_{pb}}, 1.5\right) \cdot S_{ul}$$

(This criterion need not be evaluated for Service Level D, except that we need to ensure that $f_{ppbj} \leq 2.1 S_{ul}$.)

Foot position						
1	j=1	0,51749	≤	250	[N/mm²]	OK!
	j=2	0,6039	≤	250	[N/mm²]	OK!
2	j=1	0,51749	≤	250	[N/mm²]	OK!
	j=2	0,6039	≤	250	[N/mm²]	OK!

GEOMETRICAL LIMITATIONS

Minimum plate edge distance for bolts

$$\begin{cases} \dfrac{L_{bhlj}}{d_{pb}} \geq \max\left\{\left(0.5 + 1.43\dfrac{f_{ppbj}}{S_{ul}}\right), 1.2\right\} & \text{Service Levels: Design, A, B, C} \\ \dfrac{L_{bhlj}}{d_{pb}} \geq \left(0.5 + 1.2\dfrac{f_{ppbj}}{S_{ul}}\right) & \text{Service Levels: D} \end{cases}$$

Foot position								
1	j=1	1,25	≥	max(	0,50185	1,2	)	OK!
	j=2	1,25	≥	max(	0,50216	1,2	)	OK!
2	j=1	1,25	≥	max(	0,50185	1,2	)	OK!
	j=2	1,25	≥	max(	0,50216	1,2	)	OK!

Minimum bolt spacing

$L_{sbhl} \geq 3d_{pb}$ 50 ≥ 48 [mm] OK!

$$L_{sbhl} \geq \frac{2V_{pb}}{S_{ul} \cdot t_l} + \frac{d_{pb}}{2}$$

Foot position					
1	50	≥	8,04831	[mm]	OK!
2	50	≥	8,04831	[mm]	OK!

Geometrical restriction for column buckling of the leg plate

$$\frac{0.65\sqrt{12}h_{pb}}{t_l} =$$ 3,50617 ≤20 OK!

Foot plate / Anchor bolts

STRESS CRITERIA FOR THE FOOT PLATE

$\sigma_{emf} \leq \kappa_f \cdot S_f$

Foot position					
1	0,03389	≤	152,95	[N/mm²]	OK!
2	0,03389	≤	152,95	[N/mm²]	OK!

$\sigma_{embf} \leq 1.5\kappa_f \cdot S_f$

Foot position					
1	0,03389	≤	229,425	[N/mm²]	OK!
2	0,03389	≤	229,425	[N/mm²]	OK!

STRESS CRITERION FOR THE ANCHOR BOLTS

Allowable tensile stress

$$F_{tab} = \begin{cases} \frac{S_{uab}}{2} & \text{ferritic steel} \\ \frac{S_{uab}}{3.33} & \text{austenitic steel} \end{cases} = 413{,}5 \text{ [N/mm}^2\text{]}$$

Allowable shear stress

$$F_{vab} = \begin{cases} \frac{0.62 S_{uab}}{3} & \text{ferritic steel} \\ \frac{0.62 S_{uab}}{5} & \text{austenitic steel} \end{cases} = 170{,}913 \text{ [N/mm}^2\text{]}$$

Combined tensile and shear stress

$$\left(\frac{f_{tab}}{\kappa_{tab} \cdot F_{tab}}\right)^2 + \left(\frac{f_{vab}}{\kappa_{vab} \cdot F_{vab}}\right)^2 \leq 1$$

Foot position			
1	8,4E-07	≤ 1	OK!
2	8,4E-07		OK!

Usage ratio

$$u_{ab} = \sqrt{\left(\frac{f_{tab}}{\kappa_{tab} \cdot F_{tab}}\right)^2 + \left(\frac{f_{vab}}{\kappa_{vab} \cdot F_{vab}}\right)^2} =$$

Foot position	
1	2
0,00091	0,00091

BEARING STRESS CRITERION

$$f_{pab} \le \min\left(\frac{L_{bhf}}{2d_{ab}}, 1.5\right) \cdot S_{uf}$$

(This criterion need not be evaluated for Service Level D, except that we need to ensure that $f_{pab} \le 2.1 S_{uf}$.)

Foot position

1	0,0679	≤	291,667	[N/mm²]	OK!
2	0,0679	≤	291,667	[N/mm²]	OK!

GEOMETRICAL LIMITATIONS

Minimum plate thickness

$t_f \ge t_l$	35	≥	35	[mm]	OK!

Minimum plate edge distance for bolts

$$\begin{cases} \dfrac{L_{bhf}}{d_{ab}} \ge \max\left\{\left(0.5 + 1.43\dfrac{f_{pab}}{S_{uf}}\right), 1.2\right\} & \text{Service Levels: Design, A, B, C} \\ \dfrac{L_{bhf}}{d_{ab}} \ge \left(0.5 + 1.2\dfrac{f_{pab}}{S_{uf}}\right) & \text{Service Levels: D} \end{cases}$$

Foot position

1	1,45833	≥	max(	0,50024	1,2	)	OK!
2	1,45833	≥	max(	0,50024	1,2	)	OK!

Minimum bolt spacing, applicable for the case of two or more anchor bolts only

$L_{sbhf} \ge 3d_{ab}$	≥		[mm]	Only one bolt!

$$L_{sbhf} \ge \frac{2V_{ab}}{S_{uf} \cdot t_f} + \frac{d_{ab}}{2}$$

Foot position

1	≥		[mm]	Only one bolt!
2	≥		[mm]	Only one bolt!

SINGLE SUPPORT FOOT C ON THE PRESSURE PLATE

INPUT

Dimensions

PLATE BOLTS

Nominal diameter and thread pitch

d_{pb} = 16 [mm]

z_{pb} = 2 [mm]

Type of bolt
- (●) Metric
- ( ) Inch

Tensile stress, root, nominal and shear stress areas

$$A_{spb} = \begin{cases} \frac{\pi}{4}\cdot\left(d_{pb} - 0.9382\cdot z_{pb}\right)^2 & \text{metric screws} \\ \frac{\pi}{4}\cdot\left(d_{pb} - 0.9743\cdot z_{pb}\right)^2 & \text{unified inch screws} \end{cases} = 156{,}668\ [\text{mm}^2]$$

$$A_{rpb} = \frac{\pi}{4}\cdot\left(d_{pb} - 1.2990\cdot z_{pb}\right)^2 = 141{,}068\ [\text{mm}^2]$$

$$A_{npb} = \frac{\pi}{4}\cdot d_{pb}^{\ 2} = 201{,}062\ [\text{mm}^2]$$

Type of shear planes
- ( ) Threads not excluded from shear planes $\Rightarrow A_{vpb} = A_{rpb}$
- (●) Threads excluded from shear planes $\Rightarrow A_{vpb} = A_{npb}$

$\Rightarrow A_{vpb}$ = 201,062 $[\text{mm}^2]$

LEG PLATE

h_l = 57 [mm] d_{bhl} = 18 [mm] h_{pb} = 54,5 [mm]

b_l = 90 [mm] s_{ypb} = 50 [mm]

t_l = 35 [mm] h_{Fpb}, h_{Ppb} = 20 [mm]

$$h_{le} = h_l - h_{pb} + \frac{t_f}{2} = 20\ [\text{mm}]$$

$$h_e = h_{pb} - (h_{Fpb}\quad or \quad h_{Ppb}) = 34{,}5\ [\text{mm}]$$

$$h_c = h_{pb} = 54{,}5\ [\text{mm}]$$

$$b_e = \frac{b_l - s_{ypb}}{2} = 20\ [\text{mm}]$$

Distance from the center of the plate bolt holes to the nearest leg plate edge

$$L_{bhl1} = L_{bhl2} = \min[b_e, h_{le}, (h_{pb} - \frac{t_f}{2})] = 20\ [\text{mm}]$$

Shortest distance between the centers of the plate bolt holes

$L_{sbhl} = s_{ypb} =$ 50 [mm]

FOOT PLATE

$l_{fa} =$ 82,5 [mm]	$N_{ab} =$ 1 [-]	$L_{bhf} =$ 40 [mm]
$l_{fe} =$ 40 [mm]	$d_{bhf} =$ 32 [mm]	$L_{sbhf} =$ [mm]
$b_f =$ 100 [mm]		
$t_f =$ 35 [mm]		

ANCHOR BOLTS

Nominal diameter and thread pitch

$d_{ab} =$ 24 [mm]

$z_{ab} =$ 3 [mm]

Type of bolt
- (●) Metric
- ( ) Inch

Tensile stress and root areas

$$A_{sab} = \begin{cases} \frac{\pi}{4} \cdot \left(d_{ab} - 0.9382 \cdot z_{ab} \right)^2 & \text{metric screws} \\ \frac{\pi}{4} \cdot \left(d_{ab} - 0.9743 \cdot z_{ab} \right)^2 & \text{unified inch screws} \end{cases} = 352{,}503 \ [\text{mm}^2]$$

$$A_{rab} = \frac{\pi}{4} \cdot \left(d_{ab} - 1.2990 \cdot z_{ab} \right)^2 = 317{,}403 \ [\text{mm}^2]$$

Component loads

Component specific temperature $T_C =$ +149 [°C] (equal to T_G if blank)

Reaction forces

R^{high}	x	y	z		R^{low}	x	y	z	
4	0	+30,321	+763,41	[N]	4	0	-30,3208	+199,15	[N]
3	0	+30,321	+763,41	[N]	3	0	-30,3208	+199,15	[N]

Material data

S_y =yield strength at temperature
S_u =ultimate tensile strength at temperature
S =maximum allowable stress value at temperature (used for code class 2 and 3)
S_m =design stress intensity value at temperature (used for code class 1)

PLATE BOLTS

Type of material

- (●) Ferritic steel
- ( ) Austenitic steel

Material ISO Grade 8,8

S_{ypb} = 634
S_{upb} = 827
[N/mm^2]

FOOT PLATE

Material SA36

S_{yf} = 219
S_{uf} = 400
S_{f} = 115
S_{mf} = 133
[N/mm^2]

LEG PLATE

Material SA36

S_{yl} = 219
S_{ul} = 400
S_{l} = 115
S_{ml} = 133
[N/mm^2]

ANCHOR BOLTS

Type of material

- (●) Ferritic steel
- ( ) Austenitic steel

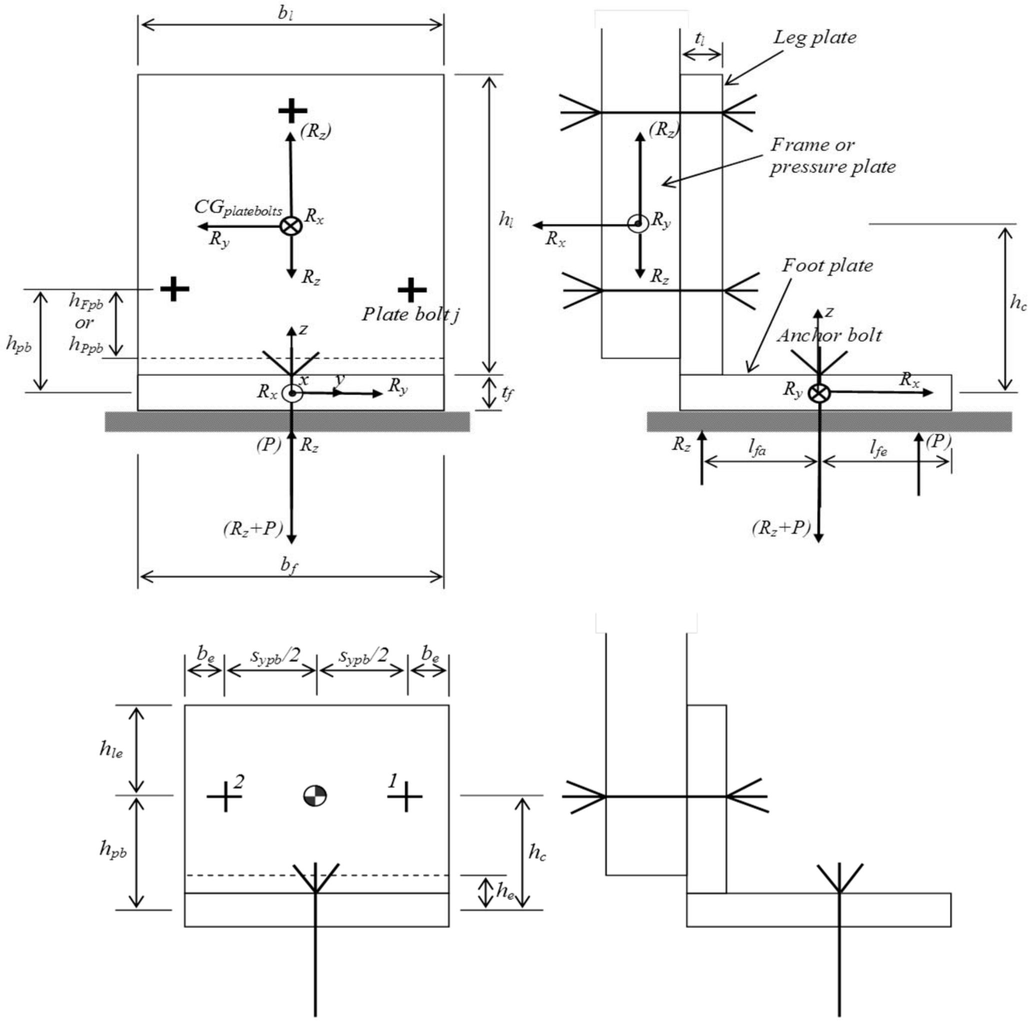
Material ISO Grade 8,8

S_{yab} = 634
S_{uab} = 827
[N/mm^2]

SINGLE SUPPORT FOOT C ON THE PRESSURE PLATE

INPUT

Schematic pictures



Loads relating to negative R_z are in parenthesis. Thus R_z and (R_z) are not acting simultaneously.

$CG_{platebolts}$ =rotational center of gravity for the plate bolt group

The numbering of the plate bolts is related to a foot placed on the outside of the frame plate or on the inside of the pressure plate.

The foot is symmetrical about the xz-midplane.

All the bolts within the plate or anchor bolt group are identical.

Definitions

d_{bhl} =diameter of the plate bolt hole
N_{ab} =number of anchor bolts per foot
d_{bhf} =diameter of the anchor bolt hole
L_{bhf} =distance from the center of an anchor bolt hole to the nearest foot plate edge
L_{sbhf} =shortest distance between the centers of any two anchor bolt holes on a foot

SINGLE SUPPORT FOOT C ON THE PRESSURE PLATE

CRITERIA

S below is only applicable to Code Class 2 and 3 components. For analysis of Class 1 components, the value of S should be replaced by S_m in all equations below.

Plate bolts / Leg plate

STRESS CRITERION FOR THE PLATE BOLTS

Allowable tensile stress

$$F_{tpb} = \begin{cases} \dfrac{S_{upb}}{2} & \text{ferritic steel} \\ \dfrac{S_{upb}}{3.33} & \text{austenitic steel} \end{cases} = \quad 413{,}5 \ [\text{N/mm}^2]$$

Allowable shear stress

$$F_{vpb} = \begin{cases} \dfrac{0.62 S_{upb}}{3} & \text{ferritic steel} \\ \dfrac{0.62 S_{upb}}{5} & \text{austenitic steel} \end{cases} = \quad 170{,}913 \ [\text{N/mm}^2]$$

Combined tensile and shear stress

$$\left(\frac{f_{tpbj}}{\kappa_{tpb} \cdot F_{tpb}}\right)^2 + \left(\frac{f_{vpbj}}{\kappa_{vpb} \cdot F_{vpb}}\right)^2 \le 1$$

	Foot position 4	Foot position 3			
j=1	7,8E-05	7,8E-05	≤ 1	OK!	OK!
j=2	0,00011	0,00011		OK!	OK!

Usage ratio

$$u_{pb} = \max\left\{\sqrt{\left(\frac{f_{tpbj}}{\kappa_{tpb} \cdot F_{tpb}}\right)^2 + \left(\frac{f_{vpbj}}{\kappa_{vpb} \cdot F_{vpb}}\right)^2}\right\} =$$

Foot position 4	Foot position 3
0,01051	0,01051

STRESS CRITERIA FOR THE LEG PLATE

$$\sigma_{eml} \le \kappa_l \cdot S_l$$

Foot position					
4	0,46203	$\le$	152,95	[N/mm²]	OK!
3	0,46203	$\le$	152,95	[N/mm²]	OK!

	Foot position					
$\sigma_{embl} \le 1.5\kappa_l \cdot S_l$	4	0,52869	≤	229,425	[N/mm²]	OK!
	3	0,52869	≤	229,425	[N/mm²]	OK!

BEARING STRESS CRITERION

$$f_{ppbj} \le \min\left(\frac{L_{bhlj}}{2d_{pb}}, 1.5\right) \cdot S_{ul}$$

(This criterion need not be evaluated for Service Level D, except that we need to ensure that $f_{ppbj} \le 2.1 S_{ul}$.)

Foot position						
4	j=1	0,62319	≤	250	[N/mm²]	OK!
	j=2	0,74113	≤	250	[N/mm²]	OK!
3	j=1	0,62319	≤	250	[N/mm²]	OK!
	j=2	0,74113	≤	250	[N/mm²]	OK!

GEOMETRICAL LIMITATIONS

Minimum plate edge distance for bolts

$$\begin{cases} \dfrac{L_{bhlj}}{d_{pb}} \ge \max\left\{\left(0.5 + 1.43\dfrac{f_{ppbj}}{S_{ul}}\right), 1.2\right\} & \text{Service Levels: Design, A, B, C} \\ \dfrac{L_{bhlj}}{d_{pb}} \ge \left(0.5 + 1.2\dfrac{f_{ppbj}}{S_{ul}}\right) & \text{Service Levels: D} \end{cases}$$

Foot position								
4	j=1	1,25	≥	max(	0,50223	1,2	)	OK!
	j=2	1,25	≥	max(	0,50265	1,2	)	OK!
3	j=1	1,25	≥	max(	0,50223	1,2	)	OK!
	j=2	1,25	≥	max(	0,50265	1,2	)	OK!

Minimum bolt spacing

$L_{sbhl} \ge 3d_{pb}$	50	≥	48	[mm]	OK!

	Foot position					
$L_{sbhl} \ge \dfrac{2V_{pb}}{S_{ul} \cdot t_l} + \dfrac{d_{pb}}{2}$	4	50	≥	8,05929	[mm]	OK!
	3	50	≥	8,05929	[mm]	OK!

Geometrical restriction for column buckling of the leg plate

$$\frac{0.65\sqrt{12}h_{pb}}{t_l} = \quad 3{,}50617 \le 20 \qquad \text{OK!}$$

Foot plate / Anchor bolts

STRESS CRITERIA FOR THE FOOT PLATE

$$\sigma_{emf} \le \kappa_f \cdot S_f$$

Foot position					
4	0,02548	≤	152,95	[N/mm²]	OK!
3	0,02548	≤	152,95	[N/mm²]	OK!

$$\sigma_{embf} \le 1.5\kappa_f \cdot S_f$$

Foot position					
4	0,02548	≤	229,425	[N/mm²]	OK!
3	0,02548	≤	229,425	[N/mm²]	OK!

STRESS CRITERION FOR THE ANCHOR BOLTS

Allowable tensile stress

$$F_{tab} = \begin{cases} \dfrac{S_{uab}}{2} & \text{ferritic steel} \\ \dfrac{S_{uab}}{3.33} & \text{austenitic steel} \end{cases} = 413{,}5\ [\text{N/mm}^2]$$

Allowable shear stress

$$F_{vab} = \begin{cases} \dfrac{0.62S_{uab}}{3} & \text{ferritic steel} \\ \dfrac{0.62S_{uab}}{5} & \text{austenitic steel} \end{cases} = 170{,}913\ [\text{N/mm}^2]$$

Combined tensile and shear stress

$$\left(\frac{f_{tab}}{\kappa_{tab} \cdot F_{tab}}\right)^2 + \left(\frac{f_{vab}}{\kappa_{vab} \cdot F_{vab}}\right)^2 \le 1$$

Foot position			
4	2,4E-07	≤ 1	OK!
3	2,4E-07		OK!

Usage ratio

$$u_{ab} = \sqrt{\left(\frac{f_{tab}}{\kappa_{tab} \cdot F_{tab}}\right)^2 + \left(\frac{f_{vab}}{\kappa_{vab} \cdot F_{vab}}\right)^2} =$$

Foot position	
4	3
0,00049	0,00049

BEARING STRESS CRITERION

$$f_{pab} \le \min\left(\frac{L_{bhf}}{2d_{ab}}, 1.5\right) \cdot S_{uf}$$

(This criterion need not be evaluated for Service Level D, except that we need to ensure that $f_{pab} \le 2.1 S_{uf}$.)

Foot position					
4	0,0361	≤	333,333	[N/mm^2]	OK!
3	0,0361	≤	333,333	[N/mm^2]	OK!

GEOMETRICAL LIMITATIONS

Minimum plate thickness

$t_f \ge t_l$	35	≥	35	[mm]	OK!

Minimum plate edge distance for bolts

$$\begin{cases} \dfrac{L_{bhf}}{d_{ab}} \ge \max\left\{\left(0.5 + 1.43\dfrac{f_{pab}}{S_{uf}}\right), 1.2\right\} & \text{Service Levels: Design, A, B, C} \\ \dfrac{L_{bhf}}{d_{ab}} \ge \left(0.5 + 1.2\dfrac{f_{pab}}{S_{uf}}\right) & \text{Service Levels: D} \end{cases}$$

Foot position							
4	1,66667	≥	max(	0,50013	1,2	)	OK!
3	1,66667	≥	max(	0,50013	1,2	)	OK!

Minimum bolt spacing, applicable for the case of two or more anchor bolts only

$L_{sbhf} \ge 3d_{ab}$	≥	[mm]	Only one bolt!

$$L_{sbhf} \ge \frac{2V_{ab}}{S_{uf} \cdot t_f} + \frac{d_{ab}}{2}$$

Foot position			
4	≥	[mm]	Only one bolt!
3	≥	[mm]	Only one bolt!

MIXTURE OF FILLET AND PARTIAL PENETRATION WELDS ON SINGLE SUPPORT FOOT ON THE FRAME PLATE

INPUT

Dimensions

WELD

a_{fw} = 5 [mm]
a_{ppw} = 10 [mm]

$a_m = \min\{a_{fw}, a_{ppw}\} =$ 5 [mm]

LEG PLATE

b_l = 90 [mm] h_{pb} = 54,5 [mm] h_c = 54,5 [mm]
t_l = 35 [mm]

FOOT PLATE

l_{fa} = 67,5 [mm]
t_f = 35 [mm]

Component loads

Component specific temperature T_C = +149 [°C] (equal to T_G if blank)

Reaction forces

R^{high}	x	y	z	
1	+52,533	+22,212	+627,58	[N]
2	+52,533	+22,212	+627,58	[N]

R^{low}	x	y	z	
1	-52,5326	-22,2117	+77,551	[N]
2	-52,5326	-22,2117	+77,551	[N]

Material data

S_y =yield strength at temperature
S_u =ultimate tensile strength at temperature
S =maximum allowable stress value at temperature (used for code class 2 and 3)
S_m =design stress intensity value at temperature (used for code class 1)

LEG PLATE

S_{yl} = 219
S_{ul} = 400
S_l = 115
S_{ml} = 133
[N/mm^2]

FOOT PLATE

S_{yf} = 219
S_{uf} = 400
S_f = 115
S_{mf} = 133
[N/mm^2]

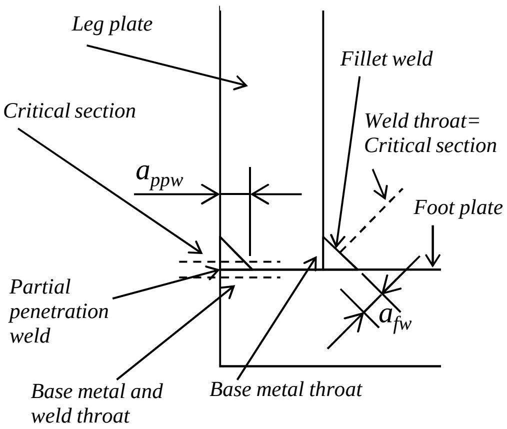
WELD

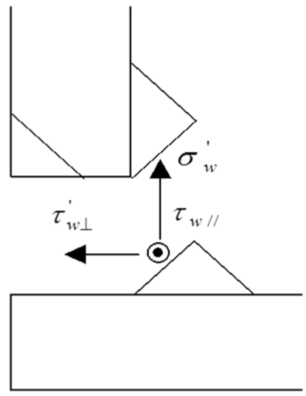
$$\left.\begin{array}{ll} S_{yw} = \min\left(S_{yl}, S_{yf}\right) = & 219 \\ S_{uw} = \min\left(S_{ul}, S_{uf}\right) = & 400 \\ S_{w} = \min\left(S_{l}, S_{f}\right) = & 115 \\ S_{mw} = \min\left(S_{ml}, S_{mf}\right) = & 133 \end{array}\right\} \text{[N/mm}^2\text{]}$$

MIXTURE OF FILLET AND PARTIAL PENETRATION WELDS ON SINGLE SUPPORT FOOT ON THE FRAME PLATE

INPUT

Schematic pictures





MIXTURE OF FILLET AND PARTIAL PENETRATION WELDS ON SINGLE SUPPORT FOOT ON THE FRAME PLATE

CRITERIA

Resultant stresses of the fillet weld part

$\tau'_{ew} \leq 0.3\kappa_w \cdot S_{uw}$

Foot position					
1	0,48245	≤	159,6	[N/mm^2]	OK!
2	0,48245	≤	159,6	[N/mm^2]	OK!

$\tau'_{ewb} \leq 0.4\kappa_{wb} \cdot S_{yw}$

Foot position					
1	0,34114	≤	116,508	[N/mm^2]	OK!
2	0,34114	≤	116,508	[N/mm^2]	OK!

Usage ratio of the partial penetration weld part

$$u_w = \sqrt{\left(\frac{\sigma_w}{\min\left\{0.3\kappa_{wt} \cdot S_{uw}, \kappa_{wc} \cdot (S_{mw} \quad or \quad S_w)\right\}}\right)^2 + \left(\frac{\tau_w}{0.5\kappa_{ws} \cdot (S_{mw} \quad or \quad S_w)}\right)^2} \leq 1$$

Foot position				
1	0,00329	≤	1	OK!
2	0,00329	≤	1	OK!

FILLET WELDS ON SINGLE SUPPORT FOOT ON THE PRESSURE PLATE

INPUT

Dimensions

WELD

$a =$ 5 [mm]

LEG PLATE

$b_l =$ 90 [mm] $h_{pb} =$ 54,5 [mm] $h_c =$ 54,5 [mm]
$t_l =$ 35 [mm]

FOOT PLATE

$l_{fa} =$ 82,5 [mm]
$t_f =$ 35 [mm]

Component loads

Component specific temperature $T_C =$ +149 [°C] (equal to T_G if blank)

Reaction forces

R^{high}	x	y	z		R^{low}	x	y	z	
4	0	+30,321	+763,41	[N]	4	0	-30,3208	+199,15	[N]
3	0	+30,321	+763,41	[N]	3	0	-30,3208	+199,15	[N]

Material data

S_y =yield strength at temperature
S_u =ultimate tensile strength at temperature
S =maximum allowable stress value at temperature (used for code class 2 and 3)
S_m =design stress intensity value at temperature (used for code class 1)

LEG PLATE

$S_{yl} =$ 219
$S_{ul} =$ 400
$S_l =$ 115
$S_{ml} =$ 133
[N/mm²]

FOOT PLATE

$S_{yf} =$ 219
$S_{uf} =$ 400
$S_f =$ 115
$S_{mf} =$ 133
[N/mm²]

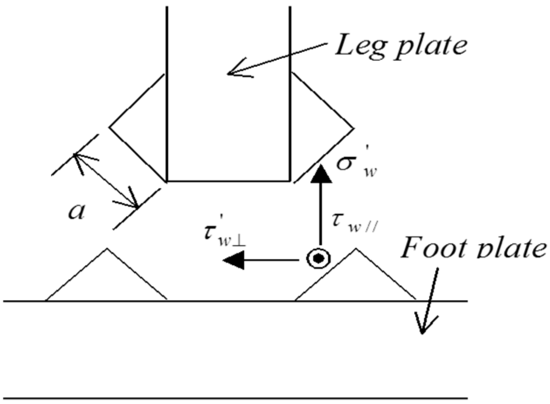
WELD

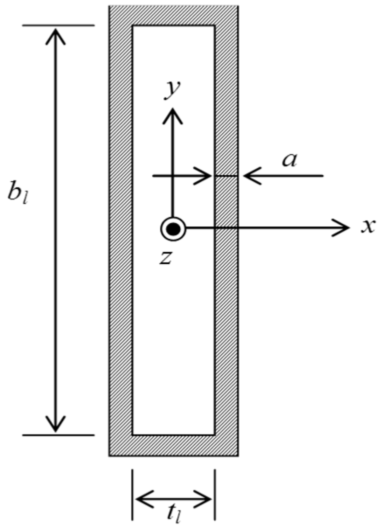
$$
\left.\begin{aligned}
S_{yw} &= \min\left(S_{yl}, S_{yf}\right) = && 219 \\
S_{uw} &= \min\left(S_{ul}, S_{uf}\right) = && 400 \\
S_{w} &= \min\left(S_{l}, S_{f}\right) = && 115 \\
S_{mw} &= \min\left(S_{ml}, S_{mf}\right) = && 133
\end{aligned}\right\} \text{[N/mm}^2\text{]}
$$

FILLET WELDS ON SINGLE SUPPORT FOOT ON THE PRESSURE PLATE

INPUT

Schematic pictures





FILLET WELDS ON SINGLE SUPPORT FOOT ON THE PRESSURE PLATE

CRITERIA

	Foot position					
$\tau'_{ew} \leq 0.3\kappa_w \cdot S_{uw}$	4	0,63662	≤	159,6	[N/mm²]	OK!
	3	0,63662	≤	159,6	[N/mm²]	OK!

	Foot position					
$\tau'_{ewb} \leq 0.4\kappa_{wb} \cdot S_{yw}$	4	0,45016	≤	116,508	[N/mm²]	OK!
	3	0,45016	≤	116,508	[N/mm²]	OK!

Customer:	Virdia B2X, LLC	SU Order No:	85480-40
Model :	TS6-MFG	Serial No:	30116-93128
Customer PO:	148	Item No:	HE-2853

Lifting Calculation for Plate Heat Exchanger

General

The following calculation is made to secure that the plate heat exchanger can be lifted with safety. The calculations are performed with respect to the following assumptions:

- The plate heat exchanger shall be lifted in vertical position. It means that the lift point and gravity center are included in a vertical line perpendicular to the ground.
- The plate heat exchanger is lifted from one of the corners of the frame plate and one of the corners in the pressure plate (two lifting points).
- The sling angle shall not be less than 60 degrees to the horizontal plane.
- The lifting load is increased by 2 times to account for lifting accelerations.

1 Input Data PHE

Estimated empty mass $M = 165\,kg$

See principal figures 1 and 2 for definitions. The PHE is lifted in point A and D.

Minimum vertical distance from upper edge of plates to lift point	$h = 300 \cdot mm$
Width between lifting lugs (y-direction)	$L_1 = 304 \cdot mm$
Width between lifting lugs (x-direction)	$L_2 = 75 \cdot mm$
Distance between frame plate and centre of gravity	$a = 43 \cdot mm$
Distance between pressure plate and centre of gravity	$b = 32 \cdot mm$
Distance between lifting point and centre of gravity (y-direction)	$c = 152 \cdot mm$
Distance between upper end of bolt hole and upper end of frame plate	$s_f = 8 \cdot mm$
Distance between upper end of bolt hole and upper end of pressure plate	$s_p = 8 \cdot mm$
Thickness of frame plate	$t_f = 30 \cdot mm$
Thickness of pressure plate	$t_p = 25 \cdot mm$

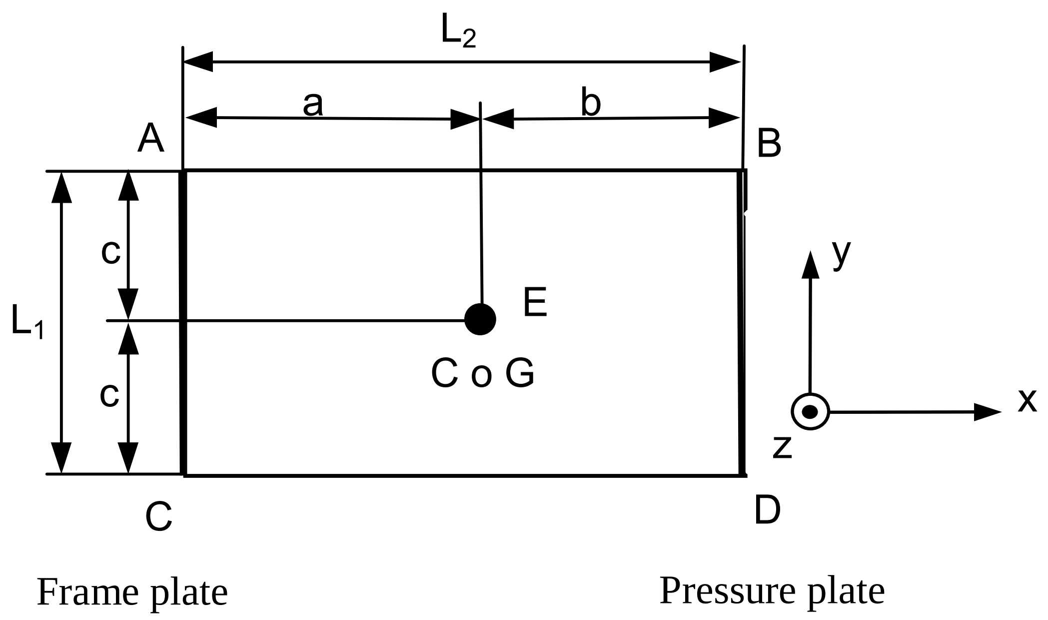


Figure 1: View from above

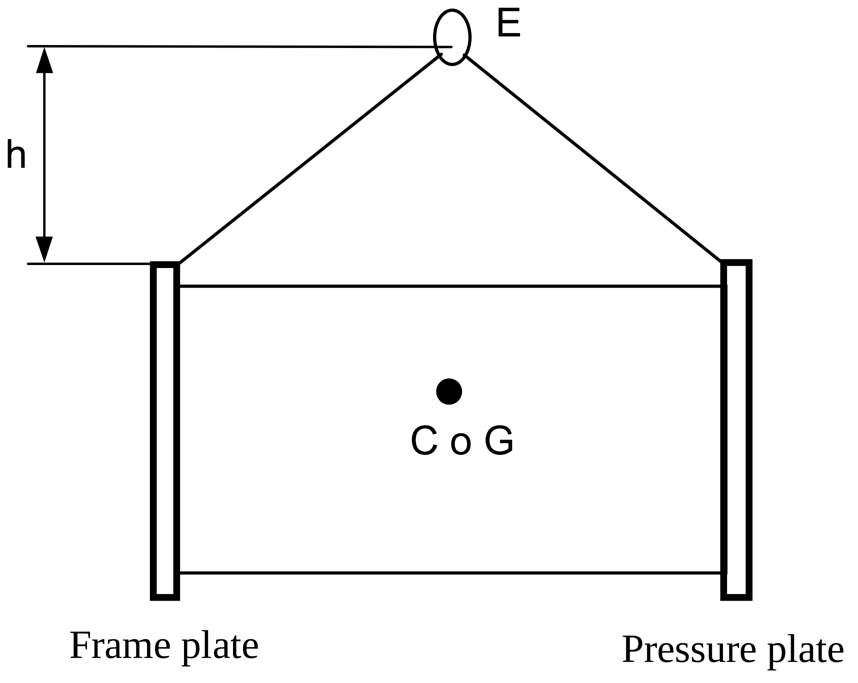


Figure 2: View from side

2 Lifting Calculation Constants

A dynamic factor is used to account for lifting accelerations.

Dynamic factor $F_d = 2.0$

3 Calculations

3.1 Design Load

The design load is calculated by multiplying the estimated weight by the dynaminc factor.

Design load $W := F_d \cdot M$ $W = 330\,kg$

3.2 Distribution Reactions

Distribution of reaction loads are calculated by the area method.

Point A: $A := \frac{2 \cdot c \cdot b \cdot W}{L_1 \cdot L_2}$ $A = 141\,kg$

Point D: $D := \frac{2 \cdot c \cdot a \cdot W}{L_1 \cdot L_2}$ $D = 189\,kg$

3.3 Design Load on A and D

Reaction force at point A $R_{A1} := A$ $R_{A1} = 141\,kg$

Reaction force at point D $R_{D1} := D$ $R_{D1} = 189\,kg$

3.4 Angles

Sling AE to the horizontal plane $\Theta_{AE} := atan\left(\frac{h}{\sqrt{a^2 + c^2}}\right)$ $\Theta_{AE} = 62.2 \cdot deg$

Sling DE to the horizontal plane $\Theta_{DE} := atan\left(\frac{h}{\sqrt{b^2 + c^2}}\right)$ $\Theta_{DE} = 62.6 \cdot deg$

Sling angles should be not be less than 60 deg $min(\Theta_{AE}, \Theta_{DE}) > 60deg = 1$ *(1=true, 0=false)*

3.5 Minimum Sling Lengths

Sling AE $L_{AE} := \frac{h}{sin(\Theta_{AE})}$ $L_{AE} = 339 \cdot mm$

Sling DE $L_{DE} := \frac{h}{sin(\Theta_{DE})}$ $L_{DE} = 338 \cdot mm$

3.6 Maximum Sling Loads

Sling AE $AE := \frac{R_{A1}}{sin(\Theta_{AE})}$ $AE = 159\,kg$

Sling DE $DE := \frac{R_{D1}}{sin(\Theta_{DE})}$ $DE = 213\,kg$

Sling loads written as load vectors:

Load vector AE $vAE := AE \cdot \begin{pmatrix} a \\ -c \\ h \end{pmatrix} \cdot \left[\left|\begin{pmatrix} a \\ -c \\ h \end{pmatrix}\right|\right]^{-1}$ $vAE = \begin{pmatrix} 20 \\ -71 \\ 141 \end{pmatrix} kg$

Load vector DE $vDE := DE \cdot \begin{pmatrix} -b \\ c \\ h \end{pmatrix} \cdot \left[\left|\begin{pmatrix} -b \\ c \\ h \end{pmatrix}\right|\right]^{-1}$ $vDE = \begin{pmatrix} -20 \\ 96 \\ 189 \end{pmatrix} kg$

3.7 Choice of Components

Required Safe Working Load for slings $SWL_r := \max(AE, DE)$

$SWL_r = 213\,kg$

Choice of Wire (1): - Wire rope, galvanized, d = 10 mm

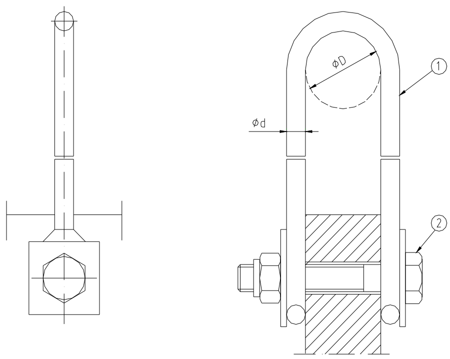
Allowable SWL $SWL_a = 2630\,kg$

Actual SWL is greater than required: $SWL_a > SWL_r = 1$ *(1=true, 0=false)*

Note!
The bending diameter, D, of the wire rope shall not be less than 6d = 60 mm, otherwise the allowable SWL must be reduced.

Choice of Bolt (2): - M20, Property Class 8.8

Root area of bolt $A_r = 220 \cdot mm^2$



3.8 Stress Calculations

Allowable stresses are according to ASME SEC. III, Subsec. NF, Service Level A.

3.8.1 Stresses in Bolt

As the sling load are the same for all slings, the bolt stresses are calculated for sling AE.

The y- and z-component of the sling load expose the bolt for stress in shear.

$$\tau_b := \frac{\sqrt{(vAE_1)^2 + (vAE_2)^2} \cdot g}{2A_r} \qquad \tau_b = 3.5 \cdot MPa \qquad \tau_{b.all} = 165.0 \cdot MPa$$

Allowed tension stress is greater than actual: $\tau_{b.all} > \tau_b = 1$ *(1=true, 0=false)*

The x-component of the sling load expose the bolt for stress in tension.

$$\sigma_b := \frac{vAE_0 \cdot g}{A_r} \qquad \sigma_b = 0.9 \cdot MPa \qquad \sigma_{b.all} = 400.0 \cdot MPa$$

Allowed tension stress is greater than actual: $\sigma_{b.all} > \sigma_b = 1$ *(1=true, 0=false)*

3.8.2 Stresses in Plates

The z-component of the sling load in sling AE expose the frame plate for stress in shear in the weakest part of the plate.

$$\tau_{fp} := \frac{vAE_2 \cdot g}{s_f \cdot t_f} \qquad \tau_{fp} = 5.8 \cdot MPa \qquad \tau_{p.all} = 138.0 \cdot MPa$$

Allowed shear stress is greater than actual: $\tau_{p.all} > \tau_{fp} = 1$ *(1=true, 0=false)*

The z-component of the sling load in sling DE expose the pressure plate for stress in shear in the weakest part of the plate.

$$\tau_{pp} := \frac{vDE_2 \cdot g}{s_p \cdot t_p} \qquad \tau_{pp} = 9.3 \cdot MPa \qquad \tau_{p.all} = 138.0 \cdot MPa$$

Allowed shear stress is greater than actual: $\tau_{p.all} > \tau_{pp} = 1$ *(1=true, 0=false)*