Mid-Continent Energy Exchange

Oil & Gas Asset Auctions

Data Packet

2019 5K Spherical Sand Separator

Equipment in
Gregg County, TX

In this Document:

Lot Summary

County/State: Gregg County, TX

Equipment Name: 2019 5K Spherical Sand Separator (Qty 1)

Description: Located in White Oak, Texas 75693.
It was leased for 7 months from October 2019 - April 2020.

Note: Buyer is responsible for shipping.

Photos


SFI-48IDX5K-102
NB 993
CERTIFIED BY
SYNERGY FABRICATION
Synergy Fabrication Inc.
1432 E. Devitt St.
Fort Worth, TX 76119
M.A.W.P.
5,000 PSIG @ 200°F
M.D.M.T.
-20°F @ 5,000 PSIG
ASME
SERIAL #:
SFI-48IDX5K-102
YEAR BUILT:
2019
U
W
RT-1
HT

Specifications

Synergy Fabrication, Inc.

DATA BOOK

30-06 LEASING

48" 5,000psi

Hemisphere Separator

S/N:

SFI-48IDX5K-102

TABLE OF CONTENTS

VESSEL INFORMATION:

U1a – Manufacturer's Data Report

FORM U-1A MANUFACTURER'S DATA REPORT FOR PRESSURE VESSELS
(Alternative Form for Single-Chamber, Completely Shop- or Field-Fabricated Vessels Only)
As Required by the Provisions of the ASME Boiler and Pressure Vessel Code Rules, Section VIII, Division 1

1. Manufactured and certified by: Synergy Fabrication, Inc., 1432 E. Devitt St., Fort Worth, Texas 76119
(Name and address of Manufacturer)

2. Manufactured for: Built For Stock
(Name and address of Purchaser)

3. Location of installation: Unknown
(Name and address)

4. Type

(Horizontal or vertical, tank)	(Manufacturer's serial number)	(CRN)	(Drawing number)	(National Board number)	(Year built)
Spherical Tank	SFI-48IDX5K-102	-----	SFI-48IDX5K-XXXR.6E	993	2019

5. ASME Code, Section VIII, Div. 1

(Edition and Addenda, if applicable (date))	(Code Case number)	[Special service per UG-120(d)]
2017	-----	-----

6. Shell

(Material spec. number, grade)	(Nominal thickness)	(Corr. allow.)	(Inner diameter)	[Length (overall)]
---	---	---	---	---

Body Flanges on Shells

No.	Type	ID	OD	Flange Thk	Min Hub Thk	Material	How Attached	Location	Bolting: Num & Size	Bolting: Bolting Material	Bolting: Washer (OD, ID, thk)	Bolting: Washer Material
--	---	---	---	---	---	---	---	---	---	---	---	---

7. Seams

[Long. (welded, dbl., sngl., lap, butt)]	[R.T. (spot or full)]	(Eff., %)	(H.T. temp.)	(Time, hr)	[Girth (welded, dbl., sngl., lap, butt)]	[R.T. (spot or full)]	(Eff., %)	(No. of courses)
---	---	---	1150°F	2.50	Type 1	Full	100	1

8. Heads: (a) Material SA-516-70N (Spec. no., grade) (b) Material SA-516-70N (Spec. no., grade)

	Location (Top, Bottom, Ends)	Minimum Thickness	Corrosion Allowance	Crown Radius	Knuckle Radius	Elliptical Ratio	Conical Apex Angle	Hemispherical Radius	Flat Diameter	Side to Pressure (Convex or Concave)
(a)	End	3.10"	0"	---	---	---	---	24" IR	---	Concave
(b)	End	3.10"	0"	---	---	---	---	24" IR	---	Concave

Body Flanges on Heads

	Location	Type	ID	OD	Flange Thk	Min Hub Thk	Material	How Attached	Bolting: Num & Size	Bolting: Bolting Material	Bolting: Washer (OD, ID, thk)	Bolting: Washer Material
(a)	---	---	---	---	---	---	---	---	---	---	---	---
(b)												

9. MAWP 5,000 psi (Internal) --- (External) at max. temp. 200°F (Internal) --- (External).

Min. design metal temp. -20°F at 5,000 psi, Hydro., pneu., or comb. test pressure Hydro 6,500 psi.

Proof test --- .

10. Nozzles, inspection, and safety valve openings:

Purpose (Inlet, Outlet, Drain, etc.)	No.	Diameter or Size	Type	Material: Nozzle	Material: Flange	Nozzle Thickness: Nom.	Nozzle Thickness: Corr.	Reinforcement Material	Attachment Details: Nozzle	Attachment Details: Flange	Location (Insp. Open.)
Inlet	1	4"	2500RTJLWN	SA-105	---	1.25"	0"	Inherent	UW-16.1(c)	---	Head (a)
Gas Outlet	1	3"	2500RTJLWN	SA-105	---	1.125"	0"	SA-516-70	UW-16.1(a-1)	---	Head (a)
Drain	1	3"	2500RTJLWN	SA-105	---	1.125"	0"	SA-516-70	UW-16.1(a-1)	---	Head (b)
PSV	2	1"	TOL	SA-105	---	CL6000	0"	Inherent	UW-16.1(a)	---	Head (a)
Utility	1	1/2"	TOL	SA-105	---	CL6000	0"	Inherent	UW-16.1(a)	---	Head (a)
---	--	---	---	---	---	---	---	---	---	---	---
---	--	---	---	---	---	---	---	---	---	---	---

11. Supports: Skirt No (Yes or no) Lugs 4 (Number) Legs 4 (Number) Other --- (Describe) Attached Head/Welded (Where and how)

12. Remarks: Manufacturer's Partial Data Reports properly identified and signed by Commissioned Inspectors have been furnished for the following items of the report:
(Name of part, item number, Manufacturer's name and identifying stamp)

Material/Productions at -20°F. Not for Lethal or Corrosive Service, Pressure Relief per UG-125. Vessel designed per UG-22(a) Only.

FORM U-1A

Manufactured by Synergy Fabrication, Inc., 1432 E. Devitt St., Fort Worth, Texas 76119

Manufacturer's Serial No. SFI-48IDX5K-102 CRN ----- National Board No. 993

CERTIFICATE OF SHOP/FIELD 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 BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 1. "U" Certificate of Authorization number 49,581 expires February 20, 2021 .

Date 8-19-19 Co. name Synergy Fabrication, Inc. (Manufacturer) Signed [signature] (Representative)

CERTIFICATE OF SHOP/FIELD INSPECTION

Vessel constructed by Synergy Fabrication, Inc. at Fort Worth, Texas .

I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and employed by OneCIS Insurance Co. of Lynn, MA have inspected the component described in this Manufacturer's Data Report on 8-19-19 , and state that, to the best of my knowledge and belief, the Manufacturer has constructed this pressure vessel in accordance with ASME BOILER AND PRESSURE VESSEL CODE, Section VIII, Division 1. By signing this certificate neither the Inspector nor his/her employer makes any warranty, expressed or implied, concerning the pressure vessel described in this Manufacturer's Data Report. Furthermore, neither the Inspector nor his/her 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 8-19-19 Signed [signature] (Authorized Inspector) Commissions NB 16591 (National Board Authorized Inspector Commission number)

INSPECTION CHECKLIST

PROJECT NUMBER ______ DATE 5-21-2019 AI ASSIGNED [initials] ALTERNATE AI ______

ITEM NUMBER 102 SERIAL# SFI-4810XSK-102 NAT'LBDNo. 993

DWG & REV NO.: SFI-4810XSK-XXX R,6E

NOTE: DONOT INITIAL A LINE UNTIL INSPECTION INDICATED IS COMPLETE.

MAWP INT.: 5,000 EXT. — AT 200°F MDMT: -20 °F AT 5,000 PSI

DESIGN FOR SPECIAL SERVICE (L, UB, LT): YES ______ NO ✓ I.T. REQ'D: YES ✓ NO ______

1. CALCS.& DWG. REVIEWED BY AI: LP DATE 1-30-19 QUESTIONS ______

SIZE: O.D. / (I.D.) 48" O.A.L. — NUMBER OF COURSES —

MATERIAL INSPECTION

		QC	DATE	AI	DATE
2.	MILL TEST REPORTS: REVIEWED BY	DM	5-17-19	[initials]	8-19-19
3.	PLATE: SPEC., GRADE & THICKNESS	⎜	⎜	⎜	⎜
	SURFACE & EDGE CONDITION	⎜	⎜	⎜	⎜
4.	PIPE: SPEC., GRADE & THICKNESS	⎜	⎜	⎜	⎜
	SURFACE AND EDGE CONDITION	⎜	⎜	⎜	⎜
5.	HEADS: SPEC., GRADE & THICKNESS	⎜	⎜	⎜	⎜
	CONDITION & SHAPE UG-81	⎜	⎜	⎜	⎜
	& UCS -79 (D) REQ'MTS.	⎜	⎜	⎜	⎜
6.	REINFORCING PADS: SPEC, SIZE, THICKNESS	⎜	⎜	⎜	⎜
7.	FLANGES: SPEC., RATING, BORE & SIZE	DM	5-17-19	[initials]	8-19-19

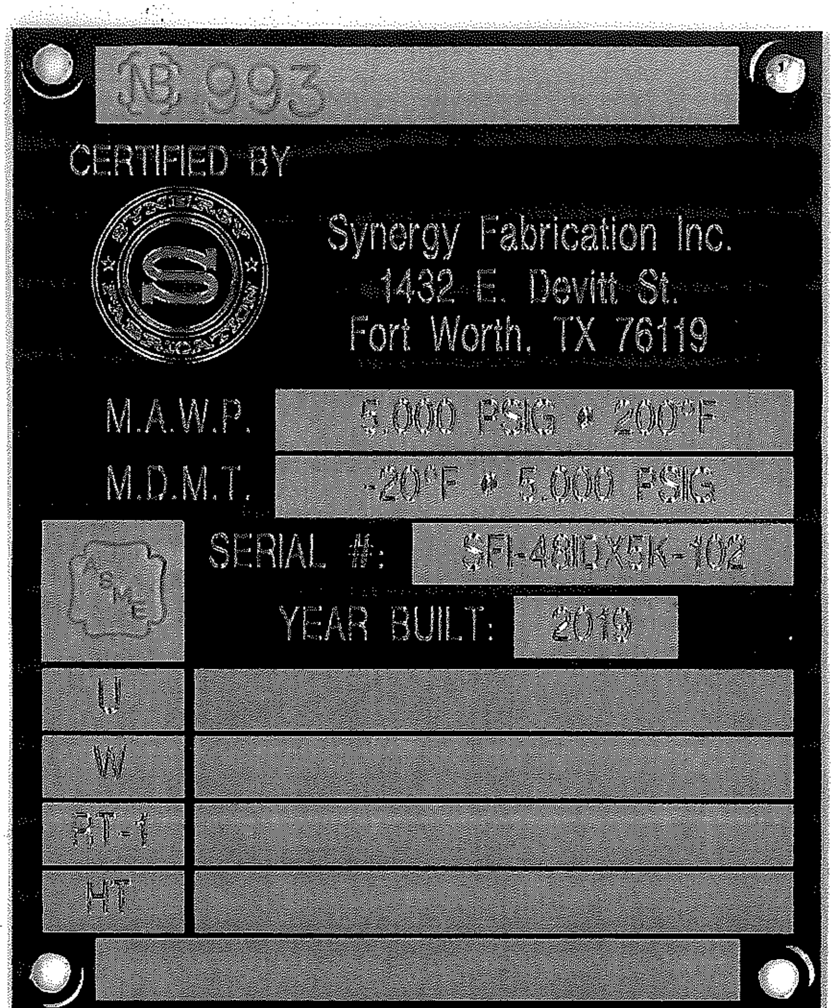
FABRICATION INSPECTION

8. SHELL SIZE (TO MATCH HEADS) ______ SH & HD BEVELS: ______ QC DM AI [initials]
9. OUT OF ROUNDNESS ______ QC ⎜ AI ⎜
10. EDGE OFFSET, LONG & GIRTH SEAMS ______ QC ⎜ AI ⎜
11. QUALIFIED WELD PROCEDURES, WELDERS & WELD ID ______ QC ⎜ AI ⎜
12. CAT. A ___ B ___ C ___ D ___ WELD REINFORCEMENT & SIZE ______ QC ⎜ AI ⎜
13. POST WELD HEAT TREAT REQ'D: YES ✓ NO ______ CK'D BY ______ QC ⎜ AI ⎜
14. PT OR MT REQ'D: YES ______ NO ✓ CK'D BY ______ QC ⎜ AI ______
15. EXTENT OF RT: (NONE, (RT-1), RT-2, RT-3, RT-4) NUMBER OF FILM ______ QC DM AI [initials]
16. RT INTERPRETATION BY: ______ QC ______ DATE ______
17. ALL FIM REVIEWED AND ACCEPTED BY AI: [initials] DATE 8-6-19
18. VESSEL INTERNAL INSPECTION BY: QC DM 8-2-2019 AI [initials] 8-2-19
19. HYDROSTATIC TEST 6,500 PSI QC DM 8-8-2019 AI [initials] DATE 8-9-19
20. NAMEPLATE CK'D BY: QC DM 8-19-19 AI [initials] DATE 8-19-19
21. MANUFACTURER'S DATA REPORT: QC DM 8-19-19 SIGNED BY AI [initials] DATE 8-19-19

NOTE: AI "HOLD" OR "INSPECTION POINTS" TO BE INDICATED BY NUMBER HERE: 1, 2, 3, 7-21

WHEN ONLY PARTIAL INSPECTION IS PERFORMED, LIST ITEM NUMBERS, DATE AND INITIAL: Head Fit 8-2-19

EXHIBIT #3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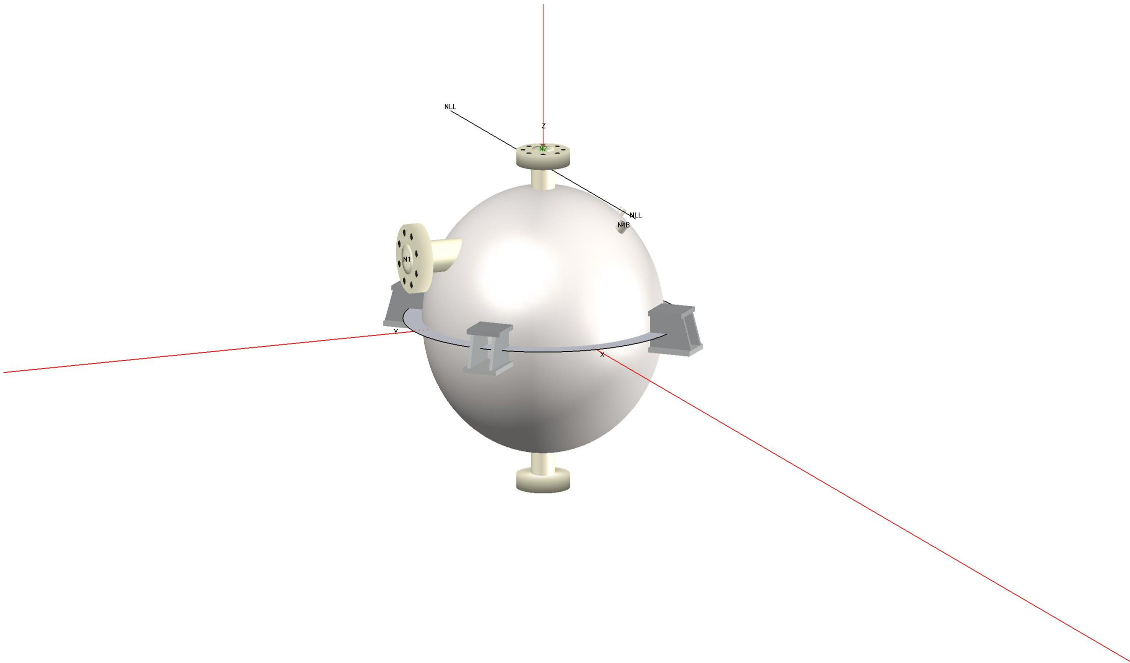
Calculations

Synergy Fabrication, Inc.

1432 E. Devitt St.

Fort Worth, TX 76119



COMPRESS Pressure Vessel Design Calculations

Item:	48" I.D. 5k Spherical Sand Separator
Vessel No:	SFI-48IDX5K-XXX DRAWING Rev. 6A
Customer:	CIMAREX
Designer:	MS / Kevin McFarland
Date:	2/12/2018 / REV 6E: 2/6/2019

3 5/8" thk heads with 2 x 1" PSV set ups
5/8" Thk Repads on Top and Bottom.

FEA OF EXEMPT NOZZLES ADDED
Rev 6E: Drain Noz size updated to 3" 2500#

Table of Contents

Deficiencies Summary

Deficiencies for Support Lugs #1

WRC 107: The local primary membrane stress (PL) is excessive (operating condition)

Nozzle Schedule

Specifications									
Nozzle mark	**Identifier**	**Size**	**Materials**		**Impact Tested**	**Normalized**	**Fine Grain**	**Flange**	**Blind**
N1	INLET	6.5 OD x 1.25	Nozzle	SA-105	No	No	No	NPS 4 Class 2500 LWN A105	No
N2	GAS OUTLET	5.25 OD x 1.125	Nozzle	SA-105	No	No	No	NPS 3 Class 2500 LWN A105	No
			Pad	SA-516 70	No	No	No		
N3	DRAIN	5.25 OD x 1.125	Nozzle	SA-105	No	No	No	NPS 3 Class 2500 LWN A105	No
			Pad	SA-516 70	No	No	No		
N4A	PSV	NPS 1 Class 6000 - threaded	Nozzle	SA-105	No	No	No	N/A	No
N4B	PSV	NPS 1 Class 6000 - threaded	Nozzle	SA-105	No	No	No	N/A	No
N5	P.I.	NPS 0.5 Class 6000 - threaded	Nozzle	SA-105	No	No	No	N/A	No

Nozzle Summary

Dimensions												
Nozzle mark	OD (in)	t_n (in)	Req t_n (in)	A_1?	A_2?	Shell			Reinforcement Pad		Corr (in)	A_a/A_r (%)
						Nom t (in)	Design t (in)	User t (in)	Width (in)	t_{pad} (in)		
N1	6.5	1.25	0.5883	Yes	Yes	3.1*	3.0774		N/A	N/A	0	100.6
N2	5.25	1.125	0.4412	Yes	Yes	3.1*	3.0771		3	0.625	0	101.0
N3	5.25	1.125	0.4414	Yes	Yes	3.1*	3.0784		3	0.625	0	100.8
N4A	2.25	0.4675	0.2557	Yes	Yes	3.1*	N/A		N/A	N/A	0	Exempt
N4B	2.25	0.4675	0.2557	Yes	Yes	3.1*	N/A		N/A	N/A	0	Exempt
N5	1.5	0.33	0.1705	Yes	Yes	3.1*	N/A		N/A	N/A	0	Exempt
*Head minimum thickness after forming												

Definitions	
tn	Nozzle thickness
Req tn	Nozzle thickness required per UG-45/UG-16
Nom t	Vessel wall thickness
Design t	Required vessel wall thickness due to pressure + corrosion allowance per UG-37
User t	Local vessel wall thickness (near opening)
A_a	Area available per UG-37, governing condition
A_r	Area required per UG-37, governing condition
Corr	Corrosion allowance on nozzle wall

Pressure Summary

<table>
<tr><th colspan="9">Component Summary</th></tr>
<tr><th>Identifier</th><th>P Design (psi)</th><th>T Design (°F)</th><th>MAWP (psi)</th><th>MAP (psi)</th><th>MDMT (°F)</th><th colspan="2">MDMT Exemption</th><th>Impact Tested</th></tr>
<tr><td>Hemi Head #1</td><td>5,000</td><td>200</td><td>5,035.41</td><td>5,036.56</td><td>-20.7</td><td colspan="2">Note 1</td><td>Yes</td></tr>
<tr><td>Cylinder #1</td><td>5,000</td><td>200</td><td>5,113.49</td><td>5,114.64</td><td>-22.6</td><td colspan="2">Note 2</td><td>Yes</td></tr>
<tr><td>Hemi Head #2</td><td>5,000</td><td>200</td><td>5,033.91</td><td>5,036.56</td><td>-20.7</td><td colspan="2">Note 3</td><td>Yes</td></tr>
<tr><td>Support Lugs #1</td><td>5,000</td><td>200</td><td>5,000</td><td>N/A</td><td>N/A</td><td colspan="2">N/A</td><td>N/A</td></tr>
<tr><td>INLET (N1)</td><td>5,000</td><td>200</td><td>5,009.53</td><td>5,010.21</td><td>-39</td><td colspan="2">Note 4</td><td>No</td></tr>
<tr><td rowspan="2">GAS OUTLET (N2)</td><td rowspan="2">5,000</td><td rowspan="2">200</td><td rowspan="2">5,011.43</td><td rowspan="2">5,011.71</td><td rowspan="2">-25.7</td><td>Nozzle</td><td>Note 5</td><td>No</td></tr>
<tr><td>Pad</td><td>Note 6</td><td>No</td></tr>
<tr><td rowspan="2">DRAIN (N3)</td><td rowspan="2">5,000</td><td rowspan="2">200</td><td rowspan="2">5,009.42</td><td rowspan="2">5,011.71</td><td rowspan="2">-25.7</td><td>Nozzle</td><td>Note 7</td><td>No</td></tr>
<tr><td>Pad</td><td>Note 8</td><td>No</td></tr>
<tr><td>PSV (N4A)</td><td>5,000</td><td>200</td><td>5,036.04</td><td>5,036.56</td><td>-55</td><td colspan="2">Note 9</td><td>No</td></tr>
<tr><td>PSV (N4B)</td><td>5,000</td><td>200</td><td>5,036.04</td><td>5,036.56</td><td>-55</td><td colspan="2">Note 9</td><td>No</td></tr>
<tr><td>P.I. (N5)</td><td>5,000</td><td>200</td><td>5,036.04</td><td>5,036.56</td><td>-55</td><td colspan="2">Note 10</td><td>No</td></tr>
</table>

<table>
<tr><th colspan="2">Chamber Summary</th></tr>
<tr><td>Design MDMT</td><td>-20 °F</td></tr>
<tr><td>Rated MDMT</td><td>-20.7 °F @ 5,000 psi</td></tr>
<tr><td>MAWP hot & corroded</td><td>5,000 psi @ 200 °F</td></tr>
<tr><td>MAP cold & new</td><td>5,010.21 psi @ 70 °F</td></tr>
<tr><td colspan="2">(1) This pressure chamber is not designed for external pressure.</td></tr>
</table>

Notes for MDMT Rating		
Note #	**Exemption**	**Details**
1.	Material is impact tested per UG-84 to -20°F.	UCS-66(i) reduction of 0.7°F applied (ratio = 0.9928).
2.	Material is impact tested per UG-84 to -20°F.	UCS-66(i) reduction of 2.6°F applied (ratio = 0.9739).
3.	Material is impact tested per UG-84 to -20°F.	UCS-66(i) reduction of 0.7°F applied (ratio = 0.993).
4.	LWN rated MDMT per UCS-66(c)(4) Flange rated MDMT per UCS-66(b)(1)(b) = -39°F (Coincident ratio = 0.8105) Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	
5.	LWN rated MDMT per UCS-66(c)(4) Flange rated MDMT per UCS-66(b)(1)(b) = -55°F (Coincident ratio = 0.8104) Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	
6.	Pad impact test exemption temperature from Fig UCS-66 Curve B = 5°F 30°F MDMT reduction per UCS-68(c) applies. Fig UCS-66.1 MDMT reduction = 0.7°F, (coincident ratio = 0.9926)	UCS-66 governing thickness = 0.625 in.
7.	LWN rated MDMT per UCS-66(c)(4) Flange rated MDMT per UCS-66(b)(1)(b) = -55°F (Coincident ratio = 0.8108) Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	
8.	Pad impact test exemption temperature from Fig UCS-66 Curve B = 5°F 30°F MDMT reduction per UCS-68(c) applies. Fig UCS-66.1 MDMT reduction = 0.7°F, (coincident ratio = 0.993)	UCS-66 governing thickness = 0.625 in.
9.	Nozzle impact test exemption temperature from Fig UCS-66 Curve B = -10.12°F 30°F MDMT reduction per UCS-68(c) applies. Fig UCS-66.1 MDMT reduction = 84.9°F, (coincident ratio = 0.4137) Rated MDMT of -125.02°F is limited to -55°F by UCS-66(b)(2)	UCS-66 governing thickness = 0.4675 in.
10.	Nozzle impact test exemption temperature from Fig UCS-66 Curve B = -20°F 30°F MDMT reduction per UCS-68(c) applies. Fig UCS-66.1 MDMT reduction = 113.6°F, (coincident ratio = 0.3744) Rated MDMT of -163.6°F is limited to -55°F by UCS-66(b)(2)	UCS-66 governing thickness = 0.33 in.

Revision History

Revisions			
No.	Date	Operator	Notes
0	9/13/2016	Kevin McFarland	New vessel created ASME Section VIII Division 1 [COMPRESS 2015 Build 7510]
1	10/13/2017	msaff	Converted from ASME Section VIII Division 1, 2013 Edition to ASME Section VIII Division 1, 2015 Edition. During the conversion, changes may have been made to your vessel (some may be listed above). Please check your vessel carefully.
2	12/18/2017	msaff	Converted from ASME Section VIII Division 1, 2015 Edition to ASME Section VIII Division 1, 2017 Edition. During the conversion, changes may have been made to your vessel (some may be listed above). Please check your vessel carefully.

Settings Summary

COMPRESS 2018 Build 7820	
ASME Section VIII Division 1, 2017 Edition	
Units	U.S. Customary
Datum Line Location	0.00" from bottom seam
Vessel Design Mode	Design Mode
Minimum thickness	0.0625" per UG-16(b)
Design for cold shut down only	No
Design for lethal service (full radiography required)	No
Design nozzles for	Design P only
Corrosion weight loss	100% of theoretical loss
UG-23 Stress Increase	1.20
Skirt/legs stress increase	1.0
Minimum nozzle projection	1"
Juncture calculations for $\alpha > 30$ only	Yes
Preheat P-No 1 Materials > 1.25" and <= 1.50" thick	No
UG-37(a) shell tr calculation considers longitudinal stress	No
Cylindrical shells made from pipe are entered as minimum thickness	No
Nozzles made from pipe are entered as minimum thickness	No
ASME B16.9 fittings are entered as minimum thickness	No
Butt welds	Tapered per Figure UCS-66.3(a)
Disallow Appendix 1-5, 1-8 calculations under 15 psi	No
Hydro/Pneumatic Test	
Shop Hydrotest Pressure	1.3 times vessel MAWP [UG-99(b)]
Test liquid specific gravity	1.00
Maximum stress during test	90% of yield
Required Marking - UG-116	
UG-116(e) Radiography	RT1
UG-116(f) Postweld heat treatment	HT
Code Cases\Interpretations	
Use Code Case 2547	No
Use Code Case 2695	No
Use Code Case 2901	No
Apply interpretation VIII-1-83-66	Yes

Apply interpretation VIII-1-86-175	Yes
Apply interpretation VIII-1-01-37	Yes
Apply interpretation VIII-1-01-150	Yes
Apply interpretation VIII-1-07-50	Yes
Apply interpretation VIII-1-16-85	No
No UCS-66.1 MDMT reduction	No
No UCS-68(c) MDMT reduction	No
Disallow UG-20(f) exemptions	No
UG-22 Loadings	
UG-22(a) Internal or External Design Pressure	Yes
UG-22(b) Weight of the vessel and normal contents under operating or test conditions	Yes
UG-22(c) Superimposed static reactions from weight of attached equipment (external loads)	No
UG-22(d)(2) Vessel supports such as lugs, rings, skirts, saddles and legs	Yes
UG-22(f) Wind reactions	No
UG-22(f) Seismic reactions	No
UG-22(j) Test pressure and coincident static head acting during the test:	No
Note: UG-22(b),(c) and (f) loads only considered when supports are present.	

License Information	
Company Name	Synergy Fabrication, Inc.
License	Commercial
License Key ID	38280
Support Expires	April 26, 2019

Radiography Summary

UG-116 Radiography							
Component	Longitudinal Seam		Top Circumferential Seam		Bottom Circumferential Seam		Mark
	Category (Fig UW-3)	Radiography / Joint Type	Category (Fig UW-3)	Radiography / Joint Type	Category (Fig UW-3)	Radiography / Joint Type	
Hemi Head #1	N/A	Seamless No RT	N/A	N/A	A	Full UW-11(a) / Type 1	RT1
Cylinder #1	N/A	Seamless No RT	A	Full UW-11(a) / Type 1	A	Full UW-11(a) / Type 1	RT1
Hemi Head #2	N/A	Seamless No RT	A	Full UW-11(a) / Type 1	N/A	N/A	RT1
Nozzle	Longitudinal Seam		Nozzle to Vessel Circumferential Seam		Nozzle free end Circumferential Seam		
INLET (N1)	N/A	Seamless No RT	D	N/A / Type 7	C	N/A	N/A
GAS OUTLET (N2)	N/A	Seamless No RT	D	N/A / Type 7	C	N/A	N/A
PSV (N4A)	N/A	Seamless No RT	D	N/A / Type 7	N/A	N/A	N/A
P.I. (N5)	N/A	Seamless No RT	D	N/A / Type 7	N/A	N/A	N/A
PSV (N4B)	N/A	Seamless No RT	D	N/A / Type 7	N/A	N/A	N/A
DRAIN (N3)	N/A	Seamless No RT	D	N/A / Type 7	C	N/A	N/A
Nozzle Flange	Longitudinal Seam		Flange Face		Nozzle to Flange Circumferential Seam		
ASME B16.5/16.47 flange attached to INLET (N1)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	N/A	N/A
ASME B16.5/16.47 flange attached to GAS OUTLET (N2)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	N/A	N/A
ASME B16.5/16.47 flange attached to DRAIN (N3)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	N/A	N/A
UG-116(e) Required Marking: **RT1**							

Thickness Summary

Component Data								
Component Identifier	Material	Diameter (in)	Length (in)	Nominal t (in)	Design t (in)	Total Corrosion (in)	Joint E	Load
Hemi Head #1	SA-516 70	48 ID	27.1	3.1*	3.0777	0	1.00	Internal
Cylinder #1	SA-516 70	48 ID	0.0625	7.25	7.0608	0	1.00	Internal
Hemi Head #2	SA-516 70	48 ID	27.1	3.1*	3.0786	0	1.00	Weight
*Head minimum thickness after forming								

Definitions	
Nominal t	Vessel wall nominal thickness
Design t	Required vessel thickness due to governing loading + corrosion
Joint E	Longitudinal seam joint efficiency
Load	
Internal	Circumferential stress due to internal pressure governs
External	External pressure governs
Wind	Combined longitudinal stress of pressure + weight + wind governs
Seismic	Combined longitudinal stress of pressure + weight + seismic governs

Weight Summary

Weight (lb) Contributed by Vessel Elements											
Component	Metal New*	Metal Corroded	Insulation	Insulation Supports	Lining	Piping + Liquid	Operating Liquid		Test Liquid		Surface Area ft²
							New	Corroded	New	Corroded	
Hemi Head #1	3,546.2	3,546.2	0	0	0	0	1,049.7	1,049.7	1,049.8	1,049.8	32
Cylinder #1	22.3	22.3	0	0	0	0	4.1	4.1	4.1	4.1	0
Hemi Head #2	3,583.8	3,583.8	0	0	0	0	1,046.4	1,046.4	1,046.4	1,046.4	32
Support Lugs #1	262.3	262.3	0	0	0	0	0	0	0	0	16
TOTAL:	**7,414.6**	**7,414.6**	**0**	**0**	**0**	**0**	**2,100.2**	**2,100.2**	**2,100.3**	**2,100.3**	**80**
*Shells with attached nozzles have weight reduced by material cut out for opening.											

Weight (lb) Contributed by Attachments											
Component	Body Flanges		Nozzles & Flanges		Packed Beds	Ladders & Platforms	Trays	Tray Supports	Rings & Clips	Vertical Loads	Surface Area ft²
	New	Corroded	New	Corroded							
Hemi Head #1	0	0	371.9	371.9	0	0	0	0	0	0	4
Cylinder #1	0	0	0	0	0	0	0	0	0	0	0
Hemi Head #2	0	0	128.9	128.9	0	0	0	0	0	0	2
TOTAL:	**0**	**0**	**500.9**	**500.9**	**0**	**0**	**0**	**0**	**0**	**0**	**6**

Vessel Totals		
	New	Corroded
Operating Weight (lb)	10,016	10,016
Empty Weight (lb)	7,915	7,915
Test Weight (lb)	10,016	10,016
Surface Area (ft²)	86	-
Capacity** (US gal)	251	251
**The vessel capacity does not include volume of nozzle, piping or other attachments.		

Vessel Lift Condition	
Vessel Lift Weight, New (lb)	7,915
Center of Gravity from Datum (in)	0.2319

Hydrostatic Test

Horizontal shop hydrostatic test based on MAWP per UG-99(b)

Gauge pressure at 70°F = 1.3*MAWP*LSR
= 1.3*5,000*1
= 6,500 psi

Horizontal shop hydrostatic test				
Identifier	Local test pressure (psi)	Test liquid static head (psi)	UG-99(b) stress ratio	UG-99(b) pressure factor
Hemi Head #1 (1)	6,501.733	1.733	1	1.30
Cylinder #1	6,501.733	1.733	1	1.30
Hemi Head #2	6,501.733	1.733	1	1.30
DRAIN (N3)	6,500.921	0.921	1	1.30
GAS OUTLET (N2)	6,500.921	0.921	1	1.30
INLET (N1)	6,500.939	0.939	1	1.30
P.I. (N5)	6,500.882	0.882	1	1.30
PSV (N4A)	6,501.382	1.382	1	1.30
PSV (N4B)	6,500.411	0.411	1	1.30

(1) Hemi Head #1 limits the UG-99(b) stress ratio.
(2) The zero degree angular position is assumed to be up, and the test liquid height is assumed to the top-most flange.

The field test condition has not been investigated.

The test temperature of 70 °F is warmer than the minimum recommended temperature of 9.3 °F so the brittle fracture provision of UG-99(h) has been met.

Hemi Head #1

ASME Section VIII Division 1, 2017 Edition					
Component		Hemispherical Head			
Material		SA-516 70 (II-D p. 18, ln. 33)			
Attached To		Cylinder #1			
Impact Tested	**Normalized**	**Fine Grain Practice**	**PWHT**		**Optimize MDMT/ Find MAWP**
Yes (-20°F)	Yes	No	Yes		No
		Design Pressure (psi)	**Design Temperature (°F)**		**Design MDMT (°F)**
Internal		5,000	200		-20
Static Liquid Head					
Condition		**P_s (psi)**	**H_s (in)**		**SG**
Operating		1.14	31.6323		1
Test horizontal		1.73	48		1
Dimensions					
Inner Diameter		48"			
Minimum Thickness		3.1"			
Corrosion	**Inner**	0"			
	Outer	0"			
Weight and Capacity					
		Weight (lb)			**Capacity (US gal)**
New		3,546.19			125.34
Corroded		3,546.19			125.34
Radiography					
Category A joints - Long Seam		Seamless No RT			
Category A joints - Circ Seam		Full UW-11(a) Type 1			

Results Summary	
Governing condition	Internal pressure
Minimum thickness per UG-16	0.0625" + 0" = 0.0625"
Design thickness due to internal pressure (t)	3.0777"
Design thickness due to combined loadings + corrosion	3.0759"
Maximum allowable working pressure (MAWP)	5,035.41 psi
Maximum allowable pressure (MAP)	5,036.56 psi
Rated MDMT	-20.7 °F

UCS-66 Material Toughness Requirements	
Material impact test temperature per UG-84 =	-20°F
t_r = 5,001.14*24 / (2*20,000*1 - 0.2*5,001.14) =	3.0776"
Stress ratio = t_r*E^* / (t_n - c) = 3.0776*1 / (3.1 - 0) =	0.9928
UCS-66(i) reduction in MDMT, T_R from Fig UCS-66.1 =	0.7°F
MDMT = max[T_{impact} - T_R, -155] = max[-20 - 0.7 , -155] =	-20.7°F
Design MDMT of -20°F is acceptable.	

Design thickness, (at 200 °F) UG-32(e)

t = P*R / (2*S*E - 0.20*P) + Corrosion
= 5,001.14*24 / (2*20,000*1.00 - 0.20*5,001.14) + 0
= 3.0777"

Maximum allowable working pressure, (at 200 °F) UG-32(e)

P = 2*S*E*t / (R + 0.20*t) - P_s
= 2*20,000*1.00*3.1 / (24 + 0.20*3.1) - 1.14
= 5,035.41 psi

Maximum allowable pressure, (at 70 °F) UG-32(e)

P = 2*S*E*t / (R + 0.20*t)
= 2*20,000*1.00*3.1 / (24 + 0.20*3.1)
= 5,036.56 psi

% Extreme fiber elongation - UCS-79(d)

EFE = (75*t / R_f)*(1 - R_f / R_o)
= (75*3.1 / 25.55)*(1 - 25.55 / ∞)
= 9.0998%

Thickness Required Due to Pressure + External Loads								
Condition	Pressure P (psi)	Allowable Stress Before UG-23 Stress Increase (psi)		Temperature (°F)	Corrosion C (in)	Load	Req'd Thk Due to Tension (in)	Req'd Thk Due to Compression (in)
		S_t	S_c					
Operating, Hot & Corroded	5,000	20,000	17,460	200	0	Weight	3.0759	3.0755
Operating, Hot & New	5,000	20,000	17,460	200	0	Weight	3.0759	3.0755
Hot Shut Down, Corroded	0	20,000	17,460	200	0	Weight	0.0012	0.0016
Hot Shut Down, New	0	20,000	17,460	200	0	Weight	0.0012	0.0016
Empty, Corroded	0	20,000	17,460	70	0	Weight	0.0012	0.0016
Empty, New	0	20,000	17,460	70	0	Weight	0.0012	0.0016
Hot Shut Down, Corroded, Weight & Eccentric Moments Only	0	20,000	17,460	200	0	Weight	0.0012	0.0016

Hemi Head #2

ASME Section VIII Division 1, 2017 Edition				
Component		Hemispherical Head		
Material		SA-516 70 (II-D p. 18, ln. 33)		
Attached To		Cylinder #1		
Impact Tested	**Normalized**	**Fine Grain Practice**	**PWHT**	**Optimize MDMT/ Find MAWP**
Yes (-20°F)	Yes	No	Yes	No
		Design Pressure (psi)	**Design Temperature (°F)**	**Design MDMT (°F)**
Internal		5,000	200	-20
Static Liquid Head				
Condition		**P_s (psi)**	**H_s (in)**	**SG**
Operating		2.01	55.6948	1
Test horizontal		1.73	48	1
Dimensions				
Inner Diameter		48"		
Minimum Thickness		3.1"		
Corrosion	**Inner**	0"		
	Outer	0"		
Weight and Capacity				
		Weight (lb)		**Capacity (US gal)**
New		3,583.83		125.34
Corroded		3,583.83		125.34
Radiography				
Category A joints - Long Seam		Seamless No RT		
Category A joints - Circ Seam		Full UW-11(a) Type 1		

Results Summary	
Governing condition	Operating, Hot & Corroded
Minimum thickness per UG-16	0.0625" + 0" = 0.0625"
Design thickness due to internal pressure (t)	3.0782"
Design thickness due to combined loadings + corrosion	3.0786"
Maximum allowable working pressure (MAWP)	5,033.91 psi
Maximum allowable pressure (MAP)	5,036.56 psi
Rated MDMT	-20.7 °F

UCS-66 Material Toughness Requirements	
Material impact test temperature per UG-84 =	-20°F
t_r = 5,002.01*24 / (2*20,000*1 - 0.2*5,002.01) =	3.0782"
Stress ratio = t_r*E^* / (t_n - c) = 3.0782*1 / (3.1 - 0) =	0.993
UCS-66(i) reduction in MDMT, T_R from Fig UCS-66.1 =	0.7°F
MDMT = max[T_{impact} - T_R, -155] = max[-20 - 0.7 , -155] =	-20.7°F
Design MDMT of -20°F is acceptable.	

Design thickness, (at 200 °F) UG-32(e)

t = P*R / (2*S*E - 0.20*P) + Corrosion
= 5,002.01*24 / (2*20,000*1.00 - 0.20*5,002.01) + 0
= 3.0782"

Maximum allowable working pressure, (at 200 °F) UG-32(e)

P = 2*S*E*t / (R + 0.20*t) - P_s
= 2*20,000*1.00*3.1 / (24 + 0.20*3.1) - 2.01
= 5,034.55 psi

Maximum allowable pressure, (at 70 °F) UG-32(e)

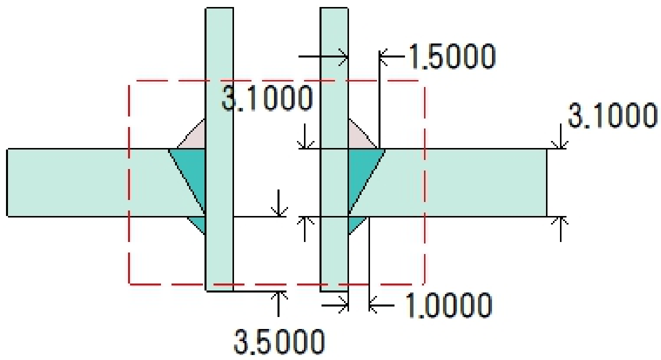
P = 2*S*E*t / (R + 0.20*t)
= 2*20,000*1.00*3.1 / (24 + 0.20*3.1)
= 5,036.56 psi

% Extreme fiber elongation - UCS-79(d)

EFE = (75*t / R_f)*(1 - R_f / R_o)
= (75*3.1 / 25.55)*(1 - 25.55 / ∞)
= 9.0998%

Thickness Required Due to Pressure + External Loads									
Condition	Pressure P (psi)	Allowable Stress Before UG-23 Stress Increase (psi)		Temperature (°F)	Corrosion C (in)	Location	Load	Req'd Thk Due to Tension (in)	Req'd Thk Due to Compression (in)
		S_t	S_c						
Operating, Hot & Corroded	5,000	20,000	17,460	200	0	Top	Weight	3.0757	3.0753
						Bottom	Weight	3.0786	3.0786
Operating, Hot & New	5,000	20,000	17,460	200	0	Top	Weight	3.0757	3.0753
						Bottom	Weight	3.0786	3.0786
Hot Shut Down, Corroded	0	20,000	17,460	200	0	Top	Weight	0.0014	0.0018
						Bottom	Weight	0.0017	0.0017
Hot Shut Down, New	0	20,000	17,460	200	0	Top	Weight	0.0014	0.0018
						Bottom	Weight	0.0017	0.0017
Empty, Corroded	0	20,000	17,460	70	0	Top	Weight	0.0014	0.0018
						Bottom	Weight	0.001	0.001
Empty, New	0	20,000	17,460	70	0	Top	Weight	0.0014	0.0018
						Bottom	Weight	0.001	0.001
Hot Shut Down, Corroded, Weight & Eccentric Moments Only	0	20,000	17,460	200	0	Top	Weight	0.0014	0.0018
						Bottom	Weight	0.0017	0.0017

INLET (N1)

ASME Section VIII Division 1, 2017 Edition	
	
Note: round inside edges per UG-76(c)	
Location and Orientation	
Located on	Hemi Head #1
Orientation	90°
Nozzle center line offset to datum line	15.0625"
Calculated as hillside	Yes (perpendicular)
Distance to head center, R	33"
Passes through a Category A joint	No
Nozzle	
Access opening	No
Material specification	SA-105 (II-D p. 18, ln. 19)
Inside diameter, new	4"
Nominal wall thickness	1.25"
Corrosion allowance	0"
Opening chord length	4.9734"
Projection available outside vessel, Lpr	5.3298"
Internal projection, h_{new}	3.5"
Projection available outside vessel to flange face, Lf	8.5798"
Local vessel minimum thickness	3.1"
Liquid static head included	0.67 psi
Longitudinal joint efficiency	1
Welds	
Inner fillet, Leg_{41}	1.5"

Lower fillet, Leg_{43}	1"
Nozzle to vessel groove weld	3.1"

ASME B16.5-2013 Flange	
Description	NPS 4 Class 2500 LWN A105
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 388, ln. 32)
Blind included	No
Rated MDMT	-39°F
Liquid static head	0.6 psi
MAWP rating	5,655 psi @ 200°F
MAP rating	6,170 psi @ 70°F
Hydrotest rating	9,275 psi @ 70°F
PWHT performed	Yes
Impact Tested	No
Notes	
Flange rated MDMT per UCS-66(b)(1)(b) = -39°F (Coincident ratio = 0.8105) Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	

UCS-66 Material Toughness Requirements	
LWN rated MDMT per UCS-66(c)(4) =	-39°F
Material is exempt from impact testing at the Design MDMT of -20°F.	

Reinforcement Calculations for MAWP

Available reinforcement per UG-37 governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in^2)							UG-45 Summary (in)	
For P = 5,010.21 psi @ 200 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A_1	A_2	A_3	A_5	A welds	t_{req}	t_{min}
15.3347	15.3348	0.1448	4.1275	7.8125	--	3.25	0.5896	1.25

UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(1)

UW-16 Weld Sizing Summary			
Weld description	**Required weld throat size (in)**	**Actual weld throat size (in)**	**Status**
Nozzle to shell fillet (Leg_{41})	0.25	1.05	weld size is adequate

Reinforcement Calculations for MAP

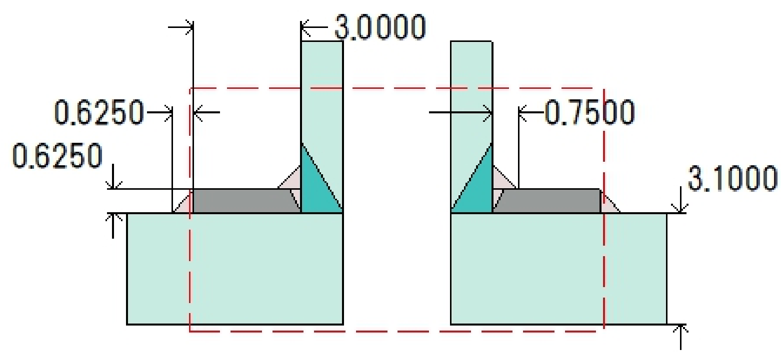
Available reinforcement per UG-37 governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in^2)							UG-45 Summary (in)	
For P = 5,010.21 psi @ 70 °F The opening is adequately reinforced							**The nozzle passes UG-45**	
A required	**A available**	**A_1**	**A_2**	**A_3**	**A_5**	**A welds**	**t_{req}**	**t_{min}**
15.3347	15.3348	0.1448	4.1275	7.8125	--	3.25	0.5896	1.25

UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(1)

UW-16 Weld Sizing Summary			
Weld description	**Required weld throat size (in)**	**Actual weld throat size (in)**	**Status**
Nozzle to shell fillet (Leg_{41})	0.25	1.05	weld size is adequate

GAS OUTLET (N2)

ASME Section VIII Division 1, 2017 Edition	
	
Note: round inside edges per UG-76(c)	
Location and Orientation	
Located on	Hemi Head #1
Orientation	0°
End of nozzle to datum line	35.0351"
Calculated as hillside	No
Distance to head center, R	0"
Passes through a Category A joint	No
Nozzle	
Access opening	No
Material specification	SA-105 (II-D p. 18, ln. 19)
Inside diameter, new	3"
Nominal wall thickness	1.125"
Corrosion allowance	0"
Projection available outside vessel, Lpr	5.13"
Projection available outside vessel to flange face, Lf	8"
Local vessel minimum thickness	3.1"
Liquid static head included	0.28 psi
Longitudinal joint efficiency	1
Reinforcing Pad	
Material specification	SA-516 70 (II-D p. 18, ln. 33)
Diameter, D_p	11.25"
Thickness, t_e	0.625"

Is split	No
Welds	
Inner fillet, Leg_{41}	0.75"
Outer fillet, Leg_{42}	0.625"
Nozzle to vessel groove weld	1.125"
Pad groove weld	0.625"

ASME B16.5-2013 Flange	
Description	NPS 3 Class 2500 LWN A105
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 388, ln. 32)
Blind included	No
Rated MDMT	-55°F
Liquid static head	0 psi
MAWP rating	5,655 psi @ 200°F
MAP rating	6,170 psi @ 70°F
Hydrotest rating	9,275 psi @ 70°F
PWHT performed	Yes
Impact Tested	No
Notes	
Flange rated MDMT per UCS-66(b)(1)(b) = -55°F (Coincident ratio = 0.8104) Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	

UCS-66 Material Toughness Requirements	
LWN rated MDMT per UCS-66(c)(4) =	-55°F
Material is exempt from impact testing at the Design MDMT of -20°F.	

UCS-66 Material Toughness Requirements Pad	
Governing thickness, t_g =	0.625"
Exemption temperature from Fig UCS-66 Curve B =	5°F
t_r = 5,000.28*24 / (2*20,000*1 - 0.2*5,000.28) =	3.0771"
Stress ratio = t_r*E* / (t_n - c) = 3.0771*1 / (3.1 - 0) =	0.9926
Reduction in MDMT, T_R from Fig UCS-66.1 =	0.7°F
Reduction in MDMT, T_{PWHT} from UCS-68(c) =	30°F
MDMT = max[MDMT - T_R - T_{PWHT}, -55] = max[5 - 0.7 - 30 , -55] =	-25.7°F
Material is exempt from impact testing at the Design MDMT of -20°F.	

Reinforcement Calculations for MAWP

Available reinforcement per UG-37 governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in^2)							UG-45 Summary (in)	
For P = 5,011.71 psi @ 200 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A_1	A_2	A_3	A_5	A welds	t_{req}	t_{min}
9.2529	9.253	0.1326	4.6929	--	3.75	0.6775	0.4424	1.125

UG-41 Weld Failure Path Analysis Summary (lb_f)				
All failure paths are stronger than the applicable weld loads				
Weld load W	Weld load W_{1-1}	Path 1-1 strength	Weld load W_{2-2}	Path 2-2 strength
182,406.6	182,408	195,711.4	105,108	224,368.62

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to pad fillet (Leg_{41})	0.25	0.525	weld size is adequate
Pad to shell fillet (Leg_{42})	0.3125	0.4375	weld size is adequate

Reinforcement Calculations for MAP

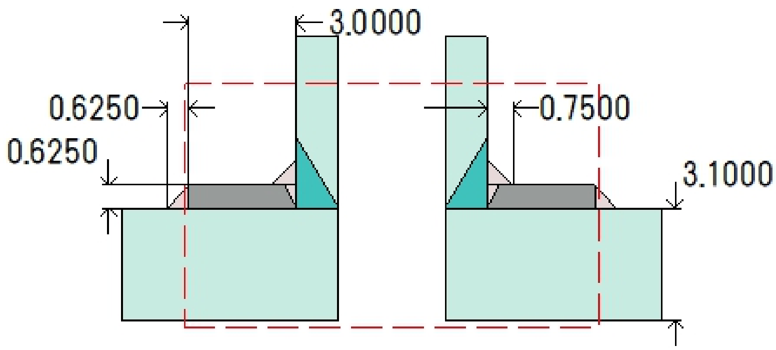
Available reinforcement per UG-37 governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in^2)							UG-45 Summary (in)	
For P = 5,011.71 psi @ 70 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A_1	A_2	A_3	A_5	A welds	t_{req}	t_{min}
9.2529	9.253	0.1326	4.6929	--	3.75	0.6775	0.4424	1.125

UG-41 Weld Failure Path Analysis Summary (lb_f)				
All failure paths are stronger than the applicable weld loads				
Weld load W	Weld load W_{1-1}	Path 1-1 strength	Weld load W_{2-2}	Path 2-2 strength
182,406.6	182,408	195,711.4	105,108	224,368.62

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to pad fillet (Leg_{41})	0.25	0.525	weld size is adequate
Pad to shell fillet (Leg_{42})	0.3125	0.4375	weld size is adequate

DRAIN (N3)

ASME Section VIII Division 1, 2017 Edition	
	
Note: round inside edges per UG-76(c)	
Location and Orientation	
Located on	Hemi Head #2
Orientation	0°
End of nozzle to datum line	-34.9726"
Calculated as hillside	No
Distance to head center, R	0"
Passes through a Category A joint	No
Nozzle	
Access opening	No
Material specification	SA-105 (II-D p. 18, ln. 19)
Inside diameter, new	3"
Nominal wall thickness	1.125"
Corrosion allowance	0"
Projection available outside vessel, Lpr	5.13"
Projection available outside vessel to flange face, Lf	8"
Local vessel minimum thickness	3.1"
Liquid static head included	2.29 psi
Longitudinal joint efficiency	1
Reinforcing Pad	
Material specification	SA-516 70 (II-D p. 18, ln. 33)
Diameter, D_p	11.25"
Thickness, t_e	0.625"

Is split	No
Welds	
Inner fillet, Leg_{41}	0.75"
Outer fillet, Leg_{42}	0.625"
Nozzle to vessel groove weld	1.125"
Pad groove weld	0.625"

ASME B16.5-2013 Flange	
Description	NPS 3 Class 2500 LWN A105
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 388, ln. 32)
Blind included	No
Rated MDMT	-55°F
Liquid static head	2.41 psi
MAWP rating	5,655 psi @ 200°F
MAP rating	6,170 psi @ 70°F
Hydrotest rating	9,275 psi @ 70°F
PWHT performed	Yes
Impact Tested	No
Notes	
Flange rated MDMT per UCS-66(b)(1)(b) = -55°F (Coincident ratio = 0.8108) Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	

UCS-66 Material Toughness Requirements	
LWN rated MDMT per UCS-66(c)(4) =	-55°F
Material is exempt from impact testing at the Design MDMT of -20°F.	

UCS-66 Material Toughness Requirements Pad	
Governing thickness, t_g =	0.625"
Exemption temperature from Fig UCS-66 Curve B =	5°F
t_r = 5,002.29*24 / (2*20,000*1 - 0.2*5,002.29) =	3.0784"
Stress ratio = t_r*E* / (t_n - c) = 3.0784*1 / (3.1 - 0) =	0.993
Reduction in MDMT, T_R from Fig UCS-66.1 =	0.7°F
Reduction in MDMT, T_{PWHT} from UCS-68(c) =	30°F
MDMT = max[MDMT - T_R - T_{PWHT}, -55] = max[5 - 0.7 - 30 , -55] =	-25.7°F
Material is exempt from impact testing at the Design MDMT of -20°F.	

Reinforcement Calculations for MAWP

Available reinforcement per UG-37 governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in^2)							UG-45 Summary (in)	
For P = 5,011.71 psi @ 200 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A_1	A_2	A_3	A_5	A welds	t_{req}	t_{min}
9.2529	9.253	0.1326	4.6929	--	3.75	0.6775	0.4424	1.125

UG-41 Weld Failure Path Analysis Summary (lb_f)				
All failure paths are stronger than the applicable weld loads				
Weld load W	Weld load W_{1-1}	Path 1-1 strength	Weld load W_{2-2}	Path 2-2 strength
182,406.6	182,408	195,711.4	105,108	224,368.62

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to pad fillet (Leg_{41})	0.25	0.525	weld size is adequate
Pad to shell fillet (Leg_{42})	0.3125	0.4375	weld size is adequate

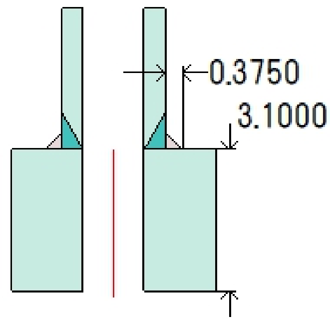
Reinforcement Calculations for MAP

Available reinforcement per UG-37 governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in^2)							UG-45 Summary (in)	
For P = 5,011.71 psi @ 70 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A_1	A_2	A_3	A_5	A welds	t_{req}	t_{min}
9.2529	9.253	0.1326	4.6929	--	3.75	0.6775	0.4424	1.125

UG-41 Weld Failure Path Analysis Summary (lb_f)				
All failure paths are stronger than the applicable weld loads				
Weld load W	Weld load W_{1-1}	Path 1-1 strength	Weld load W_{2-2}	Path 2-2 strength
182,406.6	182,408	195,711.4	105,108	224,368.62

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to pad fillet (Leg_{41})	0.25	0.525	weld size is adequate
Pad to shell fillet (Leg_{42})	0.3125	0.4375	weld size is adequate

ASME Section VIII Division 1, 2017 Edition	
	
Note: round inside edges per UG-76(c)	
Location and Orientation	
Located on	Hemi Head #1
Orientation	225°
End of nozzle to datum line	21.0103"
Calculated as hillside	No
Distance to head center, R	18.48"
Passes through a Category A joint	No
Nozzle	
Description	NPS 1 Class 6000 - threaded
Access opening	No
Material specification	SA-105 (II-D p. 18, ln. 19)
Inside diameter, new	1.315"
Nominal wall thickness	0.4675"
Corrosion allowance	0"
Projection available outside vessel, Lpr	1.563"
Local vessel minimum thickness	3.1"
Liquid static head included	0.52 psi
Longitudinal joint efficiency	1
Welds	
Inner fillet, Leg_{41}	0.375"

UCS-66 Material Toughness Requirements Nozzle	
Governing thickness, t_g =	0.4675"
Exemption temperature from Fig UCS-66 Curve B =	-10.12°F
t_r = 5,000.52*0.6575 / (20,000*1 - 0.6*5,000.52) =	0.1934"
Stress ratio = t_r*E^* / (t_n - c) = 0.1934*1 / (0.4675 - 0) =	0.4137
Reduction in MDMT, T_R from Fig UCS-66.1 =	84.9°F
Reduction in MDMT, T_{PWHT} from UCS-68(c) =	30°F
MDMT = max[MDMT - T_R - T_{PWHT}, -55] = max[-10.12 - 84.9 - 30 , -55] =	-55°F
Material is exempt from impact testing at the Design MDMT of -20°F.	

Reinforcement Calculations for MAWP

The vessel wall thickness governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in^2)							UG-44 Summary (in)	
For P = 5,036.56 psi @ 200 °F							The nozzle passes UG-44	
A required	A available	A_1	A_2	A_3	A_5	A welds	t_{req}	t_{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2574	0.4675

UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg_{41})	0.25	0.2625	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

Reinforcement Calculations for MAP

The vessel wall thickness governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in^2)							UG-44 Summary (in)	
For P = 5,036.56 psi @ 70 °F							The nozzle passes UG-44	
A required	A available	A_1	A_2	A_3	A_5	A welds	t_{req}	t_{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2574	0.4675

UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg_{41})	0.25	0.2625	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

PSV (N4B)

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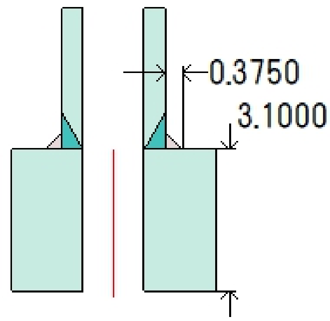

Note: round inside edges per UG-76(c)

Location and Orientation	
Located on	Hemi Head #1
Orientation	315°
End of nozzle to datum line	21.0103"
Calculated as hillside	No
Distance to head center, R	18.48"
Passes through a Category A joint	No

Nozzle	
Description	NPS 1 Class 6000 - threaded
Access opening	No
Material specification	SA-105 (II-D p. 18, ln. 19)
Inside diameter, new	1.315"
Nominal wall thickness	0.4675"
Corrosion allowance	0"
Projection available outside vessel, Lpr	1.563"
Local vessel minimum thickness	3.1"
Liquid static head included	0.52 psi
Longitudinal joint efficiency	1

Welds	
Inner fillet, Leg_{41}	0.375"

UCS-66 Material Toughness Requirements Nozzle	
Governing thickness, t_g =	0.4675"
Exemption temperature from Fig UCS-66 Curve B =	-10.12°F
t_r = 5,000.52*0.6575 / (20,000*1 - 0.6*5,000.52) =	0.1934"
Stress ratio = t_r*E^* / (t_n - c) = 0.1934*1 / (0.4675 - 0) =	0.4137
Reduction in MDMT, T_R from Fig UCS-66.1 =	84.9°F
Reduction in MDMT, T_{PWHT} from UCS-68(c) =	30°F
MDMT = max[MDMT - T_R - T_{PWHT}, -55] = max[-10.12 - 84.9 - 30 , -55] =	-55°F
Material is exempt from impact testing at the Design MDMT of -20°F.	

Reinforcement Calculations for MAWP

The vessel wall thickness governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in^2)							UG-44 Summary (in)	
For P = 5,036.56 psi @ 200 °F							The nozzle passes UG-44	
A required	A available	A_1	A_2	A_3	A_5	A welds	t_{req}	t_{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2574	0.4675

UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg_{41})	0.25	0.2625	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

Reinforcement Calculations for MAP

The vessel wall thickness governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in^2)							UG-44 Summary (in)	
For P = 5,036.56 psi @ 70 °F							The nozzle passes UG-44	
A required	A available	A_1	A_2	A_3	A_5	A welds	t_{req}	t_{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2574	0.4675

UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg_{41})	0.25	0.2625	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

P.I. (N5)

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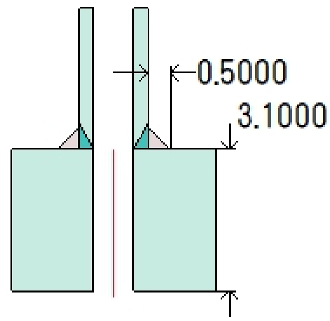	
Note: round inside edges per UG-76(c)	
Location and Orientation	
Located on	Hemi Head #1
Orientation	270°
End of nozzle to datum line	20.9541"
Calculated as hillside	No
Distance to head center, R	18.5"
Passes through a Category A joint	No
Nozzle	
Description	NPS 0.5 Class 6000 - threaded
Access opening	No
Material specification	SA-105 (II-D p. 18, ln. 19)
Inside diameter, new	0.84"
Nominal wall thickness	0.33"
Corrosion allowance	0"
Projection available outside vessel, Lpr	1.5"
Local vessel minimum thickness	3.1"
Liquid static head included	0.52 psi
Longitudinal joint efficiency	1
Welds	
Inner fillet, Leg_{41}	0.5"

UCS-66 Material Toughness Requirements Nozzle	
Governing thickness, t_g =	0.33"
Exemption temperature from Fig UCS-66 Curve B =	-20°F
t_r = 5,000.52*0.42 / (20,000*1 - 0.6*5,000.52) =	0.1235"
Stress ratio = t_r*E* / (t_n - c) = 0.1235*1 / (0.33 - 0) =	0.3744
Reduction in MDMT, T_R from Fig UCS-66.1 =	113.6°F
Reduction in MDMT, T_{PWHT} from UCS-68(c) =	30°F
MDMT = max[MDMT - T_R - T_{PWHT}, -55] = max[-20 - 113.6 - 30 , -55] =	-55°F
Material is exempt from impact testing at the Design MDMT of -20°F.	

Reinforcement Calculations for MAWP

The vessel wall thickness governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in^2)							UG-44 Summary (in)	
For P = 5,036.56 psi @ 200 °F							The nozzle passes UG-44	
A required	A available	A_1	A_2	A_3	A_5	A welds	t_{req}	t_{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1716	0.33

UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg_{41})	0.231	0.35	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

Reinforcement Calculations for MAP

The vessel wall thickness governs the MAP of this nozzle.

<table>
<tr><th colspan="7">UG-37 Area Calculation Summary (in^2)</th><th colspan="2">UG-44 Summary (in)</th></tr>
<tr><td colspan="7">For P = 5,036.56 psi @ 70 °F</td><td colspan="2">The nozzle passes UG-44</td></tr>
<tr><td>A required</td><td>A available</td><td>A_1</td><td>A_2</td><td>A_3</td><td>A_5</td><td>A welds</td><td>t_{req}</td><td>t_{min}</td></tr>
<tr><td colspan="7">This nozzle is exempt from area calculations per UG-36(c)(3)(a)</td><td>0.1716</td><td>0.33</td></tr>
</table>

UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg_{41})	0.231	0.35	weld size is adequate

This opening does not require reinforcement per UG-36(c)(3)(a)

Support Lugs #1

Inputs	
Support material	
This support is attached to	Hemi Head #2
Distance from baseplate to datum	-3.875"
Lug allowable stress, S_b	50,000 psi
Shell to center of load bearing area, d	5"
Lug length, circumferential direction, L	8"
Lug attachment fillet weld size	0.75"
Radial/bending lug stiffness ratio	3
Number of support lugs	4
Local Shell	
Outer Diameter	54.2"
Thickness	3.1"
Inner Corrosion	0"
Outer Corrosion	0"
Top Plate	
Width, W_p	8"
Thickness, t_a	1"
Base Plate	
Width, b	10"
Thickness, t_b	1"
Load Bearing Width, L_b	6.5"
Gusset	
Height, h	6.5"
Thickness, t_g	0.75"
Separation, L_g	4.5"
Anchor Bolts	
Anchor bolt size	0.375" coarse threaded
Anchor bolt material	
Bolt circle, BC	62.5"
Anchor bolts/lug, n	1
Anchor bolt allowable stress, S_b	20,000 psi
Anchor bolt corrosion allowance	0"

Anchor bolt hole clearance	0.375"

Stresses in Shell at Lug Supports													
Condition	Total Weight (lb)	Shear V (lb_f)	Moment M (lb_f-ft)	Lug orient	Lug Loading						Stress in Shell (psi)		
					W (lb)	P_r (lb_f)	V_L (lb_f)	M_L (lb_f-ft)	V_c (lb_f)	M_c (lb_f-ft)	Primary Circ (P_L)	Primary Long (P_L)	Combined P_L+P_b+Q
Weight, operating Attack angle = 0°	10,016	0	657	0°	2,504	0	2,627	1,094.48	0	0.00	38,745	19,368	38,851
				90°	2,504	0	2,504	1,043.30	0	0.00	38,744	19,368	38,845
				180°	2,504	0	2,627	1,094.48	0	0.00	38,745	19,368	38,851
				270°	2,504	0	2,504	1,043.30	0	0.00	38,744	19,368	38,845
Weight, operating Attack angle = 45°	10,016	0	657	0°	2,504	0	2,591	1,079.49	0	0.00	38,745	19,368	38,850
				90°	2,504	0	2,591	1,079.49	0	0.00	38,745	19,368	38,850
				180°	2,504	0	2,591	1,079.49	0	0.00	38,745	19,368	38,850
				270°	2,504	0	2,591	1,079.49	0	0.00	38,745	19,368	38,850
Weight, operating, new Attack angle = 0°	10,016	0	657	0°	2,504	0	2,627	1,094.48	0	0.00	38,745	19,368	38,851
				90°	2,504	0	2,504	1,043.30	0	0.00	38,744	19,368	38,845
				180°	2,504	0	2,627	1,094.48	0	0.00	38,745	19,368	38,851
				270°	2,504	0	2,504	1,043.30	0	0.00	38,744	19,368	38,845
Weight, operating, new Attack angle = 45°	10,016	0	657	0°	2,504	0	2,591	1,079.49	0	0.00	38,745	19,368	38,850
				90°	2,504	0	2,591	1,079.49	0	0.00	38,745	19,368	38,850
				180°	2,504	0	2,591	1,079.49	0	0.00	38,745	19,368	38,850
				270°	2,504	0	2,591	1,079.49	0	0.00	38,745	19,368	38,850
Weight, empty, new Attack angle = 0°	7,915	0	657	0°	1,979	0	2,102	875.72	0	0.00	-21	-6	-130
				90°	1,979	0	1,979	824.53	0	0.00	-20	-6	-122
				180°	1,979	0	2,102	875.72	0	0.00	-21	-6	-130
				270°	1,979	0	1,979	824.53	0	0.00	-20	-6	-122
Weight, empty, new Attack angle = 45°	7,915	0	657	0°	1,979	0	2,066	860.72	0	0.00	-21	-6	-127
				90°	1,979	0	2,066	860.72	0	0.00	-21	-6	-127
				180°	1,979	0	2,066	860.72	0	0.00	-21	-6	-127
				270°	1,979	0	2,066	860.72	0	0.00	-21	-6	-127

Applied Loads (Weight, operating, Attack angle = 0°, lug orientation = 0°)	
Radial load, P_r	0 lb_f
Circumferential moment, M_c	0 lb_f-in
Circumferential shear, V_c	0 lb_f
Longitudinal moment, M_L	13,133.8 lb_f-in
Longitudinal shear, V_L	2,626.76 lb_f
Torsion moment, M_t	0 lb_f-in
Internal pressure, P	5,001.17 psi
Mean shell radius, R_m	25.55"
Local shell thickness, T	3.1"
Design factor	3

Maximum stresses due to the applied loads at the lug edge (includes pressure)

$\gamma = R_m / T = 25.55 / 3.1 = 8.2419$

$C_1 = 4$, $C_2 = 4.25$ in

Local circumferential pressure stress = $P*R_i / T$ =38,719 psi

Local longitudinal pressure stress = $P*R_i / (2*T)$ =19,360 psi

Maximum combined stress (P_L+P_b+Q) = 38,851 psi
Allowable combined stress (P_L+P_b+Q) = ±3*S = ±60,000 psi

The maximum combined stress (P_L+P_b+Q) is within allowable limits.

Maximum local primary membrane stress (P_L) = 38,745 psi
Allowable local primary membrane stress (P_L) = ±1.5*S = ±30,000 psi

WRC 107: The local primary membrane stress (P_L) is excessive

Stresses at the lug edge per WRC Bulletin 107										
Figure	**value**	β	A_u	A_l	B_u	B_l	C_u	C_l	D_u	D_l
3C*	1.3856	0.1674	0	0	0	0	0	0	0	0
4C*	1.5191	0.1639	0	0	0	0	0	0	0	0
1C	0.1526	0.1599	0	0	0	0	0	0	0	0
2C-1	0.1187	0.1599	0	0	0	0	0	0	0	0
3A*	0.1922	0.1598	0	0	0	0	0	0	0	0
1A	0.0991	0.1826	0	0	0	0	0	0	0	0
3B*	0.7371	0.163	-26	-26	26	26	0	0	0	0
1B-1	0.0542	0.1639	-106	106	106	-106	0	0	0	0
Pressure stress*			38,719	38,719	38,719	38,719	38,719	38,719	38,719	38,719
Total circumferential stress			38,587	38,799	38,851	38,639	38,719	38,719	38,719	38,719
Primary membrane circumferential stress*			38,693	38,693	38,745	38,745	38,719	38,719	38,719	38,719
3C*	1.3946	0.1639	0	0	0	0	0	0	0	0
4C*	1.5126	0.1674	0	0	0	0	0	0	0	0
1C-1	0.1509	0.1645	0	0	0	0	0	0	0	0
2C	0.1157	0.1645	0	0	0	0	0	0	0	0
4A*	0.2821	0.1598	0	0	0	0	0	0	0	0
2A	0.059	0.1905	0	0	0	0	0	0	0	0
4B*	0.1984	0.163	-8	-8	8	8	0	0	0	0
2B-1	0.0849	0.1765	-154	154	154	-154	0	0	0	0
Pressure stress*			19,360	19,360	19,360	19,360	19,360	19,360	19,360	19,360
Total longitudinal stress			19,198	19,506	19,522	19,214	19,360	19,360	19,360	19,360
Primary membrane longitudinal stress*			19,352	19,352	19,368	19,368	19,360	19,360	19,360	19,360
Shear from M_t			0	0	0	0	0	0	0	0
Circ shear from V_c			0	0	0	0	0	0	0	0
Long shear from V_L			0	0	0	0	-50	-50	50	50
Total Shear stress			0	0	0	0	-50	-50	50	50
Combined stress (P_L+P_b+Q)			38,587	38,799	38,851	38,639	38,719	38,719	38,719	38,719

* denotes primary stress.

Lug top plate required thickness, Bednar 5.2

$t_a = 0.75*(V_L*d*L)/(S_b*W_p^2*h)$
= 0.75*(2,626.76*5*8)/(50,000*8²*6.5)
= 0.0038 in

To prevent buckling $t_{a(min)}$ = (Top plate width)/12 =0.6667 in.

The top plate thickness of 1 in is adequate.

Gusset plate required thickness, Bednar 5.2

$S_c = 37{,}500 / (1 + (1/37{,}500)*(h/(0.289*t_g))^2)$
$= 37{,}500 / (1 + (1/37{,}500)*(6.5/(0.289*0.75))^2)$
= 36,622 psi

$t_g = V_L*(3*d - b)/(S_c*b^2*(\mathrm{Sin}(\alpha))^2)$
$= 2{,}626.76*(3*5 - 10)/(36{,}622*10^2*(\mathrm{Sin}(72.897))^2)$
= 0.0039 in

The gusset thickness of 0.75 in is adequate.

Lug base plate required thickness

From Escoe table 4-8 (l/b = 2.2222)

$C_x = 0.13144$, $C_y = -0.125$

$f_c = V_L/(L_b*L)$
= 2,626.76/(6.5*8)
= 51 psi

$M_x = C_x*f_c*L_g^2$
$= 0.13144*51*4.5^2$
= 134.45 in-lb_f/in

$M_y = C_y*f_c*L_b^2$
$= -0.125*51*6.5^2$
= -266.78 in-lb_f/in

$M = \mathrm{Max}[\mathrm{Abs}(M_x), \mathrm{Abs}(M_y)]$
= Max[Abs(134.45), Abs(-266.78)]
= 266.78 in-lb_f/in

$t_b = \mathrm{Sqr}(6*M / S_b)$
= Sqr(6*266.8 / 50,000)
= 0.1789 in

The base plate thickness of 1 in is adequate.

Support Lug to Shell Fillet Weld Sizing - Bednar chapters 5.2 and 10.3

Note: continuous welding is assumed for all support lug fillet welds.

$d_h = t_a + h + t_b$

$L_w = 2*(b + d_h) = 2*(8 + 8.5) = 33$ in

$Z_w = b*d_h + d_h^2/3 = 8*8.5 + 8.5^2/3 = 92.08\ in^2$
$Z_z = d_h*b + b^2/3 = 8.5*8 + 8^2/3 = 89.33\ in^2$

Shear $f_1 = V_L/L_w$ = 2,626.76/33 = 80 lb_f/in
Shear $f_2 = V_c/L_w$ = 0/33 = 0 lb_f/in
Bending f_3 = larger absolute value of M_L/Z_w or M_c/Z_z
= M_L/Z_w
= 13,133.8/92.08
= 142.63 lb_f/in

Resultant load $f = (f_1^2 + f_2^2 + f_3^2)^{1/2}$

$= (79.6^2 + 0^2 + 142.63^2)^{1/2}$
= 163.34 lb_f/in

Required weld size $w = F/(0.707*0.55*S_a)$

= 163.34/(0.707*0.55*20,000)
= 0.021 in

The support lug fillet weld size of 0.75 in is adequate.

Anchor bolts - Weight empty new condition governs

Tensile loading per lug (1 bolt per lug)

R = 48*M / (N*BC) - W / N
= 48*657.2 / (4*62.5) - 7,915.48 / 4
= -1,852.68 lb_f
There is no net uplift (R is negative).

0.375" coarse threaded bolts are satisfactory.

Liquid Level bounded by Hemi Head #2

ASME Section VIII Division 1, 2017 Edition	
Location from Datum (in)	31.6948
Operating Liquid Specific Gravity	1

PSV (N4A): FEA Results

Results were generated with the finite element program FE/Pipe&#174. Stress results are post-processed in accordance with the rules specified in ASME Section III and ASME Section VIII, Division 2.

Analysis Time Stamp: Wed Feb 06 13:44:41 2019.

```
Model Notes
Model Notes

  Input Echo:

  Model Type                   : Hemispherical Head

  Parent Geometry
         Parent Outside Diam.   :      54.200 in.
         Thickness              :       3.100 in.
         Attached Shell Length  :       0.063 in.
         Attached Shell Thick   :       7.250 in.
         Shell Transition Length:      12.450 in.
         Shell Transition SCF   :       0.000 in.
         Fillet Along Shell     :       0.375 in.

  Parent Properties:
         Cold Allowable         :     20000.0 psi
         Hot  Allowable         :     20000.0 psi
         Material ID #2         :  Low Alloy Steel
         Ultimate Tensile (Amb) :     70000.0 psi
         Yield Strength (Amb)   :     38000.0 psi
         Yield Strength (Hot)   :     34800.0 psi
         Elastic Modulus (Amb)  :  29400000.0 psi
         Poissons Ratio         :       0.300
         Weight Density         :  0.2830E+00 lb./cu.in.

  Nozzle Geometry
         Nozzle Outside Diam.   :       2.250 in.
         Thickness              :       0.468 in.
         Length                 :       3.090 in.
         Nozzle Weld Length     :       0.375 in.
         Location perpendicular
         to the head centerline :      18.480 in.

         Nozzle Tilt Angle      :      42.994 deg.

  Nozzle Properties
         Cold Allowable         :     20000.0 psi
         Hot  Allowable         :     20000.0 psi
         Material ID #2         :  Low Alloy Steel
         Ultimate Tensile (Amb) :     70000.0 psi
         Yield Strength (Amb)   :     36000.0 psi
```

```
      Yield Strength (Hot)    :     33000.0 psi
      Elastic Modulus (Amb)   :  29200000.0 psi
      Poissons Ratio          :       0.300
      Weight Density          :  0.2830E+00 lb./cu.in.

Design Operating Cycles       :          0.
Ambient Temperature (Deg.)    :       70.00

Uniform thermal expansion produces no stress in this geometry.
Any thermal loads will come through operating forces and
moments applied through the nozzle.

Nozzle Inside  Temperature    :      200.00 deg.
Nozzle Outside Temperature    :      200.00 deg.
Vessel Inside  Temperature    :      200.00 deg.
Vessel Outside Temperature    :      200.00 deg.

Nozzle Pressure               :      5000.0 psi
Vessel Pressure               :      5000.0 psi



FEA Model Loads:
Loads are given at the Nozzle/Header Junction
Loads are defined in Global Coordinates

Forces( lb.)  Moments (ft-lb)

Load Case        FX          FY          FZ          MX          MY          MZ
---------------------------------------------------------------------------
 WEIGHT:      524.5       582.1      -242.9       -60.0        81.5      -480.0
   OPER:      524.5       582.1      -242.9       -60.0        81.5      -480.0

Stresses are NOT averaged.

Vessel Centerline       Vector:  0.000   1.000   0.000
Nozzle Centerline       Vector:  0.000   1.000   0.000
Zero Degree Orientation Vector:  1.000   0.000   0.000

Nozzle Orientation Angle      :135.000
```

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```
Load Case Report
FE/Pipe Version 10.0          Jobname: PSV                     $P
Released Nov 2017             1:44pm   FEB  6,2019



Load Case Report                                       $X

Inner and outer element temperatures are the same
throughout the model.  No thermal ratcheting
calculations will be performed.

THE   9  LOAD CASES ANALYZED ARE:

  1   WEIGHT ONLY    (Wgt Only)

      Weight ONLY case run to get the stress range
      between the installed and the operating states.

      /-------- Loads in Case   1
        Loads due to Weight

  2   SUSTAINED      (Wgt+Pr)
```

```
     Sustained case run to satisfy local primary
     membrane and bending stress limits.

     /-------- Loads in Case   2
       Loads due to Weight
       Pressure Case    1

 3   OPERATING

     Case run to compute the operating stresses used in
     secondary, peak and range calculations as needed.

     /-------- Loads in Case   3
       Pressure Case    1
       Loads from (Operating)

 4   RANGE          (Fatigue Calc Performed)

     Case run to get the RANGE of stresses.
     as described in NB-3222.2, 5.5.3.2, 5.5.5.2 or 5.5.6.1.

     /-------- Combinations in Range Case   4
       Plus  Stress Results from CASE   3
       Minus Stress Results from CASE   1

 5   Program Generated -- Force Only

     Case run to compute sif's and flexibilities.
     /-------- Loads in Case   5
       Loads from (Axial)

 6   Program Generated -- Force Only

     Case run to compute sif's and flexibilities.
     /-------- Loads in Case   6
       Loads from (Inplane)

 7   Program Generated -- Force Only

     Case run to compute sif's and flexibilities.
     /-------- Loads in Case   7
       Loads from (Outplane)

 8   Program Generated -- Force Only

     Case run to compute sif's and flexibilities.
     /-------- Loads in Case   8
       Loads from (Torsion)

 9   Program Generated -- Force Only

     Case run to compute sif's and flexibilities.
     /-------- Loads in Case   9
       Pressure Case    1
```

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Solution Data

Maximum Solution Row Size = 1158
Number of Nodes = 3301
Number of Elements = 1108
Number of Solution Cases = 8

Summation of Loads per Case

Case #	FX	FY	FZ
1	524.	-6833.	-243.
2	528.	10247333.	-239.
3	528.	10247333.	-239.
4	-25247.	38297.	-25247.
5	0.	0.	0.
6	0.	0.	0.
7	0.	0.	0.
8	4.	10254166.	4.

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ASME Code Stress Output Plots
FE/Pipe Version 10.0 Jobname: PSV $P
Released Nov 2017 1:44pm FEB 6,2019

ASME Code Stress Output Plots $X

1) Pl <(1.5)(S) (SUS,Membrane) Case 2

2) Qb <SPS (SUS,Bending) Case 2

3) S1+S2+S3 <4S (SUS,S1+S2+S3) Case 2

4) Pl+Pb+Q <SPS (OPE,Inside) Case 3

5) Pl+Pb+Q <SPS (OPE,Outside) Case 3

6) Membrane <User (OPE,Membrane) Case 3

7) Bending <User (OPE,Bending) Case 3

8) Pl+Pb+Q+F <Sa (SIF,Outside) Case 5

9) Pl+Pb+Q+F <Sa (SIF,Outside) Case 6

10) Pl+Pb+Q+F <Sa (SIF,Outside) Case 7

11) Pl+Pb+Q+F <Sa (SIF,Outside) Case 8

12) Pl+Pb+Q+F <Sa (SIF,Outside) Case 9

13) Pl+Pb+Q <SPS (EXP,Inside) Case 4

14) Pl+Pb+Q <SPS (EXP,Outside) Case 4

15) Pl+Pb+Q+F <Sa (EXP,Inside) Case 4

16) Pl+Pb+Q+F <Sa (EXP,Outside) Case 4

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```
Stress Results - Notes
FE/Pipe Version 10.0          Jobname: PSV                    $P
Released Nov 2017             1:44pm   FEB  6,2019



Stress Results - Notes


- Results  in  this  analysis  were  generated using the finite
  element solution method.

- Using 07-12 ASME Section VIII Division 2

- Use Polished Bar fatigue curve.

  Assume pressure increases all other stresses.

- Assume free end displacements of attached pipe
  (e.g. thermal loads) are secondary within the limits
  of nozzle reinforcement.

- Use Equivalent Stress (Von Mises).

- S1+S2+S3 evaluation omitted from operating stress.
  Include S1+S2+S3 evaluation in primary case evaluation.
  Assume bending stress not local primary for S1+S2+S3.

- Use local tensor values for averaged and not
  averaged stresses.
```

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```
ASME Overstressed Areas
FE/Pipe Version 10.0          Jobname: PSV                    $P
Released Nov 2017             1:44pm   FEB  6,2019



ASME Overstressed Areas                                 $X


             *** NO OVERSTRESSED NODES IN THIS MODEL ***
```

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```
Highest Primary Stress Ratios
FE/Pipe Version 10.0          Jobname: PSV                    $P
Released Nov 2017             1:44pm   FEB  6,2019



Highest Primary Stress Ratios                           $X


Shell Next to Nozzle 1
```

```
      Pl        (1.5)(S)     Primary Membrane Load Case 2
  21,265          30,000     Plot Reference:
     psi             psi     1) Pl <(1.5)(S) (SUS,Membrane) Case 2

            70%
```

Nozzle 1 Next to Shell

```
      Pl        (1.5)(S)     Primary Membrane Load Case 2
  22,114          30,000     Plot Reference:
     psi             psi     1) Pl  <(1.5)(S) (SUS,Membrane) Case 2

            73%
```

Shell In Nozzle 1 Vicinity

```
      Pl        (1.5)(S)     Primary Membrane Load Case 2
  21,362          30,000     Plot Reference:
     psi             psi     1) Pl  <(1.5)(S) (SUS,Membrane) Case 2

            71%
```

Nozzle 1

```
      Pl        (1.5)(S)     Primary Membrane Load Case 2
   9,758          30,000     Plot Reference:
     psi             psi     1) Pl  <(1.5)(S) (SUS,Membrane) Case 2

            32%
```

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```
Highest Secondary Stress Ratios
FE/Pipe Version 10.0          Jobname: PSV                  $P
Released Nov 2017             1:44pm   FEB  6,2019
```

Highest Secondary Stress Ratios $X

Shell Next to Nozzle 1

```
  Pl+Pb+Q            SPS     Primary+Secondary (Inner) Load Case 4
  30,010          72,800     Plot Reference:
     psi             psi     13) Pl+Pb+Q <SPS (EXP,Inside) Case 4

            41%
```

Nozzle 1 Next to Shell

```
  Pl+Pb+Q            SPS     Primary+Secondary (Inner) Load Case 3
  52,016          69,000     Plot Reference:
     psi             psi     4) Pl+Pb+Q  <SPS (OPE,Inside) Case 3

            75%
```

Shell In Nozzle 1 Vicinity

```
  Pl+Pb+Q            SPS     Primary+Secondary (Inner) Load Case 3
```

```
   24,510         72,800     Plot Reference:
      psi            psi     4) Pl+Pb+Q  <SPS (OPE,Inside) Case 3

            33%


Nozzle 1

  Pl+Pb+Q            SPS     Primary+Secondary (Inner) Load Case 3
   14,514         69,000     Plot Reference:
      psi            psi     4) Pl+Pb+Q  <SPS (OPE,Inside) Case 3

            21%
```

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```
Highest Fatigue Stress Ratios
FE/Pipe Version 10.0          Jobname: PSV                    $P
Released Nov 2017             1:44pm   FEB  6,2019



Highest Fatigue Stress Ratios                          $X


Shell Next to Nozzle 1

Pl+Pb+Q+F     Damage Ratio    Primary+Secondary+Peak (Inner) Load Case 4
   20,256      0.000 Life     Stress Concentration Factor = 1.350
      psi      0.011 Stress   Strain Concentration Factor = 1.000
                              Cycles Allowed for this Stress = 84,926.
Allowable                     "B31" Fatigue Stress Allowable = 50000.0
1,799,215                     Markl Fatigue Stress Allowable = 245000.0
      psi                     WRC 474 Mean Cycles to Failure = 147,762.
                              WRC 474 99% Probability Cycles = 34,327.
       1%                     WRC 474 95% Probability Cycles = 47,660.
                              BS5500 Allowed Cycles(Curve F) = 30,062.
                              Membrane-to-Bending Ratio = 1.771
                              Bending-to-PL+PB+Q Ratio = 0.361
                              Plot Reference:
                              15) Pl+Pb+Q+F <Sa (EXP,Inside) Case 4


Nozzle 1 Next to Shell

Pl+Pb+Q+F     Damage Ratio    Primary+Secondary+Peak (Inner) Load Case 4
   33,699      0.000 Life     Stress Concentration Factor = 1.350
      psi      0.019 Stress   Strain Concentration Factor = 1.000
                              Cycles Allowed for this Stress = 14,236.
Allowable                     "B31" Fatigue Stress Allowable = 50000.0
1,786,975                     Markl Fatigue Stress Allowable = 245000.0
      psi                     WRC 474 Mean Cycles to Failure = 121,657.
                              WRC 474 99% Probability Cycles = 28,263.
       1%                     WRC 474 95% Probability Cycles = 39,240.
                              BS5500 Allowed Cycles(Curve F) = 17,342.
                              Membrane-to-Bending Ratio = 0.525
                              Bending-to-PL+PB+Q Ratio = 0.656
                              Plot Reference:
                              15) Pl+Pb+Q+F  <Sa (EXP,Inside) Case 4


Shell In Nozzle 1 Vicinity

Pl+Pb+Q+F     Damage Ratio    Primary+Secondary+Peak (Inner) Load Case 4
   12,248      0.000 Life     Stress Concentration Factor = 1.000
```

```
      psi     0.007 Stress    Strain Concentration Factor = 1.000
                              Cycles Allowed for this Stress = 1,003,911.
Allowable                     "B31" Fatigue Stress Allowable = 50000.0
1,799,215                     Markl Fatigue Stress Allowable = 245000.0
      psi                     WRC 474 Mean Cycles to Failure = 271,572.
                              WRC 474 99% Probability Cycles = 63,090.
       0%                     WRC 474 95% Probability Cycles = 87,593.
                              BS5500 Allowed Cycles(Curve F) = 55,277.
                              Membrane-to-Bending Ratio = 6.423
                              Bending-to-PL+PB+Q Ratio = 0.135
                              Plot Reference:
                              15) Pl+Pb+Q+F  <Sa (EXP,Inside) Case 4
```

Nozzle 1

```
Pl+Pb+Q+F    Damage Ratio    Primary+Secondary+Peak (Inner) Load Case 4
    5,965     0.000 Life     Stress Concentration Factor = 1.000
      psi     0.003 Stress   Strain Concentration Factor = 1.000
                             Cycles Allowed for this Stress = 1.0000E11
Allowable                    "B31" Fatigue Stress Allowable = 50000.0
1,786,975                    Markl Fatigue Stress Allowable = 245000.0
      psi                    WRC 474 Mean Cycles to Failure = 9,854,857.
                             WRC 474 99% Probability Cycles = 2,289,416.
       0%                    WRC 474 95% Probability Cycles = 3,178,612.
                             BS5500 Allowed Cycles(Curve F) = 1,270,589.
                             Membrane-to-Bending Ratio = 1.070
                             Bending-to-PL+PB+Q Ratio = 0.483
                             Plot Reference:
                             15) Pl+Pb+Q+F  <Sa (EXP,Inside) Case 4
```

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Stress Intensification Factors

```
FE/Pipe Version 10.0        Jobname: PSV                 $P
Released Nov 2017           1:44pm   FEB  6,2019
```

Stress Intensification Factors $X

Branch/Nozzle Sif Summary

	Peak	Primary	Secondary	SSI
Axial :	0.893	1.016	1.322	0.974
Inplane :	0.892	0.809	1.322	0.963
Outplane:	0.889	0.805	1.318	0.973
Torsion :	1.177	0.968	1.744	1.085
Pressure:	0.771	0.489	1.142	0.942

The above stress intensification factors are to be used in a beam-type analysis of the piping system. Inplane, Outplane and Torsional sif's should be used with the matching branch pipe whose diameter and thickness is given below. The axial sif should be used to intensify the axial stress in the branch pipe calculated by F/A. The pressure sif should be used to intensify the nominal pressure stress in the PARENT or HEADER, calculated from PDo/2T. B31 calculations use mean diameters and Section VIII calculations use outside diameters. SSIs are based on peak stress factors and correlated test results.

```
Pipe OD :        2.250  in.
Pipe Thk:        0.468  in.
```

```
Z approx:        1.167  cu.in.
Z exact :        0.988  cu.in.

  (SSI = SIF^x)        Axial   Inpl    Outpl   Tors    Pres
SIF/SSI Exponents:    -0.137   1.861   1.848  -0.197   2.754

SIF/SSI exponent based on relationship between primary and
peak stress factors from the finite element analysis.

B31.3 Branch Pressure i-factor =        7.071
      Header Pressure i-factor =        1.635

The B31.3 pressure i-factors should be used with with
F/A, where F is the axial force due to pressure, and
A is the area of the pipe wall. This is equivalent to
finding the pressure stress from (ip)(PD/4T).

B31.3   (Branch)
Peak Stress Sif ....    0.000         Axial
                        1.000         Inplane
                        1.000         Outplane
                        1.000         Torsional
B31.1  (Branch)
Peak Stress Sif ....    0.000         Axial
                        1.000         Inplane
                        1.000         Outplane
                        1.000         Torsional
WRC 330  (Branch)
Peak Stress Sif ....    0.000         Axial
                        1.000         Inplane
                        1.500         Outplane
                        1.000         Torsional
```

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```
Allowable Loads
FE/Pipe Version 10.0          Jobname: PSV                      $P
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Allowable Loads                                           $X
```

SECONDARY Load Type (Range):	Maximum Individual Occuring	Conservative Simultaneous Occuring	Realistic Simultaneous Occuring
Axial Force (lb.)	136589.	15247.	22870.
Inplane Moment (in. lb.)	51551.	5603.	11886.
Outplane Moment (in. lb.)	51726.	5622.	11927.
Torsional Moment (in. lb.)	39088.	3602.	5403.
Pressure (psi)	6910.47	5000.00	5000.00

PRIMARY Load Type:	Maximum Individual Occuring	Conservative Simultaneous Occuring	Realistic Simultaneous Occuring
Axial Force (lb.)	77325.	8280.	12420.
Inplane Moment (in. lb.)	36622.	2773.	5882.
Outplane Moment (in. lb.)	36797.	2786.	5911.
Torsional Moment (in. lb.)	30599.	3277.	4915.
Pressure (psi)	7024.01	5000.00	5000.00

NOTES:

1) Maximum Individual Occuring Loads are the maximum allowed values of the respective loads if all other load components are zero, i.e. the listed axial force may be applied if the inplane, outplane and torsional moments, and the pressure are zero.

2) The Conservative Allowable Simultaneous loads are the maximum loads that can be applied simultaneously. A conservative stress combination equation is used that typically produces stresses within 50-70% of the allowable stress.

3) The Realistic Allowable Simultaneous loads are the maximum loads that can be applied simultaneously. A more realistic stress combination equation is used based on experience at Paulin Research. Stresses are typically produced within 80-105% of the allowable.

4) Secondary allowable loads are limits for expansion and operating piping loads.

5) Primary allowable loads are limits for weight, primary and sustained type piping loads.

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```
Flexibilities
FE/Pipe Version 10.0          Jobname: PSV                  $P
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Flexibilities                                         $X


  The following stiffnesses should be used in a piping,
  "beam-type" analysis of the intersection.  The stiff-
  nesses should be inserted at the surface of the
  branch/header or nozzle/vessel junction.  The general
  characteristics used for the branch pipe should be:

  Outside Diameter =    2.250  in.
  Wall Thickness   =    0.468  in.

  Axial Translational Stiffness   =      32297196.  lb./in.

  The following stiffness(es) were not generated because
  of errors in input or because the finite element model
  is stiffer than the piping model.

  Inplane Rotational Stiffness
  Outplane Rotational Stiffness
  Torsional Rotational Stiffness


  Intersection Flexibility Factors for Branch/Nozzle

  Find axial stiffness: K = 3EI/(kd)^3  lb./in.
  Find bending and torsional stiffnesses: K = EI/(kd)  in.lb.per radian.
  The EI product is   0.32671E+08   lb.in.^2
  The value of (d) to use is:   1.783  in..
  The resulting bending stiffness is in units of force x length per radian.

  Axial Flexibility Factor     (k) =     0.812
```

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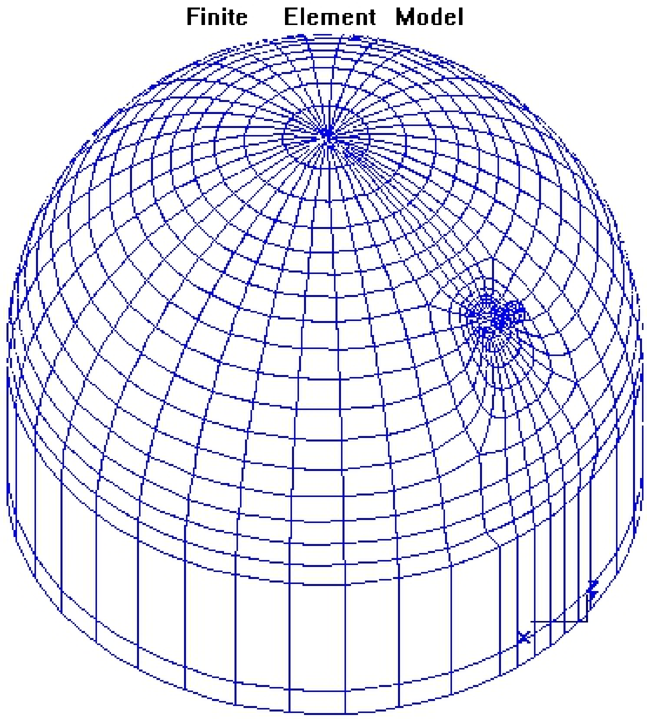
Finite Element Model

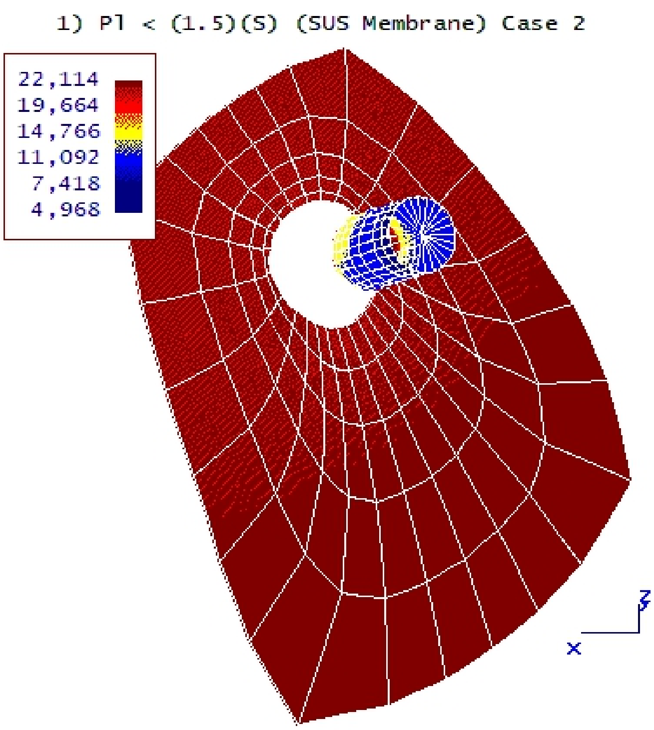
- Finite Element Model

Area of Discontinuity at Nozzle

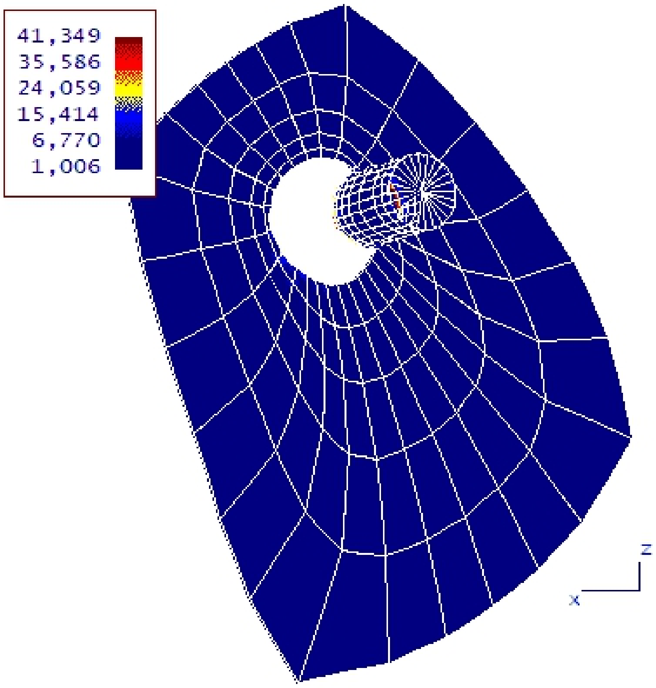
- 1) Pl < (1.5)(S) (SUS Membrane) Case 2
- 2) Qb < SPS (SUS Bending) Case 2
- 3) S1+S2+S3 < 4S (SUS S1+S2+S3) Case 2
- 4) Pl+Pb+Q < SPS (OPE Inside) Case 3
- 5) Pl+Pb+Q < SPS (OPE Outside) Case 3
- 6) Membrane < User (OPE Membrane) Case 3
- 7) Bending < User (OPE Bending) Case 3
- 13) Pl+Pb+Q < SPS (EXP Inside) Case 4
- 14) Pl+Pb+Q < SPS (EXP Outside) Case 4
- 15) Pl+Pb+Q+F < Sa (EXP Inside) Case 4
- 16) Pl+Pb+Q+F < Sa (EXP Outside) Case 4
- 8) Pl+Pb+Q+F < Sa (SIF Outside) Case 5
- 9) Pl+Pb+Q+F < Sa (SIF Outside) Case 6
- 10) Pl+Pb+Q+F < Sa (SIF Outside) Case 7
- 11) Pl+Pb+Q+F < Sa (SIF Outside) Case 8
- 12) Pl+Pb+Q+F < Sa (SIF Outside) Case 9

Tabular Results

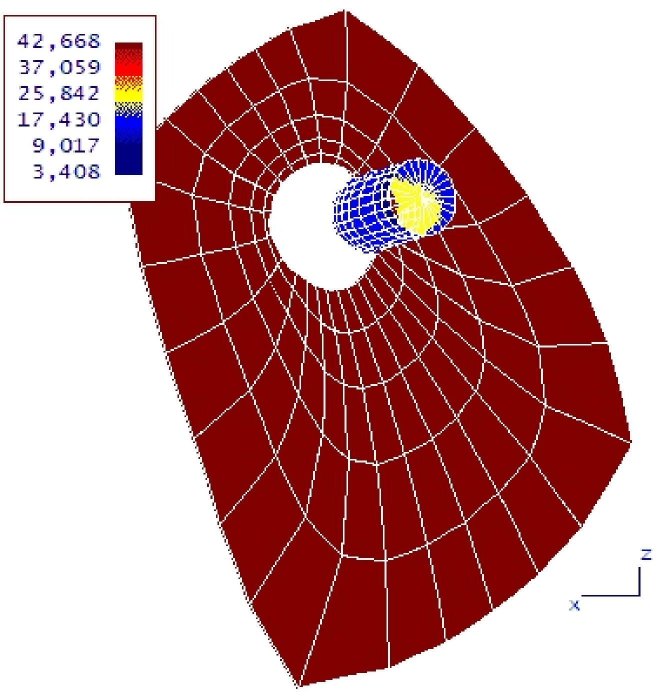

Finite Element Model
Z
X


1) Pl < (1.5)(S) (SUS Membrane) Case 2
22,114
19,664
14,766
11,092
7,418
4,968
Z
X

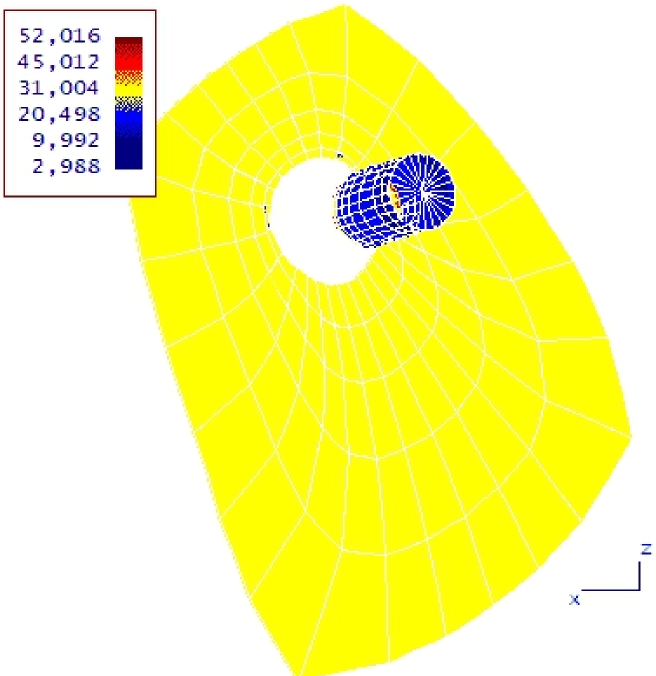
2) Qb < SPS (SUS Bending) Case 2



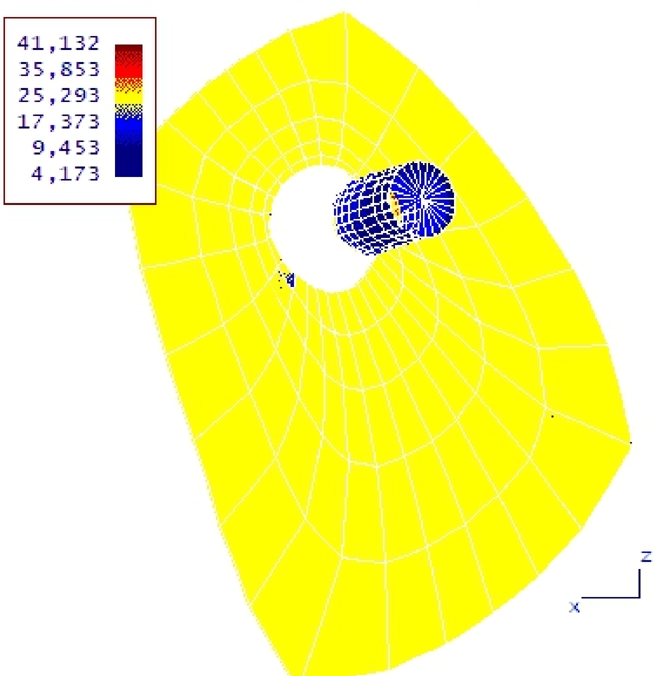
3) S1+S2+S3 < 4S (SUS S1+S2+S3) Case 2



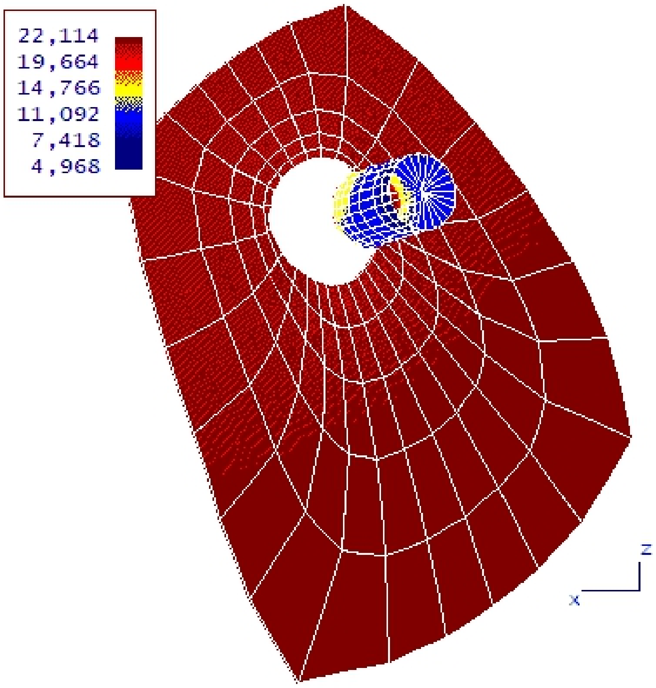
4) Pl+Pb+Q < SPS (OPE Inside) Case 3



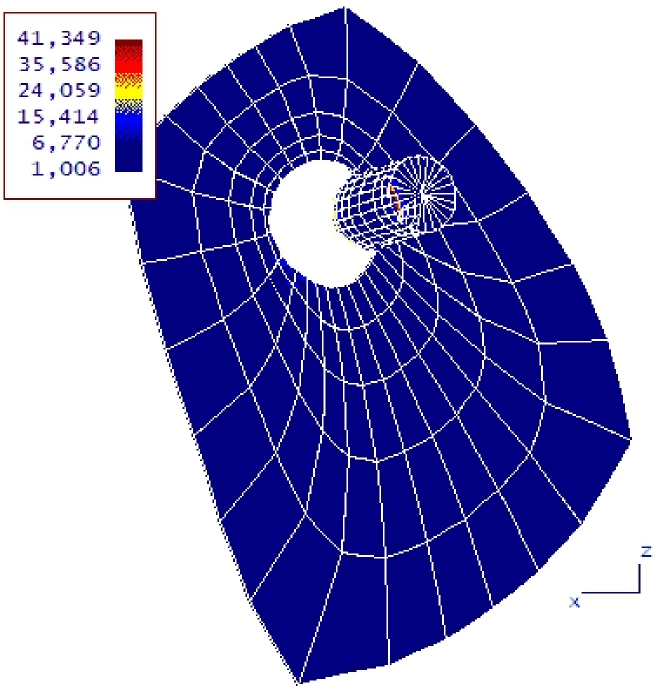
5) Pl+Pb+Q < SPS (OPE Outside) Case 3



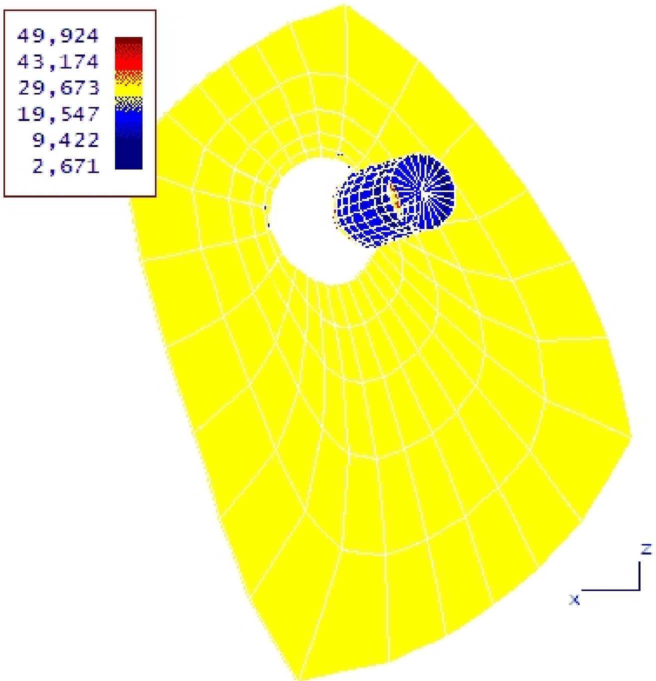
6) Membrane < User (OPE Membrane) Case 3



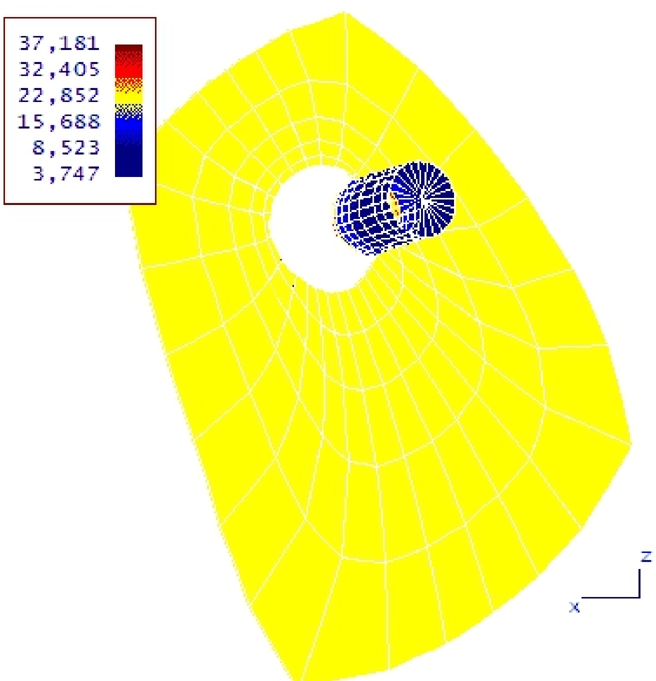
7) Bending < User (OPE Bending) Case 3



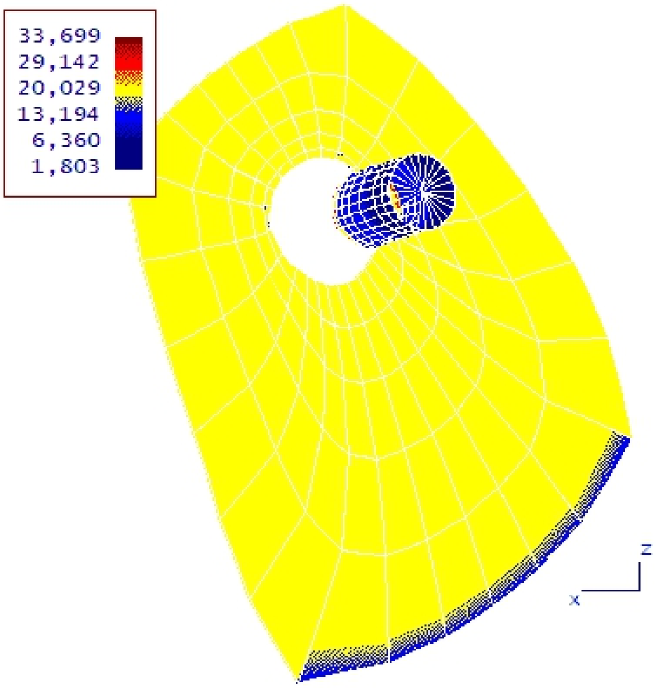
13) Pl+Pb+Q < SPS (EXP Inside) Case 4



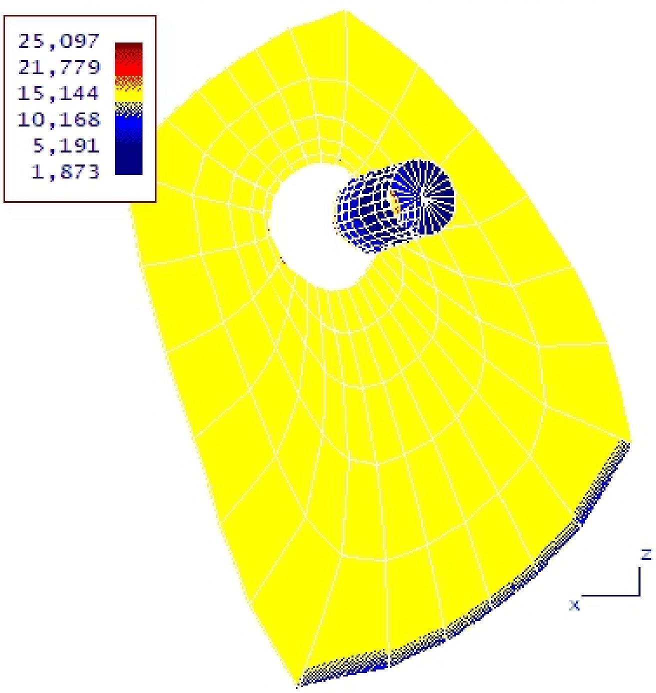
14) Pl+Pb+Q < SPS (EXP Outside) Case 4



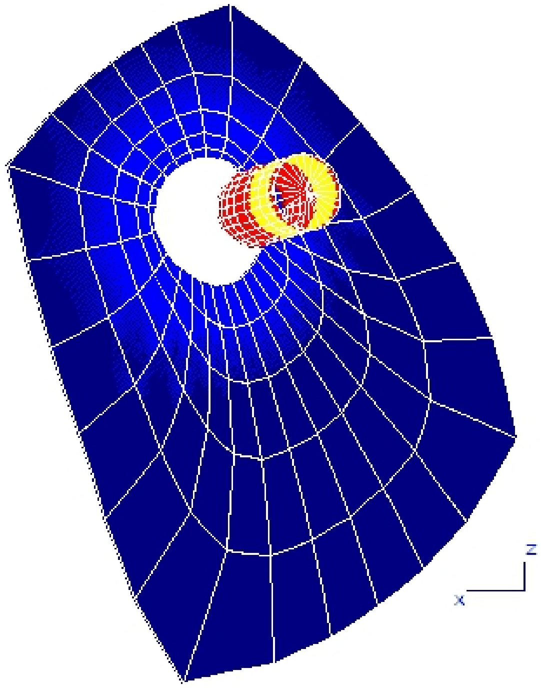
15) Pl+Pb+Q+F < Sa (EXP Inside) Case 4



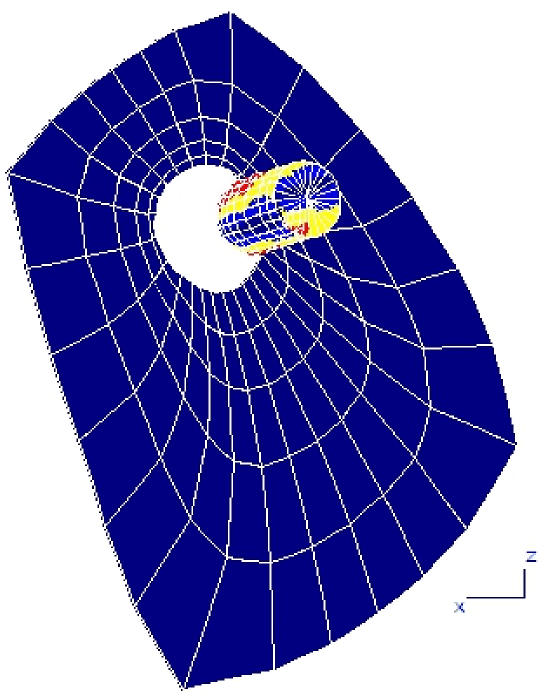
16) Pl+Pb+Q+F < Sa (EXP Outside) Case 4



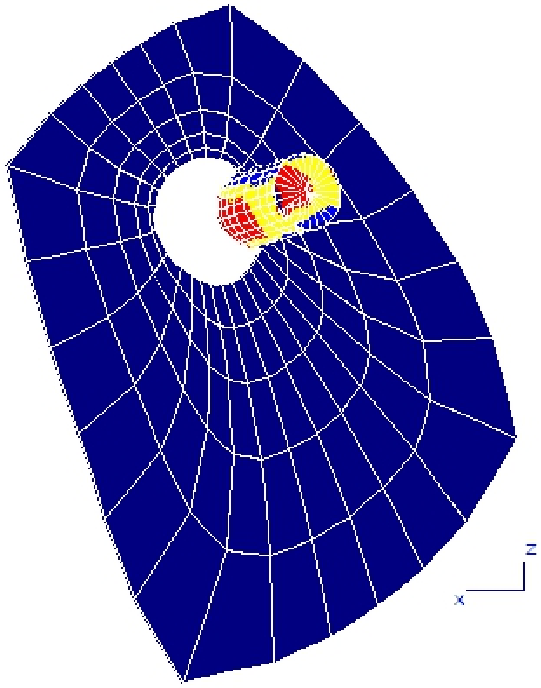
8) Pl+Pb+Q+F < Sa (SIF Outside) Case 5



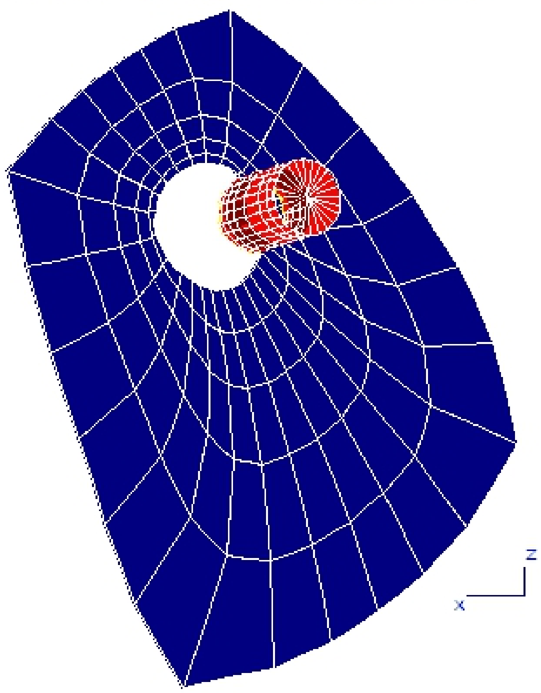
9) Pl+Pb+Q+F < Sa (SIF Outside) Case 6



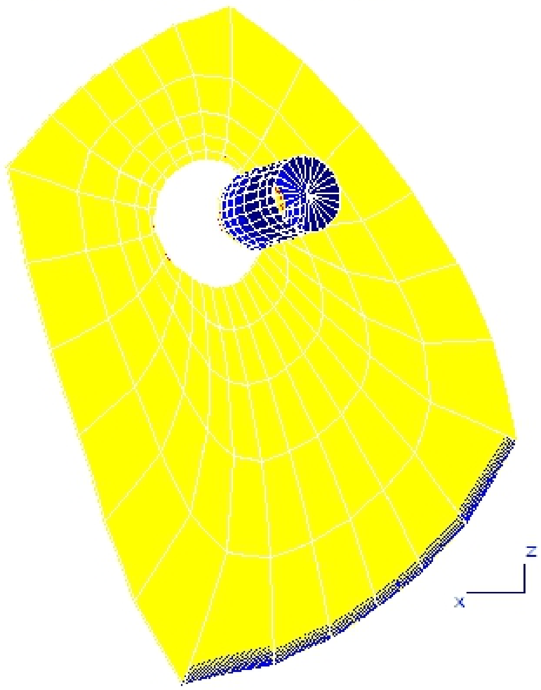
10) Pl+Pb+Q+F < Sa (SIF Outside) Case 7



11) Pl+Pb+Q+F < Sa (SIF Outside) Case 8



12) Pl+Pb+Q+F < Sa (SIF Outside) Case 9



P.I. (N5): FEA Results

Results were generated with the finite element program FE/Pipe&#174. Stress results are post-processed in accordance with the rules specified in ASME Section III and ASME Section VIII, Division 2.

Analysis Time Stamp: Wed Feb 06 13:44:45 2019.

```
 Model Notes
 Model Notes

   Input Echo:

   Model Type                    : Hemispherical Head

   Parent Geometry
          Parent Outside Diam.   :      54.200 in.
          Thickness              :       3.100 in.
          Attached Shell Length  :       0.063 in.
          Attached Shell Thick   :       7.250 in.
          Shell Transition Length:      12.450 in.
          Shell Transition SCF   :       0.000 in.
          Fillet Along Shell     :       0.500 in.

   Parent Properties:
          Cold Allowable         :     20000.0 psi
          Hot  Allowable         :     20000.0 psi
          Material ID #2         :  Low Alloy Steel
          Ultimate Tensile (Amb) :     70000.0 psi
          Yield Strength (Amb)   :     38000.0 psi
          Yield Strength (Hot)   :     34800.0 psi
          Elastic Modulus (Amb)  :  29400000.0 psi
          Poissons Ratio         :       0.300
          Weight Density         :  0.2830E+00 lb./cu.in.

   Nozzle Geometry
          Nozzle Outside Diam.   :       1.500 in.
          Thickness              :       0.330 in.
          Length                 :       3.040 in.
          Nozzle Weld Length     :       0.500 in.
          Location perpendicular
          to the head centerline :      18.500 in.

          Nozzle Tilt Angle      :      43.052 deg.

   Nozzle Properties
          Cold Allowable         :     20000.0 psi
          Hot  Allowable         :     20000.0 psi
          Material ID #2         :  Low Alloy Steel
          Ultimate Tensile (Amb) :     70000.0 psi
          Yield Strength (Amb)   :     36000.0 psi
```

```
       Yield Strength (Hot)   :     33000.0 psi
       Elastic Modulus (Amb)  :  29200000.0 psi
       Poissons Ratio         :       0.300
       Weight Density         :  0.2830E+00 lb./cu.in.

  Design Operating Cycles       :          0.
  Ambient Temperature (Deg.)    :       70.00

  Uniform thermal expansion produces no stress in this geometry.
  Any thermal loads will come through operating forces and
  moments applied through the nozzle.

  Nozzle Inside  Temperature    :      200.00 deg.
  Nozzle Outside Temperature    :      200.00 deg.
  Vessel Inside  Temperature    :      200.00 deg.
  Vessel Outside Temperature    :      200.00 deg.

  Nozzle Pressure               :      5000.0 psi
  Vessel Pressure               :      5000.0 psi



  FEA Model Loads:
  Loads are given at the Nozzle/Header Junction
  Loads are defined in Global Coordinates

  Forces( lb.)  Moments (ft-lb)

  Load Case         FX         FY         FZ         MX         MY         MZ
  ---------------------------------------------------------------------------
     OPER:      542.0      581.9      198.1      298.9       79.8     -383.4

  Stresses are NOT averaged.

  Vessel Centerline       Vector:  0.000   1.000   0.000
  Nozzle Centerline       Vector:  0.000   1.000   0.000
  Zero Degree Orientation Vector:  1.000   0.000   0.000

  Nozzle Orientation Angle      : 90.000
```

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```
Load Case Report
FE/Pipe Version 10.0          Jobname: PI                     $P
Released Nov 2017             1:44pm   FEB  6,2019



Load Case Report                                       $X

Inner and outer element temperatures are the same
throughout the model.  No thermal ratcheting
calculations will be performed.

THE   9  LOAD CASES ANALYZED ARE:

  1   WEIGHT ONLY    (Wgt Only)

      Weight ONLY case run to get the stress range
      between the installed and the operating states.

      /-------- Loads in Case   1
        Loads due to Weight

  2   SUSTAINED      (Wgt+Pr)
```

```
     Sustained case run to satisfy local primary
     membrane and bending stress limits.

     /-------- Loads in Case   2
       Loads due to Weight
       Pressure Case    1

 3   OPERATING

     Case run to compute the operating stresses used in
     secondary, peak and range calculations as needed.

     /-------- Loads in Case   3
       Pressure Case    1
       Loads from (Operating)

 4   RANGE          (Fatigue Calc Performed)

     Case run to get the RANGE of stresses.
     as described in NB-3222.2, 5.5.3.2, 5.5.5.2 or 5.5.6.1.

     /-------- Combinations in Range Case   4
       Plus  Stress Results from CASE   3
       Minus Stress Results from CASE   1

 5   Program Generated -- Force Only

     Case run to compute sif's and flexibilities.
     /-------- Loads in Case   5
       Loads from (Axial)

 6   Program Generated -- Force Only

     Case run to compute sif's and flexibilities.
     /-------- Loads in Case   6
       Loads from (Inplane)

 7   Program Generated -- Force Only

     Case run to compute sif's and flexibilities.
     /-------- Loads in Case   7
       Loads from (Outplane)

 8   Program Generated -- Force Only

     Case run to compute sif's and flexibilities.
     /-------- Loads in Case   8
       Loads from (Torsion)

 9   Program Generated -- Force Only

     Case run to compute sif's and flexibilities.
     /-------- Loads in Case   9
       Pressure Case    1
```

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Solution Data

Maximum Solution Row Size = 1326
Number of Nodes = 3313
Number of Elements = 1076
Number of Solution Cases = 8

Summation of Loads per Case

Case #	FX	FY	FZ
1	0.	-4538.	0.
2	4.	6216518.	-8458247.
3	546.	6217100.	-8458048.
4	0.	17727.	-16561.
5	0.	0.	0.
6	0.	0.	0.
7	0.	0.	0.
8	4.	6221056.	-8458247.

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ASME Code Stress Output Plots
FE/Pipe Version 10.0   Jobname: PI $P
Released Nov 2017   1:44pm   FEB 6,2019

ASME Code Stress Output Plots $X

1) Pl <(1.5)(S) (SUS,Membrane) Case 2

2) Qb <SPS (SUS,Bending) Case 2

3) S1+S2+S3 <4S (SUS,S1+S2+S3) Case 2

4) Pl+Pb+Q <SPS (OPE,Inside) Case 3

5) Pl+Pb+Q <SPS (OPE,Outside) Case 3

6) Membrane <User (OPE,Membrane) Case 3

7) Bending <User (OPE,Bending) Case 3

8) Pl+Pb+Q+F <Sa (SIF,Outside) Case 5

9) Pl+Pb+Q+F <Sa (SIF,Outside) Case 6

10) Pl+Pb+Q+F <Sa (SIF,Outside) Case 7

11) Pl+Pb+Q+F <Sa (SIF,Outside) Case 8

12) Pl+Pb+Q+F <Sa (SIF,Outside) Case 9

13) Pl+Pb+Q <SPS (EXP,Inside) Case 4

14) Pl+Pb+Q <SPS (EXP,Outside) Case 4

15) Pl+Pb+Q+F <Sa (EXP,Inside) Case 4

16) Pl+Pb+Q+F <Sa (EXP,Outside) Case 4

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Stress Results - Notes
FE/Pipe Version 10.0 Jobname: PI $P
Released Nov 2017 1:44pm FEB 6,2019

Stress Results - Notes

- Results in this analysis were generated using the finite element solution method.

- Using 07-12 ASME Section VIII Division 2

- Use Polished Bar fatigue curve.

  Assume pressure increases all other stresses.

- Assume free end displacements of attached pipe (e.g. thermal loads) are secondary within the limits of nozzle reinforcement.

- Use Equivalent Stress (Von Mises).

- S1+S2+S3 evaluation omitted from operating stress.
  Include S1+S2+S3 evaluation in primary case evaluation.
  Assume bending stress not local primary for S1+S2+S3.

- Use local tensor values for averaged and not averaged stresses.

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ASME Overstressed Areas
FE/Pipe Version 10.0 Jobname: PI $P
Released Nov 2017 1:44pm FEB 6,2019

ASME Overstressed Areas $X

*** NO OVERSTRESSED NODES IN THIS MODEL ***

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Highest Primary Stress Ratios
FE/Pipe Version 10.0 Jobname: PI $P
Released Nov 2017 1:44pm FEB 6,2019

Highest Primary Stress Ratios $X

Shell Next to Nozzle 1

Pl	(1.5)(S)	Primary Membrane Load Case 2
21,170	30,000	Plot Reference:

```
      psi            psi     1) Pl <(1.5)(S) (SUS,Membrane) Case 2

            70%


Nozzle 1 Next to Shell

       Pl       (1.5)(S)     Primary Membrane Load Case 2
   24,960         30,000     Plot Reference:
      psi            psi     1) Pl  <(1.5)(S) (SUS,Membrane) Case 2

            83%


Nozzle 1

       Pl       (1.5)(S)     Primary Membrane Load Case 2
    7,909         30,000     Plot Reference:
      psi            psi     1) Pl  <(1.5)(S) (SUS,Membrane) Case 2

            26%
```

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```
Highest Secondary Stress Ratios
FE/Pipe Version 10.0          Jobname: PI                    $P
Released Nov 2017             1:44pm   FEB  6,2019



Highest Secondary Stress Ratios                        $X


Shell Next to Nozzle 1

  Pl+Pb+Q            SPS     Primary+Secondary (Inner) Load Case 4
   26,927         72,800     Plot Reference:
      psi            psi     13) Pl+Pb+Q <SPS (EXP,Inside) Case 4

            36%


Nozzle 1 Next to Shell

  Pl+Pb+Q            SPS     Primary+Secondary (Inner) Load Case 4
   63,007         69,000     Plot Reference:
      psi            psi     13) Pl+Pb+Q  <SPS (EXP,Inside) Case 4

            91%


Nozzle 1

  Pl+Pb+Q            SPS     Primary+Secondary (Outer) Load Case 4
   22,318         69,000     Plot Reference:
      psi            psi     14) Pl+Pb+Q  <SPS (EXP,Outside) Case 4

            32%
```

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```
Highest Fatigue Stress Ratios
FE/Pipe Version 10.0          Jobname: PI                    $P
```

Highest Fatigue Stress Ratios $X

Shell Next to Nozzle 1

```
Pl+Pb+Q+F    Damage Ratio    Primary+Secondary+Peak (Inner) Load Case 4
   18,176     0.000 Life     Stress Concentration Factor = 1.350
      psi     0.010 Stress   Strain Concentration Factor = 1.000
                             Cycles Allowed for this Stress = 131,241.
Allowable                    "B31" Fatigue Stress Allowable = 50000.0
1,799,215                    Markl Fatigue Stress Allowable = 245000.0
      psi                    WRC 474 Mean Cycles to Failure = 205,049.
                             WRC 474 99% Probability Cycles = 47,636.
       1%                    WRC 474 95% Probability Cycles = 66,137.
                             BS5500 Allowed Cycles(Curve F) = 41,615.
                             Membrane-to-Bending Ratio = 2.502
                             Bending-to-PL+PB+Q Ratio = 0.286
                             Plot Reference:
                             15) Pl+Pb+Q+F <Sa (EXP,Inside) Case 4
```

Nozzle 1 Next to Shell

```
Pl+Pb+Q+F    Damage Ratio    Primary+Secondary+Peak (Inner) Load Case 4
   42,530     0.000 Life     Stress Concentration Factor = 1.350
      psi     0.024 Stress   Strain Concentration Factor = 1.000
                             Cycles Allowed for this Stress = 6,608.
Allowable                    "B31" Fatigue Stress Allowable = 50000.0
1,786,975                    Markl Fatigue Stress Allowable = 245000.0
      psi                    WRC 474 Mean Cycles to Failure = 72,561.
                             WRC 474 99% Probability Cycles = 16,857.
       2%                    WRC 474 95% Probability Cycles = 23,404.
                             BS5500 Allowed Cycles(Curve F) = 8,627.
                             Membrane-to-Bending Ratio = 0.707
                             Bending-to-PL+PB+Q Ratio = 0.586
                             Plot Reference:
                             15) Pl+Pb+Q+F  <Sa (EXP,Inside) Case 4
```

Nozzle 1

```
Pl+Pb+Q+F    Damage Ratio    Primary+Secondary+Peak (Outer) Load Case 4
   11,159     0.000 Life     Stress Concentration Factor = 1.000
      psi     0.006 Stress   Strain Concentration Factor = 1.000
                             Cycles Allowed for this Stress = 5,310,248.
Allowable                    "B31" Fatigue Stress Allowable = 50000.0
1,786,975                    Markl Fatigue Stress Allowable = 245000.0
      psi                    WRC 474 Mean Cycles to Failure = 1,692,902.
                             WRC 474 99% Probability Cycles = 393,284.
       0%                    WRC 474 95% Probability Cycles = 546,033.
                             BS5500 Allowed Cycles(Curve F) = 194,117.
                             Membrane-to-Bending Ratio = 4.142
                             Bending-to-PL+PB+Q Ratio = 0.194
                             Plot Reference:
                             16) Pl+Pb+Q+F  <Sa (EXP,Outside) Case 4
```

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Stress Intensification Factors

Stress Intensification Factors $X

Branch/Nozzle Sif Summary

	Peak	Primary	Secondary	SSI
Axial :	0.788	1.009	1.167	0.947
Inplane :	0.812	0.794	1.202	0.933
Outplane:	0.797	0.789	1.180	0.949
Torsion :	1.120	0.980	1.660	1.058
Pressure:	0.786	0.571	1.165	0.946

The above stress intensification factors are to be used in a beam-type analysis of the piping system. Inplane, Outplane and Torsional sif's should be used with the matching branch pipe whose diameter and thickness is given below. The axial sif should be used to intensify the axial stress in the branch pipe calculated by F/A. The pressure sif should be used to intensify the nominal pressure stress in the PARENT or HEADER, calculated from PDo/2T. B31 calculations use mean diameters and Section VIII calculations use outside diameters. SSIs are based on peak stress factors and correlated test results.

Pipe OD :	1.500	in.
Pipe Thk:	0.330	in.
Z approx:	0.355	cu.in.
Z exact :	0.299	cu.in.

(SSI = SIF^x)	Axial	Inpl	Outpl	Tors	Pres
SIF/SSI Exponents:	-0.038	1.105	1.040	-0.175	2.327

SIF/SSI exponent based on relationship between primary and peak stress factors from the finite element analysis.

B31.3 Branch Pressure i-factor = 7.753
Header Pressure i-factor = 1.668

The B31.3 pressure i-factors should be used with with F/A, where F is the axial force due to pressure, and A is the area of the pipe wall. This is equivalent to finding the pressure stress from (ip)(PD/4T).

B31.3 (Branch)		
Peak Stress Sif	0.000	Axial
	1.000	Inplane
	1.000	Outplane
	1.000	Torsional
B31.1 (Branch)		
Peak Stress Sif	0.000	Axial
	1.000	Inplane
	1.000	Outplane
	1.000	Torsional
WRC 330 (Branch)		
Peak Stress Sif	0.000	Axial
	1.000	Inplane
	1.500	Outplane
	1.000	Torsional

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Allowable Loads
FE/Pipe Version 10.0 Jobname: PI $P

Allowable Loads $X

SECONDARY Load Type (Range):		Maximum Individual Occuring	Conservative Simultaneous Occuring	Realistic Simultaneous Occuring
Axial Force	(lb.)	71722.	6792.	10188.
Inplane Moment	(in. lb.)	17143.	1870.	3967.
Outplane Moment	(in. lb.)	17465.	1905.	4042.
Torsional Moment	(in. lb.)	12421.	1086.	1629.
Pressure	(psi)	6777.45	5000.00	5000.00

PRIMARY Load Type:		Maximum Individual Occuring	Conservative Simultaneous Occuring	Realistic Simultaneous Occuring
Axial Force	(lb.)	36064.	2018.	3027.
Inplane Moment	(in. lb.)	11288.	447.	948.
Outplane Moment	(in. lb.)	11354.	450.	954.
Torsional Moment	(in. lb.)	9143.	512.	767.
Pressure	(psi)	6008.77	5000.00	5000.00

NOTES:

1) Maximum Individual Occuring Loads are the maximum allowed values of the respective loads if all other load components are zero, i.e. the listed axial force may be applied if the inplane, outplane and torsional moments, and the pressure are zero.

2) The Conservative Allowable Simultaneous loads are the maximum loads that can be applied simultaneously. A conservative stress combination equation is used that typically produces stresses within 50-70% of the allowable stress.

3) The Realistic Allowable Simultaneous loads are the maximum loads that can be applied simultaneously. A more realistic stress combination equation is used based on experience at Paulin Research. Stresses are typically produced within 80-105% of the allowable.

4) Secondary allowable loads are limits for expansion and operating piping loads.

5) Primary allowable loads are limits for weight, primary and sustained type piping loads.

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Flexibilities
FE/Pipe Version 10.0 Jobname: PI $P
Released Nov 2017 1:44pm FEB 6,2019

Flexibilities $X

The following stiffnesses should be used in a piping, "beam-type" analysis of the intersection. The stiffnesses should be inserted at the surface of the branch/header or nozzle/vessel junction. The general characteristics used for the branch pipe should be:

```
Outside Diameter =    1.500  in.
Wall Thickness   =    0.330  in.

Axial Translational Stiffness   =     259963600.  lb./in.
```

The following stiffness(es) were not generated because of errors in input or because the finite element model is stiffer than the piping model.

Inplane Rotational Stiffness
Outplane Rotational Stiffness
Torsional Rotational Stiffness

Intersection Flexibility Factors for Branch/Nozzle

```
Find axial stiffness: K = 3EI/(kd)^3  lb./in.
Find bending and torsional stiffnesses: K = EI/(kd)  in.lb.per radian.
The EI product is   0.65875E+07   lb.in.^2
The value of (d) to use is:   1.170  in..
The resulting bending stiffness is in units of force x length per radian.

Axial Flexibility Factor     (k) =     0.362
```

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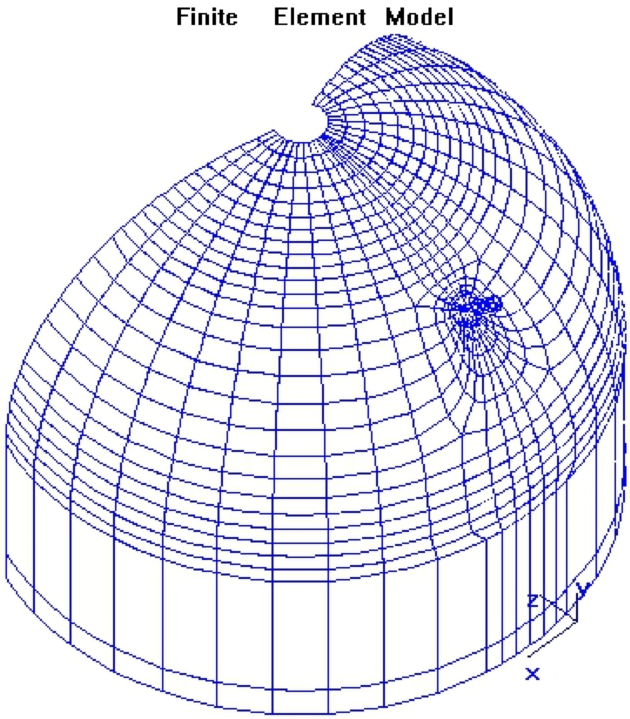
Finite Element Model

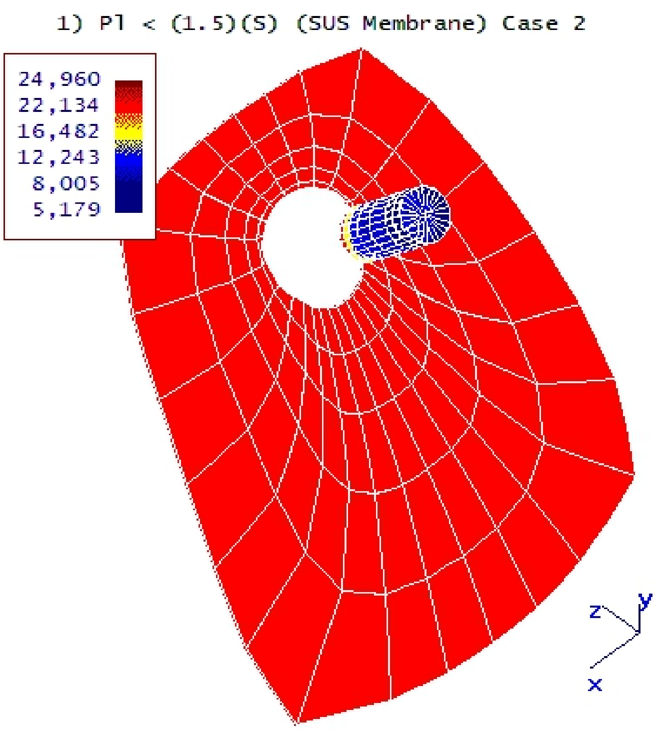
- Finite Element Model

Area of Discontinuity at Nozzle

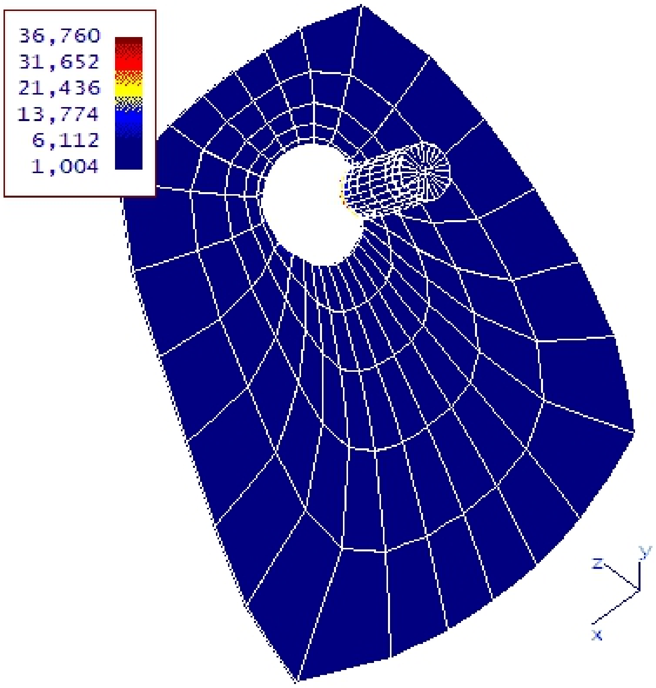
- 1) Pl < (1.5)(S) (SUS Membrane) Case 2
- 2) Qb < SPS (SUS Bending) Case 2
- 3) S1+S2+S3 < 4S (SUS S1+S2+S3) Case 2
- 4) Pl+Pb+Q < SPS (OPE Inside) Case 3
- 5) Pl+Pb+Q < SPS (OPE Outside) Case 3
- 6) Membrane < User (OPE Membrane) Case 3
- 7) Bending < User (OPE Bending) Case 3
- 13) Pl+Pb+Q < SPS (EXP Inside) Case 4
- 14) Pl+Pb+Q < SPS (EXP Outside) Case 4
- 15) Pl+Pb+Q+F < Sa (EXP Inside) Case 4
- 16) Pl+Pb+Q+F < Sa (EXP Outside) Case 4
- 8) Pl+Pb+Q+F < Sa (SIF Outside) Case 5
- 9) Pl+Pb+Q+F < Sa (SIF Outside) Case 6
- 10) Pl+Pb+Q+F < Sa (SIF Outside) Case 7
- 11) Pl+Pb+Q+F < Sa (SIF Outside) Case 8
- 12) Pl+Pb+Q+F < Sa (SIF Outside) Case 9

Tabular Results

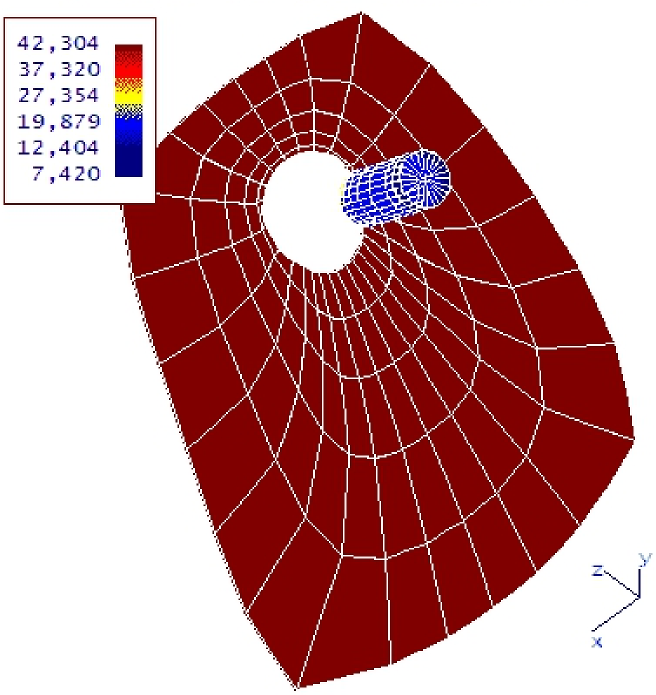

Finite Element Model
z
y
x


1) Pl < (1.5)(S) (SUS Membrane) Case 2
24,960
22,134
16,482
12,243
8,005
5,179
z
y
x

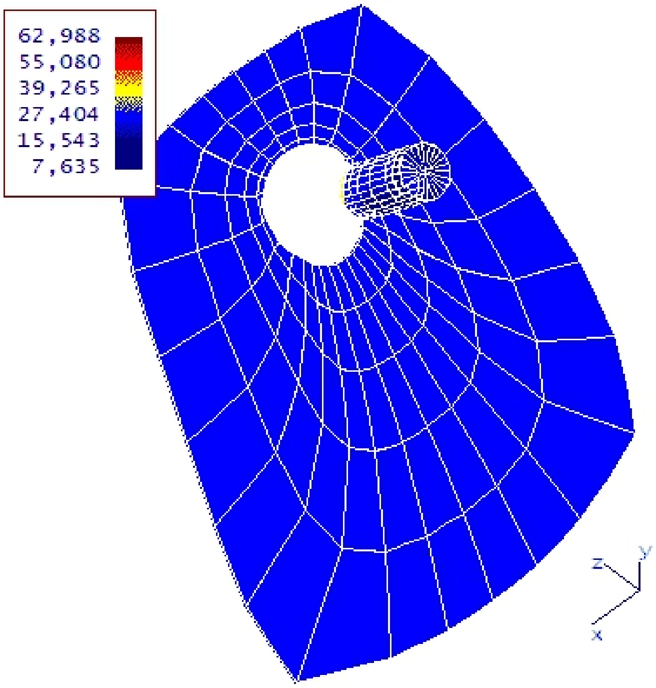
2) Qb < SPS (SUS Bending) Case 2



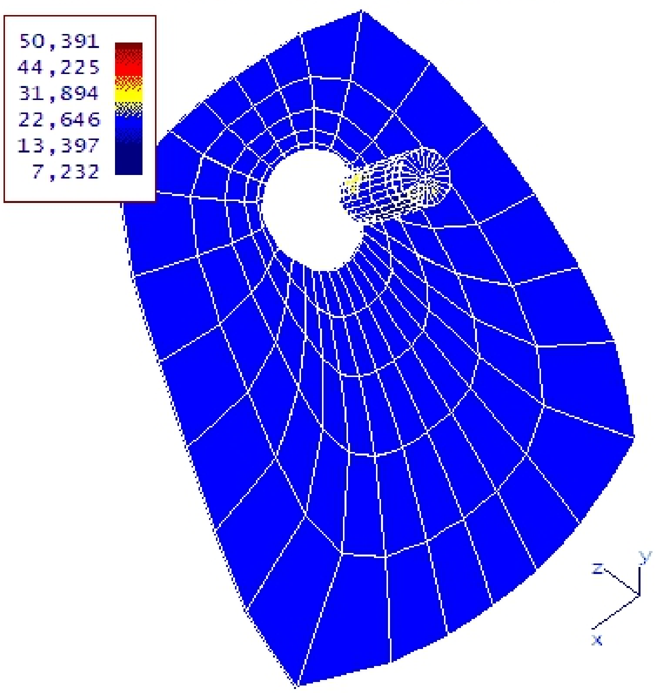
3) S1+S2+S3 < 4S (SUS S1+S2+S3) Case 2



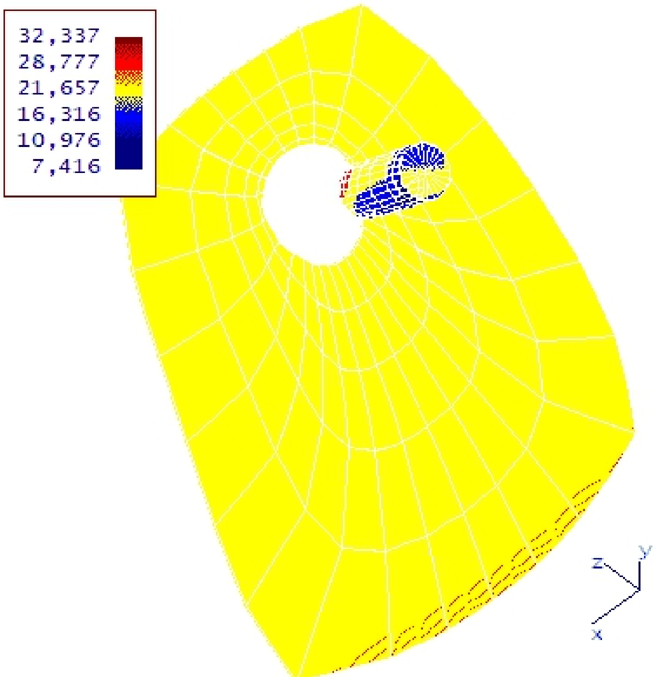
4) Pl+Pb+Q < SPS (OPE Inside) Case 3



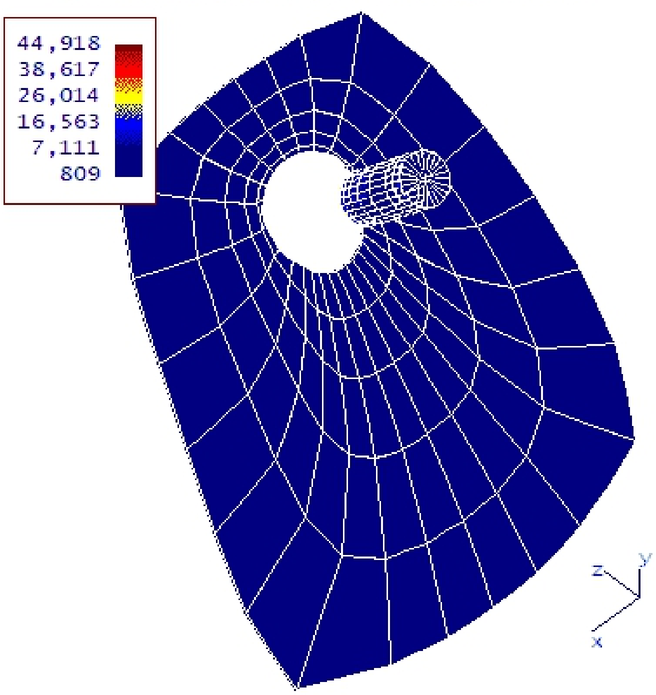
5) Pl+Pb+Q < SPS (OPE Outside) Case 3



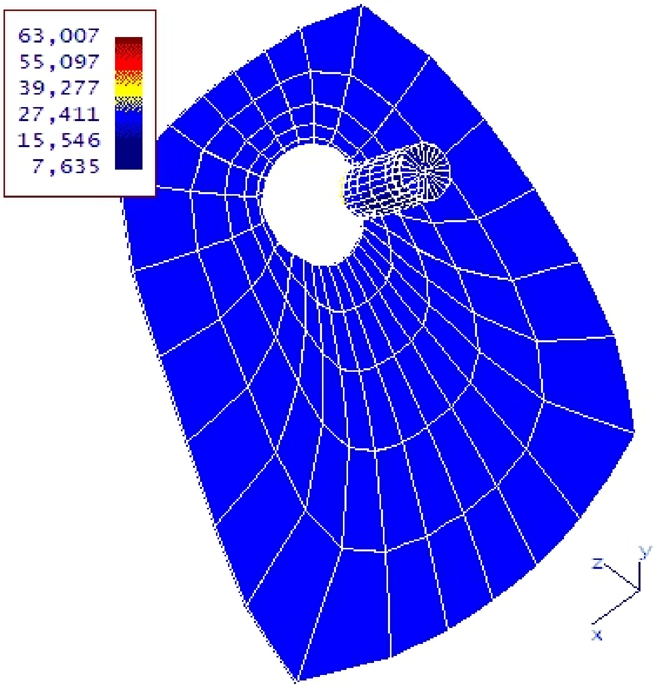
6) Membrane < User (OPE Membrane) Case 3



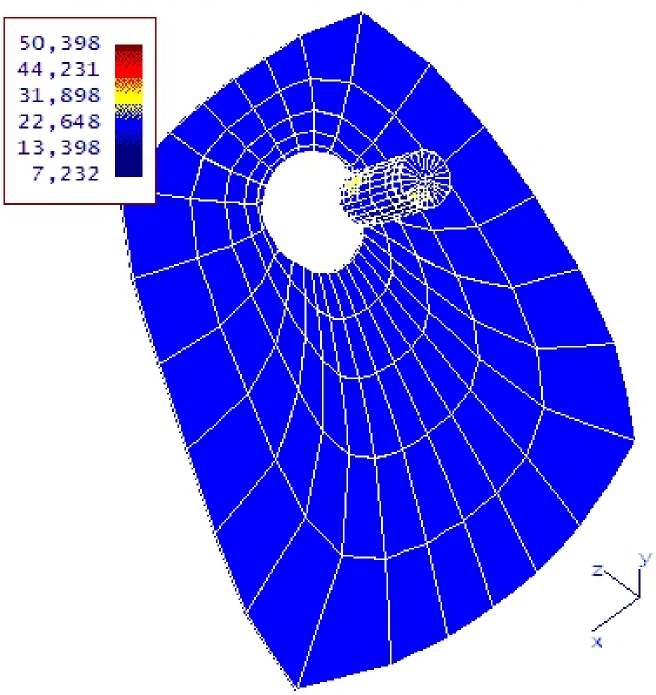
7) Bending < User (OPE Bending) Case 3



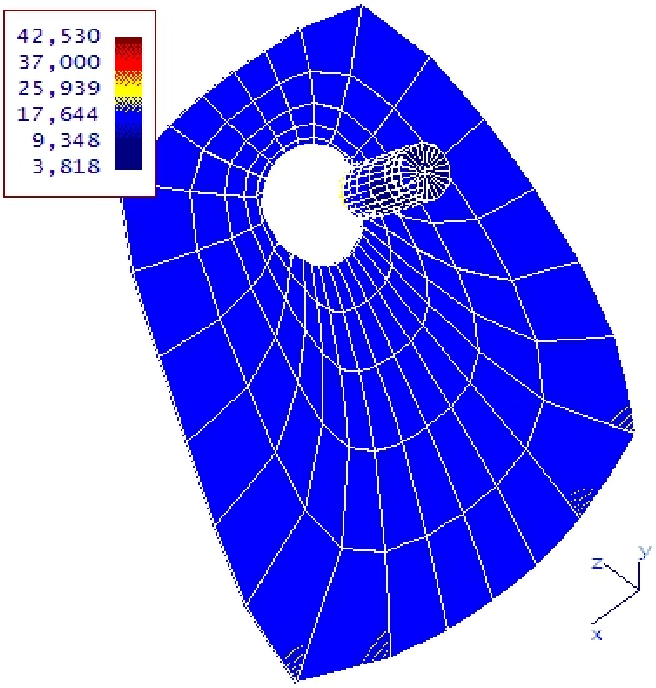
13) Pl+Pb+Q < SPS (EXP Inside) Case 4



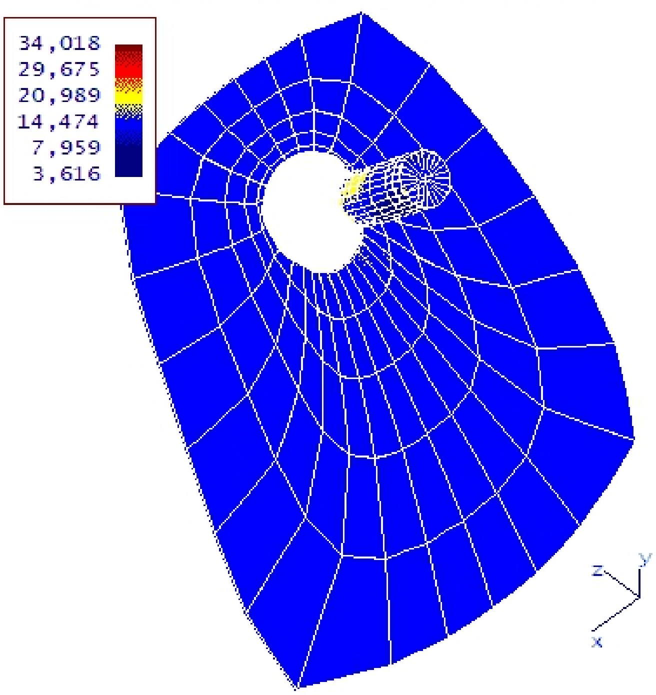
14) Pl+Pb+Q < SPS (EXP Outside) Case 4



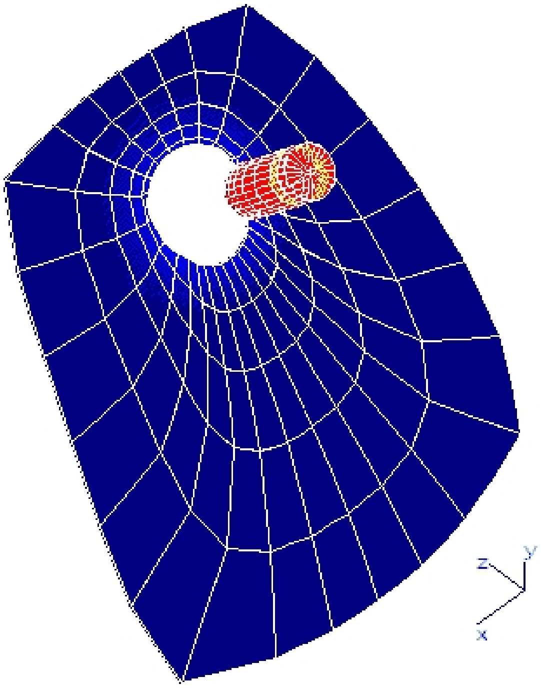
15) Pl+Pb+Q+F < Sa (EXP Inside) Case 4



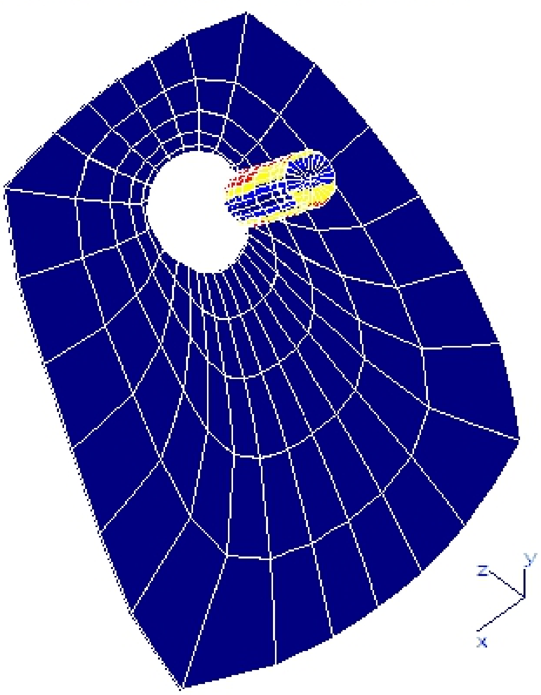
16) Pl+Pb+Q+F < Sa (EXP Outside) Case 4



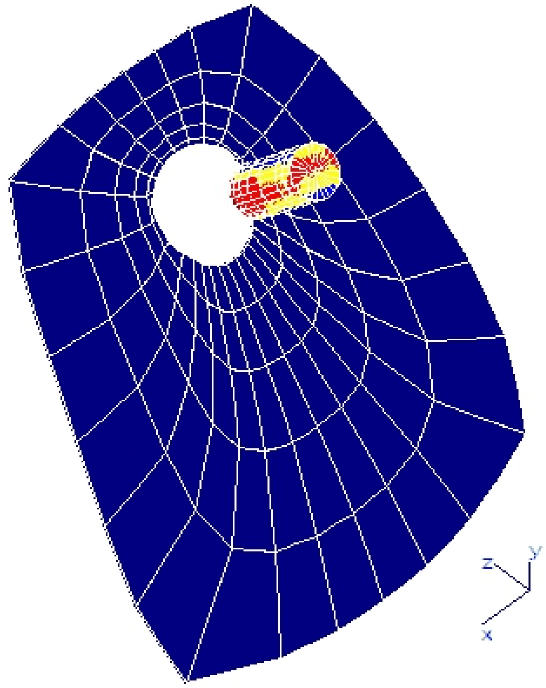
8) Pl+Pb+Q+F < Sa (SIF Outside) Case 5



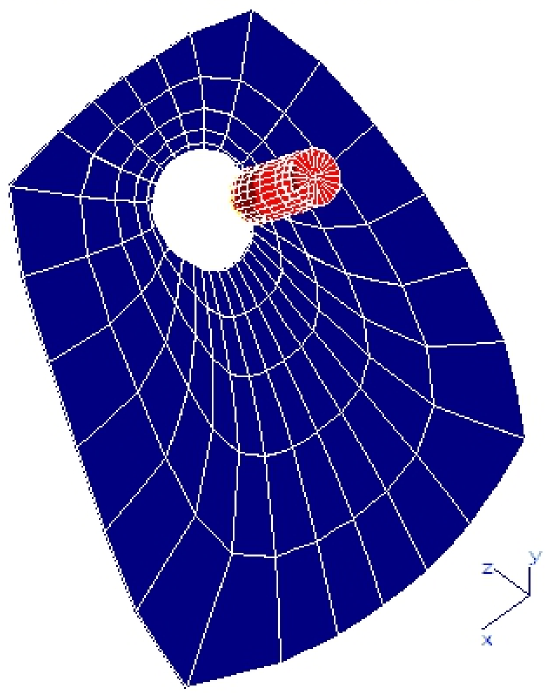
9) Pl+Pb+Q+F < Sa (SIF Outside) Case 6



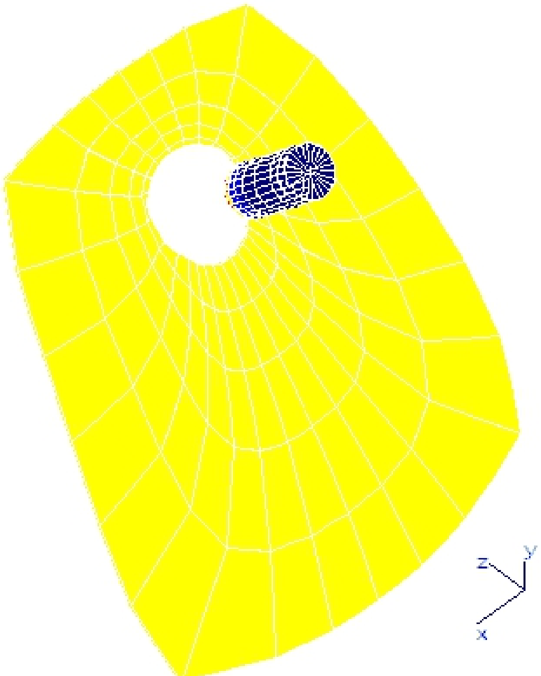
10) Pl+Pb+Q+F < Sa (SIF Outside) Case 7



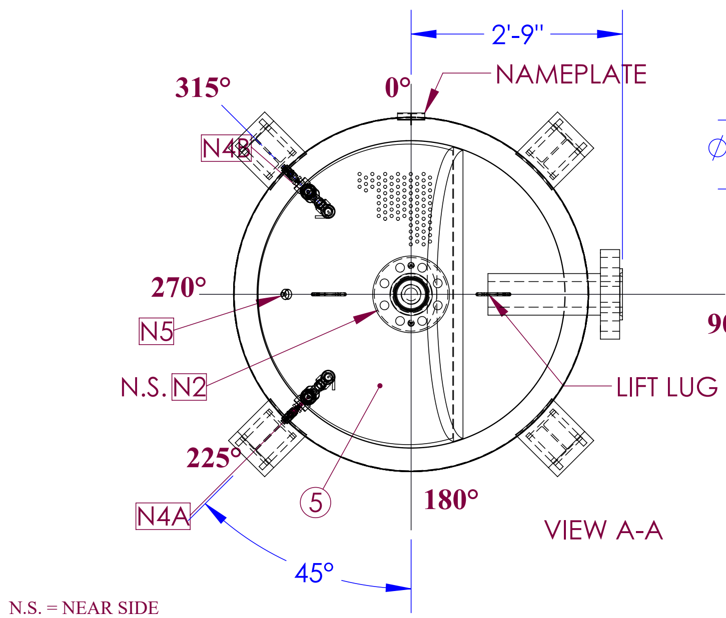
11) Pl+Pb+Q+F < Sa (SIF Outside) Case 8

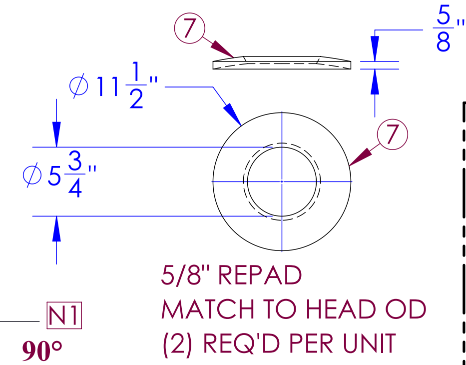


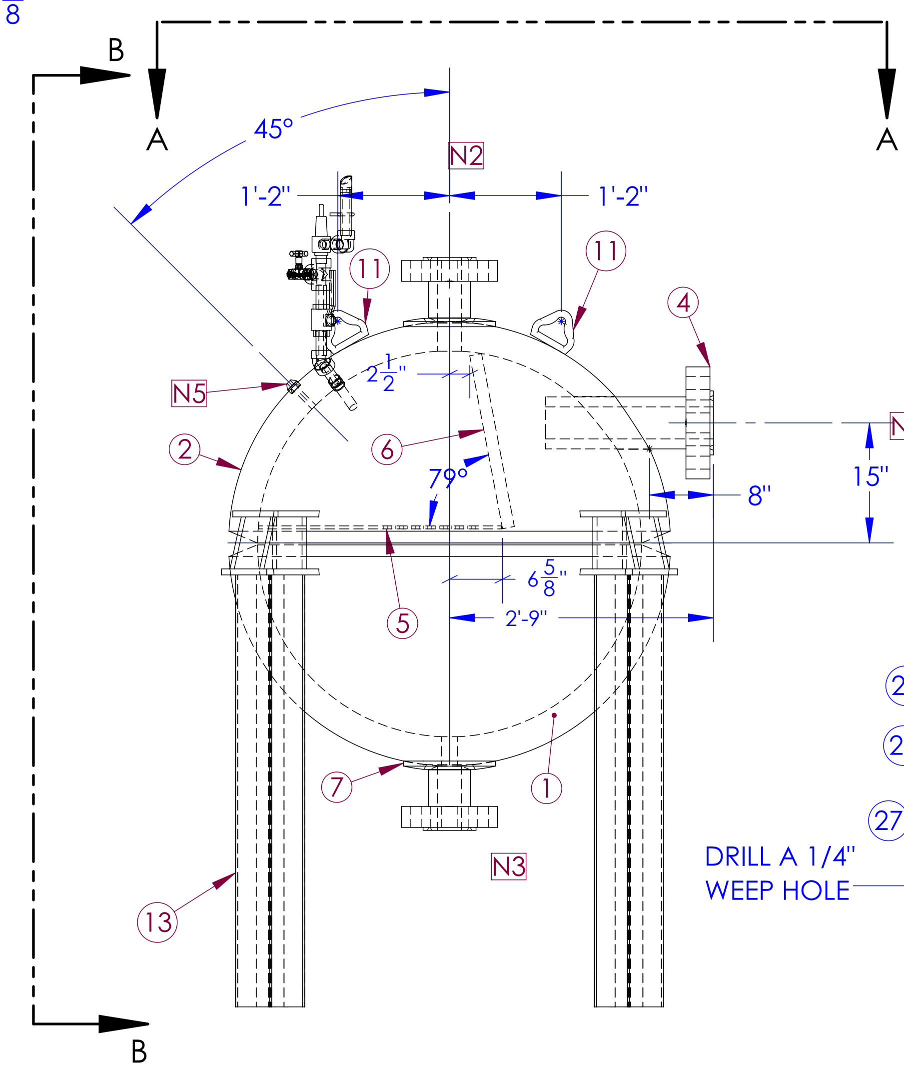
12) Pl+Pb+Q+F < Sa (SIF Outside) Case 9

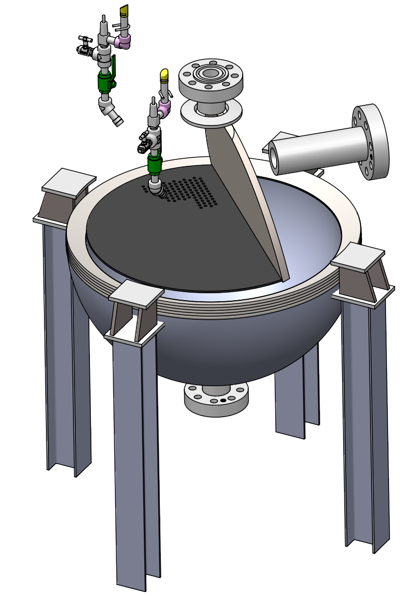


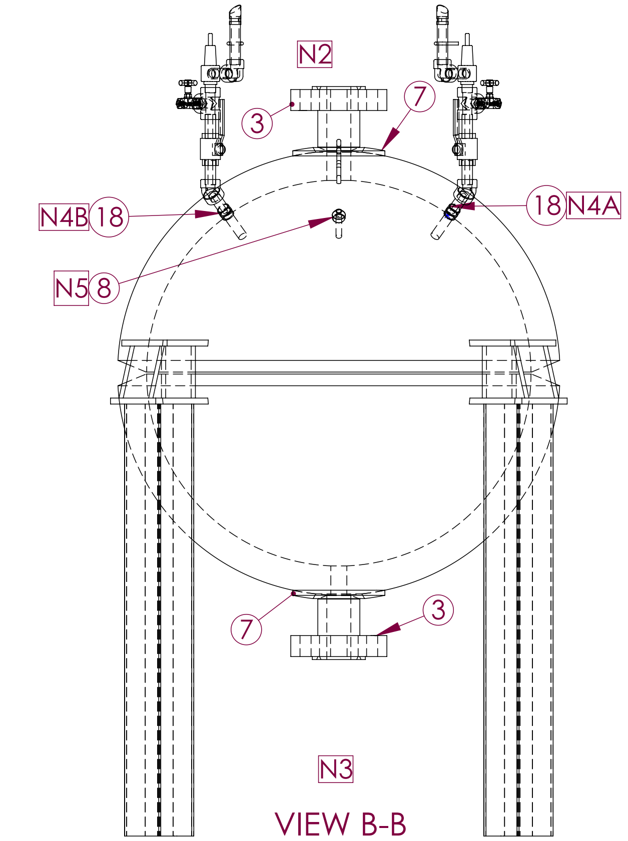
Drawings

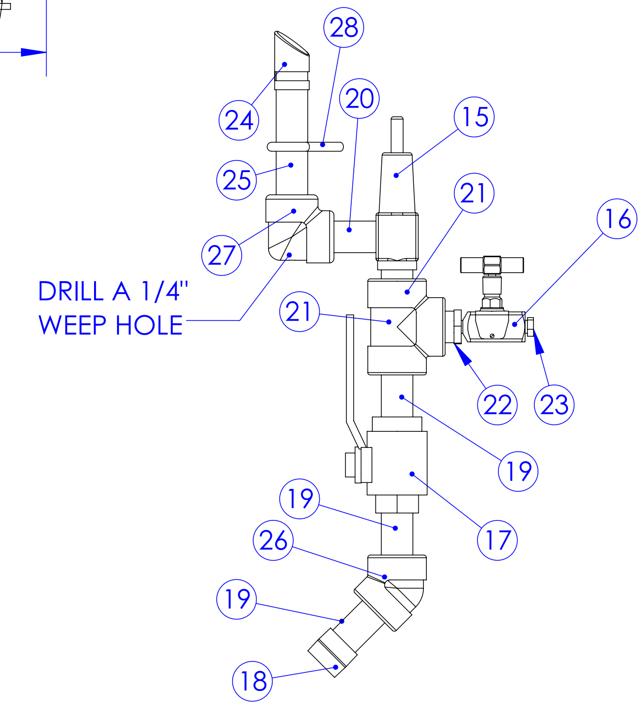










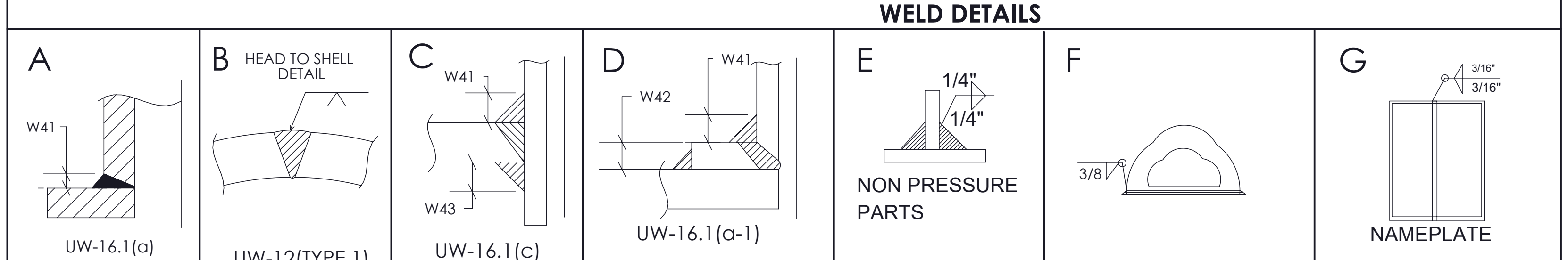


NOTES	WELD PROC.		
- PREHEAT TO MIN. 200°F PRIOR TO WELDING	WELD JOINT	PROCEDURE	WELD DETAIL
- Production Impacts @ -20°F Required	NOZZLES	SFI-3-4P	A,C, D
-	GIRTH SEAM	SFI-3-4PI	B
-	EXTERNALS	SFI-3-4P	E,F,G
-	INTERNALS	SFI-3-4P	SEE THIS SHT

VESSEL SPECIFICATIONS

JOB NO: 300164-01,02 , 300165-01-> 300167-01
WEIGHT: 12,000 LBS
SERIALNO: SFI-48IDX5K-XXX
HYDRO PRESS: 6,500 PSI
NATIONAL BD NO.: TBD
X-RAY: LG SEAM - N/A
GIRTH SM - 100% PER SFI
PAINT: YES
REMARKS: NONE
PWHT: YES
MDMT: -20°F
CA: 0"
CODE: ASME SEC. VIII DIV. I 2017 EDITION

WELD DETAILS



NOTE: FOR BORES AND HOLE LOCATIONS SEE SHEET 5

NOZZLE SCHEDULE

ITEM	QTY	SERVICE	SIZE	RAT'G	TYPE	MATR'L	BORE	BOM #	PROJECTION O.S.	PROJECTION I.S	NOZZLE NECK O.D.	NOZZLE NECK WALL	NOZZLE NECK MATR'L	REPAD DETAIL O.D.	REPAD DETAIL THK	REPAD DETAIL MATR'L	WELD DETAIL	W41	W42	W43
N1	1	INLET	4"	2500#	RTJLWN	-	4"	4	8"	3-1/2"	6.50"	1.25"	SA-105	-	-	-	C	1-1/2"	-	1"
N2	1	GAS OUTLET	3"	2500#	RTJLWN	-	3"	3,7	8"	-	5.25"	1.125"	SA-105	11.50"	0.625"	SA516-70	D	3/4"	5/8"	-
N3	1	DUMP	3"	2500#	RTJLWN	-	3"	3,7	8"	-	5.25"	1.125"	SA-105	11.5"	0.625"	SA516-70	D	1"	5/8"	-
N4A, N4B	1	PSV	1"	6M	TRDLET	SA-105	1.141"	18	1.563"	-				-	-	-	A	3/8"	-	-
N5	1	P.I.	1/2"	6M	TRDLET	SA-105	0.703	8	1.25"	-	-	-	-	-	-	-	A	1/2"	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

REVISIONS

NO.		DATE	NO.		DATE
0	FOR APPROVAL	2/8/17	6C	N1, N2, N3 CROSSOVER TO HU REMOVED, PSV isolating valve brand changed, MAWT = +200°F	12/7/2018
1	UPDATED LWN O.D. AND WALL DIMENSIONS	2/28/17			
2	UPDATED WELD FIG. C	4/3/17	6D	WEEP HOLE ADDED TO POST PSV, SKID VERTICAL SECTION REMOVED, WEAR PAD AND SUPPORT REMOVED	1/10/2019
3	BM#104,113,120 lengthes updated	5/30/17			
4	N2 NOZ NECK LENGTH INCREASED BY 1"	8/21/2017	6E	DUMP SIZE CHANGED TO 3", WELD AND NOZZLE DETAIL CHANGED	1/30/2019
5	SKID UPDATED- HEAD THK. 3.75", DESIGN CODE 2017, CALCS UPDATED	12/18/2017			
5A	HEAD THK. CHANGED TO 3.625, PSV SET UP: 2 X 1" PSVs, WELDS UPDATED	2/12/2018			
6A	Noz schedule Table modified, Weld Detail Block Updated	3/9/2018			

NB

CERTIFIED BY
SYNERGY FABRICATION, INC.
1432 E. DEVITT ST.
FORT WORTH, TX 76119

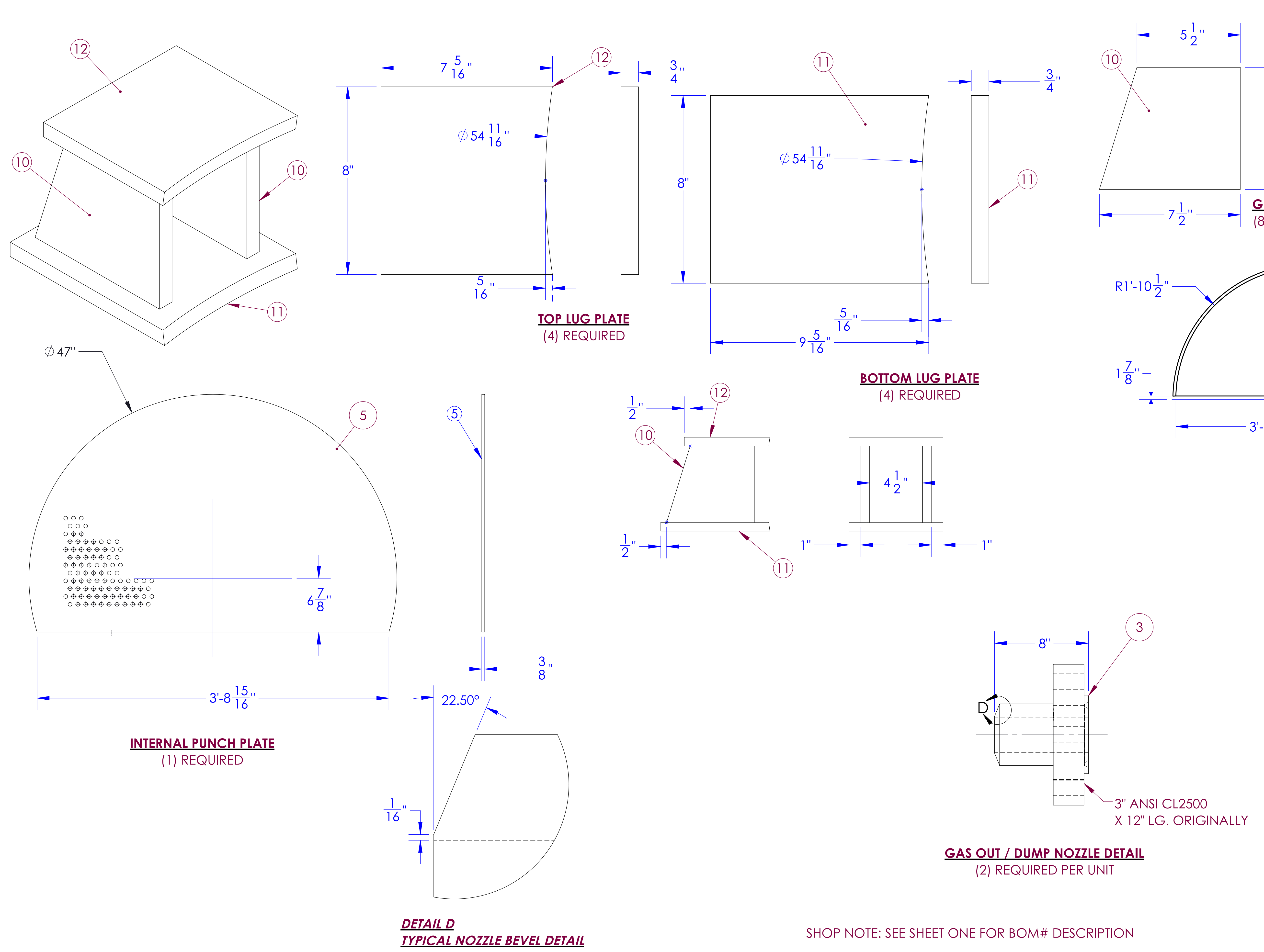
M.A.W.P.	5,000 PSIG @ 200 °F
M.D.M.T.	-20°F @ 5,000 PSIG
SERIAL	SFI-48IDX5K-XXX
YEAR	2019
U	
W	
HT	
RT-1	

APPROVED FOR CONSTRUCTION BY:
X MSaffari
1 / 3 0 / 2 0 1 9

FOR SM ENERGY UNITS

SCALE N.T.S.
DRAWING SIZE B
DRAWN BY Kevin McFarland
DRAWING NO. SFI-48IDX5K-XXX
SHEET 1
REV 6E

BOM Table					
MARK	QTY	IMPACT	DESCRIPTION	LENGTH	Material
1	1	YES,-20F	PLATE- 48" I.D. x 3.625" NOM. (3.1" Min.), Full Hemi, 22° O.S. Bevel		SA-516-70N
2	1	YES, -20F	PLATE- 48" I.D. x 3.625" NOM. (3.1" Min.), Full Hemi, 22° O.S. Bevel		SA-516-70N
3	2		FLANGE, RTJ, LWN, 3" ANSI CL2500 x 12" Lg. (CUT TO DETAIL)	8"	SA-105
4	1		FLANGE, RTJ, LWN, 4" ANSI CL2500 x 21" Lg.		SA-105
5	1		INTERNAL, 0.375 PUNCH PLT, 1/2 DIA. @ 1 CTRS, SEE SHT 2		AR400
6	1		INTERNAL, 1.50" THK. X 24" RAD., SEE DETAIL		AR400
7	2		REPAD: PLATE- 5/8" THK. X 11-1/2 O.D. X 5.750 I.D., Match to Heads, see Detail		SA-516 70
8	1		THREAD-O-LET 1/2" NPT on 52", 6M C.S. A-105		SA-105
11	2		MEDIUM LIFTING LUG, PHOENIX, P/N: 2-899-MLL		C.S.
10	8	LEGS	PLATE-3/4 X 7 1/2" X 6 1/2" CUT TO DETAIL		SA-516 70
11	4	LEGS	PLATE-3/4 X 9 5/16" X 8" - CUT TO DETAIL		SA-516 70
12	4	LEGS	PLATE-3/4 X 7 5/16" X 8" CUT TO DETAIL		SA-516 70
13	4	LEGS	W6X20 - 4'-6" LONG	4'-6"	SA-36
14	1		STANDARD N.P. BRACKET		SA-36
15	2	PSV ASSEMLY	TAYLOR 1" 8200 THREADED VALVE - (ORIFICE D), P/N = 82D9341315, Set @ 5000PSI		C.S.
16	2	PSV ASSEMLY	VALVE, 1/4" M x F Needle, Balon P/N: N263-MF		C.S.
17	2	PSV ASSEMLY	Valve 1" FP 5000psi, KF Model# 05050-11911, Series CXH Floating Ball Valve, CS/C/Delrin/Buna/Handle		
18	2	PSV ASSEMLY	THREAD-O-LET 1" NPT ON 48" OD, 6M C.S. A-105		SA-105
19	6	PSV ASSEMLY	NIPPLE - 1" Sch XXH (0.358" Wall) Nipple	3"	SA-106B/C
20	2	PSV ASSEMLY	NIPPLE-1" Sch 80 (0.179" Wall) Nipple	3"	SA-106B/C
21	2	PSV ASSEMLY	TEE, 1" THREADED, CLASS 6000		SA-234 WPC
22	2	PSV ASSEMLY	BUSHING- 1" x 1/4" 6M THD x THD Bushing, SA-105		SA-105
23	2	PSV ASSEMLY	PLUG- 1/4" 6000# Hex Plug		SA-105
24	2	PSV ASSEMLY	YELLOW RAIN CAP, 1"		Rubber
25	2	PSV ASSEMLY	Nipple- 1" Sch 80 (0.179" Wall)	6"	SA-106C
26	2	PSV ASSEMLY	ELL, 45°, 1" CLASS 6000 THREADED, SA-234 WPC OR SA-105		SA-234 WPC
27	2	PSV ASSEMLY	ELBOW, THREADED, 90, 1" CLASS 3000, FEMALE		SA-234 WPC
28	2		U BOLT - 3/8" DIAM. FITS 1" PIPE W/ 2 HEX NUTS AND RUBBER CUSHION (PAD)		SA-193 B7

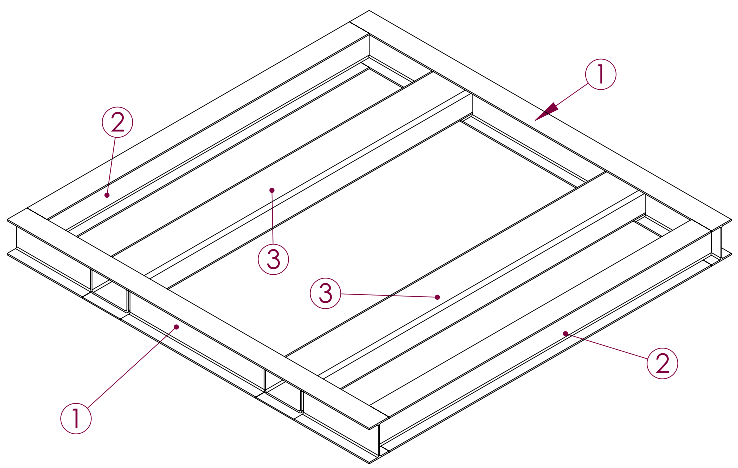


SHOP NOTE: SEE SHEET ONE FOR BOM# DESCRIPTION

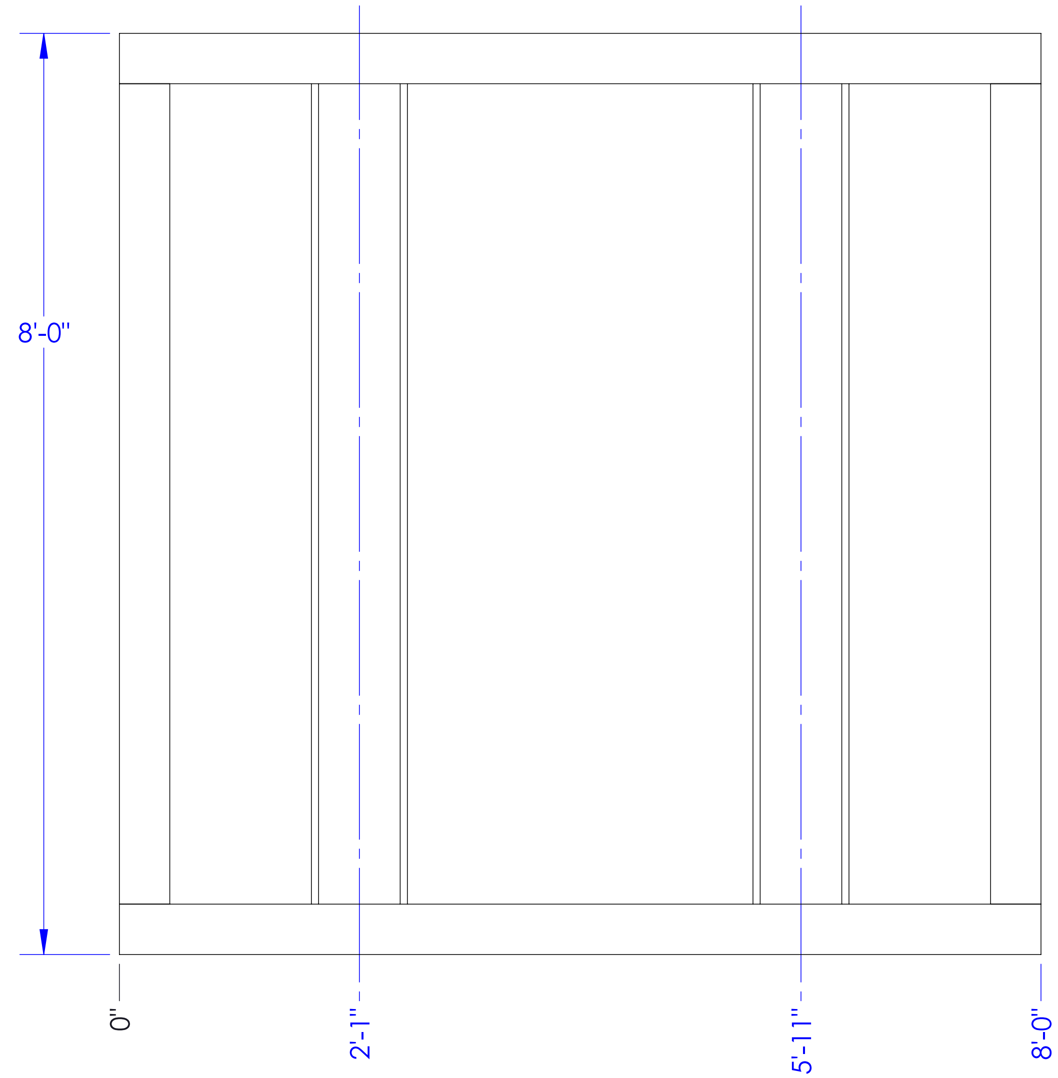
SYNERGY FABRICATION, INC.
1432 E. DEVITT ST.
FORT WORTH, TX 76119

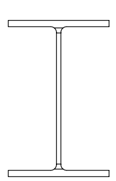
TITLE: 48" ID -5K SPHERICAL Sand Separator		
DWG. NO. SFI-48IDX5K-XXX		REV 6E
DRAWN KM 2/8/2017	CHECKED MS 5/30/2017	APPR. MS 5/30/2017
DRAWING SIZE B	REV. DATE 1/30/2019	SHT 2 OF 5

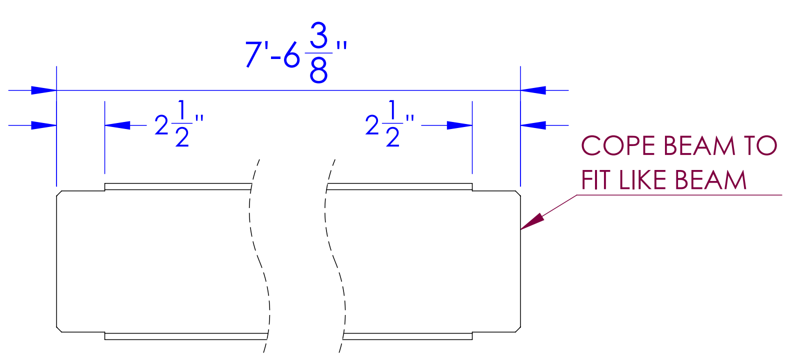
ITEM NO.	QTY.	DESCRIPTION	LENGTH
1	2	W8x18	8'
2	2	W8x18	7'-6 1/2"
3	2	TR10x6x0.375	7'-7 3/4"



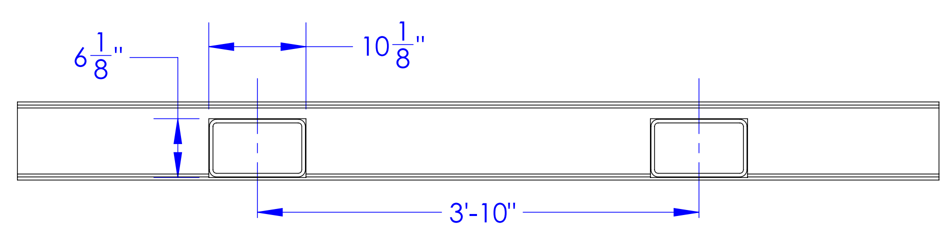
TR = TUBE RECTANGULAR







CROSS SUPPORT BEAMS - W8x18
COPING DETAILS

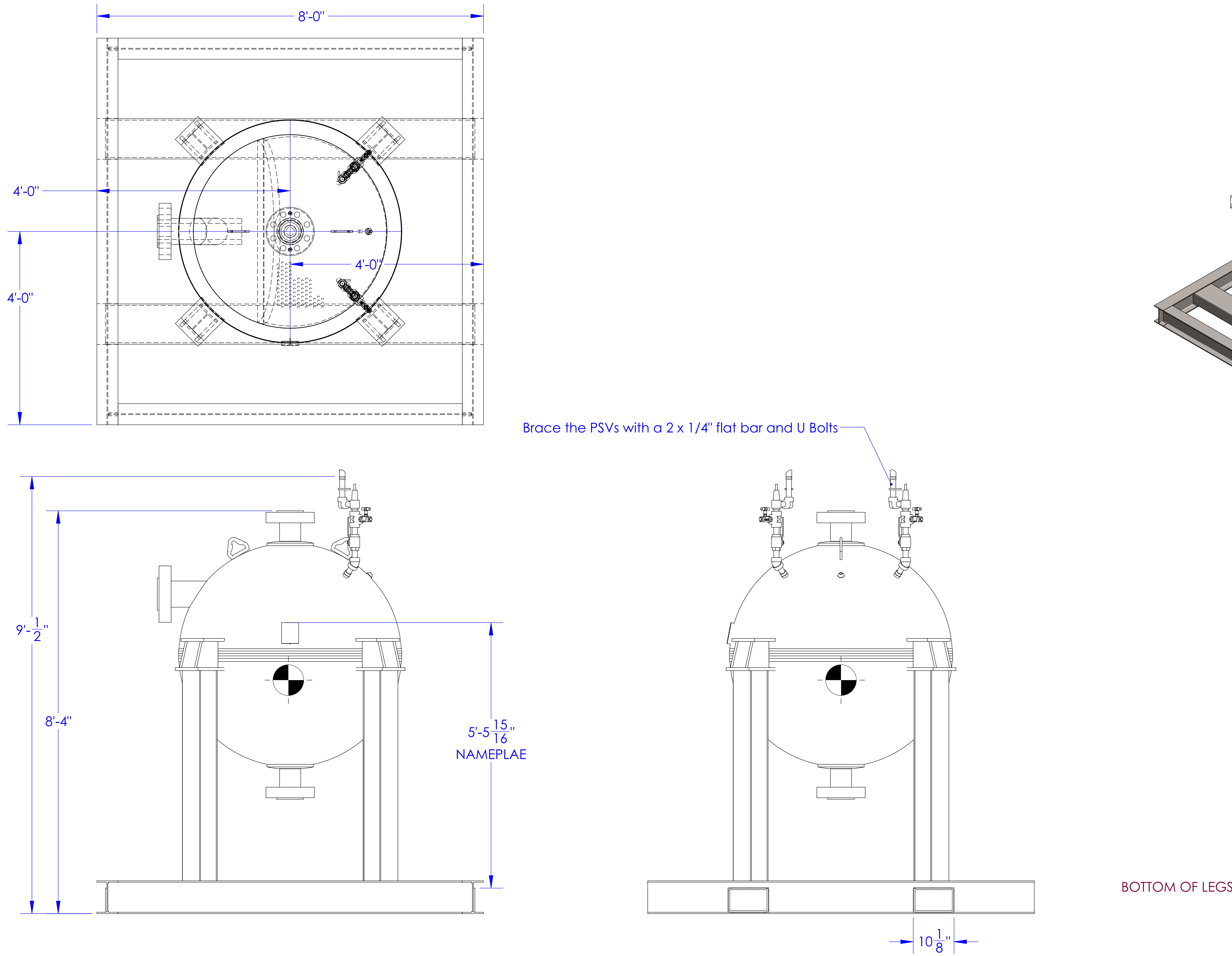


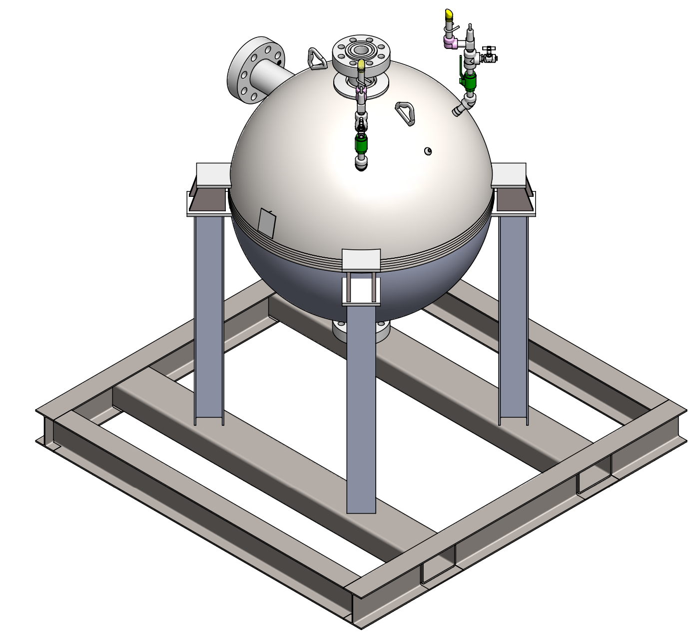
SYNERGY FABRICATION, INC.
1432 E. DEVITT ST.
FORT WORTH, TX 76119

TITLE: 48" ID -5K SPHERICAL Sand Separator

DWG. NO.	REV
SFI-48IDX5K-XXX	6E

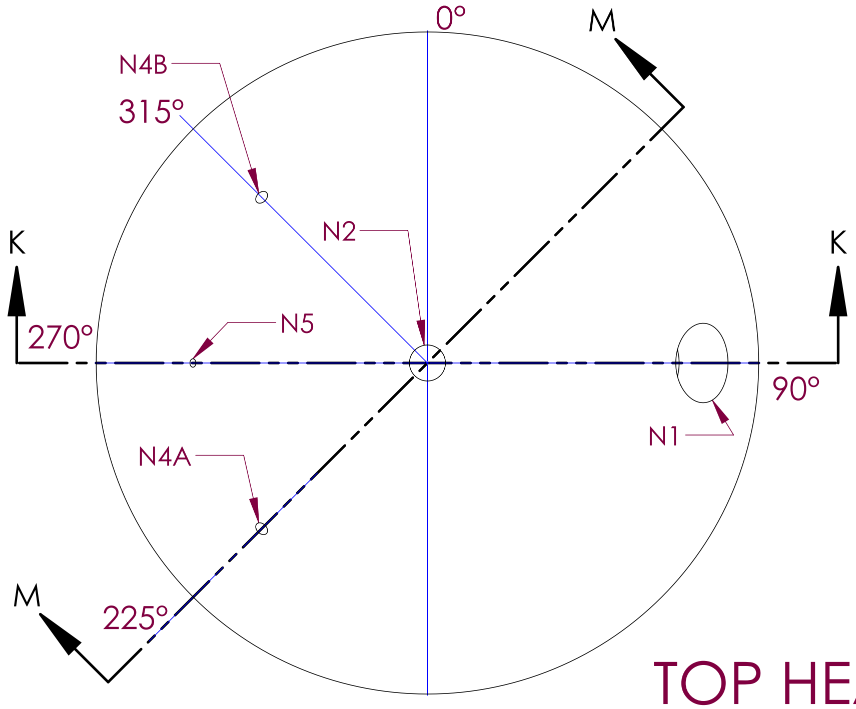
DRAWN	CHECKED	APPR.
KM 2/8/2017	MS 5/30/2017	MS 5/30/2017
DRAWING SIZE B	REV. DATE 1/30/2019	SHT 3 OF 5



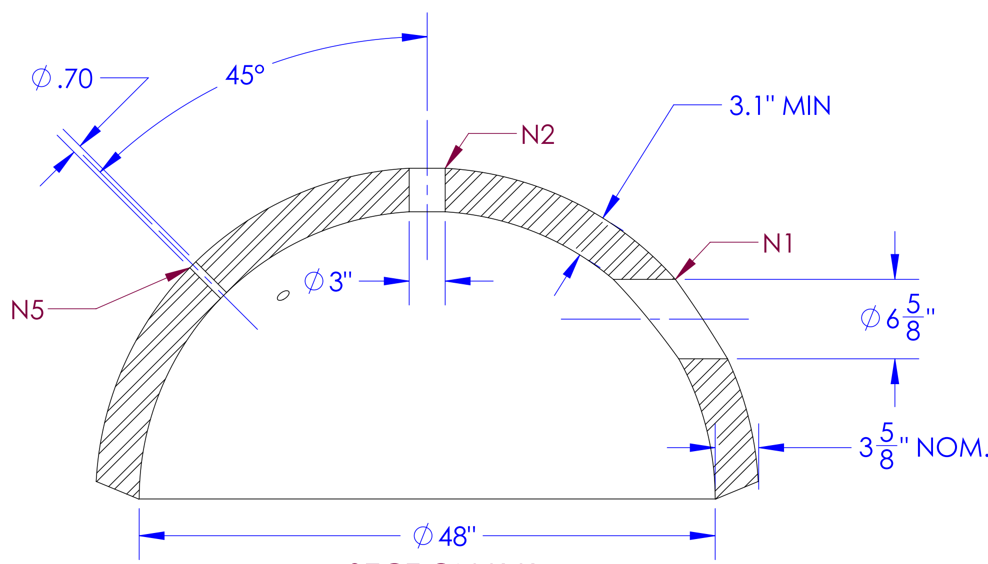


SYNERGY FABRICATION, INC.
1432 E. DEVITT ST.
FORT WORTH, TX 76119

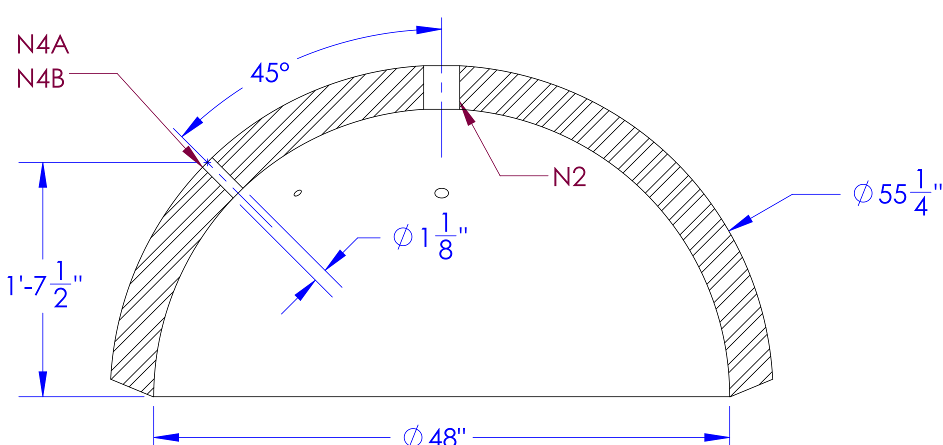
TITLE: 48" ID -5K SPHERICAL Sand Separator		
DWG. NO. SFI-48IDX5K-XXX		REV 6E
DRAWN KM 2/8/2017	CHECKED MS 5/30/2017	APPR. MS 5/30/2017
DRAWING SIZE B	REV. DATE 1/30/2019	SHT 4 OF 5



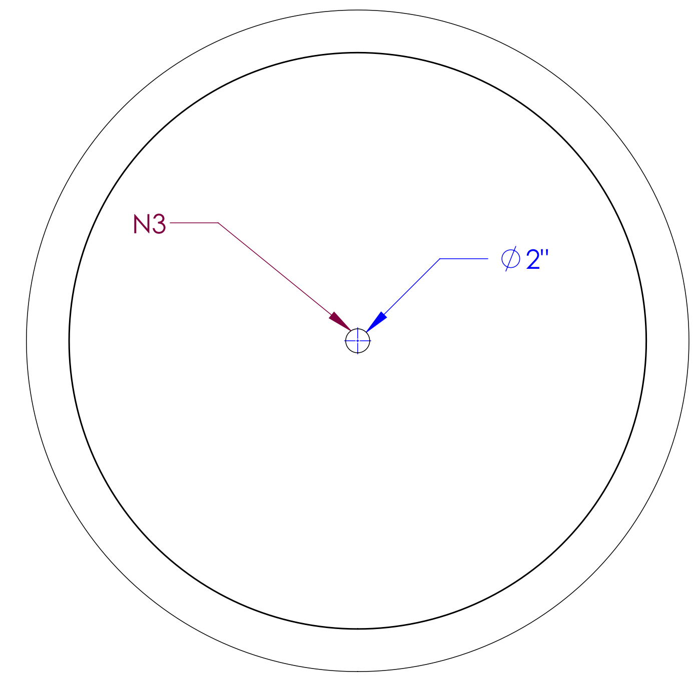
TOP HEAD
3.625" THK - 2 X 1" PSVs



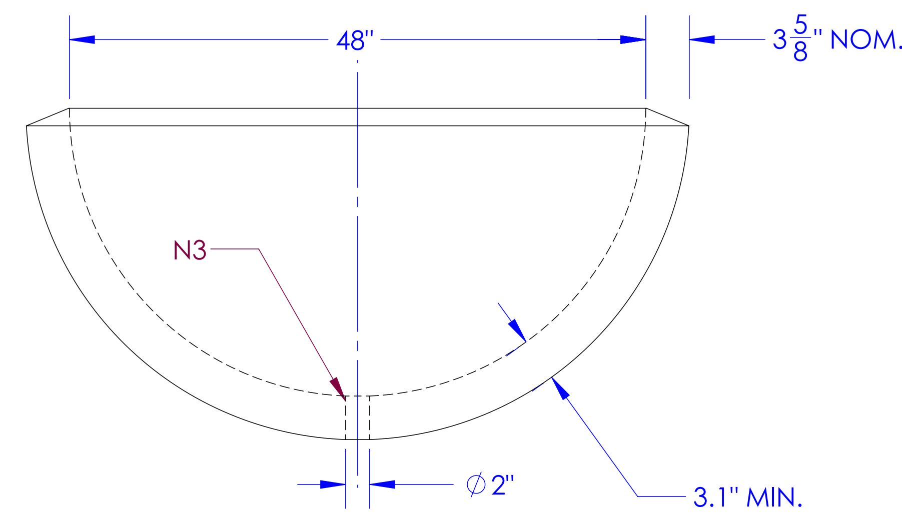
SECTION K-K



SECTION M-M



BOTTOM HEAD



SYNERGY FABRICATION, INC.
1432 E. DEVITT ST.
FORT WORTH, TX 76119

TITLE: 48" ID -5K SPHERICAL Sand Separator		
DWG. NO. SFI-48IDX5K-XXX		REV 6E
DRAWN KM 2/8/2017	CHECKED MS 5/30/2017	APPR. MS 5/30/2017
DRAWING SIZE B	REV. DATE 1/30/2019	SHT 5 OF 5

Material Test Reports

STRAIGHT BILL OF LADING - Loading Copy - Not Negotiable

PLACE PRO-LABEL HERE

CPU
(Name of Carrier)

SHIPPER: FORT WORTH F & D HEAD COMPANY		DATE: 5/16/2019	SALES ORDER NUMBER: 621301
STREET: 3040 PEDEN ROAD, FORT WORTH, TX	ZIP CODE: 76179	BILL TO:	
CONSIGNEE: SYNERGY FABRICATIONS INC	CONSIGNEE PHONE NO: (817) 832-6735	STREET ADDRESS:	
STREET: 1432 E DEVITT ST	CITY: FORT WORTH STATE: TX ZIP CODE: 76119	CITY:	STATE: ZIP:

No. Shipping Units	(X) HM	Kind of Packaging, Description of Articles, Special Marks and Exceptions	Weight (Subject to Correction)	Class or Rate
4		48 X 3.5 HOT PRESS HEMI STL TANKEND UNF	16,604	50
1		ENVELOPE	2	
AG 5-17-19				
		(12) SM Energy 48" Hemi's		
		SF1-481D & SK-097		
		QC APPROVAL ✓		
		BY: D.M. 102		
		DATE: 5-21-2019		
Tt. # of Units		**P.O. Number:** / **Customer No:**	**Total Wt.**	
5		203612 / 4266 / 217592	16,606	50

NMFC Item 180690, Sub. 4/ Company check acceptable: ☐ Yes ☐ No

Remit: C.O.D. TO: ADDRESS: FORT WORTH F & D HEAD COMPANY, P.O. BOX 79700, SAGINAW, TEXAS 76179	**COD** Amt: $	C.O.D Fee: Prepaid ☐ Collect ☐ $

Note - Where the rate is dependent on value, shippers are required to state specifically in writing the agreed or declared value of the property.
The agreed or declared value of the property is hereby specifically stated by the shipper to be not exceeding.

$ ________ per ________

Subject to Section of the conditions, if this shipment is to be delivered to the consignee without recourse on the consignor, the consignor shall sign the following statement.
The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges.

________ (Signature of Consignor)

Total Charges $

FREIGHT CHARGES
Prepaid ☐ Collect ☑

FREIGHT COLLECT EXCEPT WHEN PREPAID BOX ABOVE IS CHECKED.

Received subject to the classification and tariffs in effect on the date of the issue of this Bill of Lading, the property described above in apparent good order, except as noted (contents and condition of contents of packages unknown), marked, consigned, and destined as indicated above which said carrier (the word carrier being understood throughout this contract as meaning any person or corporation in possession of the property under the contract) agrees to carry its usual place of delivery at said destination, if on its route, otherwise to deliver to another carrier on the route to said destination. It is mutually agreed as to each carrier of all or any of, said property over all any portion of said route to destination and as to each party at any time interested in all or any said property, that every service to be performed hereunder shall be to all the bill of lading terms and conditions in the governing classification on the date or shipment.

Shipper hereby certifies that he is familiarr with all the bill of lading terms and conditions in the governing classification and the said terms and conditions are hereby agreed to by the shipper and accepted for himself and his assigns.

SHIPPER: FORT WORTH F & D HEAD CO		CARRIER:	
PER	DATE 5/16/2019	PER	DATE
PERMANENT ADDRESS OF SHIPPER: 3040 PEDEN ROAD, FORT WORTH, TX 76179, (817) 236-8773		MARK "X" IN "HM" COLUMNS FOR HAZARDOUS MATERIALS	

STRAIGHT BILL OF LADING - Loading Copy - Not Negotiable

3rd

PLACE PRO-LABEL HERE

CPU

(Name of Carrier)

SHIPPER: FORT WORTH F & D HEAD COMPANY				DATE: 5/17/2019	SALES ORDER NUMBER: 621301
STREET: 3040 PEDEN ROAD, FORT WORTH, TX		ZIP CODE: 76179		BILL TO:	
CONSIGNEE: SYNERGY FABRICATIONS INC		CONSIGNEE PHONE NO: (817) 832-6735		STREET ADDRESS:	
STREET: 1432 E DEVITT ST	CITY: FORT WORTH	STATE: TX	ZIP CODE: 76119	CITY:	STATE: ZIP:

No. Shipping Units	(X) HM	Kind of Packaging, Description of Articles, Special Marks and Exceptions			Weight (Subject to Correction)	Class or Rate
4		48 X 3.5	HOT PRESS HEMI	STL TANKEND UNF	16,604	50
1		ENVELOPE			2	
RG 5-18-19						
		(12) SM Energy 48" Hemis				
		SFI - 4810 x SK - 097				
		QC APPROVAL ✓				
		BY: DM 102				
		DATE: 5-21-2019				
Tt. # of Units		**P.O. Number:**	**Customer No:**		**Total Wt.**	
5		203612	4266	217592	16,606	50

NMFC Item 180690, Sub. 4/ Company check acceptable: ☐ Yes ☐ No

Remit: FORT WORTH F & D HEAD COMPANY
C.O.D. TO: P.O. BOX 79700
ADDRESS: SAGINAW, TEXAS 76179

COD Amt: $

C.O.D Fee: Prepaid ☐ Collect ☐ $

Note - Where the rate is dependent on value, shippers are required to state specifically in writing the agreed or declared value of the property.
The agreed or declared value of the property is hereby specifically stated by the shipper to be not exceeding.

$ __________ per __________

Subject to Section of the conditions, if this shipment is to be delivered to the consignee without recourse on the consignor, the consignor shall sign the following statement.
The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges.

__________ (Signature of Consignor)

Total Charges $

FREIGHT CHARGES
Prepaid ☐ **Collect** ☑

FREIGHT COLLECT EXCEPT WHEN PREPAID BOX ABOVE IS CHECKED.

Received subject to the classification and tariffs in effect on the date of the issue of this Bill of Lading, the property described above in apparent good order, except as noted (contents and condition of contents of packages unknown), marked, consigned, and destined as indicated above which said carrier (the word carrier being understood throughout this contract as meaning any person or corporation in possession of the property under the contract) agrees to carry its usual place of delivery at said destination, if on its route, otherwise to deliver to another carrier on the route to said destination. It is mutually agreed as to each carrier of all or any of, said property over all any portion of said route to destination and as to each party at any time interested in all or any said property, that every service to be performed hereunder shall be to all the bill of lading terms and conditions in the governing classification on the date or shipment.
Shipper hereby certifies that he is familiarr with all the bill of lading terms and conditions in the governing classification and the said terms and conditions are hereby agreed to by the shipper and accepted for himself and his assigns.

SHIPPER: FORT WORTH F & D HEAD CO		CARRIER:	
PER	DATE 5/17/2019	PER	DATE
PERMANENT ADDRESS OF SHIPPER:	3040 PEDEN ROAD, FORT WORTH, TX 76179, (817) 236-8773	MARK "X" IN "HM" COLUMNS FOR HAZARDOUS MATERIALS	

STRAIGHT BILL OF LADING - Loading Copy - Not Negotiable

2ND

PLACE PRO-LABEL HERE

CPU

(Name of Carrier)

SHIPPER:				DATE:	SALES ORDER NUMBER:
FORT WORTH F & D HEAD COMPANY				**5/17/2019**	**621301**
STREET: **3040 PEDEN ROAD, FORT WORTH, TX**		ZIP CODE: **76179**		BILL TO:	
CONSIGNEE: **SYNERGY FABRICATIONS INC**		CONSIGNEE PHONE NO: **(817) 832-6735**		STREET ADDRESS:	
STREET: **1432 E DEVITT ST**	CITY: **FORT WORTH**	STATE: **TX**	ZIP CODE: **76119**	CITY: STATE: ZIP:	

No. Shipping Units	(X) HM	Kind of Packaging, Description of Articles, Special Marks and Exceptions	Weight (Subject to Correction)	Class or Rate
4		48 X 3.5 HOT PRESS HEMI STL TANKEND UNF	16,604	**50**
1		ENVELOPE	2	
5-18-19				
		(12) Sm Energy 48" Hemis		
		SP1-481D & SR-097		
		QC APPROVAL ✓		
		BY: DM 102		
		DATE: 5-21-2019		
Tt. # of Units		**P.O. Number:** / **Customer No:**	**Total Wt.**	
5		203612 / 4266 / 217592	16,606	**50**

NMFC Item 180690, Sub. 4/ Company check acceptable: ☐ Yes ☐ No

Remit: FORT WORTH F & D HEAD COMPANY
C.O.D. TO: P.O. BOX 79700
ADDRESS: SAGINAW, TEXAS 76179

COD Amt: $

C.O.D Fee: Prepaid ☐ Collect ☐ $

Note - Where the rate is dependent on value, shippers are required to state specifically in writing the agreed or declared value of the property.
The agreed or declared value of the property is hereby specifically stated by the shipper to be not exceeding.

$ ________ per ________

Subject to Section of the conditions, if this shipment is to be delivered to the consignee without recourse on the consignor, the consignor shall sign the following statement.
The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges.

(Signature of Consignor)

Total Charges $

FREIGHT CHARGES
Prepaid ☐ Collect ☑

FREIGHT COLLECT EXCEPT WHEN PREPAID BOX ABOVE IS CHECKED.

Received subject to the classification and tariffs in effect on the date of the issue of this Bill of Lading, the property described above in apparent good order, except as noted (contents and condition of contents of packages unknown), marked, consigned, and destined as indicated above which said carrier (the word carrier being understood throughout this contract as meaning any person or corporation in possession of the property under the contract) agrees to carry its usual place of delivery at said destination, if on its route, otherwise to deliver to another carrier on the route to said destination. It is mutually agreed as to each carrier of all or any of, said property over all any portion of said route to destination and as to each party at any time interested in all or any said property, that every service to be performed hereunder shall be to all the bill of lading terms and conditions in the governing classification on the date or shipment.

Shipper hereby certifies that he is familiarr with all the bill of lading terms and conditions in the governing classification and the said terms and conditions are hereby agreed to by the shipper and accepted for himself and his assigns.

SHIPPER: FORT WORTH F & D HEAD CO	CARRIER:
PER DATE 5/17/2019	PER DATE
PERMANENT ADDRESS OF SHIPPER: 3040 PEDEN ROAD, FORT WORTH, TX 76179, (817) 236-8773	MARK "X" IN "HM" COLUMNS FOR HAZARDOUS MATERIALS

FORT WORTH F & D HEAD CO
P.O. BOX 79700
FORT WORTH, TEXAS 76179-0700

COVER SHEET

CUSTOMER **SYNERGY FABRICATION**	CUSTOMERS P.O. NUMBER **203612**	DATE **5/13/19**

CODE LETTER	QTY.	SIZE-OD. OR ID.	THICKNESS	PLATE MFG.	HEAT NUMBER	SLAB NUMBER
CODB ✓	**4** ✓	**48"ID** ✓	**3 1/2"NOM** ✓	**JSW STEEL**	**S27086**	**04B1**
COEJ ✓	**4** ✓	**48"ID** ✓	**3 1/2"NOM** ✓	**JSW STEEL**	**S26396**	**08B1**
COEK ✓	**4** ✓	**48"ID** ✓	**3 1/2"NOM** ✓	**JSW STEEL**	**S26397**	**09B1**

HOT FORMED ☒

MATERIAL **SA516-70 NORM** ✓
CHARPY @ -30 ✓

STYLE **HEMI**

SF:
BEVEL: **22 DEG** ✓ OUTSIDE ☒ INSIDE ☐
DR:
MIN: **3.1"** ✓ LAND ICR

WO# 217592

FORT WORTH F & D HEAD COMPANY CERTIFIES THAT HEADS MANUFACTURED FROM MATERIAL LISTED ON THIS REPORT COMPLY WITH ASME CODE SECTION II & SECTION VIII, DIVISION I. ALL HEADS COMPLY WITH UG-81(a) AHD UCS 79.

WE CERTIFY THAT THESE HEADS WERE HOT FORMED ABOVE 1,650 DEGREES FAHRENHEIT, HELD FOR A MINIMUM OF **135** MINUTES, AND AIR COOLED.

Roxanne L. Taylor
FORT WORTH F & D HEAD CO.

BONDED INSPECTIONS

10817 Sanden Dr. Dallas, Texas 75238

Phone: 972-276-0846

Web: www.bondedndt.com

Customer: Fort Worth F&D Head, Co. Inc.

Report Number: KP-MPTR-05-10-2019-17-46-03

PO Number:

Sales Order Number: 6736

Report Date & Time: 05/10/2019 12:43 PM

Magnetic Particle Test Report

Material: 516-70 CARBON STEEL	**Thickness:** 3.50"
Acceptance Criteria: ASME Sec. VIII Div. 1 Appendix 6	**BI Proc Rev:** BI MT 1.0 Rev. 13
Equipment: Yoke	**AC or DC:** AC
Model: Contour Probe B-100 (yoke)	**Cal Date Due:** 05/10/2019
Wet or Dry Particles: Dry	**Visible Media:** 2 Yellow
Fluorescent Media N/A	**Cir Amps:**
Long Amps:	**Light Equipment:** Flashlight
Black Light / 1000 uW/CM2 Min. @ Exam Surface: N/A	**White Light / 100 fc Min. @ Exam Surface:** OK
DC Lift Test 40lb. - Weight SN:	**AC Lift Test 10lb. - Weight SN:** 1023

ID Number	Description	Acc	Rej	Flaw Description Location
W/O: 217592; Heat Code: CODB	Qty: 4 Heads	✓		N/A
W/O: 217592; Heat Code: COEJ	Qty: 4 Heads	✓		N/A
W/O: 217592; Heat Code: COEK	Qty: 4 Heads	✓		N/A

Notes

Dry magnetic particle inspection performed on 100% of bevels after forming to locate possible defects. No relevant indications noted upon completion of this inspection.

[illegible]	(signature)	[illegible]	

BONDED INSPECTIONS

10817 Sanden Dr. Dallas, Texas 75238

Phone: 972-276-0846

Web: www.bondedndt.com

Customer: Fort Worth F&D Head, Co. Inc.

Report Number: CS-UR-05-10-2019-17-51-12

PO Number:

Sales Order Number: 6791

Report Date & Time: 05/10/2019 12:47 PM

Ultrasonic Report

BI Proc Rev: UT 1.0 REV 17	**Acceptance Criteria:** ASTM-A578
Material: SA516 GR70	**Material Thickness:** 3.5"
Couplant: Water	

Ultrasonic Instrument Identification

Manufacturer: G.E.	**Model:** USM 36
Display Type: A-scan	**Serial Number:** 15037593
Cal Due: 7/3/19	**Software Ver:** USM_36(4.2.0.17. 3/April/2014)

Search Unit Identification

Manufacturer	SN	Frequency	Size	Shape	Angle	Cable Type	Cable Length
Panametrics	23152	2.25 Mhz	1"	Round	0°	B.N.C. to B.N.C.	6'

Calibration Information

Setup No	Range Used	Dampening	Reject	Velocity	Delay	Calibration Block ID	Reflector Size	Reference Level Gain
1	10"	1000	off	.2331	.683	IIW TYPE II	Part Back Wall Reflection	37DB

Testing Disposition

Part ID	Weld Identification	Scan Surface/Condition	Acc	Rej	Indication % of DAC	Indication Length x Depth	Indication (x,y)
W/O-217592, SA516 GR70, 48" ID x 3.5"	CODB (Qty-4)	Moderate Grain	✓				
	COEJ (Qty-4)	Moderate Grain	✓				
	COEK (Qty-4)	Moderate Grain	✓				

Notes

(After Forming)Level B

Level II/III Signature	S 8	Level III	

JSW Steel (USA) INC.
5200,East McKinney Road,
BAYTOWN, TX 77523

METALLURGICAL TEST REPORT

P.36576

MET - 04 Rev. No.: 3 Rev. Date:02/27/2018

4/11/2019

Bulletin	Order Item	Heat	PO No.	Shipping Mode		Order Dimensions	Slab Origin	TC No.
T053335	JSW12205-01	S27086	V16849	TRUCK		3.5x73x292	BRAZIL	T053335-7086-1

TEST FREQUENCY TO MEETASTM A370 AND A673NACE MR0175

CODB

Plates Certified for the Following grades
ASTM-A516-70, ASME-SA516-70 2017 EDITION TN

Hot Rolled Carbon Steel Plates
Plates Manufactured In the USA

Specifications
TEST NORMALIZED AT 1650 °F FOR 105 MINS

Marking Instructions
Stencil in 2 location(s); X Loc. 18 Y Loc. 30; CUST; MADEINUSA PN PO; DIM GRADE; FREIGHT ORDERITEM PLATEID SHIPWEEK SLABID TRANSMODE Stamp in 2 location(s); X Loc. 18 Y Loc. 12; Slab ID; Slab ID; Slab ID

Sold To: LEECO STEEL LLC. 1011 WARRENVILLE RD LISLE, IL 60532

Ship To: Fort Worth FD Head Company 3040 E. Peden Rd. Fort Worth, TX 76179

Test	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Sn	Al	N	V	B	Ti	Nb	Ca	CE
LADLE	0.24	1.16	0.012	0.004	0.19	0.020	0.010	0.010	0.000	0.000	0.032	0.0070	0.004	0.0000	0.002	0.001	0.0024	0.44

– CODB

Carbon Equivalent CE = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15
PCM = C + Si/30 + Mn/20 + Cu/20 + Ni/60+ Cr/20 + Mo/15 + V/10 + 5B

Plate	Slab Identity	Gauge Tested	Test Cond	Test Dir.	Yield Point	Tensile Stgth.	Elong in 2"	YS/UTS Ratio	Yield Strenght Determind At	Impact Test (LCVN) Full Energy in Ft/Lb °F Temp	Test1	Test2	Test3	Avg	Test1	Test2	Test3	Avg
1123493A	04B1	3.5000	TN	T	53	81	31.0%	0.65	0.2%	-30	66	68	60	65				

HARDNESS

Plate	Test Method	Test1	Test2	Test3	Avg
1123493	ROCKWELL C	2	2	2	2

Plates Certified For The Above Tests

Material	Thick(IN)	Width (IN)	Len(IN)	Wgt(LB)	Material	Thick(IN)	Width(IN)	Len (IN)	Wgt(LB)	Material	Thick(IN)	Width(IN)	Len(IN)	Wgt(LB)
1123493A	3.5000	73.000	292.00	21158.262										

PO.47010

Q.C. by
J.D.

DIN: EN 10204 2004 3.1 This is to certify that the product decribed herein was manufactured, sampled, and tested in accordance with the specifications and requirements in such specifications. Fine Grain, Si-Al Fully Killed Steel. We certify that delivery of this product with the requirement of the specification and purchase order received from customer. DRC Conflict Free. Does not contain Hg .

April W

April Watkins 8323835325 april.watkins@jswsteel.us

JSW Steel (USA) INC.
5200,East McKinney Road,
BAYTOWN, TX 77523

METALLURGICAL TEST REPORT

MET - 04 Rev. No.: 3 Rev. Date:02/27/2018

P.36609

4/17/2019

Bulletin	Order Item	Heat	PO No.	Shipping Mode		Order Dimensions	Slab Origin	TC No.
T053818	JSW12205-01	S26396	V16849	TRUCK		3.5x73x292	BRAZIL	T053818-6396-1

COEJ

TEST FREQUENCY TO MEETASTM A370 AND A673NACE MR0175

Plates Certified for the Following grades
ASTM-A516-70, ASME-SA516-70 2017 EDITION TN

Hot Rolled Carbon Steel Plates
Plates Manufactured In the USA

Specifications
"TEST NORMALIZED AT 1650 °F FOR 105 MINS

Marking Instructions
Stencil in 2 location(s); X Loc. 18 Y Loc. 30; CUST; MADEINUSA PN PO; DIM GRADE; FREIGHT ORDERITEM PLATEID SHIPWEEK SLABID TRANSMODE Stamp in 2 location(s); X Loc. 18 Y Loc. 12; Slab ID; Slab ID; Slab ID

Sold To: LEECO STEEL LLC. 1011 WARRENVILLE RD LISLE, IL 60532

Ship To: Fort Worth FD Head Company 3040 E. Peden Rd. Fort Worth, TX 76179

Test	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Sn	Al	N	V	B	Ti	Nb	Ca	CE
LADLE	0.24	1.14	0.012	0.004	0.18	0.020	0.010	0.020	0.000	0.000	0.034	0.0050	0.004	0.0001	0.002	0.001	0.0024	0.44

— COEJ

Carbon Equivalent CE = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15
PCM = C + Si/30 + Mn/20 + Cu/20 + Ni/60+ Cr/20 + Mo/15 + V/10 + 5B

COEJ

Plate	Slab Identity	Gauge Tested	Test Cond	Test Dir.	Yield Point	Tensile Stgth.	Elong in 2"	YS/UTS Ratio	Yield Strenght Determind At
1123488A	08B1	3.5000	TN	T	52	78	28.0%	0.67	0.2%

Impact Test (LCVN) Full Energy in Ft/Lb °F								
Temp	Test1	Test2	Test3	Avg	Test1	Test2	Test3	Avg
-30	88	95	82	88				

HARDNESS					
Plate	Test Method	Test1	Test2	Test3	Avg
1123488	ROCKWELL C	2	4	6	4

Plates Certified For The Above Tests

Material	Thick(IN)	Width (IN)	Len(IN)	Wgt(LB)	Material	Thick(IN)	Width(IN)	Len (IN)	Wgt(LB)	Material	Thick(IN)	Width(IN)	Len(IN)	Wgt(LB)
1123488A	3.5000	73.000	292.00	21158.262										

PO.47010

Q.C. By J.D.

DIN: EN 10204 2004 3.1 This is to certify that the product decribed herein was manufactured, sampled, and tested in accordance with the specifications and requirements in such specifications. Fine Grain, Si-Al Fully Killed Steel. We certify that delivery of this product with the requirement of the specification and purchase order received from customer. DRC Conflict Free. Does not contain Hg .

April W

April Watkins 8323835325 april.watkins@jswsteel.us

JSW Steel (USA) INC.
5200,East McKinney Road,
BAYTOWN, TX 77523

METALLURGICAL TEST REPORT

P. 3660

MET - 04 Rev. No. 3 Rev. Date:02/27/2018

4/11/2019

Bulletin	Order Item	Heat	PO No.	Shipping Mode		Order Dimensions	Slab Origin	TC No.
T053336	JSW12205-01	S26397	V16849	TRUCK		3.5x73x292	BRAZIL	T053336-6397-1

COEK

TEST FREQUENCY TO MEETASTM A370 AND A673NACE MR0175

Plates Certified for the Following grades
ASTM-A516-70, ASME-SA516-70 2017 EDITION TN

Hot Rolled Carbon Steel Plates
Plates Manufactured In the USA

Specifications
"TEST NORMALIZED AT 1650 °F FOR 105 MINS

Marking Instructions
Stencil in 2 location(s); X Loc. 18 Y Loc. 30; CUST; MADEINUSA PN PO; DIM GRADE; FREIGHT ORDERITEM PLATEID SHIPWEEK SLABID TRANSMODE Stamp in 2 location(s); X Loc. 18 Y Loc. 12; Slab ID; Slab ID; Slab ID

Sold To: LEECO STEEL LLC. 1011 WARRENVILLE RD LISLE, IL 60532

Ship To: Fort Worth FD Head Company 3040 E. Peden Rd. Fort Worth, TX 76179

Test	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Sn	Al	N	V	B	Ti	Nb	Ca	CE
LADLE	0.23	1.16	0.013	0.004	0.18	0.030	0.010	0.020	0.000	0.000	0.035	0.0060	0.004	0.0001	0.002	0.002	0.0016	0.43

—COEK

Carbon Equivalent CE = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15
PCM = C + Si/30 + Mn/20 + Cu/20 + Ni/60+ Cr/20 + Mo/15 + V/10 + 5B

COEK

Plate	Slab Identity	Gauge Tested	Test Cond	Test Dir.	Yield Point	Tensile Stgth.	Elong in 2"	YS/UTS Ratio	Yield Strenght Determind At
1123489A	09B1	3.5000	TN	T	52	77	29.0%	0.68	0.2%

Impact Test (LCVN) Full Energy in Ft/Lb °F								
Temp	Test1	Test2	Test3	Avg	Test1	Test2	Test3	Avg
-30	68	92	88	83				

HARDNESS					
Plate	Test Method	Test1	Test2	Test3	Avg
1123489	ROCKWELL C	2	2	2	2

Plates Certified For The Above Tests

Material	Thick(IN)	Width (IN)	Len(IN)	Wgt(LB)	Material	Thick(IN)	Width(IN)	Len (IN)	Wgt(LB)	Material	Thick(IN)	Width(IN)	Len(IN)	Wgt(LB)
1123489A	3.5000	73.000	292.00	21158.262										

Po. 47010

Q.C. By J.D.

DIN: EN 10204 2004 3.1 This is to certify that the product decribed herein was manufactured, sampled, and tested in accordance with the specifications and requirements in such specifications. Fine Grain, Si-Al Fully Killed Steel. We certify that delivery of this product with the requirement of the specification and purchase order received from customer. DRC Conflict Free. Does not contain Hg .

April W

April Watkins 8323835325 april.watkins@jswsteel.us

Welders Log

Welder	Stamp	Process	Orig Qual Date	2019											
				Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Manuel Castaneda	M	GMAW	2/18/2015	Inactive											
Julian Enriquez	JJ	GMAW	2/25/2015	1/8/2019				Inactive							
Julian Enriquez	JJ	GMAW-P	3/2/2015	1/2/2019				Inactive							
Julian Enriquez	JJ	FCAW	5/13/2015	1/8/2019				Inactive							
Jonathan Ortiz	JO	GMAW	2/27/2015	1/9/2019					6/3/2019						
Jonathan Ortiz	JO	FCAW	4/17/2015	1/9/2019					6/4/2019						
Jose Orosco	1	FCAW	5/25/2015	1/4/2019					6/3/2019						
Jose Orosco	1	GMAW	2/25/2015	1/2/2019					6/6/2019						
Guadalupe Villagomez	4	GMAW	8/15/2017	1/7/2019					6/3/2019						
Salvador Garcia	S	FCAW	3/3/2017	Inactive											
Salvador Garcia	S	GMAW	3/9/2017	Inactive											
Manuel Castaneda Sr.	2	GMAW	2/19/2015	1/3/2019					6/3/2019						
Manuel Castaneda Sr.	2	FCAW	5/25/2015	1/9/2019					6/5/2019						
Jose Nunez	N	SAW	10/22/2015	1/24/2019					6/3/2019						
Jose Nunez	N	GMAW	8/7/2015	1/8/2019					6/4/2019						
Jose Nunez	N	FCAW	8/9/2015	1/22/2019					6/4/2019						
Adrian Rodriguez	R	FCAW	8/15/2016	1/11/2019					6/6/2019						
Adrian Rodriguez	R	GMAW	8/15/2016	1/2/2019					6/7/2019						
Adrian Rodriguez	R	SAW	8/17/2016	1/24/2019					6/5/2019						
Jose Licerio	L	GMAW	1/27/2017	1/8/2019					6/3/2019						
Jose Licerio	L	SAW	3/2/2017	1/18/2019					6/17/2019						
Jose Licerio	L	FCAW	7/27/2017	1/7/2019					6/3/2019						
Gregory Scott	AA	GMAW	3/2/2018	1/2/2019					6/3/2019						
Gregory Scott	AA	SAW	5/16/2018	1/18/2019					6/17/2019						
Marcos Alvarez	Z	GMAW	3/9/2017	Inactive											
Marcos Alvarez	Z	FCAW	3/9/2017	Inactive											
Cesar Herrera	I	GMAW	5/23/2017	1/7/2019		Inactive									
Jose G. Lopez	G	GMAW	4/20/2017	1/10/2019					6/3/2019						
Jose G. Lopez	G	FCAW	4/20/2017	1/22/2019					6/3/2019						
Jose G. Lopez	G	SAW	12/4/2017	1/29/2019					6/11/2019						
Sergio Cervantez	D	GMAW	9/12/2018	Inactive											

Welder	Stamp	Process	Orig Qual Date	2019											
				Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Sergio Cervantez	D	FCAW	9/17/2018	Inactive											
Sergio Cervantez	D	SAW	9/12/2018	Inactive											
Jimmy Rodriguez	J	SAW	3/26/2018	1/24/2019					6/3/2019						
Jimmy Rodriguez	J	GMAW	3/3/2018	1/10/2019					6/3/2019						
Mark Medellin	V	SAW	7/31/2018	1/23/2019			Inactive								
Freddy Lara	F	GMAW	2/3/2018	1/7/2019					6/6/2019						
Freddy Lara	F	SAW	3/8/2018	1/28/2019					6/10/2019						
Miguel Carreon	Y	GMAW	5/17/2017	1/2/2019					6/3/2019						
Miguel Carreon	Y	SAW	8/16/2017	1/24/2019					6/10/2019						
Candido Mena	C	GMAW	2/7/2018	1/2/2019					6/3/2019						
Candido Mena	C	FCAW	2/7/2018	1/2/2019					6/3/2019						
Victor Rangel	VV	GMAW	10/1/2018	1/3/2019					6/4/2019						
Mark Medellin	V	GMAW	2/4/2018	1/3/2019			Inactive								
Victor Rangel	VV	SAW	10/18/2018	1/25/2019					6/9/2019						
Jorge Luna	A	GMAW	3/30/2017	1/4/2019					6/3/2019						
Jose Ferreira	3	GMAW	8/8/2017	1/4/2019					6/3/2019						
Miguel Meza	4	GMAW	8/7/2017	1/7/2019					6/3/2019						
Jose Garcia	5	GMAW	4/2/2019				4/3/2019	Inactive							
Ramon Hernandez	H	GMAW	5/13/2019					5/15/2019							
Ramon Hernandez	H	FCAW	5/13/2019					5/15/2019							

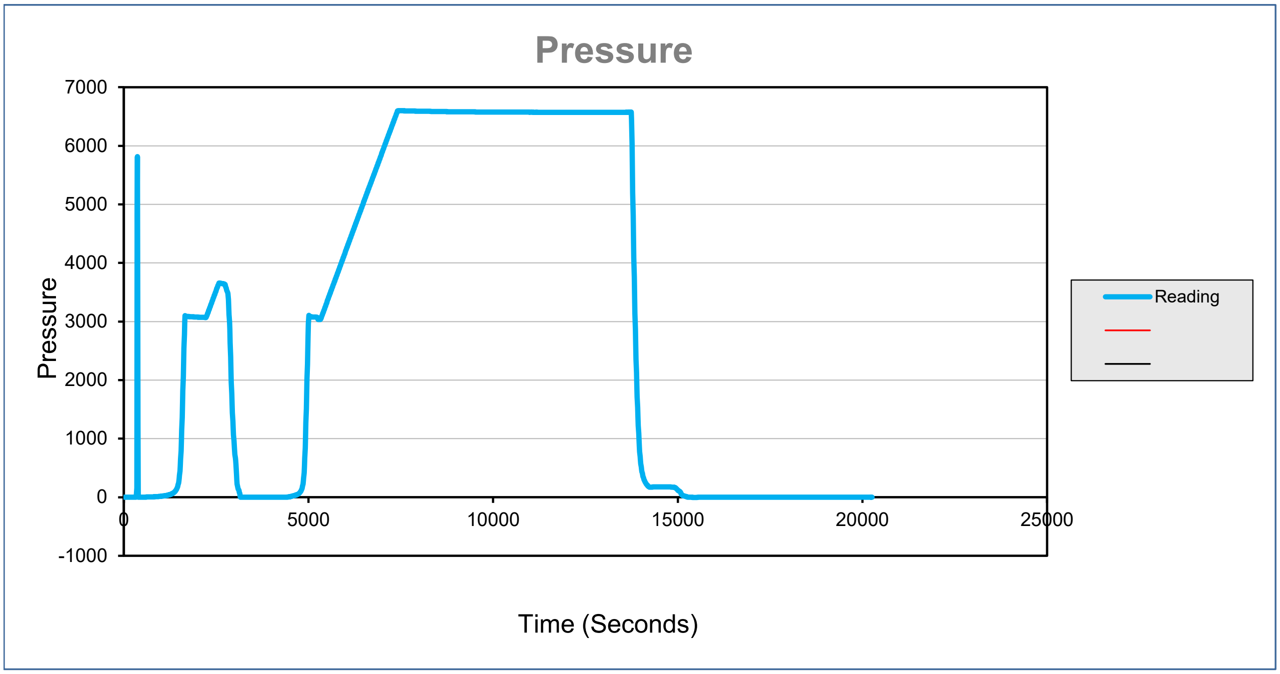
HYDRO CHART

SFI Hydrostatic Test Report

Job Description: ***SFI-48IDX5K-101 & 102***

Gauge Information	
Serial Number	780817
Model	15KPSIXP2I
Message Store	SYNERGY 15K
Units	PSI

Run Info	
Start Time	8/9/19 8:15:35 AM
Stop Time	8/9/19 1:53:23 PM
Logging Interval	10



HEAT TREAT REPORTS

Synergy Fabrication, Inc. PWHT PROCEDURE

PWHT Furnace Specifications

Serial_SFI-48IDX5K-101, 102 PO#203882

Part(s) (2) - 48" x 5K Spheres

1. Two thermocouples are required on every single part up to 15 feet long. An additional thermocouple is required for every additional 15 feet or fraction thereof. No two couples may be more than 15 feet apart. Placement of thermocouples must represent the maximum temperature spread expected both vertically and horizontally. Measurement of furnace gas temperature alone is not acceptable.
2. When more than one part is heat treated in one furnace charge, thermocouples shall be placed on parts at bottom center, and top of the charge or in other zones of possible temperature variation so that the temperature indicated shall be true temperature for all parts in those zones.
3. The temperature of the furnace shall not exceed 800°F at the time the part(s) is placed in it.
4. Above 800°F, the rate of heating shall not be more than 100°F per hour. During the heating period there shall be no greater variation in temperatures throughout the charge than 250 F.
5. Minimum hold at 1150°F for 2 hour(s) 30 minutes. During the holding period there shall not be a variation of more than 150 F between the highest and lowest temperatures recorded.
6. During the heating and holding periods, the furnace atmosphere shall be so controlled as to avoid excessive oxidation of the surface of the part(s) being heat treated. The furnace shall be of such design as to prevent direct impingement of the flame on the part(s).
7. Above 800 F, cooling shall be done in a closed furnace at a rate not to exceed 125°F per hour. From 800 F the part(s) may be cooled in still air.
8. Tack welds made to the part(s) for the thermocouple placement shall be made using a welding procedure qualified in accordance with Section IX of the ASME Code.
9. Holding temperature may not exceed 1200°F nor may time at temperature exceed 2 hour(s) 45 minutes.

   Heating rate _100°F/Hr_MAX

   Cooling rate _125°F/Hr MAX

10. Additional Instructions or Requirements

Southwest Metal Treating Corp.

CERTIFICATION

Synergy Fabrication, INC.
1432 Devitt
Fort Worth, TEXAS 76119 USA

Certification ID: **114283-1**
Date: 8/8/2019
Cert Date: 08/08/2019
Purchase Order: 203882
Material: All

We are pleased to provide you with the following Certification.

Part Number	Part Description	Qty	Weight
48" ID SPHERICAL SAND SEPERATOR	48" 5K SPHERE, S/N: SFI-48IDx5K-102	1	10,410.00

Customer Requirements

Inspection Type	U Of M	Lower Spec	Lower Control	Target Value	Upper Control	Upper Spec

Results

Inspection Type	Qty Tested	Qty Passed	Qty Rejected	Scale	Minimum	Maximum	Range
	0	0	0				

Miscellaneous Comments

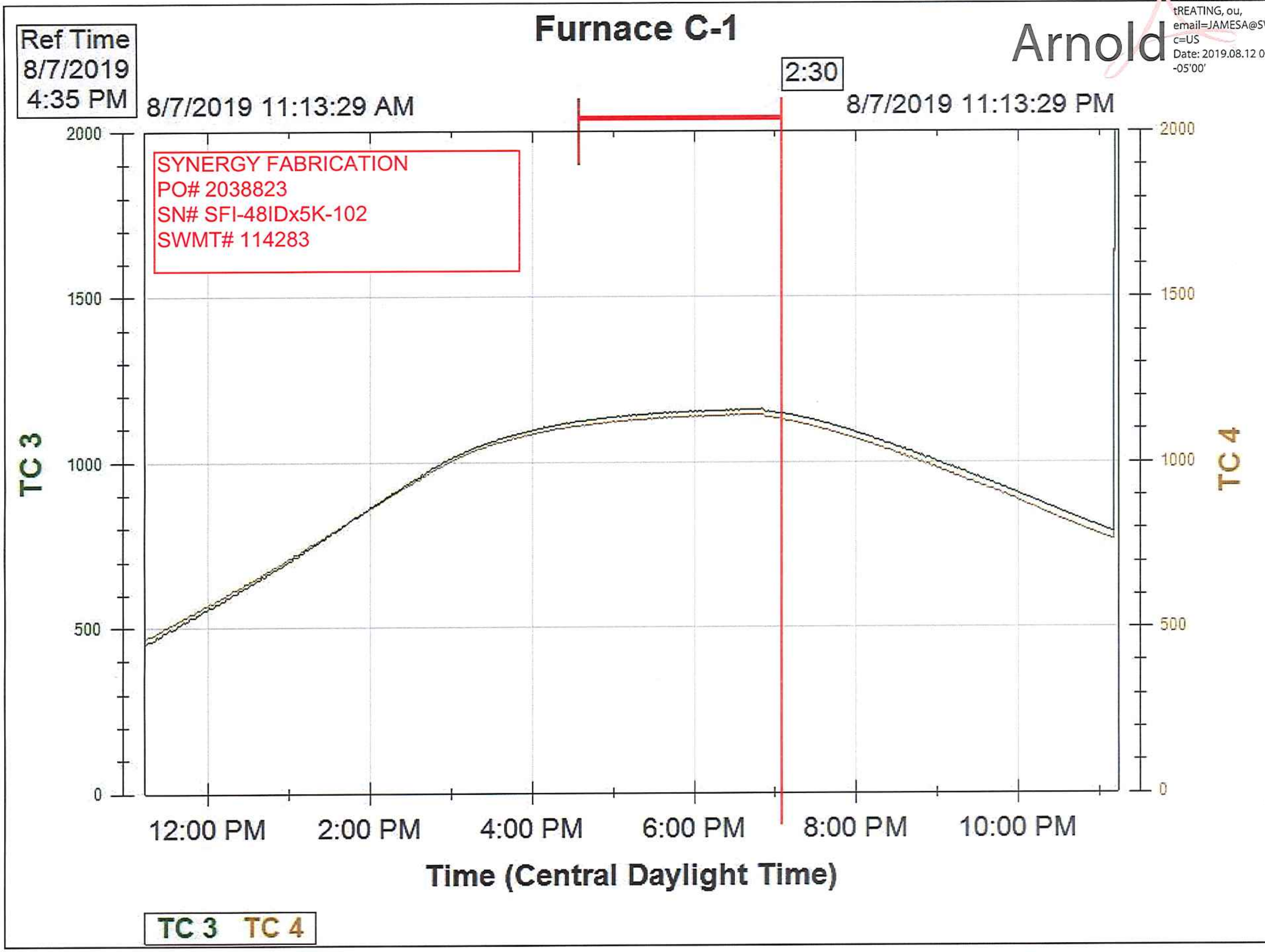
PWHT Process:
Post Weld Heat Treat
Step 1. Start Furnace at 800°F
Step 2. Heat 100°F /hr Max to 1150°F ±50°F
Step 3. Hold at 1150°F ±50°F for 2 Hrs 30 Min
Step 4. Cool 125°F /hr Max to 800°F
Step 5. Pull Parts

Certification Statement

SWMT is please to provide you with the following certification.

Certified By: James Arnold
Title: Plant Manager
Date: 08/08/2019

James Arnold
Digitally signed by James Arnold
DN: cn=James Arnold, o=sOUTHWEST mETAL tREATING, ou, email=JAMESA@SWMT.NET, c=US
Date: 2019.08.12 09:42:57 -05'00'



NDE
REPORTS

BONDED INSPECTIONS

10817 Sanden Dr. Dallas, Texas 75238

Phone: 972-276-0846

Web: www.bondedndt.com

Customer: Synergy Fabrication, Inc.

Report Number: GB-RER-08-04-2019-23-46-46-REV1

PO Number: SFI-48IDx5K-102

Sales Order Number: 8052

Report Date & Time: 08/ 4/2019 06:39 PM

Radiographic Examination Report

BI Proc Rev: BI RT 1.0 REV 19	**Acceptance Criteria:** ASME Sec. VIII Div. 1 UW 51
Percent or Random: 100%	**Xray KV:** N/A
Xray MA: N/A	**Xray Focal Spot Size:** N/A
Isotope: Co 60	**Isotope Physical Size:** .122
Number of Exposures: 2	**Number of Film Per Holder:** 1
Base Material Type: CS	**Diameter:** 48ID
Thickness: 3.500	**Weld Thickness:** 3.625
Weld Reinforcement Thickness: .125	**IQI Type:** (Film Side) ASTM C-Set
IQI Designated Hole or Wire: #13 wire	**Shim:** N/A
Exposure Time: 9min - 14min	**Film Size:** 7" x 17"
MFR + Film Speed: Agfa D7	**Min Source to Object Distance:** 24
Source Side Object to Film Distance: 3.500	**Wall Exposure:** Single
Wall View: Single	**Chemistry:** Manual

Serial Number	Weld Number	Film	Acc	Rej	Def Codes	Film Density	Remarks
SFI-48IDx5K-102	Girth	1-2		✗	SL		
		2-3		✗	SL, P		
		3-4	✓				
		4-5	✓				
		5-6	✓				
		6-7	✓				
		7-8	✓				
		8-9	✓		SL		Less than .750
		9-10	✓				
		10-11	✓				
		11-12	✓				
		12-13	✓		P		Pass on cap
		13-14	✓		P		Pass on cap
		14-1	✓				

Notes

11qty. 7x17(D7)
3qty. 7x17(D5)

3 of 3

Radiographer: Leon Baker			
Level II: Gerimaine Bradford		**Level III:**	

cr = crack	ip = incomplete penetration	iu = internal undercut	if = incomplete fusion	eu = external undercut	bt = burn through
lc = low crown	si = slag inclusion	sb = suck back (concave root)	sl = slag line	wt = wagon tracks	p = porosity

BONDED INSPECTIONS

10817 Sanden Dr. Dallas, Texas 75238

Phone: 972-276-0846

Web: www.bondedndt.com

Customer: Synergy Fabrication, Inc.

Report Number: GB-RER-08-06-2019-19-08-42

PO Number: SFI-48IDx5K-102

Sales Order Number: 8082

Report Date & Time: 08/ 6/2019 02:02 PM

Radiographic Examination Report

BI Proc Rev: BI RT 1.0 REV 19	**Acceptance Criteria:** ASME Sec. VIII Div. 1 UW 51
Percent or Random: 100%	**Xray KV:** N/A
Xray MA: N/A	**Xray Focal Spot Size:** N/A
Isotope: Ir 192	**Isotope Physical Size:** .138
Number of Exposures: 1	**Number of Film Per Holder:** 1
Base Material Type: CS	**Diameter:** 48ID
Thickness: 3.500	**Weld Thickness:** 3.625
Weld Reinforcement Thickness: .125	**IQI Type:** (Film Side) ASTM C-Set
IQI Designated Hole or Wire: #13 wire	**Shim:** N/A
Exposure Time: 1hr 30min	**Film Size:** 7" x 17"
MFR + Film Speed: Agfa D7	**Min Source to Object Distance:** 27.5
Source Side Object to Film Distance: 3.625	**Wall Exposure:** Single
Wall View: Single	**Chemistry:** Manual

Serial Number	Weld Number	Film	Acc	Rej	Def Codes	Film Density	Remarks
SFI-48IDx5K-102	Girth	1-2	✓				
SFI-48IDx5K-102	Girth	2-3	✓				

Notes

2qty. 7x17(D5)

1 of 6

Radiographer: Andy Hathaway			
Level II: Gerimaine Bradford		**Level III:**	

cr = crack	ip = incomplete penetration	iu = internal undercut	if = incomplete fusion	eu = external undercut	bt = burn through
lc = low crown	si = slag inclusion	sb = suck back (concave root)	sl = slag line	wt = wagon tracks	p = porosity

PSV
CERTIFICATION