

UOP RUSSELL LLC
Tulsa, Oklahoma

JOB NO: **TRJ-488** TAG NO: **V-481** DATE: **11/29/2010**
 CLIENT: S.O./P.O. NO: BY: **JRG**
 SUBJECT: **60 MMscfd Cryo RSV Plant** SERVICE: **Fuel Gas Scrubber**

PRESSURE VESSELS

MECHANICAL DESIGN		PROCESS DESIGN	
Type (vertical, horizontal, tower)	Vertical	Operating Pressure (psia)	100
Diameter: (inch)	24" OD	Operating Temperature (°F)	105
S/S Length (ft-inch)	6'-0"	Vapor Flow (Lb/Hr)	3,500
Skirt Length(ft-inch)	1"-0"	Vapor Density (Lb/cf)	0.2768
Design Pressure (psig)	▲ 265	Liquid Flow (Lb/Hr)	----
Design Temperature (°F)	150	Liquid Density (Lb/cf)	----
MDMT (°F) @ Pressure (psig)	-20 @ 265 ▲	Liquid Residence Time (Min)	NA
Corrosion Allowance (inch)	0.0625	MIST PAD	
Radiography	RT-2	Req'd : Yes	Diameter: 24
PWHT Req'd?	No	Overall Thk: 8	Pad Thk: 6"
Wind / Seismic Code	ASCE 7-10 / ASCE 7-10	Removable: No	Grid Mat: CS
Wind Code	Cf=0.7, V=120 mph, Exp. C, Cat. III	Wire Diameter: 0.011	Mesh Mat: 316SS
Seismic Code	Site D, I=1.25, S _S =100% , S _I =40%	MATERIAL SPECIFICATIONS	
Insulation	Note 2	Shell	SA- 106B
Fireproof	No	Head	SA- 516-70
Code	ASME VIII, Div I	Nozzle Necks	SA- 106B
Code Stamp Req'd	Yes	Flanges	SA- 105
Sandblast / Paint	SSPC-SP6 / TRCo Std ENG-36c (Note 3)	Couplings	SA- 105
Ladder / Platform Clips Req'd?	No	Studs	SA- 193-B7
Pipe Supports Req'd?	No	Nuts	SA- 194-2H
		Skirt / Baseplate	SA- 106-B/516-70

NOZZLES						
SERVICE	MK	QTY	SIZE	RATING	FACE & TYPE	NOZZLE APPURTENANCES
Inlet	A	1	4" ▲	150	RF FLG	diverter
Vapor Outlet / Inspection	B	1	4"	150	RF FLG	
Liquid Outlet	C	1	1"	6000	CPLG	syphon
LG	D	2	.75"	6000	CPLG	
TI	E	1	.75"	6000	CPLG	
LSHH	F	2	1"	6000	CPLG	
Inspection	G	1	2"	3000	CPLG	
LC (future)	H	2	1.5"	3000	CPLG	Plugged

INTERNALS AND APPURTENANCES									
PACKING	Size (in.)	Type	Bed Height (ft.)	PLATFORMS	Quantity	Angle / Area	BOOM	BOOM	BOOM
Top				Access:		(deg)	Diameter (in):		
Middle				Stepoff:		(deg)	Length (in):		
Bottom				Other:		(Sq.Ft.)	with flanges		
TRAYS	Quantity	No. of Passes	Weldins by:	Platepack Length (inch):			Qty Break Flg Pairs:		
				Total Ladder Length (ft):			Qty of Hat Trays:		
NOTES:	1) See scope of supply for oversizing mist pads.						Weir Plate:	No	
	2) Electric heat trace w/ 1" H to NLL						Wave Baffle:	No	
	3) Use TRCo Paint System 3 with a Top Coat						Nat'l Board Req'd:	Yes	
REVISION	A	0	1	▲ 2			Charcoal Bed Height (ft):		
ENGINEER/DATE	JRG 11/29/10	JRG 7/14/2011	BH 11/21/11	KLS 9/18/2017			Qty Catalyst bed Supports:		
ISSUED FOR	RFQ	Purchase	Revised	Revised					

UOP RUSSELL, LLC
Tulsa, Oklahoma

FORM # MST-ELM

MIST ELIMINATOR SPECIFICATION

Job Number TRJ-488

Spec. No.: ME-

Vessel Tag V-481

Spec. By: _____

Checked By: _____

Date: 11/29/2010

Mistpad Installed Diameter: 24 inches

Mesh Thickness: 6 inches

Mesh Material: 316SS

Density Required: 12 lbs/cf

Wire Diameter: 0.011 inches

Grid Material: CS

Grid Diameter: 22.5 inches

Mistpad Overall Thickness: 8 inches

Oversize mesh (on all sides): 0.375 inch

Manway I.D.: 17 inches

Number of Segments: 4

Removeable (Yes / No): No

Note 1: Oversized diameter of Mist Extractor shall allow the vessel to be shipped horizontally with the

<u>No. of segments</u>	<u>Oversize (all sides of each sections)</u>
1 or 2	1/2"
3 or 4	3/8"
More than 4	1/4"

Note 2: Grid diameter shall be 1-1/2" less than the installed diameter shown above.

Note 3: OD of each grid section shall be banded.

REVISION				
ENGINEER/DATE				
ISSUED FOR				

LEWIS INDUSTRIES CORPORATION
816 N. 5TH STREET, COLLINSVILLE, OKLA. 74021

Date Printed: 02/28/18

CUSTOMER

UOP Russell LLC
7050 South Yale, Ste. 210
Tulsa, Oklahoma 74136

VESSEL LOCATION

UOP Russell LLC
7050 South Yale, Ste 210
Tulsa, Oklahoma 74136

VESSEL DESCRIPTION

24" O.D. X 6'-0" SM/SM VERT. FUEL GAS SCRUBBER

Vessel designed per the ASME Boiler & Pressure Vessel Code,
Section VIII Division 1, 2015 Edition
Vessel is ASME Code Stamped

Job No:

185215

Vessel Number:

TAG #V-481

Purchase Order No.:

4500827189

NAMEPLATE INFORMATION

MAWP: 265 PSI at 150 Deg. F
MDMT -20 Deg. F at 265 PSI
Serial Number(s): 185215
National Board Number(s): 2992

Radiography: RT-2
Postweld Heat Treated: NO
Construction Types: W

Signatures

Quality Control Mgr: George E. Lewis Date: 3/8/18

Authorized Inspector: _____ Date: 1/1

LEWIS INDUSTRIES

V-481

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10. Material Test Reports
11. Design Calculations
12. Drawings

Skid 2 relocated from
UOPR Job 409 to 447

National Board Number: 2992

Mfr. Representative: DC Date: 3-21-18

Authorized Inspector: DC Date: 3-21-18

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 Lewis Industries Corporation, 816 North 5th Street, Collinsville, Oklahoma 74021
(Name and address of Manufacturer)

2. Manufactured for UOP Russell LLC, 7050 South Yale, Ste. #210, Tulsa, Oklahoma 74136
(Name and address of Purchaser)

3. Location of installation Unknown
(Name and address)

4. Type Vertical Tank 185215 SC6-307 A & B 2992 2018
(Horizontal or vertical, tank) (Manufacturer's serial number) (CRN) (Drawing number) (National Board number) (Year built)

5. ASME Code, Section VIII, Div. 1 2015 SC6-307 A & B 2992 2018
(Edition and Addenda, if applicable (date)) (Code Case number) (Special service per UG-120(d))

6. Shell SA-106-B .375 .0625 24" O.D. 6'-0"
(Material spec. number, grade) (Nominal thickness) (Corr. allow.) (Inner diameter) (Length (overall))

Body Flanges on Shells										Bolting		
No.	Type	ID	OD	Flange Thk	Min Hub Thk	Material	How Attached	Location	Num & Size	Bolting Material	Washer (OD, ID, thk)	Washer Material

7. Seams SMLS - 100 - TYPE 1 Spot 100 1
(Long. (welded, dbl., snlg., lap, butt)) (R.T. (spot or full)) (Eff. %) (H.T. temp.) (Time, hr) (Girth (welded, dbl., snlg., lap, butt)) (R.T. (spot or full)) (Eff. %) (No. of courses)

8. Heads: (a) Material SA-516-70 (b) Material SA-516-70
(Spec. no., grade) (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)	Top	.3125	.0625	-	-	2:1	-	-	-	Concave
(b)	Bottom	.3125	.0625	-	-	2:1	-	-	-	Concave

Body Flanges on Heads										Bolting		
	Location	Type	ID	OD	Flange Thk	Min Hub Thk	Material	How Attached	Num & Size	Bolting Material	Washer (OD, ID, thk)	Washer Material
(a)												
(b)												

9. MAWP 265 - 150 -
(Internal) (External) at max. temp. (Internal) (External)
Min. design metal temp. -20 at 265 Hydro., pneu., or comb. test pressure HYDRO 345
Proof test -

10. Nozzles, inspection, and safety valve openings:

Purpose (Inlet, Outlet, Drain, etc.)	No.	Diameter or Size	Type	Material		Nozzle Thickness		Reinforcement Material	Attachment Details		Location (Insp. Open.)
				Nozzle	Flange	Nom.	Corr.		Nozzle	Flange	
Inlet	1	4"	RFWN	SA-106-B	SA-105	.337	.0625	-	UW16.1(c)	Type 1	Shell
Outlet	1	4"	RFWN	SA-106-B	SA-105	.337	.0625	-	UW16.1(c)	Type 1	Head (a)
Connection	1	2"	CPLG	-	SA-105	CL3000	.0625	-	UW16.1(y)	-	Shell
Connections	2	1 1/2"	CPLG	-	SA-105	CL3000	.0625	-	UW16.1(y)	-	Shell
Connections	3	1"	CPLG	-	SA-105	CL6000	.0625	-	UW16.1(y)	-	Shell
Connections	3	3/4"	CPLG	-	SA-105	CL6000	.0625	-	UW16.1(y)	-	Shell

11. Supports: Skirt Yes Lugs - Legs - Other - Attached Bottom Head-Welded
(Yes or no) (Number) (Number) (Describe) (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: SAFETY VALVE(S) SUPPLIED BY OTHERS PER UG-125(a), IMPACT TESTING EXEMPT PER UCS-66(b)(3)
(Name of part, item number, Manufacturer's name and identifying stamp)

National Board Number: _____ 2992

Mfr. Representative: DC Date: 3-21-18

Authorized Inspector: _____ Date: 3-21-18

FORM U-1A (Back)

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 _____ expires 08/03/20 24,989

Date 3-21-18 Co. name Lewis Industries Corporation Signed George E. Lewis
(Manufacturer) (Representative)

CERTIFICATE OF SHOP/FIELD INSPECTION

Vessel constructed by Lewis Industries Corporation at Collinsville, Oklahoma.
I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and employed by OneCIS Insurance Company

have inspected the component described in this Manufacturer's Data Report on 3-21-2018, 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 3-21-2018 Signed Den Cal Commissions NB 15483
(Authorized Inspector) [National Board (incl. endorsements)]

(04/14)

Skid 2 relocated from
UOPR Job 488 to 447

Lewis Industries Corporation
Collinsville, OK
ITP / TRAVELER

Job No.: 185215 Dimensions: 24" O.D. X 6'-0" SM/SM Hydro Press: 345 PSI
 Serial No.: 185215 RT.: 2 PWHT: N/A
 National Board No.: 2992 MAWP: 265 Other NDE: N/A

* A. I. Inspection Points A. I. Review <u>D. W</u> Date <u>3-21-18</u>	Customer Inspector	Q. C. Initial/Date	A. I. Initial/Date
1. Design Calculations		<u>AP 3-8-18</u>	<u>DC 3-21-18</u>
2. Drawings		<u>AP 3-8-18</u>	<u>DC</u>
3. Welding Procedure Specification (WPS) Qualified		<u>AP 3-8-18</u>	<u>DC</u>
4. Welder/Welding Operator Qualified (WPQ) (WPQ)		<u>AP 3-8-18</u>	<u>DC</u>
5.			-
6. Longitudinal Joint Fit-up		<u>AP 3-14-18</u>	<u>DC 3-21-18</u>
7. Tack Welds		<u>AP 3-8-18</u>	<u>DC 3-21-18</u>
8. Out of Roundness *		<u>AP 3-8-18</u>	<u>DC 3-21-18</u>
9. Plate for Conformity			-
10. Circumferential Joint Fit-up		<u>AP 3-13-18</u>	<u>DC 3-21-18</u>
11. Layout Prior to Cutting		<u>AP 3-14-18</u>	<u>DC</u>
12. Internal Welding *		<u>AP 3-14-18</u>	<u>DC</u>
13. No. 1 Head to Shell Fit-up		<u>AP 3-14-18</u>	<u>DC</u>
14. Closing Head Fit-up-up		<u>AP 3-14-18</u>	<u>DC</u>
15. Nozzle/Coupling Fit-up			
16.			
17. Longitudinal Weld Seams			
18.	<u>AD</u>	<u>AP 3-15-18</u>	<u>DC 3-21-18</u>
19. Circumferential Weld Seams			
20.	<u>AD</u>	<u>AP 3-19-18</u>	<u>DC 3-21-18</u>
21. Radiographs <u>R 8-D</u>			
22. Radiographs of Repaired Areas	<u>AD</u>	<u>AP 3-15-18</u>	<u>DC 3-21-18</u>
23. Nozzle/Coupling Welds			
24. Air Test Repads			
25. NDE (Other Than Radiography)			
26.			
27. Post Weld Heat Treatment		<u>AP 3-21-18</u>	<u>DC 3-21-18</u>
28. Final Inspection *		<u>AP 3-21-18</u>	<u>DC 3-21-18</u>
29. Mill Test Reports/Certificates of Compliance		<u>AP 3-21-18</u>	<u>DC 3-21-18</u>
30. Hydrostatic Test		<u>AP 3-21-18</u>	<u>DC 3-21-18</u>
31. Code Stamping - Nameplate		<u>AP 3-21-18</u>	<u>DC 3-21-18</u>
32. Nameplate Attached to Vessel		<u>AP 3-21-18</u>	<u>DC 3-21-18</u>
33. Manufacturer's Data Report Signed *		<u>AP 3-21-18</u>	<u>DC 3-21-18</u>
34. Vessel File Compiled		<u>AP 3-21-18</u>	

Slide 2 relocated from
COPR Job 488 to 447

J-488

P.O.#
4500827189

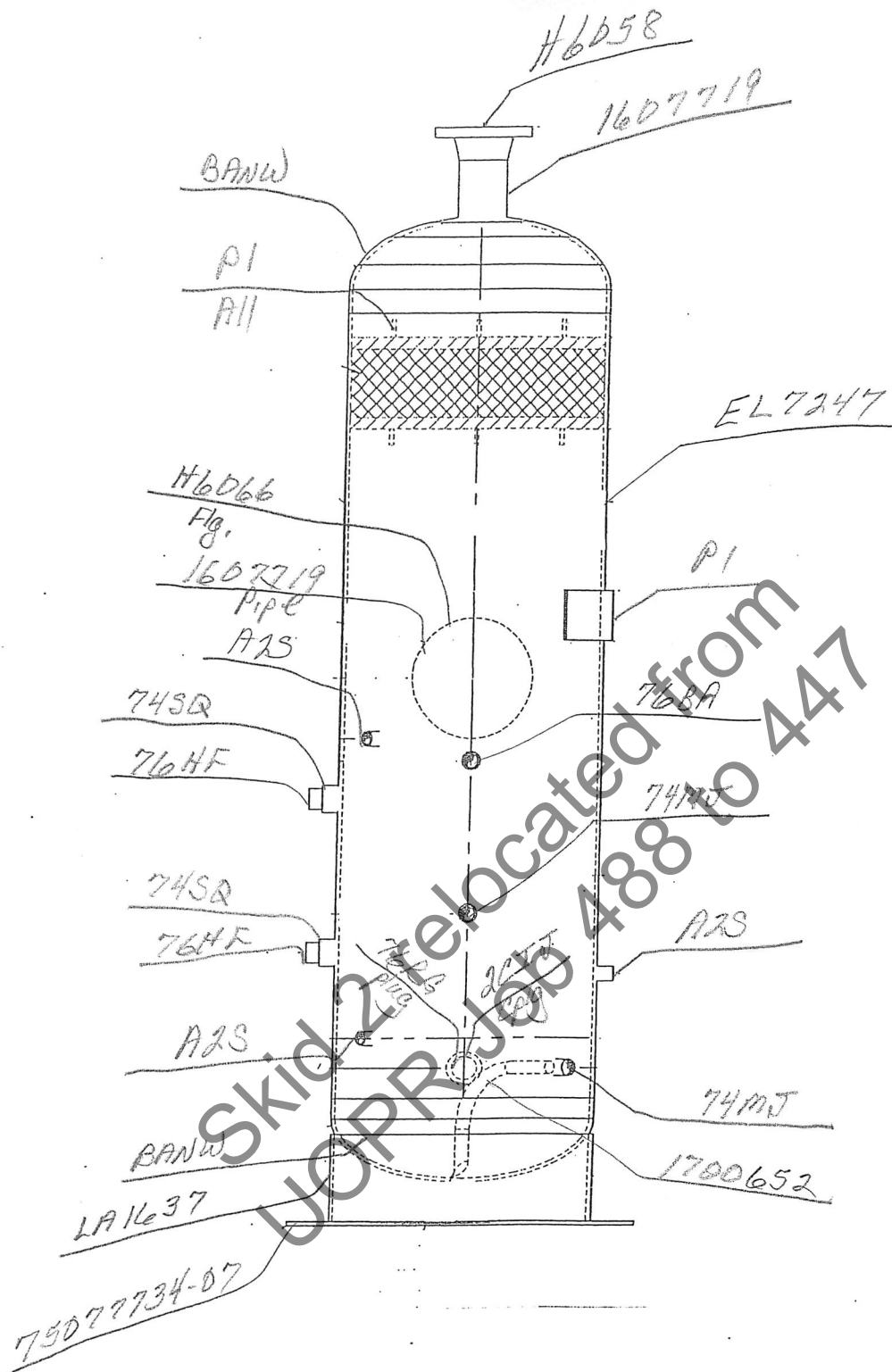
LIC# 185215

Tag #
V-481

ITEM#	QTY	DESCRIPTION	COMMENTS	MATERIAL	WEIGHT	HEAT#
1	2	2:1 ELLIP. HEAD 24" O.D. (0.3125" MIN. THK.) WITH 2" SF	HEAD #1 & #2	SA-516-70	188	BANU
2	1	PIPE, 24" STD. (0.375" THK.) x 6'-0" LG. BE x BE	SHELL	SA-106-B	570	EL 7247
3	1	PIPE, 24" STD. SMLS. (0.375" THK.) x 8 1/8" LG. PBE	SKIRT	SA-106-B	65	LA 1637
4	1	PLATE, 3/8" THK. x 32" O.D. x 21" I.D. W/(4) 7/8" DIA. HOLES x 28 1/2" DIA B.C. EQUALLY SPACED & STRADDLE NORMAL CENTERLINES	BASE RING	SA-516-70	48	75 677734-0
5	1	FLANGE, 4" RFWN 150#	A	SA-105	16	H6.066
6	1	FLANGE, 4" RFWN 150#	B	SA-105	16	H6.058
7	2	CPLG, 1 1/2" 3000# TOE x 3" LG.	H1,H2	SA-105	4	7450
8	2	PLUG, 1 1/2" SOLID THRD., ROUND HEAD	H1,H2	SA-105	2	76 HF
9	3	CPLG, 1" 6000# TOE x 3" LG.	C,F1,F2	SA-105	3	1-76BP
10	1	CPLG, 2" 3000# TOE x 3 3/8" LG.	G	SA-105	3	76 TG
11	1	PLUG, 2" SOLID THRD., ROUND HEAD	G	SA-105	2	76 TG
12	3	CPLG, 3/4" 6000# TOE x 3" LG.	E,D1,D2	SA-105	3	A2S
13	2	FLAT BAR, 3/8" THK. x 1 1/2" WD. x 1'-11 1/8" LG.	WIST PAD	SA-36	7	PI
14	4	FLAT BAR, 3/8" THK. x 1 1/2" WD. x 1'-4 3/4" LG.	WIST PAD	SA-36	11	PI
15	1	PIPE, SMLS, 4" XS x 6 1/8" LG. BE x PE	A	SA-106-B	8	16D774
16	1	PIPE, SMLS, 4" XS x 5 3/4" LG. BE x PE	B	SA-106-B	7	16D774
17	1	WIRE MESH PAD, 12 PCF, .011" WIRE, 6" THK. x 23 1/4" O.D., W/1" GRID (CS)	WIST PAD	316SS	24	
18	1	W6x15 x 4 1/2" LG. (CUT PER DETAIL)	NAMEPLATE	SA-36	3	PI
19	1	PLATE, 1/2" THK. x 8 1/2" WD. x 8 7/8" LG. (CUT PER DETAIL "A")	DIVERTER	SA-516-70	11	7507097-08
20	1	ANGLE, 6" x 6" x 1/2" x 7 1/2" LG.	DIVERTER	SA-36	25	PI
21	2	PIPE, 3/4" XH x 7 3/8" LG. MBE	DIVERTER	SA-106-B	2	4F5671
22	1	PIPE, 1" S/80 x 1'-7" LG. PE x MITER (45 DEG) (BEND PER DETAIL "D")	C (SIPHON)	SA-106-B	5	7700652

Skid 2 relocated from UOPR Job 488 to 44A

PVA 3/8/10

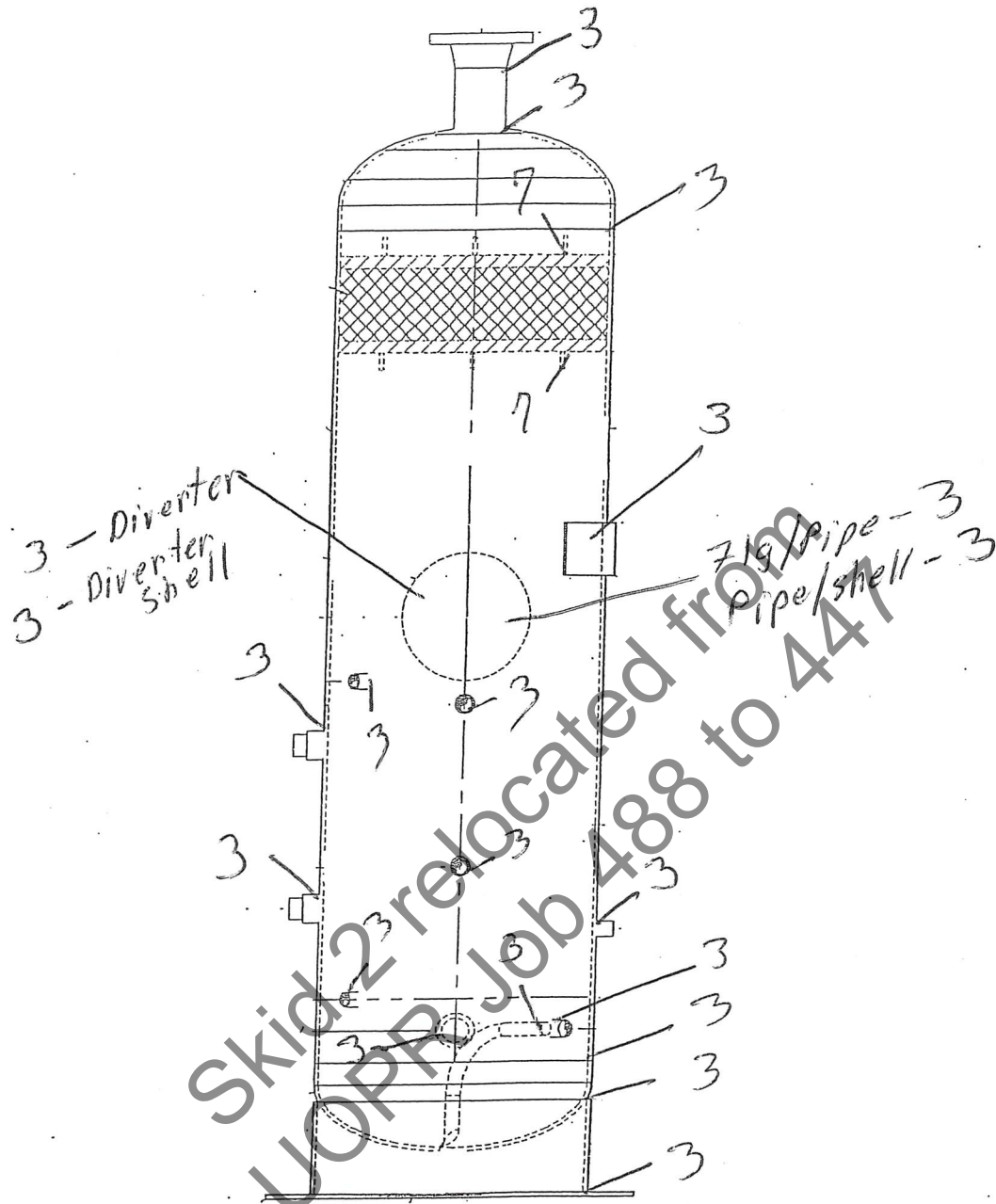


HEAT MAP

LIC #185215

UOP TAG #V-481

AVD 3/6/18

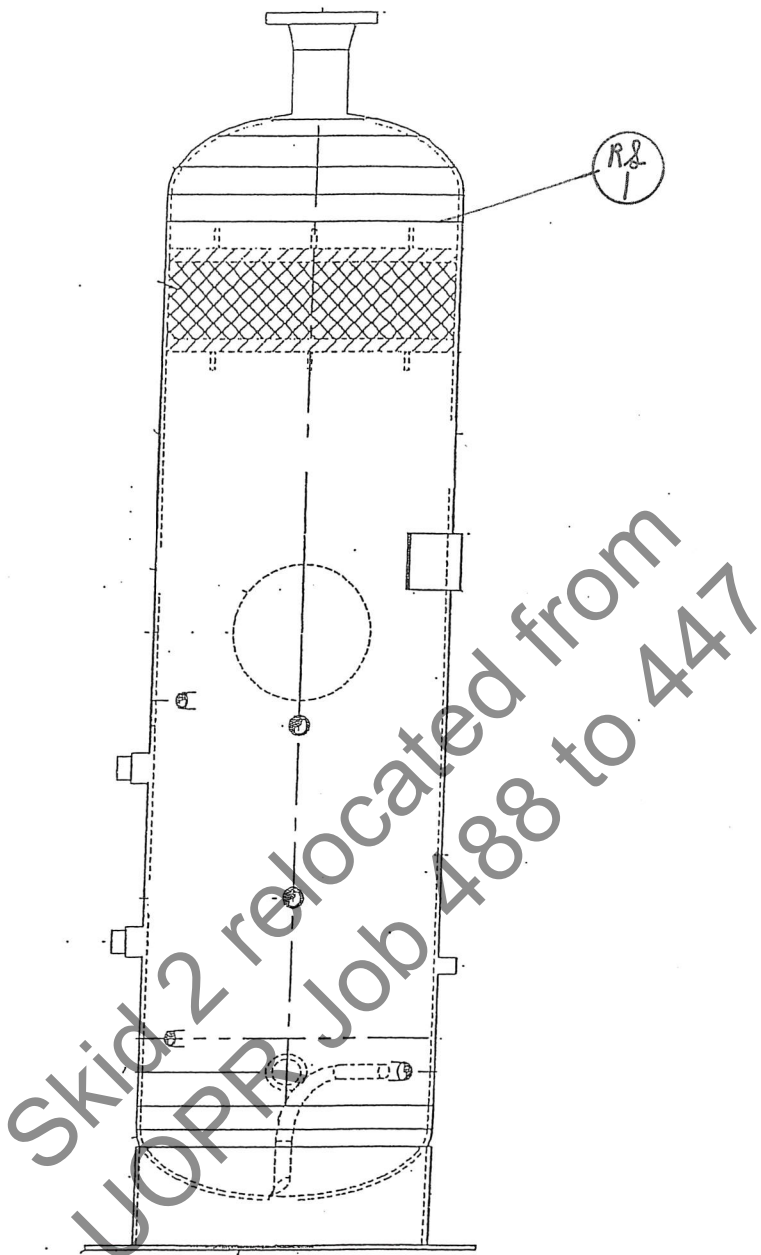


W E L D M A P

LIC #185215

UOP TAG #V-481

AKD 3/19/15



X - R A Y M A P

LIC #185215

UOP TAG #V-481

PKR 3/19/12

AMERICAN PIPING INSPECTION, INC.

17110 East Pine

Tulsa, Oklahoma 74116

(918) 234-6300 FAX (918) 234-6301

TECHNIQUE / INSPECTION REPORT

DATE 3-15-18 DAY Thursday

J-488 - V-451 UOPR

CUSTOMER DATA

NAME Lewis
 ADDRESS _____
 PHONE _____ ATTN: _____
 W.O. # 185215 P.O. # _____
 JOB LOCATION Collinsville, OK
 DESCRIPTION Spot MATERIAL TYPE: C/S

DEFECT CODE

AB - ARC BURN
 AI - ALIGNED INDICATION
 BT - BURN THROUGH
 CON - CONCAVITY
 CRACK - CRACK
 HB - HOLLOW BEAD
 IF - INADEQUATE FUSION
 IP - INCOMPLETE PENETRATION
 MA - MISALIGNMENT
 POR - POROSITY

SLI - SLAG INCLUSION
 SLL - SLAG LINE
 SURF - SURFACE INDICATION
 UCE - UNDERCUT EXTERNAL
 UCI - UNDERCUT INTERNAL

ABBREVIATED TERMS

SOD = SOURCE TO OBJECT DISTANCE
 OFD = SOURCE SIDE OF OBJECT TO FILM DISTANCE
 OD = OUTER DIAMETER
 WT = WELD THICKNESS
 WR = WELD REINFORCEMENT
 REP = REPAIR
 RES = RESHOOT
 RET = RETAKE
 BM = BASE MATERIAL

WELD/FILM NUMBER	JOB NUMBER	OD	BM	WR	WT	WITHIN STD'S		# FILM	FILM SIZE / MFG / TYPE	SOD	OFD	IQI	# EXP	DEFECT LOCATION
						YES	NO							
1-2	RS-1	24"	3/8	1/8	1/2	✓		1	4 1/2 x 10 P20	24"	1/2	15	1	
2														
3														
4														
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Skid 2 relocated from UOPR Job 488 to 447

[Signature]

[Signature]
3-19-18

METHOD RT SOURCE SIZE DIAG. 1150 ISOTOPE FR192 NO. CURIES 115 DEV. TIME 5:00 DEV. TEMP 68° DENSITY 2-4

NO. OF WELDS 1 FT. LONG SEAMS _____ STANDARDS UW-52 PERDIEM _____ NO. OF FILM 1 FILM/CASSETTE 111 EXPOSURE: DBL WALL S. WALL _____ MTR SCREENS 3 RS

VIEWING: DBL WALL S. WALL _____

TRUCK NO. / SHOP T-113 REPORT NO. _____ OF _____ PAGE NO. _____ OF _____ TECH. HOURS _____ ASST. HOURS _____ TRAVEL HOURS _____ TOTAL HOURS _____ MILEAGE _____

FILM INTERPRETER K. Pilant ASST. NAME Tommie Grodner ASNT LEVEL III

COMPANY REPRESENTATIVE _____ NDT TECHNICIAN [Signature] ASNT LEVEL III

SIGNATURE CERTIFIES TIME & MATERIALS CORRECT

SIGNATURE

AMERICAN PIPING INSPECTION, INC. ASSUMES NO RESPONSIBILITY FOR LOSSES OF ANY KIND DUE TO INTERPRETATION

242666

LEWIS INDUSTRIES CORPORATION
816 N. 5TH STREET
COLLINSVILLE, OKLAHOMA 74021 (918) 371-2596

HYDROSTATIC TEST CERTIFICATION

This Vessel was hydrostatic tested with satisfactory results in accordance with the A.S.M.E. Code, Section VIII, Division 1, paragraph UG-99.

JOB NUMBER: 185215

ITEM NUMBER: 24" O.D. X 6'-0" SM/SM VERT. FUEL GAS SCRUBBER TAG #V-481
J-488

CUSTOMER: UOP RUSSELL LLC/HONEYWELL

PURCHASE ORDER NUMBER: 4500827189

MAX. ALLOW. WORKING PRESS.:

SHELL SIDE: 265 P.S.I.

TUBE SIDE: P.S.I.

TEST PRESSURE:

SHELL SIDE: 345 P.S.I.

TUBE SIDE: P.S.I.

HOLDING TIME ONE (1) HR(S)

TEST GAUGE SERIAL NUMBER L600-1 600#

SPECIAL INSTRUCTIONS: WITH CHART

Quality Control Manager:

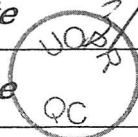
George E. Lewis Date 3-21-18

Authorized Inspector:

[Signature] Date 3/20/18

Customer Inspector:

[Signature] Date QC 3.21-18



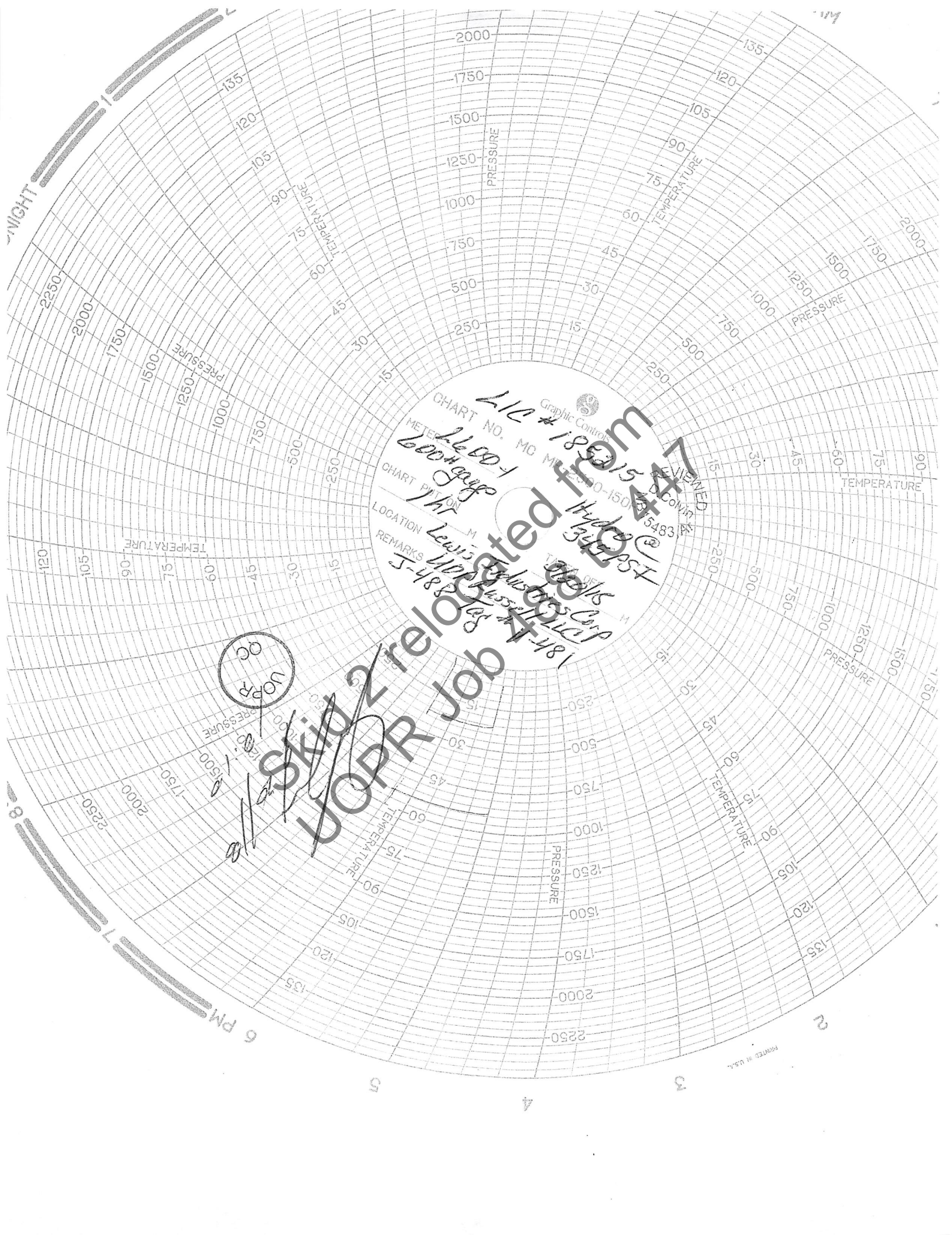
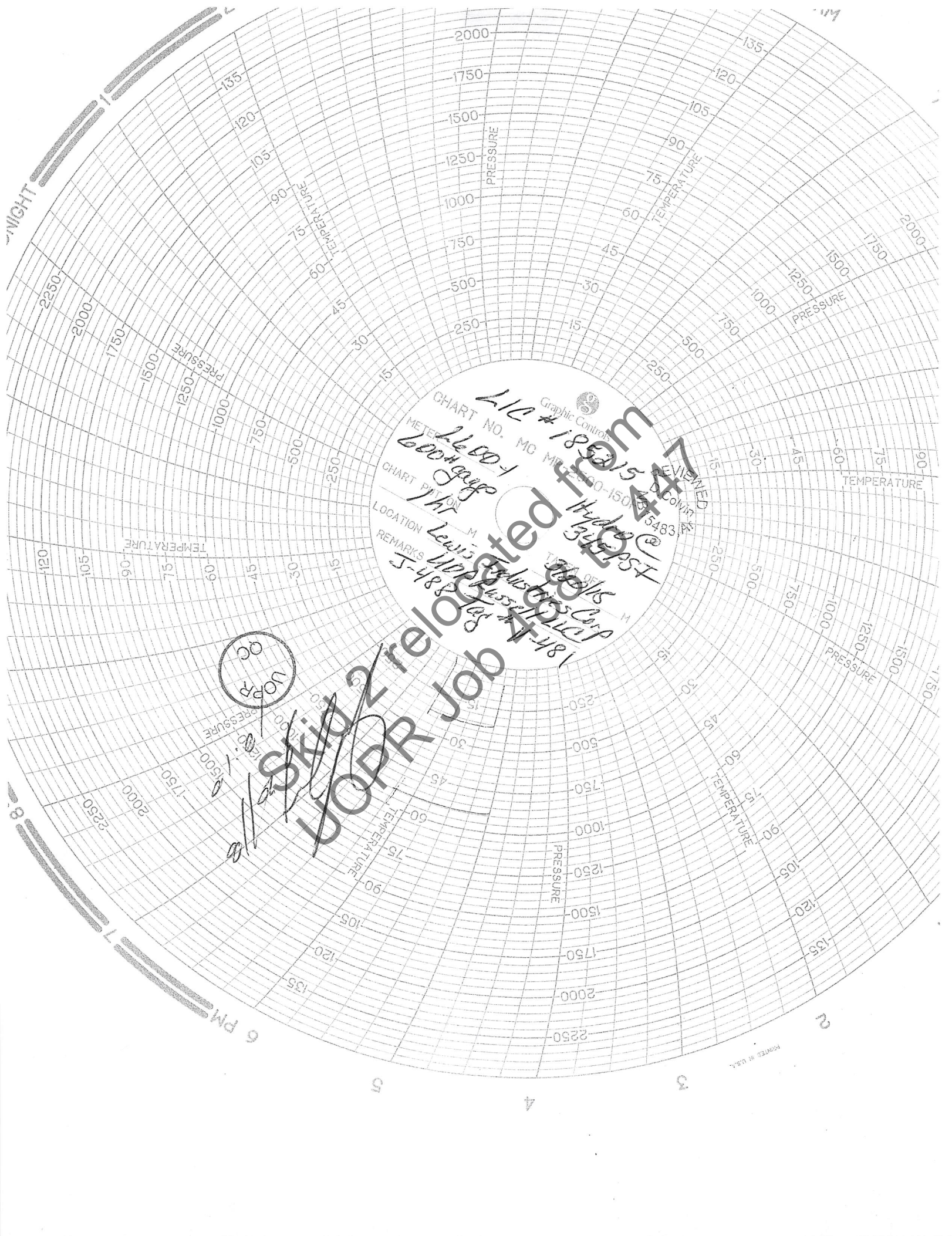


CHART NO. *210 # 183015*
 METERS *2600-1*
 CHART PITCH *1 hr*
 LOCATION *Lewis Industrial Corp*
 REMARKS *UOPR Job # 1481*
5-48

UOPR
 20
 25

UOPR Job # 1481
 relocated from
 Lewis Industrial Corp
 1874
 Lewis Industrial Corp
 1874
 Lewis Industrial Corp
 1874



Graphic Controls
 CHART NO. 2110 # 185215
 METER 2600-1
 CHART PIT ON 600' gauge
 LOCATION M Hydro @ 1542 PST
 REMARKS Lewis Industries Corp
 5-48
 18-1-48

OC
 NOD
 20

UOPPR relocated from

ASME NB 2992

Certified by

LEWIS INDUSTRIES CORP.
816 N. FIFTH STREET, COLLINSVILLE, OK.



MAWP 265 psi at 150 °F

MDMT -20 °F at 265 psi

U

W

S/N 185215 BUILT 2018

RT2

J488 V481

NB 2992

Certified by

LEWIS INDUSTRIES CORP.
816 N. FIFTH STREET, COLLINSVILLE, OK.



MAWP 265 psi at 150 °F

MDMT -20 °F at 265 psi

U

W

S/N 185215 BUILT 2018

RT2

J488 V481



A Honeywell Company

Inspection and Test Plan - ITP Vessel Equipment - New Manufacture UOPR SF-005

Quality Management System

Job Number : 185215 Equipment Number : J488/V-481 Date : 02/28/18

TP Prepared By : ITP Reviewed By

Customer Name : UOPR RUSSELL LLC Customer Phone Number : Customer E Mail :

Customer Approval Signature : Date :

Surveillance Action Codes

1-Hold W-Witness M-Monitor V-Verify P-Process D-Documentation N-No Action

- 1) Hold: Activity is required to be witnessed by UOP Honeywell...designated as on hold, pending formal authorization/approval to proceed further
- 2) Witness: Activity is required to be witnessed by customer/customer representative(s). In the event they cannot attend, activity may proceed
- 3) Monitor: Activity may be surveyed by UOP Honeywell at UOP Honeywell's discretion
- 4) Verify: Results of activity will be verified by UOP Honeywell and/or Customer/Customer Representative
- 5) Process: Activity is identified as a point of process, performed by Vendor
- 5) Documentation: Activity is required to be documented, this shall include all pertinent measured values, by the Vender and submitted to UOPR before proceeding and upon completion for review/verification

* Note: Location of activity to be performed at vendor shop unless noted otherwise.

			Activity Information		Code
No	Acceptance Criteria	UOP Notes to Fabricator	Description	UOP	
1			Pre-Inspection Meeting	H	
2	UOP QMS/ASME Sec 8		Review Vendor Inspection and Test Plan (ITP)/Traveler	V	
A	PO	Advise UOPR Inspector	Notification of Job Start	M	
B	PO/ASME Sec 2		Review of MTR's per Bill of Material	V	BS
C	ASME Sec 8 & 5		Review Radiographs and Reader Sheet	V	BS
D	ASME Sec 5		Monitor Liquid Penetrant/Magnetic Particle Examinations	M	
E	ASME Sec 8		Monitor Pneumatic tests of repads	V	
F	ASME Sec 8		Head Fit-up(s) Top/Bottom - Inspect for mis-alignment	H	BS
G	UOPR Drawing		Internal Inspection (Final Weld out)	H	BS
H	ASME Sec 8/ITP		Out of Roundness, Code allowable and Internals Vendors Criteria	H	BS
I	Drawings		Final Dimensional Inspection (Before stress)	H	BS
J	Drawings		External Piping Supports Present and Match Drawing if Applicable	P	
K	Drawings		Lift and Tailing Lugs Present and Match Drawing if Applicable	H	
L	Drawings		(After stress) Re-check Nozzle levelness and flange face's	H	
M	ASME Sec 8		Hydrostatic/Pneumatic Pressure Test - * Recorder with chart required	H	
N	Drawings		Review of Final Documentation package	H	
O	Drawings/ASME Sec 8		Nameplate Stamped with ASME Mark, NB/ CRN Registration Number as Required	H	
P	ASME Sec 8/Data Sheet		Nameplate Stamped with Process Conditions Matching Drawings	W	



A Honeywell Company

Inspection and Test Plan - ITP Vessel Equipment - New Manufacture UOPR SF-005

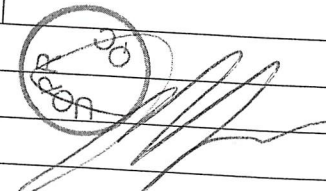
Quality Management System

ob Number :	185215	Equipment Number :	J488/V-481	Date :	02/28/18	
Q	ASME Sec 8/Data Sheet				ASME Data Reports (U-1a or Equivalent)	W
R	Drawing/Paint Spec				Paint Applied Per Drawing (If Applicable)	H
S	PO/Fabricator Spec				Final preparation for shipment after paint (If Applicable)	H
A	Fabricator Drawings				Fit up and weld in of distributors (If Applicable)	H
C	Fabricator Drawings				Distributor depth, width, hole count & size, levelness after erection (If Applicable)	H
D	Drawings				Fit up, Weld in and Assembly of Demister (If Applicable)	H
E	PO/UOPR Standard				Knitted mesh should be oversized to fit snugly (compressing) (If Applicable)	H
F	Drawings/PO				Verify packing type, size and material	H
G	Drawings				Verify installation of any internal piping/ Size of piping # of openings if applicable, and size of opening (If Applicable)	H
H	Drawing				Inspect all nozzles, manways, and welded in supports/clips for orientation and elevation.	H

* Hold Points require 48 hour notification

* Weekend Inspection and testing Hold Points require 72 hour notification

UOPR SF-005 488 to 447

UOPR PROJECT:		Name: LEWIS INDUSTRIES CORP.	Number: J488
Technical Document(s):	Applicable codes/Drawings/Customer requirements		
Equipment Description:	FUEL GAS SCRUBBER		
UOP Primary Contacts:	Position : QA/QC Manager Name :James Bogue Phone: 918-370-0932 Email: James.bogue@honeywell.com		
UOP Backup Contacts:	Position: Lead CWI Name: Matthew Hensinger Phone: 918-314-0010 Email: Matt.hensinger@honeywell.com		
UOP CONTRACT INSPECTION:	Company: Inspector: Location: Email address: Cell:	Coordinator: Matthew Hensinger Location: UOPR Tulsa office Email address: Matt.hensinger@honeywell.com Phone: 918-314-0010	
SUPPLIER:	Company: LEWIS INDUSTRIES Inspection Location: COLLINSVILLE Office Phone: 918/371-2596	QA Contact Name: GEORGE LEWIS Phone: Email:	
UOPR PO No. to External Supplier:	4500827189		
PO Delivery Date :			
SCOPE OF INSPECTION:	Inspection of the equipment described per the applicable documents:		
Date of shop visit:			
Applicable Documents:	ITP, Third Party Inspection Report		
Communications:	Email communications with UOPR on any items requiring UOPR clarification. Items requiring immediate resolution, please contact UOPR directly by e-mail. For any items not in compliance, please notify the supplier directly by email and copy UOPR.		
Supplier Test Report Review:	UOPR/Third Party inspector to stamp test reports after review and acceptance by the supplier and the inspector.		
Inspection Report Frequency and Additional Instructions			
Inspection Report distribution (to and copy) :	UOPR QA/QC-Project Management		
Issued by:		Date:	
Reviewed by:		Date:	5/20/11
Acknowledged by:		Date:	

AMERICAN ALLOY
PLATE #2194389

1506 River Rd
Coffield, NC 27922
(252) 366-3700

NUCOR
It's Our Nature

Mill Test Report
Page 1

P.O. Box 279
Winton, NC 27386
(252) 366-3700

NUCOR
PLATE MILL

Issuing Date: 11/01/2017 B/L No.: 498249
 Vehicle No: TTPX 81143
 Specification: 0.3750" x 96.0000" x 240.0000"
 A37M A816 70-10(2015)ASME SA816 70 PVQ20152015 Normalized
 Test Coupons at 1650F Hold 30 Min per inch of thickness Air Cooled
 NACE MR0175 Annex 2.1.2 (2015), MH0103(2019) Section 2.1.2 (2015)
 13.1.1, 13.1.2) Compliant
 Marking: 113276-OK

Load No.: 498113 Our Order No.: 151486/1
 Solid To: AMERICAN ALLOY STEEL INC
 6230 N HOUSTON ROSSLYN RD
 PO BOX 40469
 NORTH HOUSTON, TX 77091

Cust. Order No.: 113276-OK
 Ship To: AMERICAN ALLOY STEEL
 8350 N ERIE AVE
 C/O SKOL TRACK #21
 OWASBO, OK 74055

Heat No	C	Mn	P	S	Si	Al(%)	V	Nb	Ti	N	Ca	B	Sn	Cu	Pcm
7506613-04	0.20	1.03	0.006	0.004	0.19	0.01	0.038	0.005	0.001	0.002	0.0030	0.0001	0.011	0.41	0.37

Plate Serial No	Pieces	Tons	Drk	(psi) Yield	(psi) Tensile	Elong. % in 2"	Elong. % in 8"
7506613-04	2	2.45	T	55,000	78,200	22.3	25.4
7506613-05	2	2.45	T	53,900	78,900	22.2	24.8
7506613-08	1	1.22	T	51,800	75,700	24.8	27.1
7506613-07	1	1.22	T	49,800	73,400	28.7	27.1
				50,200	72,800	22.1	26.8
				47,000	70,900	26.2	

UOPR Job 488 to 447
 Kid 2 relocated from
 BANN
 11/5/2018

Attached is true copy of the
 original signed in the file
 AMERICAN ALLOY STEEL, INC.
 System by

HOT ROLLED CARBON STEEL PLATE

Test coupons only, normalized 30 minutes per inch of thickness at 1650 F ± 25 F. Hold 30 minutes minimum.
 Manufactured to fully killed fine grain practice by Electric Arc Furnace. Welding or weld repair was not performed on this material.
 Mercury has not been used in the direct manufacturing of this material. Produced as continuous cast deoxidized plate as-rolled, unless otherwise noted in Specification. For Mexico shipment: the-Sales@NuCor.com
 Yield by 0.5EUL method unless otherwise specified. Ceq = C+(Mn/6)+(Cr+Mo+V)/5+(Cu+Ni)/15
 Pcm = C+(Si/30)+(Mn/20)+(Cu/20)+(Ni/10)+(Mo/15)+(V/10)+Sb
 Metted and Manufactured in the USA. ISO 9001:2008 certified (8010840) by SRI Quality System Registrar (60365-09). PED 97236C 72 Annex 1, Para. 4.3 Compliant.
 DIN 9049 3.1.8VEN 10208 3.18(2004). DIN EN 10204 3.1(2005) compliant. For ABS grades only. Quality Assurance certificate 14-MMPD-A-723

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

T. A. Depreis, Metallurgist

11/1/2017 10:01:32 AM

PKC 3/8/18
 HIC # 185215



U.S.S. SEAMLESS TUBULAR OPS

TUBULAR PRODUCTS
 CERTIFIED TEST REPORT
 (IN ACCORDANCE WITH ISO 10474/EN10204/DIN50049 "type 3.1")

DATE: 09/19/17
 TIME: 10:52:11
 SERIAL NO: L0060392
 EBS NO: 2002272531 1

MILL ORDER/ITEM NO DR96529 01	SHIPPER'S NO.	P.O. NUMBER 220555	VEHICLE ID
SOLD TO ADDRESS		MAIL TO ADDRESS	
VENDOR U.S.S. SEAMLESS TUBULAR OPS LORAIN TUBULAR OPERATIONS 2199 EAST 28TH ST. LORAIN, OH 44055			

SPECIFICATION AND GRADE

SMLS STANDARD AND LINE PIPE API 5L 45TH EDITION DATED 12/1/12 GRADE B/X42 R N OR Q PSL-2, ASTM A106-15 GRADE B/C SPECIAL OD TOLERANCE OF +/- 1%, ASTM A53-12 GRADE B, ASME SA106-2015 GRADE B/C, ASME SA53-2015 GRADE B REG MILL COAT PE BEV 30 DEGREE APPLICABLE REQUIREMENTS OF NACE MR0103-2012 ED AND NACE MR0175/ISO 15156-2 2015 ED

MATERIAL COND: AS ROLLED O.D. 24.000 (609.500) in (mm) WALL 0.375 (9.525) in (mm)

PRODUCT IDENTIFICATION	TENSILE TEST TYPE/ ORIENTATION	TEST COND.	GAUGE WIDTH IN	YIELD		EXT. %	TENSILE		ELONG % (IN 2")	HARDNESS SCALE	MIN HYDRO PSI	DWELL (SEC)
				MIN: PSI	MAX: PSI		MIN: PSI	MAX: PSI				
EL7247 K514AA	STRIP/L/B	AR	1.500	42100	48800	.50	70000	74000	0.93	28.0	1180	5
** END OF DATA THIS SHEET **												

LEGEND: L - LONGITUDINAL T - TRANSVERSE QT - QUENCH & TEMPERED AR - AS ROLLED B - BODY W - WELD
 U - UPSET NM - NORMALIZED SR - STRESS RELIEVED TR - THERMOMECHANICAL ROLLED

PRODUCT IDENTIFICATION	TYPE	C	MN	P	S	SI	CU	NI	CR	MO	AL	N	V	B	TI	CB	CO	C.E.*
		MAX.																
EL7247	HEAT	.20	.02	.009	.005	.27	.14	.09	.07	.04	.034	.04	.0002	.002	.001			.42
EL7247 K514AA	PROD	.17	.99	.010	.007	.27	.14	.08	.06	.05	.039	.04	.0006	.002	.006			.38
EL7247 K514AA	PROD	.18	1.01	.010	.008	.28	.14	.08	.07	.05	.040	.04	.0006	.002	.007			.39
** END OF DATA THIS SHEET **																		

*C.E. IS BASED ON THE FOLLOWING EQUATION(S): C+MN/6+CR/5+MO/5+V/5+NI/15+CU/15 (EUROPEAN CEV)



U.S.S. SEAMLESS TUBULAR OPS

TUBULAR PRODUCTS

CERTIFIED TEST REPORT
(IN ACCORDANCE WITH ISO 10474/EN10204/DIN50049 "type 3.1")

DATE: 09/19/17

TIME: 10:52:11

SERIAL NO: L0060392

EBS NO: 2002272531 1

MILL ORDER ITEM NO DR96529 01		SHIPPERS NO.		P.O. NUMBER 220555													
MATERIAL COND: AS ROLLED				O.D.: 24.000 (609.600) In (mm)				WALL: 0.375 (9.525) In (mm)									
PRODUCT IDENTIFICATION	FLAT	BEND	GRAIN SIZE	MIN COLLAPSE	CHARPY V-NOTCH IMPACT TESTING												
					DR	TEST LOC.	TEMP	SIZE	TEST COND.	FT-LBS			% SHEAR				
					DEG F					1	2	3	AVG	1	2	3	AVG
EL7247 K514AA	OK				T	B	+ 32	3/4	AR	68	74	70	70	60	80	60	66
** END OF DATA THIS SHEET **																	
LEGEND L - LONGITUDINAL T - TRANSVERSE B - BODY W - WELD HAZ - HEAT AFFECTED ZONE																	
TESTING / INSPECTION INFORMATION																	
TEST / INSPECTION		YES	RESULTS / COMMENTS														
FULL LENGTH VISUAL		X															
FULL LENGTH EM		X	OD	X	ODD		L	X	L/T	10.0% NOTCH							
FULL LENGTH MPI																	
FULL LENGTH UT		X	ID	X	ODD		L	X	L/T	10.0% NOTCH							
END AREA INSPECTION (PLAIN END)		X	MPI	X	UT												
SPECIAL END AREA (SEA) INSP			MPI		UT												
FULL LENGTH DRIFT			DRIFT MANOREL SIZE:														
ADDITIONAL NOTES/COMMENTS																	
MELTED AND MANUFACTURED IN THE USA, NO REPAIRS BY WELDING, NO MERCURY COMPOUNDS ARE ADDED TO THE STEEL AND ALL MERCURY BEARING EQUIPMENT IS PROTECTED BY A DOUBLE BOUNDARY OF CONTAINMENT. MANUFACTURED IN AN ISO 9001 CERTIFIED FACILITY - CERTIFICATE #32022. IMPACT STRIKER RADIUS 8MM.																	

THIS IS TO CERTIFY THAT THE PRODUCT DESCRIBED HEREIN WAS MANUFACTURED, SAMPLED, TESTED AND/OR INSPECTED IN ACCORDANCE WITH THE SPECIFICATION AND FULFILLS THE REQUIREMENTS IN SUCH RESPECTS.

PREPARED BY THE OFFICE OF: R. BULLOCK - MANAGER, Q.A.
LORAIN TUBULAR OPERATIONS

DATE: 09/19/17

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PRR 3/8/18
LIC # 185215



U.S.S. SEAMLESS TUBULAR OPS

TUBULAR PRODUCTS
 ADDITIONAL COMMENTS SHEET

DATE: 09/19/17
 TIME: 10:52:39
 PAGE: 1 OF 1

MILL ORDER ITEM NO DR96529 01	SHIPPER NO.	P.O. NUMBER 220555	HEAT	SERIAL NUMBER: L0060392
SOLD TO ADDRESS		MAIL TO ADDRESS		VENDOR U.S.S. SEAMLESS TUBULAR OPS LORAIN TUBULAR OPERATIONS 2199 EAST 28TH ST. LORAIN, OH 44055

HEAT EL7223 - MELTED AT:TIMKEN, CANTON, OH 44706
 HEAT EL7247 - MELTED AT:TIMKEN, CANTON, OH 44706
 END OF DATA

Skid 2 relocated from
 UOPR Job 488 to 447

AKP 3/8/18
 LIC # 185215

USS2113 / LA1637 / 24.0A106STDD / 24 STD A106B SMLS PIPE

DATE: 03/24/15
 TIME: 12:25:21
 SERIAL NO: L0055934
 EBS NO: 2001032296 1

TUBULAR PRODUCTS
 CERTIFIED TEST REPORT

(IN ACCORDANCE WITH ISO 10474/EN10204/DIN50049 "Type 3.1")

UNITED STATES STEEL CORPORATION

MILL ORDER/ITEM NO DR92589 01	SHIPPERS NO. 205952	VEHICLE ID	VENDOR UNITED STATES STEEL CORP LORAIN TUBULAR OPERATIONS 2199 EAST 28TH ST. LORAIN, OH 44055
SOLD TO ADDRESS		MAIL TO ADDRESS	

SPECIFICATION AND GRADE

SMLS STANDARD AND LINE PIPE API 5L 45TH EDITION DATED 12/1/12 GRADE B/X42 R N OR Q PSL-2, ASTM A106-14 GRADE B/C SPECIAL OD TOLERANCE OF +/- 1%, ASTM A53-12 GRADE B, ASME SA106-2013 GRADE B/C, ASME SA53-2013 GRADE B REG MILL COAT PE BEV 30 DEGREE APPLICABLE REQUIREMENTS OF NACE MR0103-2012 ED AND NACE MR0175/ISO 15156-2 2009 ED

MATERIAL COND:	AS ROLLED	O.D.:		I.D.:		WALL:		E.LONG %		HARDNESS		MIN HYDRO		DWELL(SEC)
		24.900	609.600	24.900	609.600	0.375	0.375	(9.525)	(IN 2")	SCALE:	MIN:	MAX:	PSI	
PRODUCT IDENTIFICATION	TEST TYPE/ ORIENTATION	TEST COND.	GAUGE WIDTH IN	YIELD		TENSILE	ELONG %	VIT	HARNESS	MIN HYDRO		DWELL(SEC)		
				MIN:	MAX:					PSI	IN			
LA1633 G453AA	STRIP/L/B	AR	1.500	52500	71800	70000	28.0	0.93	MIN:	MAX:	1180	5		
LA1637 G454AA	STRIP/L/B	AR	1.500	52000	71800	70000	32.6	0.69	MIN:	MAX:	1180	5		
		**	END OF DATA THIS SHEET **											

*C.E. IS BASED ON THE FOLLOWING EQUATION(S): G+MN/6+CR/5+MO/5+V/5+NI/15+CU/15 (EUROPEAN CEV)

DECIMAL POSITIONS FOR ELEMENTS ARE INDICATED BY THE LEFT MARGIN, VERTICAL DOTTED LINE OR DECIMAL POINT. ELEMENTS REPORTED IN MASS FRACTION (%)

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PKP 3/28/18
 21C # 185215

USS2113 / LA1637 / 24.0A106STDD / 24 STD A106B SMLS PIPE



UNITED STATES STEEL CORPORATION

TUBULAR PRODUCTS

CERTIFIED TEST REPORT
(IN ACCORDANCE WITH ISO 10474/EN10204/DIN50049 "type 3.1")

DATE: 03/24/15
TIME: 12:25:21
SERIAL NO: L0055934
EBS NO: 2001032296.1

MILL ORDER/ITEM NO DR92589_01	SHIPPERS NO. 205952	P.O. NUMBER	O.D.: 24.000 (609.600)		WALL: 0.375 (9.525)		In (mm)							
MATERIAL COND: A.S ROLLED	MIN COLLAPSE		TEMP DEG F		CHARPY V-NOTCH IMPACT TESTING FT-LES			% SHEAR						
PRODUCT IDENTIFICATION	FLAT	BEND	GRAIN SIZE	TEST LOC.	DIR	TEST COND.	1	2	3	AVG	1	2	3	AVG
LA1633 G453AA LA1637 G454AA	OK OK			B B	B B	AR AR	111 83	102 85	105 84	106 84	100 70	100 70	100 70	100 70
** END OF DATA THIS SHEET **														
LEGEND	L - LONGITUDINAL	T - TRANSVERSE	B - BODY	W - WELD	HAZ - HEAT AFFECTED ZONE									
TESTING / INSPECTION INFORMATION														
TEST / INSPECTION	YES	RESULTS / COMMENTS												
FULL LENGTH VISUAL	X													
FULL LENGTH EMI	X	L X LT 10.0% NOTCH												
FULL LENGTH MPI	X	L X LT 10.0% NOTCH												
FULL LENGTH UT	X	L X LT 10.0% NOTCH												
END AREA INSPECTION (PLAIN END)	X	L X LT 10.0% NOTCH												
SPECIAL END AREA (SEA) INSP														
FULL LENGTH DRIFT														
ADDITIONAL NOTES/COMMENTS														
MELTED AND MANUFACTURED IN THE USA, NO REPAIRS BY WELDING, NO MERCURY COMPOUNDS ARE ADDED TO THE STEEL AND ALL MERCURY BEARING EQUIPMENT IS PROTECTED BY A DOUBLE BOUNDARY OF CONTAINMENT. MANUFACTURED IN AN ISO 9001 CERTIFIED FACILITY - CERTIFICATE #32022.														

THIS IS TO CERTIFY THAT THE PRODUCT DESCRIBED HEREIN WAS MANUFACTURED, SAMPLED, TESTED AND/OR INSPECTED IN ACCORDANCE WITH THE SPECIFICATION AND FULFILLS THE REQUIREMENTS IN SUCH RESPECTS.

PREPARED BY THE OFFICE OF: BRAD KOURY - MANAGER, Q.A.

DATE 03/24/15

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**
APR 28/18
L0055934

USS2113 / LA1637 / 24.0A106STDD / 24 STD A106B SMLS PIPE

UNITED STATES STEEL CORPORATION

TUBULAR PRODUCTS
ADDITIONAL COMMENTS SHEET

DATE: 03/24/15
TIME: 12:25:23
PAGE: 1 OF 1



MILL ORDER/ITEM NO DR92589 01	SHIPPERS NO.	P.O. NUMBER 205952	HEAT	SERIAL NUMBER: I0055934
SOLD TO ADDRESS		MAIL TO ADDRESS		
<p>HEAT LA1629 - MELTED AT: REPUBLIC ENGINEERED PRODUCTS, LORAIN, OH 44055-1883 HEAT LA1630 - MELTED AT: REPUBLIC ENGINEERED PRODUCTS, LORAIN, OH 44055-1883 HEAT LA1633 - MELTED AT: REPUBLIC ENGINEERED PRODUCTS, LORAIN, OH 44055-1883 HEAT LA1637 - MELTED AT: REPUBLIC ENGINEERED PRODUCTS, LORAIN, OH 44055-1883 END OF DATA</p>				
<p>VENDOR UNITED STATES STEEL CORP LORAIN TUBULAR OPERATIONS 2199 EAST 28TH ST. LORAIN, OH 44055</p>				

SKIPPER relocated from
COR Job 488 to 447

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PAR 3/18/18
L/M/RSa/15

Issuing Date : 12/03/2017 B/L No. : 489032 Our Order No. : 15294714
 Vehicle No: TTPX 80026 Load No. : 498801
 Ship To: METALS USA - SOUTH CENTRAL
 Ship To: METALS USA - PLATES AND SHAPES
 TRACK 747
 MUSKOGEE, OK 74403
 MUSKOGEE, OK 74401

Specification: 0.3750" x 120.000" x 480.000"
 ASTM A516 70-17/ASME SA516 70 PVQ 2013/2015 Normalized Test
 Coupons at 1650 F NACE MR0175 Annex 2.1.2 (2015), MR0103 (2010)
 Section 2.1.2(2015) 13.1.1, 13.1.2

Marking :

Heat No	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Al(tot)	V	Nb	Ti	N	Ca	B	Sn	Ceq	Pcm
7507734	0.19	1.06	0.010	0.000	0.23	0.24	0.10	0.13	0.06	0.037	0.006	0.003	0.005	0.0030	0.0000	0.010	0.43	0.28	

Plate Serial No	Pieces	Tons	Dir.	Tensile Test		Elong. % in 8"
				(psi) Yield	(psi) Tensile	
7507734-02	1	3.06	T	52,500	74,500	24.3
			T	50,000	74,700	26.1
7507734-03	6	18.37	T	53,700	78,500	25.9
			T	50,000	75,300	21.9
7507734-04	6	18.37	T	48,600	73,500	23.0
			T	50,200	75,600	26.4
7507734-07	6	18.37	T	51,300	73,700	24.0
			T	50,900	76,100	26.7

UOP RUSSELL LLC. HT# 7507734
 PO# 4500828678 SL# 07
 SO# 346565 ITM# 3, 4

Skid 2 relocated from UOPR Job 488 to 447

PO #10 7156

02-13-2018

NACE MR0175 ANNEX 2.1.2 COMPLIANT
 Test coupons only, normalized 60 minutes per inch of thickness at 1650 F ± 25 F. Hold 30 minutes minimum. ;
 Manufactured to fully killed fine grain practice by Electric Arc Furnace. Welding or weld repair was not performed on this material.
 Mercury has not been used in the direct manufacturing of this material. Produced as continuous cast discrete plate as-rolled, unless otherwise noted in Specification. For Mexico shipments: nhc.SalesMX@Nucor.com

Yield by 0.5EUL method unless otherwise specified. Ceq = C+(Mn/6)H+(Cr+Mo+V)/5+(Cu+Ni)/15
 Pcm = C+(Si/30)+(Mn/20)+(Cu/20)+(Ni/60)+(Cr/20)+(Mo/15)H+(V/10)+5B
 Melted and Manufactured in the USA. ISO 9001:2008 certified (#010940) by SRI Quality System Registrar (#0985-09). PED 97/23/EC 7/2 Annex 1, Para. 4.3 Compliant.
 DIN 50049 3.1.B/EN 10204 3.1B(2004). DIN EN 10204 3.1(2005) compliant. For ABS grades only. Quality Assurance certificate 14-MMPQA-723

By: T.A. Depretis
 Date: 12/3/2017
 12/3/2017 10:12:56 AM

Q.A. APPROVED
 By: [Signature]
 Date: 12/3/2017
 12/3/2017 10:12:56 AM
 HT# 7507734

R.N. GUPTA & COMPANY LTD., C-55, FOCAL POINT, LUDHIANA -141 010 (INDIA)
MATERIAL / MILL TEST CERTIFICATE EN 10204 : 2004 - 3.1

F-MTR-01-01



CERTIFICATE NO. 11705 DATE 26/10/2017

RAW MATERIAL SPECIFICATION : ASTM A105-14/ASME SA105-13

SPECIFICATION FOR INSPECTION : ANSIIASME B16.5-2013

P.O NO. 41017RG DT. 10/04/2017

INVOICE NO. RNG/EXP/17-2211 DT. 16/10/2017

MECHANICAL REQUIREMENTS

Sr. No.	Description	Qty (PCS)	Heat No.	Supp. Code	Y.S(PSI) Min	T.S(PSI) Min	E% Min	RA% Min	Heat Treatment	Soaking Time (Min.)	Hardness BHN
1	4 150# THRD RF FLGS L1TR4-RG	750	H 6057	20	45574	77560	34.44	66.37	AS FORGED		152 - 154
2	4 150# THRD RF FLGS L1TR4-RG	146	H 6006	20	46233	75364	30.50	67.61	AS FORGED		150 - 152
3	4 150# WNRF XH FLGS L1WRX4-RG	603	H 6066	20	43602	73770	30.64	66.28	AS FORGED		146 - 148
4	4 150# WNRF XH FLGS L1WRX4-RG	1058	H 6058	20	49115	76146	36.10	67.59	AS FORGED		150 - 152
5	4 150# WNRF XH FLGS L1WRX4-RG	339	H 8057	20	45574	77560	34.44	66.37	AS FORGED		152 - 154

CHEMICAL REQUIREMENTS

Sr. No.	Heat No.	SPECIFIED ELEMENTS						UNSPECIFIED ELEMENTS					
		C.E. Max	C Max	Mn	P Max	S Max	Si Max	Cu Max	Ni Max	Cr Max	Mo Max	V Max	
1	H 6057	0.38	0.35	0.90	0.035	0.002	0.22	0.077	0.120	0.003	0.007		
2	H 6006	0.39	0.35	0.95	0.023	0.009	0.30	0.037	0.100	0.003	0.025		
3	H 6066	0.42	0.21	0.90	0.015	0.009	0.25	0.069	0.170	0.015	0.007		
4	H 6058	0.39	0.21	0.88	0.011	0.004	0.20	0.097	0.100	0.003	0.007		
5	H 6057	0.38	0.35	0.90	0.007	0.002	0.22	0.077	0.120	0.003	0.007		

Certificate that the materials described above are in accordance with the order and specifications. For R.N. GUPTA & COMPANY LTD. Page No : 1
 Material in accordance with NACE MRO 175-2003 and NACE MRO 103

Note:- We hereby confirm that our QA system comply with requirements of Annex I, Clause 4.3 of PED 97/68/EU and it is certified by Mrs DNV BUSINESS ASSURANCE vide certificate No. 4487-2014-CE-IND-DNV-GL Valid upto 31-03-2020. ISO 9001:2015 certificate No. is 39752-2008-QA-IND-RVA Valid upto 22/07/2020. Products also conform to requirements of ASTM A105/ASME SA105

METALLURGIST

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 1107185215



Capitol Manufacturing
1125 Capitol Avenue
Crowley, LA 70526

Phoenix Capitol Camco
CapProducts

Certified Mill Test Report

Printed: 7/26/2017

Certified: 05/23/2016

Customer

LEE SUPPLY CO
PO BOX 1475
TULSA, OK 74101

P.O. 17-4104-DS

Tag

Material ASTM A105-2014 / ASME SA105-2015 Edition

Heat No 166223

Heat Code 74SQ

Phoenix Order # 1300312

Part Number

12202015TOE.4L

Description

1-1/2" 3M CPLG TOE 4"LONG

Chemical Properties

C	Mn	P	S	Si	Cu	Ni	Cr	C Eq. Long	
0.2100	0.9100	0.0070	0.0210	0.2100	0.1700	0.0740	0.1240	0.4143	

Mo	V	Co	Al	Cb	N	Pb	Sn	Ta	Ti
0.0230	0.0350		0.0030	0.0003					

Additional Chemical Properties

					Cr + Cu + Ni
					0.3680

Mechanical Properties

Tensile (PSI)	Yield (PSI)	Elong. % in 2 in. or 4D	R of A	HBW	HBW2
84,700	59,300	26.0%	50.0%	162	162

Charpy Minimum Impact - ft/lbs

Test 1	Test 2	Test 3	Average	Test Temp.
N/A	N/A	N/A	N/A	N/A

We hereby certify that these parts were manufactured, sampled, tested, and inspected in accordance with the product specifications stated and were found to meet the requirements.

We further certify that this material was inspected using independent inspectors conforming to the requirements of EN 10204 3.1. These products meet the requirements of the latest editions of NACE MR0175, NACE MR0103, and ISO 15156. No weld repair has been performed on these products. This material was not exposed to mercury or any other metal alloy that is liquid at ambient temperatures during processing or while in our possession.

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PHOENIX / 1-1/2" ROUND HEAD PLUG A105

CapProducts

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Printed: 11/1/2017

Certified: 09/27/2017

Customer

P.O. 17-6206 DS

Heat No 177321

LEE SUPPLY CO

Tag

Heat Code 76HF

PO BOX 1475

Phoenix Order # 1324355

TULSA, OK 74101

Material ASTM A105-2014 / ASME SA105-2015 Edition

Part Number

12203515

Description

1-1/2" FS RD HD PLUG

Chemical Properties

C	Mn	P	S	Si	Cu	Ni	Cr	C Eq. Long	
0.2200	0.9400	0.0070	0.0220	0.2100	0.1700	0.0620	0.1000	0.4235	

Mo	V	Co	Al	Cb	N	Pb	Sn	Ta	Ti
0.0190	0.0380		0.0020	0.0003					

Additional Chemical Properties

--	--	--	--	--

Cr + Cu + Ni
0.3320

Mechanical Properties

Tensile (PSI)	Yield (PSI)	Elong. % in 2 in. or 4D	R of A	HBW	HBW2
84,900	62,700	25.0%	49.0%	165	0

Charpy Minimum Impact - ft/lbs

Test 1	Test 2	Test 3	Average	Test Temp.
N/A	N/A	N/A	N/A	N/A

We hereby certify that these parts were manufactured, sampled, tested, and inspected in accordance with the product specifications stated and were found to meet the requirements.

We further certify that this material was inspected using independent inspectors conforming to the requirements of EN 10204 3.1. These products meet the requirements of the latest editions of NACE MR0175, NACE MR0103, and ISO 15156. No weld repair has been performed on these products. This material was not exposed to mercury or any other metal alloy that is liquid at ambient temperatures during processing or while in our possession.

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Customer
LEE SUPPLY CO
PO BOX 1475
TULSA, OK 74101

Certified: 06/14/2016
P.O. 17-2169-DS
Tag

Heat No 155770
Heat Code 74MJ
Phoenix Order # 1276879

Material ASTM A105-2014 / ASME SA105-2015 Edition

Part Number

12302010.3-3/8L

Description

1" 6M THRD CPLG 3-3/8" LONG TOE

Chemical Properties

C	Mn	P	S	Si	Cu	Ni	Cr	C Eq. Long	
0.2100	0.9400	0.0060	0.0310	0.2300	0.1800	0.0680	0.1130	0.4174	
Mo	V	Co	Al	Cb	N	Pb	Sn	Ta	Ti
0.0220	0.0360		0.0030	0.0040					

Additional Chemical Properties

										C + Cu + Ni
										0.3610

Mechanical Properties

Tensile (PSI)	Yield (PSI)	Elong. % in 2 in. or 4D	R of A	HBW	HBW2
83,200	55,700	25.0%	47.0%	169	169

Charpy Minimum Impact - ft/lbs

Test 1	Test 2	Test 3	Average	Test Temp.
N/A	N/A	N/A	N/A	N/A

We hereby certify that these parts were manufactured, sampled, tested, and inspected in accordance with the product specifications stated and were found to meet the requirements.

We further certify that this material was inspected using independent inspectors conforming to the requirements of EN 10204 3.1. These products meet the requirements of the latest editions of NACE MR0175, NACE MR0103, and ISO 15156. No weld repair has been performed on these products. This material was not exposed to mercury or any other metal alloy that is liquid at ambient temperatures during processing or while in our possession.

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Capitol Manufacturing
1125 Capitol Avenue
Crowley, LA 70526

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Certified Mill Test Report

Printed: 5/17/2017
Customer
LEE SUPPLY CO
PO BOX 1475
TULSA, OK 74101

Certified: 05/16/2017
P.O. 17-2169-DS
Tag

Heat No C124634
Heat Code 76BA
Phoenix Order # 1276879

Material ASTM A105-2014 / ASME SA105-2015 Edition

Part Number

12302010.3-3/8L

Description

1" 6M THRD CPLG 3-3/8" LONG TOE

Chemical Properties

C	Mn	P	S	Si	Cu	Ni	Cr	C Eq. Long		
0.1900	0.8500	0.0080	0.0380	0.2400	0.0800	0.0700	0.0500	0.3625		
Mo	V	Co	Al	Cb	N	Pb	Sn	Ta	Ti	
0.0320	0.0220		0.0000	0.0000						

Additional Chemical Properties

								Cr + Cu + Ni	
								0.2000	

Mechanical Properties

Tensile (PSI)	Yield (PSI)	Elong. % in 2 in. or 4D	R of A	HBW	HBW2
73,100	43,600	36.0%	65.0%	133	144

Charpy Minimum Impact - ft/lbs

Test 1	Test 2	Test 3	Average	Test Temp.
N/A	N/A	N/A	N/A	N/A

We hereby certify that these parts were manufactured, sampled, tested, and inspected in accordance with the product specifications stated and were found to meet the requirements.

We further certify that this material was inspected using independent inspectors conforming to the requirements of EN 10204 3.1. These products meet the requirements of the latest editions of NACE MR0175, NACE MR0103, and ISO 15156. No weld repair has been performed on these products. This material was not exposed to mercury or any other metal alloy that is liquid at ambient temperatures during processing or while in our possession.

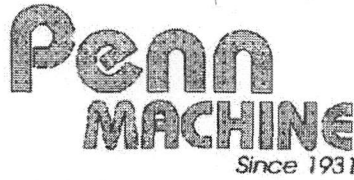
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1/3/18
LIC # 185215



TEXAS PMW, INC.
315 NORTH WAYSIDE DRIVE HOUSTON, TX 77020
(713) 879-7800 - FAX (713) 879-7820



PENNSYLVANIA MACHINEWORKS, INC.
201 BETHEL AVENUE ASTON, PA 18014
(610) 487-3300 - FAX (610) 487-3325



US DROP FORGE CO.
P.O. BOX 131 - ROUTE 551
1368 ALBURN ROAD WOOLWICH TOWNSHIP, NJ 08085
(856) 487-0500 - FAX (856) 487-4588

CERTIFIED MATERIAL TEST REPORT

LEE SUPPLY CO.
P.O. BOX 1475
TULSA, OK 74101

P.O. 132938KB
ORDER # 03 230105
6/27/13

2X 3-3/8 3MTD HFPC A105

QTY: 184

HEAT CODE: 2C1J
SPECIFICATION: A105
UNS NUMBER: K03504

MATERIAL: A105
SPEC. YEAR: 11
SPEC. REV:

CHEMICAL ANALYSIS									
C	MN	P	S	SI	NI	CR	MO	CU	V
.260	.860	.010	.023	.250	.070	.120	.030	.150	.002

PHYSICAL ANALYSIS						
YS (PSI)	TS (PSI)	%EL 4D	%RA %	HARDNESS (HB)	PMI	C.B.
49350	84230	31.50	60.50	187	OK	45

MATERIAL I/A/W ASME-SEC II SA SPECIFICATION-CERTIFICATE I/A/W EN10204 TYPE 3.1
 MATERIAL MEETS NACE-MRO175/ISO15156-2009
 MATERIAL IS CAPABLE OF PASSING A HYDROSTATIC TEST COMPATIBLE WITH THE RATING OF THE FINISHED FITTING
 MATERIAL MEETS NACE-MRO103-2007
 DURING THE MANUFACTURE AND PROCESSING OF THIS PRODUCT, IT DID NOT COME IN DIRECT CONTACT WITH MERCURY
 OR ANY OF ITS COMPOUNDS NOR WITH ANY MERCURY CONTAINING DEVICE THAT EMPLOYED A SINGLE BOUNDARY OF CONTAINMENT.
 NO WELD REPAIRED MATERIAL - MADE IN THE U.S.A

Skid 2 reprinted from UOPR Job 490 to 447

WE HEREBY CERTIFY THAT THE REPORTED FIGURES ARE CORRECT AS CONTAINED IN THE RECORDS OF THE CORPORATION.

James B. Friant
(E-S-ELECTRONIC SIGNATURE)
JAMES B. FRIANT
QUALITY MANAGER



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REC 3/8/18
LIC# 185215



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Crowley, LA 70526

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Certified Mill Test Report

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Printed: 7/26/2017

Customer
LEE SUPPLY CO
PO BOX 1475
TULSA, OK 74101

Certified: 07/06/2017

P.O. 17-4104-DS

Tag

Material ASTM A105-2014 / ASME SA105-2015 Edition

Heat No 76RG(74RG)

Heat Code 76RG

Phoenix Order # 1300312

Part Number

12203520

Description

2" FS RD HD PLUG

Chemical Properties

C	Mn	P	S	Si	Cu	Ni	Cr	C Eq. Long	
0.2000	0.9600	0.0100	0.0250	0.2300	0.1800	0.0560	0.1180	0.4101	

Mo	V	Co	Al	Cb	N	Pb	Sn	Ta	Ti
0.0170	0.0370		0.0030	0.0040					

Additional Chemical Properties

Cr + Cu + Ni
0.3540

Mechanical Properties

Tensile (PSI)	Yield (PSI)	Elong. % in 2 in. or 4D	R of A	HBW	HBW2
81,700	55,000	28.0%	59.0%	165	165

Charpy Minimum Impact - ft/lbs

Test 1	Test 2	Test 3	Average	Test Temp.
N/A	N/A	N/A	N/A	N/A

We hereby certify that these parts were manufactured, sampled, tested, and inspected in accordance with the product specifications stated and were found to meet the requirements.

We further certify that this material was inspected using independent inspectors conforming to the requirements of EN 10204 3.1. These products meet the requirements of the latest editions of NACE MR0175, NACE MR0103, and ISO 15156. No weld repair has been performed on these products. This material was not exposed to mercury or any other metal alloy that is liquid at ambient temperatures during processing or while in our possession.

Meets ASME SA-181-70 2013 Edition. Manufactured in the USA.

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PKR 3/18/18
LIC # 185215



TEST REPORT

13/4 X .461 SA105
A2S A4S

SHIPMENT
001

5315

MICHIGAN SEAMLESS TUBE

SOUTH LYON, MICHIGAN 48178

ORDER NUMBER	CUSTOMER ORDER NUMBER	DATE	OPC	COM	DIV	NET SLS	GRSLS	ACCOUNT NUMBER	US	PAGE
065176	214171	10/06/14	21	00	15	05	01	06587000000	2ME	1

XUTING

COLL/O-T/TARPED/FDB S LYON MI/GBOYD@SPECIALMETALSINC.COM

CUST PU

ANALYSIS	SHAPE	PRODUCT	PC	ANNEAL	REQUESTED
1026	ROUND	COLD DRAWN		NORMALIZED	10/31/14
SEAMLESS	SPECIFICATION	CUST	DESCRIPTION	PROLISE	
	A105/A519		CD CARBON MECHANICAL	10/31/14	

SPECIAL INSTRUCTIONS

DIL S-0.020 MAX. CHEM/PHYS ASTM A105/ASME SA105. MUST MEET NACE MRD 175-97, NACE MRD 103-2010 SEC 2.1.1-2.1.7, ISO 15156-2 A 2 & EN 10204 SEC 3.1, 3.2, 4.1, 4.2. MK W/MST, SIZE, GR, CUST NAME, PDR, SPEC & HTB. T/R TO INCL COMPLETE CHEM (INCL UNSPECIFIED ELEMENTS) PHYS, HBW & GRAIN SIZE. GUARANTEED FINISH BORE SIZE 0.921"

ITEM	QUANTITY	O.D.	I.D.	WALL	LENGTH	WT/FT	WEIGHT
		1.750		.467 AVG		6.399	13:46:46 02/04/15

ITM NUM	BALE NUM	PCS	FTG	HEAT NO.	LENGTH	STATUS	PART NUMBER
1	1 2	42	633	00A145044	RAND 12'-17'	COM	705787
1	5 2	42	636	00A145044	RAND 12'-17'	COM	705787
1	2 2	44	665	00A145042	RAND 12'-17'	COM	705787
1	3 2	44	667	00A145042	RAND 12'-17'	COM	705787
1	4 2	44	667	00A145042	RAND 12'-17'	COM	705787

HEAT NO.	C	Mn	P	S	Si	Ni	Cr	Mo	Cu	Al	REMARKS
00A145044	.240	.750	.007	.015	.210	.060	.140	.020	.120	.019	EF SDI GS 7
00A145042	.240	.750	.007	.017	.250	.060	.130	.030	.130	.017	EF SDI GS 7

HEAT NO.	ULT. STR. PSI	YIELD, PSI	% ELONG	HARDNESS	HYDRO TEST PSI	ULTRA SONIC %	EDDY CURRENT	EXPANSION	
00A145044	73,266	45,942	34.4	HRB 78-81			OK		
00A145042	73,574	50,505	34.4	HRB 79-81					
				Lee Supply 15-0539KF	BEND	FLATTEN	FLARE	REV. FLATTEN	FLANGE

V SN NB SE AS
A145042 .002 .009 .000 .002 .004
A145044 .002 .009 .000 .002 .004
MELTED AND MANUFACTURED IN USA
MTR REVISED 2/4/15

HEAT CODE 3/4-6000# X 4 TOE

Reduction of area HT A145042 55.84 %
" " " " A145044 57.69 %
MTR Revised 8/12/2015

We hereby certify that the reported data are correct according to Michigan Seamless Tube tests and those of its suppliers.

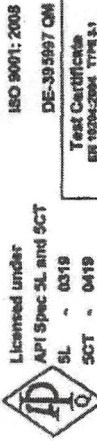
6.2.P8.F9 Rev 2

PKR 3/8/18
HC 185219

ISC949 / 1607719 / 4.0A106XHA / 4 XH A106B SMLS PIPE

**MATERIAL TEST CERTIFICATE
SEAMLESS TUBE**

ArcelorMittal South Africa Limited
Tubular Products
273 Genl. Hertzog Rd,
Peacehaven Vereeniging 1939
P O Box 48 Vereeniging 1930
South Africa



ISO 9001: 2008
DE-39 9997 QM

ArcelorMittal

Customer: 4000023425
Order No: 040062127314
Certificate Reference No: FULLY KILLED HOT FINISHED CARBON STEEL SEAMLESS TUBES
Product: ISO3183:2012/API 5L-2012 L245/250/B/X42 PSL1 ASTM A53B.12 A106B/C.15
Specification: ARCELORMITTAL SA ISO3183/SAE 5L-0319 MONOGRAM 04-17 ASTM/ASME A53B 4.500 0.337 40.080 L245/B L290/X42 PSL1 SMLS TESTED 3000
Product Marking: psi CAST NO: 1607719 PROD/O NO: 7044242510 MADE IN SOUTH AFRICA NDE

Customer Order/Contract No: SUSA 155556
Material No: 1000042301
Cast/Heat No: 1607719 Page 1 of 1

General Information

Quantity	Mass	Dimensions		Total Length
		Tube OD	Thickness	
248	148,882.987(lb)	4.500(")	0.337(")	9,920.000(ft)

Steel making process	Final Rolling Operation
Electric Arc	As Rolled
	Final box rolling finished above 1380°F and cooled in still air

Chemical Composition

Element(%)	R22-IV + Nb + Ti														R24-(Nb + V)													
	C	Si	Mn	S	P	Cr	Ni	Mo	Cu	V	Al	Ti	Sn	Ca	N	B	Nb	CE	R22	R24								
Minimum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
Maximum	0.200	-	1.30	0.030	0.030	0.50	0.50	0.150	0.500	-	-	-	-	-	-	-	-	0.41	0.15	0.060								
Heat	0.120	0.13	1.02	0.004	0.011	0.02	0.01	0.003	0.005	0.010	0.024	0.001	0.000	0.0020	0.0060	0.0003	0.0005	0.30	0.01	0.011								
Product	0.1200	0.1300	1.0200	0.0040	0.0110	0.0200	0.0100	0.0030	0.0050	0.0100	0.0240	0.0007	0.0004	0.0020	0.0060	0.0003	0.0005	0.2976	0.0112	0.0105								
Product (ADD)	0.1200	0.1300	1.0200	0.0040	0.0110	0.0200	0.0100	0.0030	0.0050	0.0100	0.0240	0.0007	0.0004	0.0020	0.0060	0.0003	0.0005	0.2976	0.0112	0.0105								

Mechanical Properties

Specification Limits	UTS (Rm)		Yield (0.5%)		Yield (0.2%)		OTHER TESTS	
	MPa	psi	MPa	psi	MPa	psi	Category	Result
Minimum	70000	42000	-	-	-	-	Hydrostatic	3000 psi for 5 Sec
(1) Actual	70343	52503	39.0	39.0	-	-	NDI: EMI	PASS - ASTM E570 - 12.5% NOTCH
(2) Actual	70923	52229	42.0	42.0	-	-	NDI: UT	UT not required
(3) Actual	-	-	-	-	-	-	HV 22 lbs	150 151 151
(4) Actual	-	-	-	-	-	-	% EL 2 inch	-

Remarks:

Material in accordance with NACE MR0175:2015/ISO15156-2:2015, MR0103:2015, MR0103:2015, Dimensions to ASME B36.10M-2015. The material conform to the hot yield strength requirements as per ASME, Sect II, Pt D, Table Y-1, 2015. All the material conform to the visual and dimensional requirements and is made to a suitable fine grain practice.

Quality Assurance Manager: **FJ Venter**

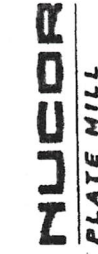
Date of Release: 2017.04.05

Certified by: *[Signature]*

We hereby certify that the material was manufactured, tested and inspected to and fully comply with the requirements of referenced specifications. No changes, amendments or additions may be made to this document. Any changes which are effected shall invalidate this certificate.

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PKL3/8/18
LIC1785215



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Winton, NC 27986
(252) 356-3700

Mill Test Report

Page 2

1505 River Rd
Cofield, NC 27922
(252) 356-3700



Issuing Date: 11/03/2017 B/L No.: 486532 Load No.: 496448 Our Order No.: 151874/1
 Vehicle No: TTPX 81123 Sold To: METALS USA - SOUTH CENTRAL
 2800 N 43RD ST E
 Muskogee, OK 74403
 Specification: 0.5000" x 120.000" x 480.000"
 ASTM A516 70-10(2015)/ASME SA516 70 PVQ 2013/2015 Normalized
 Test Coupons at 1650 F NACE MR0175 Annex 2.1.2 (2015), MR0103
 (2010) Section 2.1.2(2015) 13.1.1, 13.1.2

Cust. Order No.: MUS-249635 Ship To: METALS USA - PLATES AND SHAPES
 TRACK 747
 MUSKOGEE, OK 74401

Heat No	C	Mn	P	S	SI	Cr	Mo	Al(tot)	V	Nb	Ti	N	Ca	B	Sn	Ceq	Pcm
7507097	0.20	1.06	0.013	0.002	0.19	0.24	0.11	0.026	0.006	0.003	0.003	0.0025	0.0001	0.0001	0.011	0.43	0.28

Plate Serial No	Pieces	Tons	Tensile Test			
			Dir	(psi) Yield	(psi) Tensile	Elong. % in 2"
7507097-07	6	24.50	T	53,600	78,000	22.0
			T	48,800	73,800	24.8
7507097-08	6	24.50	T	53,900	76,700	22.9
			T	49,300	74,400	24.3

UOP RUSSELL LLC. HT# 75070977
 PO# 4500828678 SL# 08
 SO# 346565 ITM# 1, 2

UOPR Job 488 to 447
 Skid 2 relocated from

NACE MR0175 ANNEX 2.1.2 COMPLIANT
 Test coupons only, normalized 60 minutes per inch of thickness at 1650 F ± 25 F. Hold 30 minutes minimum. ;
 Manufactured to fully killed fine grain practice by Electric Arc Furnace. Welding or weld repair was not performed on this material.
 Mercury has not been used in the direct manufacturing of this material. Produced as continuous cast discrete plate as-rolled, unless otherwise noted in Specification. For Mexico shipments: nkc.SalesMX@NuCor.com
 Yield by 0.5EUL method unless otherwise specified. Ceq = C+(Mn/16)+(Cr+Mo+V/5)+(Cu+Ni/15)
 Pcm = C+(S/30)+(Mn/20)+(Cu/20)+(Ni/60)+(Cr/20)+(Mo/15)+(V/10)+5B
 Meltd and Manufactured in the USA. ISO 9001:2008 certified (#010940) by SRI Quality System Registrar (#0985-09). PED 97/23/EC 7/2 Annex 1. Para. 4.3 Compliant.
 DIN 50049 3.1.B/EN 10204 3.1B(2004). DIN EN 10204 3.1(2005) compliant. For ABS grades only, Quality Assurance certificate 14-MMPQA-723

T.A. Depretis, Metallurgist
 T. A. Depretis, Metallurgist

Q.A. APPROVED
 By: *[Signature]* Date: 12/11/07
 11/3/2017 8:31:58 AM
 11/3/2017 8:31:58 AM
 11/3/2017 8:31:58 AM

EN 10204-3.1

QUALITY CERTIFICATE № 1127/14

Sheet 1 Sheets2



Seller (Exporter)

Made in Russia

Joint-Stock Company "Pervouralsk New Pipe Plant"

Buyer (Address, country)

Contract № 27-03/13-01/KLF on 27.03.2013

Order-Nariad № 9,S-1

Freight car №

Export Licence

Order № 2205198/14

Description of goods	Standard	Type of pack	Quantity
Seamless Carbon Steel Pipe for High-Temperature Service	ASTM A106(14)/NDE/ASME SA106/ASTM A53(12)/ASME SA53/ASME B36.10M	in bundles	9

Item №	Nos. of Heats	Nos. of Lots	Grades of steel	Dimensions			Métrage	Number of pcs.	Mass (tons)		
				Diameter, inches	Wall, inches	Length, feet			Gross	Net	
1	4F5672	31400	Gr.B/Gr.C	1.050	0.154	20-21	1020	162		2.23	
2	"	31418	"	1.050	0.154	"	1046	168		2.22	
3	"	31408	"	1.050	0.154	"	713	115		1.54	
4	"	31394	"	1.050	0.154	"	1020	163		2.20	
5	"	31320	"	1.050	0.154	"	615	99		1.345	
6	"	31355	"	1.050	0.154	"	1039	163		2.215	
7	4F5671	31377	"	1.050	0.154	"	1076	169		2.305	
Total:											

It is hereby certified that the quality of goods mentioned in this Quality Certificate is in conformity with standards and specifications. Visual and dimensional control: no remarks.

Quality characteristics of goods

Compositions (%)

Item №	C	Mn	Si	S	P	Cr	Ni	Cu	V	Mo
1-6	0.25	0.77	0.28	0.007	0.005	0.14	0.21	0.20	0.01	0.02
7	0.25	0.77	0.25	0.012	0.005	0.07	0.14	0.21	0.01	0.02

Mechanical Properties

Item №	Tensile strength, psi	Yield strength, psi	Elongation (%)
1	85000	51000	26
2	82000	55000	22
3	79000	51000	25
4	92000	60000	26
5	78000	49000	27
6	89000	62000	24
7	90000	72000	27

NOTE: Pipes have been tested by non-destructive method with satisfactory result. Pipes are produced ungalvanized, threadless. The present requirements are correspond to NACE MR 0175(2009).

Control test is satisfactory.

Marking: is made as per requirements of the order

Date: 27/10/2014



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EN 10204-3.1

QUALITY CERTIFICATE № 1127/14

Sheet 2 Sheets2



Seller (Exporter)

Made in Russia

Joint-Stock Company "Pervouralsk New Pipe Plant"

Buyer (Address, country)

Contract № 27-03/13-01/KLF on 27.03.2013

Order-Nariad № 9,S-1

Freight car №

Export Licence

Order № 2205198/14

Description of goods	Standard	Type of pack	Quantity
Seamless Carbon Steel Pipe for High-Temperature Service	ASTM A106(14)NDE/ASME SA106/ASTM A53(12)/ASME SA53/ASME B36.10M	in bundles	

Item №	Nos. of Heats	Nos. of Lots	Grades of steel	Dimensions			Metrage	Number of pcs.	Mass (tons)	
				Diameter, inches	Wall, inches	Length, feet			Gross	Net
8	4F5671	±1366	Gr.B/Gr.C	1.050	0.154	20-21	907	144		2.03
9	47524	±1388	"	1.050	0.154	"	408	65		0.87
Total:							7844	1248	17.333	16.955

It is hereby certified that the quality of goods mentioned in this Quality Certificate is in conformity with standards and specifications. Visual and dimensional control: no remarks.

Quality characteristics of goods

Compositions (%)

Item №	C	Mn	Si	S	P	Cr	Ni	Cu	V	Mo
8	0.25	0.77	0.25	0.012	0.005	0.07	0.14	0.21	0.01	0.02
9	0.25	0.80	0.27	0.005	0.007	0.04	0.03	0.06	0.026	0.031

Mechanical Properties

Item №	Tensile strength, psi	Yield strength, psi	Elongation (%)
8	81000	51000	29
9	79000	50000	26

NOTE: Pipes have been tested by non-destructive method with satisfactory result. Pipes are produced ungalvanized, threadless. The present requirements are correspond to NACE MR 0175(2009).

Bend test is satisfactory.

Stamping: is made per requirements of the order



Date: 27/10/2014

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110# 185215

EN 10204-3.1

QUALITY CERTIFICATE № 1138/14

Sheet 1 Sheets 1



Seller (Exporter)

Made in Russia

Joint-Stock Company "Pervouralsk New Pipe Plant"

Buyer (Address, country)

Contract № 27-03/13-01/KLF on 27.03.2013

Order-Nariad № 9,S-1

Freight car №

Export Licence

Order № 2205198/14

Description of goods	Standard	Type of pack	Quantity
Seamless Carbon Steel Pipe for High-Temperature Service	ASTM A106(14)NDE/ASME SA106/ASTM A53(12)/ASME SA53/ASME B36.10M	in bundles	5

Item №	Nos. of Heats	Nos. of Lots	Grades of steel	Dimensions			Metrage	Number of pcs.	Mass (tons)	
				Diameter, inches	Wall, inches	Length, feet			Gross	Net
1	4F5672	31501	Gr.B/Gr.C	1.050	0.154	202	1022	167		2.30
2	"	31496	"	1.050	0.154	"	1032	167		2.31
3	"	31504	"	1.050	0.154	"	1008	163		2.24
4	"	31503	"	1.050	0.154	"	995	161		2.205
5	4F5671	31521	"	1.050	0.154	"	1048	168		2.28
Total:							5105	826	11.545	11.335

It is hereby certified that the quality of goods mentioned in this Quality Certificate is in conformity with standards and specifications. Visual and dimensional control: no remarks.

Quality characteristics of goods

Compositions (%)

Item №	C	Mn	Si	S	P	Cr	Ni	Cu	V	Mo
1-4	0.25	0.77	0.28	0.007	0.005	0.14	0.21	0.20	0.01	0.02
5	0.25	0.77	0.25	0.012	0.005	0.07	0.14	0.21	0.01	0.02

Mechanical Properties

Item №	Tensile strength, psi	Yield strength, psi	Elongation (%)
1	90000	59000	28
2	76000	51000	29
3	90000	57000	28
4	90000	57000	32
5	82000	52000	27

NOTE: Pipes have been tested by non-destructive method with satisfactory result. Pipes are produced ungalvanized, threadless. The present requirements are correspond to NACE MR 0175(2009).

Bend test is satisfactory.

Marking is made in accordance with requirements of the order
 Signatures: *[Signature]* Date: 31/10/2014



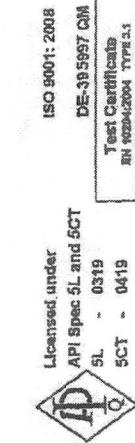
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Acc 3/8/18
LIC 185215

ISC887 / 1700652 / 1.0A106XHA / 1 XH A106B SMLS PIPE

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ISO 9001: 2008
 DE-39 5937 DM
 Test Certificate
 EN 10204/2004 TYPE 3.1

ArcelorMittal

Customer: 4000023322
 Order No: 040062136546
 Certificate Reference No: FULLY KILLED HOT FINISHED CARBON STEEL SEAMLESS TUBES
 Product: ISO3183-2012/API 5L-2012 L245/L290B/X42 FSL1 ASTM A533B.12 A106B/C.15 AS530.15
 Specification: ARCELORMITTAL SA ISO3183/Spec 5L-0319 MONOGRAM 04-17 ASTM/ASME A/SA106B/C A533 B.1.315 0.179 20.000 L245/B L290/X42 FSL1 SMLS TESTED 3000
 Product Marking: psi CAST NO: 1700652 PROD/O NO: TB342332210 MADE IN SOUTH AFRICA NDE

Customer Order/Contract No: SUS4 155484
 Material No: 1000038076
 Cast/Heat No: 1700652
 Page 1 of 1

General Information

Quantity	Mass	Dimensions	Total Length
392	17,068.013(lb)	Tube OD 1.315() Thickness 0.179()	20,000 (ft) 7,840,000(ft)

Steel making process	Final Rolling Operation
Electric Arc	As Rolled
	Final hot rolling finished above 1580°F and cooled in still air

Chemical Composition

Element(%)	C	Si	Mn	S	P	Cr	Ni	Mo	Cu	V	Al	Ti	Sn	Ca	Nb	B	N	CE	R05	R22	R24
Minimum	0.200	0.170	0.28	0.030	0.030	0.020	0.010	0.010	0.005	0.001	0.005	0.002	0.001	0.0015	0.0067	0.0004	0.00005	0.41	0.04	0.15	0.060
Maximum	0.170	0.280	0.86	0.0030	0.012	0.0240	0.0100	0.0010	0.0050	0.0010	0.0332	0.0071	0.0007	0.0015	0.0067	0.0004	0.00005	0.3189	0.0410	0.0036	0.0015
Heat	0.1700	0.2800	0.8560	0.0030	0.0121	0.0240	0.0100	0.0010	0.0050	0.0010	0.0332	0.0071	0.0007	0.0015	0.0067	0.0004	0.00005	0.3189	0.0410	0.0036	0.0015
Product	0.1700	0.2800	0.8560	0.0030	0.0121	0.0240	0.0100	0.0010	0.0050	0.0010	0.0332	0.0071	0.0007	0.0015	0.0067	0.0004	0.00005	0.3189	0.0410	0.0036	0.0015
Product (ADD)	0.1700	0.2800	0.8560	0.0030	0.0121	0.0240	0.0100	0.0010	0.0050	0.0010	0.0332	0.0071	0.0007	0.0015	0.0067	0.0004	0.00005	0.3189	0.0410	0.0036	0.0015

Mechanical Properties

Specification	UTS (Rm)	Yield (0.5%)	% EL
Limits	MPa	MPa	2 inch
Minimum	70000	42000	30.0
Maximum	70923	46412	43.0
(1) Actual	71068	47137	45.0
(2) Actual			
(3) Actual			
(4) Actual			

Remarks:

Material in accordance with NACE MR0175:2015/ISO15156-2:2015, MR0103:2015, Dimensions to ASME B36.10M-2015.
 The material conform to the hot yield strength requirements as per ASME, Sect II, Pt D, Table Y-1, 2015. All the material conform to the visual and dimensional requirements and is made to a suitable fine grain practice.

Quality Assurance Manager: PJ Venier

Date of Release: 2017.04.27

Certified by: [Signature]

We hereby certify that the material was manufactured, tested and inspected to and fully comply with the requirements of referenced specifications. No changes, amendments or additions may be made to this document. Any changes which are effected shall invalidate this certificate.

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PLC 3/8/18
 LIC #185415

UOP Russell

7050 South Yale

Suite 210

Tulsa OK 74136



COMPRESS Pressure Vessel Design Calculations

Item: Fuel Gas Scrubber

Vessel No: V-481

Job & Customer: J-488 SC6 RSV

Revision: 0

Designer & Date: ABM 11/16/2017

Designed in accordance with UG-22

Reviewed: JAT 11/17/2017

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Skid 2 relocated from
UOPR Job 488 to 447

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Skid 2 relocated from
UOPR Job 488 to 447

Deficiencies Summary

No deficiencies found.

Warnings Summary

Warnings for [BTM HEAD](#)

UCS-79: The extreme fiber elongation exceeds 5 percent. Heat treatment per UCS-56 may be required. See UCS-79(d)(4) or (5). (warning)

Warnings for [Inlet \(A\)](#)

The attached ASME B16.5 flange limits the nozzle MAWP. (warning)
The attached ASME B16.5 flange limits the nozzle MAP. (warning)

Warnings for [TOP HEAD](#)

UCS-79: The extreme fiber elongation exceeds 5 percent. Heat treatment per UCS-56 may be required. See UCS-79(d)(4) or (5). (warning)

Warnings for [Vapor Out/Inspection \(B\)](#)

The attached ASME B16.5 flange limits the nozzle MAWP. (warning)
The attached ASME B16.5 flange limits the nozzle MAP. (warning)

Warnings for Vessel

Changes to steelmaking practices have increased the risk of brittle fracture at temperatures higher than the ASME impact test exemption temperatures. It is highly recommended that the following supplemental requirements be applied for SA-105, SA-106 B, SA-53 seamless, and SA-234: material composition should have a minimum Mn:C ratio of 5, and SA-105 flanges should require a grain size of 7 or finer. (warning)

ASME B16.5 / B16.47 Flange Warnings Summary

Flange	Applicable Warnings
Vapor Out/Inspection (B)	1
Inlet (A)	1

No.	Warning
1	For Class 150 flanges, ASME B16.5 para. 5.4.3 recommends gaskets to be in accordance with Nonmandatory Appendix B, Table B1, Group No. I.

Nozzle Schedule

Specifications									
Nozzle mark	Identifier	Size	Materials		Impact Tested	Normalized	Fine Grain	Flange	Blind
A	Inlet	NPS 4 Sch 80 (XS)	Nozzle	SA-106 B Smls pipe	No	No	No	NPS 4 Class 150 WN A105	No
B	Vapor Out/Inspection	NPS 4 Sch 80 (XS)	Nozzle	SA-106 B Smls pipe	No	No	No	NPS 4 Class 150 WN A105	No
C	Liquid Out	NPS 1 Class 6000 - threaded	Nozzle	SA-105	No	No	No	N/A	No
D1	LG	NPS 0.75 Class 6000 - threaded	Nozzle	SA-105	No	No	No	N/A	No
D2	LG	NPS 0.75 Class 6000 - threaded	Nozzle	SA-105	No	No	No	N/A	No
E	TI	NPS 0.75 Class 6000 - threaded	Nozzle	SA-105	No	No	No	N/A	No
F1	LSHH	NPS 1 Class 6000 - threaded	Nozzle	SA-105	No	No	No	N/A	No
F2	LSHH	NPS 1 Class 6000 - threaded	Nozzle	SA-105	No	No	No	N/A	No
G	Inspection	NPS 2 Class 3000 - threaded	Nozzle	SA-105	No	No	No	N/A	No
H1	LC (Future)	NPS 1.5 Class 3000 - threaded	Nozzle	SA-105	No	No	No	N/A	No
H2	LC (Future)	NPS 1.5 Class 3000 - threaded	Nozzle	SA-105	No	No	No	N/A	No

Skid 2 relocated from UOPR Job 488 to 447

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)		
A	4.5	0.337	0.2826	Yes	Yes	0.375	0.2473		N/A	N/A	0.0625	107.3
B	4.5	0.337	0.2497	Yes	Yes	0.3125*	0.2041		N/A	N/A	0.0625	140.2
C	2.25	0.4675	0.125	Yes	Yes	0.375	N/A		N/A	N/A	0.0625	Exempt
D1	1.75	0.35	0.125	Yes	Yes	0.375	N/A		N/A	N/A	0.0625	Exempt
D2	1.75	0.35	0.125	Yes	Yes	0.375	N/A		N/A	N/A	0.0625	Exempt
E	1.75	0.35	0.125	Yes	Yes	0.375	N/A		N/A	N/A	0.0625	Exempt
F1	2.25	0.4675	0.125	Yes	Yes	0.375	N/A		N/A	N/A	0.0625	Exempt
F2	2.25	0.4675	0.125	Yes	Yes	0.375	N/A		N/A	N/A	0.0625	Exempt
G	3	0.3125	0.125	Yes	Yes	0.375	N/A		N/A	N/A	0.0625	Exempt
H1	2.5	0.3	0.125	Yes	Yes	0.375	N/A		N/A	N/A	0.0625	Exempt
H2	2.5	0.3	0.125	Yes	Yes	0.375	N/A		N/A	N/A	0.0625	Exempt

*Head minimum thickness after forming

Definitions	
t _n	Nozzle thickness
Req t _n	Nozzle thickness required per UG-45/UG-16 Increased for pipe to account for 12.5% pipe thickness tolerance
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

Skid 2 relocated from
 UOPR Job 488 to 447

Pressure Summary

Component Summary							
Identifier	P Design (psi)	T Design (°F)	MAWP (psi)	MAP (psi)	MDMT (°F)	MDMT Exemption	Impact Tested
TOP HEAD	265	150	427.63	533.33	-155	Note 1	No
Straight Flange on TOP HEAD	265	150	526.32	632.91	-155	Note 2	No
SHELL #1	265	150	381.41	472.75	-55	Note 3	No
Straight Flange on BTM HEAD	265	150	525.79	632.91	-155	Note 5	No
BTM HEAD	265	150	427	533.33	-155	Note 4	No
Inlet (A)	265	150	272.5	285	-55	Note 6	No
Vapor Out/Inspection (B)	265	150	272.5	285	-55	Note 6	No
Liquid Out (C)	265	150	381.42	472.71	-55	Note 7	No
LG (D1)	265	150	381.87	472.71	-55	Note 8	No
LG (D2)	265	150	381.48	472.71	-55	Note 9	No
TI (E)	265	150	381.58	472.71	-55	Note 10	No
LSHH (F1)	265	150	381.87	472.71	-55	Note 8	No
LSHH (F2)	265	150	381.68	472.71	-55	Note 11	No
Inspection (G)	265	150	381.41	472.71	-155	Note 12	No
LC (Future) (H1)	265	150	381.87	472.71	-155	Note 13	No
LC (Future) (H2)	265	150	381.61	472.71	-155	Note 14	No

Chamber Summary	
Design MDMT	-20 °F
Rated MDMT	-55 °F @ 150 psi
MAWP hot & corroded	150 psi @ 150 °F
MAP cold & new	285 psi @ 70 °F
(1) The MAWP is limited due to the MAWP limit set in the Calculations tab of the Set Mode dialog. (2) This pressure chamber is not designed for external pressure.	

Skid 2 relocated from UOPR Job 488 to 447

Notes for MDMT Rating		
Note #	Exemption	Details
1.	Straight Flange governs MDMT	
2.	Material is impact test exempt to -155°F per UCS-66(b)(3) (coincident ratio = 0.2871)	
3.	Material impact test exemption temperature from Fig UCS-66 Curve B = -20°F Fig UCS-66.1 MDMT reduction = 95.7°F, (coincident ratio = 0.3962) Rated MDMT of -115.7°F is limited to -55°F by UCS-66(b)(2)	UCS-66 governing thickness = 0.3281 in
4.	Straight Flange governs MDMT	
5.	Material is impact test exempt to -155°F per UCS-66(b)(3) (coincident ratio = 0.2881)	
6.	Flange rating governs: Flange rated MDMT per UCS-66(b)(1)(b) = -55°F (Coincident ratio = 0.5263) Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	
7.	Nozzle impact test exemption temperature from Fig UCS-66 Curve B = -20°F Fig UCS-66.1 MDMT reduction = 95.7°F, (coincident ratio = 0.3961) Rated MDMT of -115.7°F is limited to -55°F by UCS-66(b)(2)	UCS-66 governing thickness = 0.3281 in.
8.	Nozzle impact test exemption temperature from Fig UCS-66 Curve B = -20°F Fig UCS-66.1 MDMT reduction = 96.6°F, (coincident ratio = 0.395) Rated MDMT of -116.6°F is limited to -55°F by UCS-66(b)(2)	UCS-66 governing thickness = 0.3281 in.
9.	Nozzle impact test exemption temperature from Fig UCS-66 Curve B = -20°F Fig UCS-66.1 MDMT reduction = 95.8°F, (coincident ratio = 0.396) Rated MDMT of -115.8°F is limited to -55°F by UCS-66(b)(2)	UCS-66 governing thickness = 0.3281 in.
10.	Nozzle impact test exemption temperature from Fig UCS-66 Curve B = -20°F Fig UCS-66.1 MDMT reduction = 96°F, (coincident ratio = 0.3957) Rated MDMT of -116°F is limited to -55°F by UCS-66(b)(2)	UCS-66 governing thickness = 0.3281 in.
11.	Nozzle impact test exemption temperature from Fig UCS-66 Curve B = -20°F Fig UCS-66.1 MDMT reduction = 96.2°F, (coincident ratio = 0.3954) Rated MDMT of -116.2°F is limited to -55°F by UCS-66(b)(2)	UCS-66 governing thickness = 0.3281 in.
12.	Nozzle is impact test exempt to -155°F per UCS-66(b)(3) (coincident ratio = 0.0378).	
13.	Nozzle is impact test exempt to -155°F per UCS-66(b)(3) (coincident ratio = 0.0321).	
14.	Nozzle is impact test exempt to -155°F per UCS-66(b)(3) (coincident ratio = 0.0322).	

Skid 2 relocated from
UOPR Job 4288 to 447

Revision History

Revisions			
No.	Date	Operator	Notes
0	10/25/2007	Bill	New vessel created ASME Section VIII Division 1 [Build 6254]
1	7/ 1/2008	Bill	Converted from ASME Section VIII Division 1, 2004 Edition, A06 Addenda to ASME Section VIII Division 1, 2007 Edition. Default Forging Material Changed to A 105. During the conversion, changes may have been made to your vessel (some may be listed above). Please check your vessel carefully.
2	9/29/2010	Bill	Converted from ASME Section VIII Division 1, 2007 Edition to ASME Section VIII Division 1, 2007 Edition, A09 Addenda. Default Forging Material Changed to A 105. During the conversion, changes may have been made to your vessel (some may be listed above). Please check your vessel carefully.
3	11/ 9/2011	Bill	Converted from ASME Section VIII Division 1, 2007 Edition, A09 Addenda to ASME Section VIII Division 1, 2010 Edition. During the conversion, changes may have been made to your vessel (some may be listed above). Please check your vessel carefully.
4	5/21/2012	Bill	Converted from ASME Section VIII Division 1, 2010 Edition to ASME Section VIII Division 1, 2010 Edition, A11 Addenda. Default Forging Material Changed to A 105. During the conversion, changes may have been made to your vessel (some may be listed above). Please check your vessel carefully.
5	2/11/2015	SHP	Revised - Code year - Removed split shell and applied insulation over full shell - Add mist pad - Adjusted nozzle orientations to match fab drawing.
6	11/ 9/2016	GAT	Converted from ASME Section VIII Division 1, 2013 Edition to ASME Section VIII Division 1, 2015 Edition.

Skid 2 relocated from
 UOPR Job 400 to 447

Settings Summary

COMPRESS 2017 Build 7710	
ASME Section VIII Division 1, 2015 Edition	
Units	U.S. Customary
Datum Line Location	6.00" 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
User has limited MAWP to	150 psi
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	No
Preheat P-No 1 Materials $> 1.25"$ and $\leq 1.50"$ 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
Test liquid specific gravity	1.00
Maximum stress during test	90% of yield
Required Marking - UG-116	
UG-116(e) Radiography	RT2
UG-116(f) Postweld heat treatment	None
Code Cases\Interpretations	
Use Code Case 2547	No
Use Code Case 2695	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	No
Apply interpretation VIII-1-07-50	No
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	Yes
UG-22(f) Seismic reactions	Yes
UG-22(j) Test pressure and coincident static head acting during the test:	Yes
Note: UG-22(b),(c) and (f) loads only considered when supports are present.	

License Information	
Company Name	Callidus Technologies, Inc.
License	Commercial
License Key ID	30164
Support Expires	July 28, 2018

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	
TOP HEAD	N/A	Seamless No RT	N/A	N/A	B	Spot UW-11(a)(5)(b) / Type 1	RT2
SHELL #1	N/A	Seamless No RT	B	Spot UW-11(a)(5)(b) / Type 1	B	Spot UW-11(a)(5)(b) / Type 1	RT2
BTM HEAD	N/A	Seamless No RT	B	Spot UW-11(a)(5)(b) / Type 1	N/A	N/A	RT2
Nozzle	Longitudinal Seam		Nozzle to Vessel Circumferential Seam		Nozzle free end Circumferential Seam		
Vapor Out/Inspection (B)	N/A	Seamless No RT	D	N/A / Type 7	C	UW-11(a)(4) exempt / Type 1	N/A
Liquid Out (C)	N/A	Seamless No RT	D	N/A / Type 7	N/A	N/A	N/A
TI (E)	N/A	Seamless No RT	D	N/A / Type 7	N/A	N/A	N/A
LG (D2)	N/A	Seamless No RT	D	N/A / Type 7	N/A	N/A	N/A
LSHH (F2)	N/A	Seamless No RT	D	N/A / Type 7	N/A	N/A	N/A
LC (Future) (H2)	N/A	Seamless No RT	D	N/A / Type 7	N/A	N/A	N/A
Inspection (G)	N/A	Seamless No RT	D	N/A / Type 7	N/A	N/A	N/A
LG (D1)	N/A	Seamless No RT	D	N/A / Type 7	N/A	N/A	N/A
LSHH (F1)	N/A	Seamless No RT	D	N/A / Type 7	N/A	N/A	N/A
LC (Future) (H1)	N/A	Seamless No RT	D	N/A / Type 7	N/A	N/A	N/A
Inlet (A)	N/A	Seamless No RT	D	N/A / Type 7	C	UW-11(a)(4) exempt / Type 1	N/A
Nozzle Flange	Longitudinal Seam		Flange Face		Nozzle to Flange Circumferential Seam		
ASME B16.5/16.47 flange attached to Vapor Out/Inspection (B)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	UW-11(a)(4) exempt / Type 1	N/A
ASME B16.5/16.47 flange attached to Inlet (A)	N/A	Seamless No RT	N/A	N/A / Gasketed	C	UW-11(a)(4) exempt / Type 1	N/A
UG-116(e) Required Marking: RT2							

Thickness Summary

Component Data								
Component Identifier	Material	Diameter (in)	Length (in)	Nominal t (in)	Design t (in)	Total Corrosion (in)	Joint E	Load
TOP HEAD	SA-516 70	24 OD	6.1563	0.3125*	0.2186	0.0625	1.00	Internal
Straight Flange on TOP HEAD	SA-516 70	24 OD	2	0.375	0.2207	0.0625	1.00	Internal
SHELL #1	SA-106 B Smls pipe	24 OD	72	0.375	0.2477	0.0625	1.00	Internal
Straight Flange on BTM HEAD	SA-516 70	24 OD	2	0.375	0.221	0.0625	1.00	Internal
BTM HEAD	SA-516 70	24 OD	6.1563	0.3125*	0.219	0.0625	1.00	Internal
SKIRT	SA-106 B Smls pipe	24 OD	8.5	0.375	0.0031	0	0.55	Seismic

*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

Skid 2 relocated from UOPR Job 488 to 447

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 ft ²
							New	Corroded	New	Corroded	
TOP HEAD	71.9	58.4	0	0	0	0	0	0	93	94.8	6
SHELL #1	561.6	469.3	73.6	0	0	0	207.7	210	1,106	1,118.1	37
BTM HEAD	73.3	59.5	10.9	0	0	0	45.5	46.3	91	92.6	6
SKIRT	64	64	8.7	0	0	0	0	0	0	0	9
BASE RING	48	48	0	0	0	0	0	0	0	0	7
TOTAL:	818.8	699.1	93.2	0	0	0	253.2	256.3	1,290	1,305.5	65

*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 ft ²
	New	Corroded	New	Corroded							
TOP HEAD	0	0	21.6	20.4	0	0	0	0	0	0	1
SHELL #1	0	0	31.3	28.4	23.6	0	0	0	0	0	2
BTM HEAD	0	0	0	0	0	0	0	0	0	0	0
SKIRT	0	0	0	0	0	0	0	0	0	0	0
TOTAL:	0	0	52.8	48.8	23.6	0	0	0	0	0	3

Vessel Totals		
	New	Corroded
Operating Weight (lb)	1,242	1,121
Empty Weight (lb)	988	865
Test Weight (lb)	2,278	2,170
Surface Area (ft ²)	68	-
Capacity** (US gal)	154	156

**The vessel capacity does not include volume of nozzle, piping or other attachments.

Vessel Lift Condition	
Vessel Lift Weight, New (lb)	895
Center of Gravity from Datum (in)	26.1049

Note: Vessel lift weight includes weight of insulation supports as they are assumed to be shop installed.

Hydrostatic Test

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

$$\begin{aligned}
 \text{Gauge pressure at } 70^{\circ}\text{F} &= \\
 &= 1.3 \cdot \text{MAWP} \cdot \text{LSR} \\
 &= 1.3 \cdot 150 \cdot 1 \\
 &= 195 \text{ psi}
 \end{aligned}$$

Horizontal shop hydrostatic test							
Identifier	Local test pressure (psi)	Test liquid static head (psi)	UG-99(b) stress ratio	UG-99(b) pressure factor	Stress during test (psi)	Allowable test stress (psi)	Stress excessive?
TOP HEAD (1)	195.909	0.909	1	1.30	6,594	34,200	No
Straight Flange on TOP HEAD	195.907	0.907	1	1.30	6,171	34,200	No
SHELL #1	195.907	0.907	1	1.30	7,038	31,500	No
Straight Flange on BTM HEAD	195.907	0.907	1	1.30	6,171	34,200	No
BTM HEAD	195.909	0.909	1	1.30	6,594	34,200	No
Inlet (A)	195.556	0.556	1	1.30	10,372	47,250	No
Inspection (G)	195.53	0.53	1	1.30	8,425	47,250	No
LC (Future) (H1)	195.975	0.975	1	1.30	7,820	47,250	No
LC (Future) (H2)	195.975	0.975	1	1.30	7,820	47,250	No
LG (D1)	195.845	0.845	1	1.30	6,939	47,250	No
LG (D2)	195.845	0.845	1	1.30	6,939	47,250	No
LSHH (F1)	195.511	0.511	1	1.30	6,927	47,250	No
LSHH (F2)	195.511	0.511	1	1.30	6,927	47,250	No
Liquid Out (C)	195.198	0.198	1	1.30	6,916	47,250	No
TI (E)	195.054	0.054	1	1.30	6,911	47,250	No
Vapor Out/Inspection (B)	195.556	0.556	1	1.30	8,940	51,300	No

(1) TOP HEAD limits the UG-99(b) stress ratio.
 (2) P_L stresses at nozzle openings have been estimated using the method described in PVP-Vol. 399, pages 77-82.
 (3) $1.5 \cdot 0.9 \cdot S_y$ used as the basis for the maximum local primary membrane stress at the nozzle intersection P_L .
 (4) 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 -25 °F so the brittle fracture provision of UG-99(h) has been met.

Seismic Code

Building Code: ASCE 7-10 ground supported		
Site Class	D	
Importance Factor, I_e	1.2500	
Spectral Response Acceleration at short period (% g), S_s	100.00%	
Spectral Response Acceleration at period of 1 sec (% g), S₁	40.00%	
Response Modification Coefficient from Table 15.4-2, R	3.0000	
Acceleration-based Site Coefficient, F_a	1.1000	
Velocity-based Site Coefficient, F_v	1.6000	
Long-period Transition Period, T_L	12.0000	
Redundancy factor, ρ	1.0000	
Risk Category (Table 1.5-1)	III	
User Defined Vertical Accelerations Considered	No	
Hazardous, toxic, or explosive contents	No	
Vessel Characteristics		
Height	7.6795 ft	
Weight	Operating, Corroded	1,121 lb
	Empty, Corroded	865 lb
Period of Vibration Calculation		
Fundamental Period, T	Operating, Corroded	0.011 sec (f = 95.0 Hz)
	Empty, Corroded	0.010 sec (f = 96.2 Hz)

The fundamental period of vibration T (above) is calculated using the Rayleigh method of approximation

$$T = 2 * \text{PI} * \text{Sqr}(\{\text{Sum}(W_i * y_i^2)\} / \{g * \text{Sum}(W_i * y_i)\}), \text{ where}$$

W_i is the weight of the ith lumped mass, and y_i is its deflection when the system is treated as a cantilever beam.

12.4.2.3 Basic Load Combinations for Allowable Stress Design

Load combinations considered in accordance with ASCE section 2.4.1:

5.	$D + P + P_s + 0.7E$	$= (1.0 + 0.14S_{DS})D + P + P_s + 0.7\rho Q_E$	
8.	$0.6D + P + P_s + 0.7E$	$= (0.6 - 0.14S_{DS})D + P + P_s + 0.7\rho Q_E$	
Parameter description			
D	= Dead load		
P	= Internal or external pressure load		
P_s	= Static head load		
E	= Seismic load	$= E_h +/- E_v$	$= \rho Q_E +/- 0.2S_{DS}D$

Seismic Shear Reports:

[Operating, Corroded](#)
[Empty, Corroded](#)
[Base Shear Calculations](#)

Seismic Shear Report: Operating, Corroded

Component	Elevation of Bottom above Base (in)	Elastic Modulus E (10 ⁶ psi)	Inertia I (ft ⁴)	Seismic Shear at Bottom (lb _f)	Bending Moment at Bottom (lb _f -ft)
TOP HEAD	83.9982	29.0	*	35	15
SHELL #1	11.9982	29.0	0.0787	208	850
BTM HEAD (top)	8.5	29.0	*	211	911
SKIRT	0	29.0	0.09367	216	1,063
*Moment of Inertia I varies over the length of the component					

Seismic Shear Report: Empty, Corroded

Component	Elevation of Bottom above Base (in)	Elastic Modulus E (10 ⁶ psi)	Inertia I (ft ⁴)	Seismic Shear at Bottom (lb _f)	Bending Moment at Bottom (lb _f -ft)
TOP HEAD	83.9982	29.4	*	31	13
SHELL #1	11.9982	29.4	0.0787	162	729
BTM HEAD (top)	8.5	29.4	*	163	776
SKIRT	0	29.4	0.09367	166	893
*Moment of Inertia I varies over the length of the component					

11.4.3: Maximum considered earthquake spectral response acceleration

The maximum considered earthquake spectral response acceleration at short period, S_{MS}

$$S_{MS} = E_a * S_s = 1.1000 * 100.00 / 100 = 1.1000$$

The maximum considered earthquake spectral response acceleration at 1 s period, S_{M1}

$$S_{M1} = E_v * S_1 = 1.6000 * 40.00 / 100 = 0.6400$$

11.4.4: Design spectral response acceleration parameters

Design earthquake spectral response acceleration at short period, S_{DS}

$$S_{DS} = 2 / 3 * S_{MS} = 2 / 3 * 1.1000 = 0.7333$$

Design earthquake spectral response acceleration at 1 s period, S_{D1}

$$S_{D1} = 2 / 3 * S_{M1} = 2 / 3 * 0.6400 = 0.4267$$

11.6 Seismic Design Category

The Risk Category is III.

From Table 11.6-1, the Seismic Design Category based on $S_{DS} = 0.7333$ is D.

From Table 11.6-2, the Seismic Design Category based on $S_{D1} = 0.4267$ is D.

This vessel is assigned to Seismic Design Category D.

12.4.2.3: Seismic Load Combinations: Vertical Term

Factor is applied to dead load.

$$\begin{aligned} \text{Compressive Side:} &= 1.0 + 0.14 * S_{DS} \\ &= 1.0 + 0.14 * 0.7333 \\ &= 1.1027 \end{aligned}$$

$$\begin{aligned} \text{Tensile Side:} &= 0.6 - 0.14 * S_{DS} \\ &= 0.6 - 0.14 * 0.7333 \\ &= 0.4973 \end{aligned}$$

Base Shear Calculations

[Operating, Corroded](#)

[Empty, Corroded](#)

Base Shear Calculations: Operating, Corroded

Paragraph 15.4.2: $I < 0.06$, so:

$$\begin{aligned} V &= 0.30 * S_{DS} * W * I_e \\ &= 0.30 * 0.7333 * 1,120.9539 * 1.2500 \\ &= 308.26 \text{ lb} \end{aligned}$$

12.4.2.1 Seismic Load Combinations: Horizontal Seismic Load Effect, E_h

$$Q_E = V$$

$$\begin{aligned} E_h &= 0.7 * \rho * Q_E \text{ (Only 70% of seismic load considered as per Section 2.4.1)} \\ &= 0.7 * 1.0000 * 308.26 \\ &= 215.78 \text{ lb} \end{aligned}$$

Base Shear Calculations: Empty, Corroded

Paragraph 15.4.2: $I < 0.06$, so:

$$\begin{aligned} V &= 0.30 * S_{DS} * W * I_e \\ &= 0.30 * 0.7333 * 864.6769 * 1.2500 \\ &= 237.79 \text{ lb} \end{aligned}$$

12.4.2.1 Seismic Load Combinations: Horizontal Seismic Load Effect, E_h

$$Q_E = V$$

$$\begin{aligned} E_h &= 0.7 * \rho * Q_E \text{ (Only 70% of seismic load considered as per Section 2.4.1)} \\ &= 0.7 * 1.0000 * 237.79 \end{aligned}$$

= 166.45 lb

Skid 2 relocated from
UOPR Job 488 to 447

Wind Code

Building Code: ASCE 7-10		
Elevation of base above grade		1.00 ft
Increase effective outer diameter by		1.50 ft
Wind Force Coefficient, C_f		0.7000
Risk Category (Table 1.5-1)		III
Basic Wind Speed, V		120.00 mph
Exposure Category		C
Wind Directionality Factor, K_d		0.9500
Topographic Factor, K_{zt}		1.0000
Enforce min. loading of 16 psf		Yes
Hazardous, toxic, or explosive contents		No
Vessel Characteristics		
Height, h		7.6795 ft
Minimum Diameter, b	Operating, Corroded	2.1667 ft
	Empty, Corroded	2.1667 ft
Fundamental Frequency, n_1	Operating, Corroded	95.0043 Hz
	Empty, Corroded	96.2270 Hz
Damping coefficient, β	Operating, Corroded	0.0259
	Empty, Corroded	0.0209

[Table Lookup Values](#)

2.4.1 Basic Load Combinations for Allowable Stress Design	
Load combinations considered in accordance with ASCE section 2.4.1:	
5.	$D + P + P_s + 0.6W$
7.	$0.6D + P + P_s + 0.6W$
Parameter Description	
D	= Dead load
P	= Internal or external pressure load
P_s	= Static head load
W	= Wind load

Wind Deflection Reports:

[Operating, Corroded](#)

[Empty, Corroded](#)

[Wind Pressure Calculations](#)

Wind Deflection Report: Operating, Corroded								
Component	Elevation of Bottom above Base (in)	Effective OD (ft)	Elastic Modulus E (10 ⁶ psi)	Inertia I (ft ⁴)	Platform Wind Shear at Bottom (lb _f)	Total Wind Shear at Bottom (lb _f)	Bending Moment at Bottom (lb _f -ft)	Deflection at Top (in)
TOP HEAD	83.9982	3.50	29.0	*	0	25	8	0.0006
SHELL #1	11.9982	3.67	29.0	0.07867	0	275	933	0.0006
BTM HEAD (top)	8.5	3.67	29.0	*	0	287	1,014	0
SKIRT	0	3.67	29.0	0.09367	0	315	1,228	0
*Moment of Inertia I varies over the length of the component								

Wind Deflection Report: Empty, Corroded								
Component	Elevation of Bottom above Base (in)	Effective OD (ft)	Elastic Modulus E (10 ⁶ psi)	Inertia I (ft ⁴)	Platform Wind Shear at Bottom (lb _f)	Total Wind Shear at Bottom (lb _f)	Bending Moment at Bottom (lb _f -ft)	Deflection at Top (in)
TOP HEAD	83.9982	3.50	29.4	*	0	25	8	0.0006
SHELL #1	11.9982	3.67	29.4	0.07867	0	275	933	0.0006
BTM HEAD (top)	8.5	3.67	29.4	*	0	287	1,014	0
SKIRT	0	3.67	29.4	0.09367	0	315	1,228	0
*Moment of Inertia I varies over the length of the component								

Wind Pressure (WP) Calculations

[Gust Factor \(G_f\) Calculations](#)

$$K_z = 2.01 * (Z/Z_g)^{2/\alpha}$$

$$= 2.01 * (Z/900.00)^{0.2105}$$

$$q_z = 0.00256 * K_z * K_{zt} * K_d * V^2$$

$$= 0.00256 * K_z * 1.0000 * 0.9500 * 120.0000^2$$

$$= 35.0208 * K_z$$

$$WP = 0.6 * \max[q_z * G * C_f, 16 \text{ lb/ft}^2]$$

$$= 0.6 * \max[q_z * G * 0.7000, 16 \text{ lb/ft}^2]$$

Design Wind Pressures							
Height Z (')	Kz	qz (psf)	WP (psf)				
			Operating	Empty	Hydrotest New	Hydrotest Corroded	Vacuum
15.0	0.8489	29.73	11.37	11.37	N.A.	N.A.	N.A.

Design Wind Force determined from: $F = \text{Pressure} * A_f$, where A_f is the projected area.

Gust Factor Calculations

[Operating, Corroded](#)

[Empty, Corroded](#)

Gust Factor Calculations: Operating, Corroded

Vessel is considered a rigid structure as $n_1 = 95.0043 \text{ Hz} \geq 1 \text{ Hz}$.

$$z^- = \max[0.60 * h, z_{\min}]$$

$$= \max[0.60 * 7.6795, 15.0000]$$

$$= 15.0000$$

$$I_z^- = c * (33 / z^-)^{1/6}$$

$$= 0.2000 * (33 / 15.0000)^{1/6}$$

$$= 0.2281$$

$$L_z^- = l * (z^- / 33)^{ep}$$

$$= 500.0000 * (15.0000 / 33)^{0.2000}$$

$$= 427.0566$$

$$Q = \text{Sqr}(1 / (1 + 0.63 * ((b + h) / L_z^-)^{0.63}))$$

$$= \text{Sqr}(1 / (1 + 0.63 * ((2.1667 + 7.6795) / 427.0566)^{0.63}))$$

$$= 0.9719$$

$$G = 0.925 * (1 + 1.7 * g_e * I_z^- * Q) / (1 + 1.7 * g_w * I_z^-)$$

$$= 0.925 * (1 + 1.7 * 3.40 * 0.2281 * 0.9719) / (1 + 1.7 * 3.40 * 0.2281)$$

$$= 0.9102$$

Gust Factor Calculations: Empty, Corroded

Vessel is considered a rigid structure as $n_1 = 96.2270 \text{ Hz} \geq 1 \text{ Hz}$.

$$z^- = \max[0.60 * h, z_{\min}]$$

$$= \max[0.60 * 7.6795, 15.0000]$$

$$= 15.0000$$

$$I_z^- = c * (33 / z^-)^{1/6}$$

$$= 0.2000 * (33 / 15.0000)^{1/6}$$

$$= 0.2281$$

$$L_z^- = l * (z^- / 33)^{ep}$$

$$= 500.0000 * (15.0000 / 33)^{0.2000}$$

$$= 427.0566$$

$$Q = \text{Sqr}(1 / (1 + 0.63 * ((b + h) / L_z^-)^{0.63}))$$

$$= \text{Sqr}(1 / (1 + 0.63 * ((2.1667 + 7.6795) / 427.0566)^{0.63}))$$

$$= 0.9719$$

$$G = 0.925 * (1 + 1.7 * g_Q * I_z * Q) / (1 + 1.7 * g_v * I_z)$$

$$= 0.925 * (1 + 1.7 * 3.40 * 0.2281 * 0.9719) / (1 + 1.7 * 3.40 * 0.2281)$$

$$= 0.9102$$

Table Lookup Values	
$\alpha = 9.5000, z_g = 900.00$ ft	[Table 26.9-1, page 256]
$c = 0.2000, l = 500.0000, ep = 0.2000$	[Table 26.9-1, page 256]
$a^- = 0.1538, b^- = 0.6500$	[Table 26.9-1, page 256]
$z_{min} = 15.0000$ ft	[Table 26.9-1, page 256]
$g_Q = 3.40$	[26.9.4 page 254]
$g_v = 3.40$	[26.9.4 page 254]

Skid 2 relocated from
UOPR Job 488 to 447

NLL

ASME Section VIII Division 1, 2015 Edition	
Location from Datum (in)	21
Operating Liquid Specific Gravity	0.5

Skid 2 relocated from
UOPR Job 488 to 447

TOP HEAD

ASME Section VIII Division 1, 2015 Edition				
Component		Ellipsoidal Head		
Material		SA-516 70 (II-D p. 18, ln. 37)		
Attached To		SHELL #1		
Impact Tested	Normalized	Fine Grain Practice	PWHT	Optimize MDMT/ Find MAWP
No	No	No	No	No
		Design Pressure (psi)	Design Temperature (°F)	Design MDMT (°F)
Internal		265	150	-20
Static Liquid Head				
Condition		P_s (psi)	H_s (in)	SG
Test horizontal		0.91	25.1875	1
Dimensions				
Outer Diameter		24"		
Head Ratio		2		
Minimum Thickness		0.3125"		
Corrosion	Inner	0.0625"		
	Outer	0"		
Length L_{sf}		2"		
Nominal Thickness t_{sf}		0.375"		
Weight and Capacity				
		Weight (lb)¹	Capacity (US gal)¹	
New		71.89	10.91	
Corroded		58.37	11.11	
Radiography				
Category A joints		Seamless No RT		
Head to shell seam		Spot UW-11(a)(5)(b) Type 1		

¹ includes straight flange

Results Summary	
Governing condition	internal pressure
Minimum thickness per UG-16	0.0625" + 0.0625" = 0.125"
Design thickness due to internal pressure (t)	0.2186"
Maximum allowable working pressure (MAWP)	427.63 psi
Maximum allowable pressure (MAP)	533.33 psi
Straight Flange governs MDMT	-155°F

Factor K		
K = (1/6)*[2 + (D / (2*h)) ²]		
Corroded	K = (1/6)*[2 + (23.5 / (2*5.9063)) ²]	0.993
New	K = (1/6)*[2 + (23.375 / (2*5.8438)) ²]	1

Design thickness for internal pressure, (Corroded at 150 °F) Appendix 1-4(c)

$$\begin{aligned}
 t &= P \cdot D_o \cdot K / (2 \cdot S \cdot E + 2 \cdot P \cdot (K - 0.1)) + \text{Corrosion} \\
 &= 265 \cdot 24 \cdot 0.992964 / (2 \cdot 20,000 \cdot 1 + 2 \cdot 265 \cdot (0.992964 - 0.1)) + 0.0625 \\
 &= \underline{0.2185"}
 \end{aligned}$$

Maximum allowable working pressure, (Corroded at 150 °F) Appendix 1-4(c)

$$\begin{aligned}
 P &= 2 \cdot S \cdot E \cdot t / (K \cdot D_o - 2 \cdot t \cdot (K - 0.1)) - P_s \\
 &= 2 \cdot 20,000 \cdot 1 \cdot 0.25 / (0.992964 \cdot 24 - 2 \cdot 0.25 \cdot (0.992964 - 0.1)) - 0 \\
 &= \underline{427.63} \text{ psi}
 \end{aligned}$$

Maximum allowable pressure, (New at 70 °F) Appendix 1-4(c)

$$\begin{aligned}
 P &= 2 \cdot S \cdot E \cdot t / (K \cdot D_o - 2 \cdot t \cdot (K - 0.1)) - P_s \\
 &= 2 \cdot 20,000 \cdot 1 \cdot 0.3125 / (1 \cdot 24 - 2 \cdot 0.3125 \cdot (1 - 0.1)) - 0 \\
 &= \underline{533.33} \text{ psi}
 \end{aligned}$$

% Extreme fiber elongation - UCS-79(d)

$$\begin{aligned}
 \text{EFE} &= (75 \cdot t / R_f) \cdot (1 - R_f / R_o) \\
 &= (75 \cdot 0.375 / 4.1613) \cdot (1 - 4.1613 / \infty) \\
 &= 6.7588\%
 \end{aligned}$$

The extreme fiber elongation exceeds 5 percent. Heat treatment per UCS-56 may be required. See UCS-79(d)(4) or (5).

Straight Flange on TOP HEAD

ASME Section VIII Division 1, 2015 Edition				
Component		Cylinder		
Material		SA-516 70 (II-D p. 18, ln. 37)		
Impact Tested	Normalized	Fine Grain Practice	PWHT	Optimize MDMT/ Find MAWP
No	No	No	No	No
		Design Pressure (psi)	Design Temperature (°F)	Design MDMT (°F)
Internal		265	150	-20
Static Liquid Head				
Condition		P_s (psi)	H_s (in)	SG
Test horizontal		0.91	25.125	1
Dimensions				
Outer Diameter		24"		
Length		2"		
Nominal Thickness		0.375"		
Corrosion	Inner	0.0625"		
	Outer	0"		
Weight and Capacity				
		Weight (lb)	Capacity (US gal)	
New		15.75	3.68	
Corroded		13.16	3.72	
Radiography				
Longitudinal seam		Seamless No RT		
Bottom Circumferential seam		Spot UW-11(a)(5)(b) Type 1		

Results Summary	
Governing condition	Internal pressure
Minimum thickness per UG-16	0.0625" + 0.0625" = 0.125"
Design thickness due to internal pressure (t)	0.2207"
Design thickness due to combined loadings + corrosion	0.1382"
Maximum allowable working pressure (MAWP)	526.32 psi
Maximum allowable pressure (MAP)	632.91 psi
Rated MDMT	-155 °F

UCS-66 Material Toughness Requirements	
$t_r = 150 \cdot 12 / (20,000 \cdot 1 + 0.4 \cdot 150) =$	0.0897"
Stress ratio $= t_r \cdot E' / (t_n - c) = 0.0897 \cdot 1 / (0.375 - 0.0625) =$	0.2871
Stress ratio ≤ 0.35 , MDMT per UCS-66(b)(3) =	-155 °F
Material is exempt from impact testing at the Design MDMT of -20 °F.	

Design thickness, (at 150 °F) Appendix 1-1

$$\begin{aligned}
 t &= P \cdot R_o / (S \cdot E + 0.40 \cdot P) + \text{Corrosion} \\
 &= 265 \cdot 12 / (20,000 \cdot 1.00 + 0.40 \cdot 265) + 0.0625 \\
 &= \a href="#">0.2207"
 \end{aligned}$$

Maximum allowable working pressure, (at 150 °F) Appendix 1-1

$$\begin{aligned}
 P &= S \cdot E \cdot t / (R_o - 0.40 \cdot t) - P_s \\
 &= 20,000 \cdot 1.00 \cdot 0.3125 / (12 - 0.40 \cdot 0.3125) - 0 \\
 &= \a href="#">526.32 \text{ psi}
 \end{aligned}$$

Maximum allowable pressure, (at 70 °F) Appendix 1-1

$$\begin{aligned}
 P &= S \cdot E \cdot t / (R_o - 0.40 \cdot t) \\
 &= 20,000 \cdot 1.00 \cdot 0.375 / (12 - 0.40 \cdot 0.375) \\
 &= \a href="#">632.91 \text{ psi}
 \end{aligned}$$

% Extreme fiber elongation - UCS-79(d)

$$\begin{aligned}
 \text{EFE} &= (50 \cdot t / R_f) \cdot (1 - R_f / R_o) \\
 &= (50 \cdot 0.375 / 11.8125) \cdot (1 - 11.8125 / \infty) \\
 &= 1.5873\%
 \end{aligned}$$

The extreme fiber elongation does not exceed 5%.

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	265	20,000	16,368	150	0.0625	Wind	0.0757	0.0757
						Seismic	0.0757	0.0756
Operating, Hot & New	265	20,000	16,750	150	0	Wind	0.0753	0.0752
						Seismic	0.0753	0.0752
Hot Shut Down, Corroded	0	20,000	16,368	150	0.0625	Wind	0	0.0001
						Seismic	0	0.0001
Hot Shut Down, New	0	20,000	16,750	150	0	Wind	0	0.0001
						Seismic	0	0.0001
Empty, Corroded	0	20,000	16,368	70	0.0625	Wind	0	0.0001
						Seismic	0	0.0001
Empty, New	0	20,000	16,750	70	0	Wind	0	0.0001
						Seismic	0	0.0001
Hot Shut Down, Corroded, Weight & Eccentric Moments Only	0	20,000	16,368	150	0.0625	Weight	0.0001	0.0001

Skid 2 relocated from UOPR Job 488 to 447

SHELL #1

ASME Section VIII Division 1, 2015 Edition				
Component		Cylinder		
Material		SA-106 B Smls pipe (II-D p. 14, In. 15)		
Pipe NPS and Schedule		NPS 24 Sch 20 (Std)		
Impact Tested	Normalized	Fine Grain Practice	PWHT	Optimize MDMT/ Find MAWP
No	No	No	No	No
		Design Pressure (psi)	Design Temperature (°F)	Design MDMT (°F)
Internal		265	150	-20
Static Liquid Head				
Condition	P_s (psi)	H_s (in)	SG	
Operating	0.49	27	0.5	
Test horizontal	0.91	25.125	1	
Dimensions				
Outer Diameter		24"		
Length		72"		
Pipe Nominal Thickness		0.375"		
Pipe Minimum Thickness¹		0.3281"		
Corrosion	Inner	0.0625"		
	Outer	0"		
Weight and Capacity				
		Weight (lb)	Capacity (US gal)	
New		561.6	132.33	
Corroded		469.25	133.76	
Insulation				
		Thickness (in)	Density (lb/ft³)	Weight (lb)
Insulation		1	22.5	73.63
		Spacing(in)	Individual Weight (lb)	Total Weight (lb)
Insulation Supports		0	0	0
Radiography				
Longitudinal seam		Seamless No RT		

Top Circumferential seam	Spot UW-11(a)(5)(b) Type 1
Bottom Circumferential seam	Spot UW-11(a)(5)(b) Type 1

¹Pipe minimum thickness = nominal thickness times pipe tolerance factor of 0.875.

Results Summary	
Governing condition	Internal pressure
Minimum thickness per UG-16	0.0625" + 0.0625" = 0.125"
Design thickness due to internal pressure (t)	0.2477"
Design thickness due to combined loadings + corrosion	0.1522"
Maximum allowable working pressure (MAWP)	381.41 psi
Maximum allowable pressure (MAP)	472.75 psi
Rated MDMT	-55 °F

UCS-66 Material Toughness Requirements	
Governing thickness, $t_g =$	0.3281"
Exemption temperature from Fig UCS-66 Curve B =	-20 °F
$t_r = 150.49 \cdot 12 / (17,100 \cdot 1 + 0.4 \cdot 150.49) =$	0.1052"
Stress ratio = $t_r \cdot E^* / (t_n - c) = 0.1052 \cdot 1 / (0.3281 - 0.0625) =$	0.3962
Reduction in MDMT, T_R from Fig UCS-66.1 =	95.7 °F
MDMT = $\max[\text{MDMT} - T_R, -55] = \max[-20 - 95.7, -55] =$	-55 °F
Material is exempt from impact testing at the Design MDMT of -20 °F.	

Design thickness, (at 150 °F) Appendix 1-1

$$\begin{aligned}
 t &= P \cdot R_o / (S \cdot E + 0.40 \cdot P) + \text{Corrosion} \\
 &= 265.49 \cdot 12 / (17,100 \cdot 1.00 + 0.40 \cdot 265.49) + 0.0625 \\
 &= \a href="#">0.2477"
 \end{aligned}$$

Maximum allowable working pressure, (at 150 °F) Appendix 1-1

$$\begin{aligned}
 P &= S \cdot E \cdot t / (R_o - 0.40 \cdot t) - P_s \\
 &= 17,100 \cdot 1.00 \cdot (0.375 \cdot 0.875 - 0.0625) / (12 - 0.40 \cdot (0.375 \cdot 0.875 - 0.0625)) - 0.49 \\
 &= \a href="#">381.41 \text{ psi}
 \end{aligned}$$

Maximum allowable pressure, (at 70 °F) Appendix 1-1

$$\begin{aligned}
 P &= S \cdot E \cdot t / (R_o - 0.40 \cdot t) \\
 &= 17,100 \cdot 1.00 \cdot (0.375 \cdot 0.875) / (12 - 0.40 \cdot (0.375 \cdot 0.875)) \\
 &= \a href="#">472.75 \text{ psi}
 \end{aligned}$$

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	265	17,100	15,953	150	0.0625	Wind	0.0897	0.0865
						Seismic	0.0896	0.0866
Operating, Hot & New	265	17,100	16,469	150	0	Wind	0.0891	0.086
						Seismic	0.0892	0.0859
Hot Shut Down, Corroded	0	17,100	15,953	150	0.0625	Wind	0.0011	0.0018
						Seismic	0.0011	0.0017
Hot Shut Down, New	0	17,100	16,469	150	0	Wind	0.0011	0.0018
						Seismic	0.0012	0.0019
Empty, Corroded	0	17,100	15,953	70	0.0625	Wind	0.0011	0.0018
						Seismic	0.0009	0.0016
Empty, New	0	17,100	16,469	70	0	Wind	0.0011	0.0018
						Seismic	0.001	0.0017
Hot Shut Down, Corroded, Weight & Eccentric Moments Only	0	17,100	15,953	150	0.0625	Weight	0.0005	0.0006

Skid 2 relocated from UOPR Job 488 to 447

Straight Flange on BTM HEAD

ASME Section VIII Division 1, 2015 Edition				
Component		Cylinder		
Material		SA-516 70 (II-D p. 18, ln. 37)		
Impact Tested	Normalized	Fine Grain Practice	PWHT	Optimize MDMT/ Find MAWP
No	No	No	No	No
		Design Pressure (psi)	Design Temperature (°F)	Design MDMT (°F)
Internal		265	150	-20
Static Liquid Head				
Condition		P_s (psi)	H_s (in)	SG
Operating		0.52	29	0.5
Test horizontal		0.91	25.125	1
Dimensions				
Outer Diameter		24"		
Length		2"		
Nominal Thickness		0.375"		
Corrosion	Inner	0.0625"		
	Outer	0"		
Weight and Capacity				
		Weight (lb)	Capacity (US gal)	
New		15.75	3.68	
Corroded		13.16	3.72	
Insulation				
		Thickness (in)	Density (lb/ft³)	Weight (lb)
Insulation		1	22.5	0
		Spacing(in)	Individual Weight (lb)	Total Weight (lb)
Insulation Supports		0	0	0
Radiography				
Longitudinal seam		Seamless No RT		
Top Circumferential seam		Spot UW-11(a)(5)(b) Type 1		

Results Summary	
Governing condition	Internal pressure
Minimum thickness per UG-16	0.0625" + 0.0625" = 0.125"
Design thickness due to internal pressure (t)	0.221"
Design thickness due to combined loadings + corrosion	0.1393"
Maximum allowable working pressure (MAWP)	525.79 psi
Maximum allowable pressure (MAP)	632.91 psi
Rated MDMT	-155 °F

UCS-66 Material Toughness Requirements	
$t_r = 150.52 \cdot 12 / (20,000 \cdot 1 + 0.4 \cdot 150.52) =$	0.09"
Stress ratio = $t_r \cdot E^* / (t_n - c) = 0.09 \cdot 1 / (0.375 - 0.0625) =$	0.2881
Stress ratio ≤ 0.35 , MDMT per UCS-66(b)(3) =	-155 °F
Material is exempt from impact testing at the Design MDMT of -20 °F.	

Design thickness, (at 150 °F) Appendix 1-1

$$\begin{aligned}
 t &= P \cdot R_o / (S \cdot E + 0.40 \cdot P) + \text{Corrosion} \\
 &= 265.52 \cdot 12 / (20,000 \cdot 1.00 + 0.40 \cdot 265.52) + 0.0625 \\
 &= \underline{0.221"}
 \end{aligned}$$

Maximum allowable working pressure, (at 150 °F) Appendix 1-1

$$\begin{aligned}
 P &= S \cdot E \cdot t / (R_o - 0.40 \cdot t) - P_s \\
 &= 20,000 \cdot 1.00 \cdot 0.3125 / (12 - 0.40 \cdot 0.3125) - 0.52 \\
 &= \underline{525.79} \text{ psi}
 \end{aligned}$$

Maximum allowable pressure, (at 70 °F) Appendix 1-1

$$\begin{aligned}
 P &= S \cdot E \cdot t / (R_o - 0.40 \cdot t) \\
 &= 20,000 \cdot 1.00 \cdot 0.375 / (12 - 0.40 \cdot 0.375) \\
 &= \underline{632.91} \text{ psi}
 \end{aligned}$$

% Extreme fiber elongation - UCS-79(d)

$$\begin{aligned}
 \text{EFE} &= (50 \cdot t / R_f) \cdot (1 - R_f / R_o) \\
 &= (50 \cdot 0.375 / 11.8125) \cdot (1 - 11.8125 / \infty) \\
 &= 1.5873\%
 \end{aligned}$$

The extreme fiber elongation does not exceed 5%.

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	265	20,000	16,368	150	0.0625	Wind	0.0768	0.074
						Seismic	0.0767	0.074
Operating, Hot & New	265	20,000	16,750	150	0	Wind	0.0763	0.0735
						Seismic	0.0764	0.0734
Hot Shut Down, Corroded	0	20,000	16,368	150	0.0625	Wind	0.001	0.0018
						Seismic	0.001	0.0017
Hot Shut Down, New	0	20,000	16,750	150	0	Wind	0.001	0.0019
						Seismic	0.0011	0.0019
Empty, Corroded	0	20,000	16,368	70	0.0625	Wind	0.001	0.0018
						Seismic	0.0008	0.0016
Empty, New	0	20,000	16,750	70	0	Wind	0.001	0.0019
						Seismic	0.0009	0.0018
Hot Shut Down, Corroded, Weight & Eccentric Moments Only	0	20,000	16,368	150	0.0625	Weight	0.0005	0.0006

Skid 2 relocated from UOPR Job 488 to 447

BTM HEAD

ASME Section VIII Division 1, 2015 Edition				
Component		Ellipsoidal Head		
Material		SA-516 70 (II-D p. 18, In. 37)		
Attached To		SHELL #1		
Impact Tested	Normalized	Fine Grain Practice	PWHT	Optimize MDMT/ Find MAWP
No	No	No	No	No
		Design Pressure (psi)	Design Temperature (°F)	Design MDMT (°F)
Internal		265	150	-20
Static Liquid Head				
Condition	P_s (psi)	H_s (in)	SG	
Operating	0.63	34.9063	0.5	
Test horizontal	0.91	25.1875	1	
Dimensions				
Outer Diameter		24"		
Head Ratio		2		
Minimum Thickness		0.3125"		
Corrosion	Inner	0.0625"		
	Outer	0"		
Length L_{sf}		2"		
Nominal Thickness t_{sf}		0.375"		
Weight and Capacity				
		Weight (lb)¹	Capacity (US gal)¹	
New		73.3	10.91	
Corroded		59.5	11.11	
Insulation				
		Thickness (in)	Density (lb/ft³)	Weight (lb)
Insulation		1	22.5	10.85
		Spacing(in)	Individual Weight (lb)	Total Weight (lb)
Insulation Supports		0	0	0
Radiography				
Category A joints		Seamless No RT		
Head to shell seam		Spot UW-11(a)(5)(b) Type 1		

¹ includes straight flange

Results Summary	
Governing condition	internal pressure
Minimum thickness per UG-16	0.0625" + 0.0625" = 0.125"
Design thickness due to internal pressure (t)	0.219"
Maximum allowable working pressure (MAWP)	427 psi
Maximum allowable pressure (MAP)	533.33 psi
Straight Flange governs MDMT	-155°F

Factor K		
K = (1/6)*[2 + (D / (2*h)) ²]		
Corroded	K = (1/6)*[2 + (23.5 / (2*5.9063)) ²]	0.993
New	K = (1/6)*[2 + (23.375 / (2*5.8438)) ²]	1

Design thickness for internal pressure, (Corroded at 150 °F) Appendix 1-4(c)

$$\begin{aligned}
 t &= P \cdot D_o \cdot K / (2 \cdot S \cdot E + 2 \cdot P \cdot (K - 0.1)) + \text{Corrosion} \\
 &= 265.63 \cdot 24 \cdot 0.992964 / (2 \cdot 20,000 \cdot 1 + 2 \cdot 265.63 \cdot (0.992964 - 0.1)) + 0.0625 \\
 &= \underline{0.2189"}
 \end{aligned}$$

Maximum allowable working pressure, (Corroded at 150 °F) Appendix 1-4(c)

$$\begin{aligned}
 P &= 2 \cdot S \cdot E \cdot t / (K \cdot D_o - 2 \cdot t \cdot (K - 0.1)) - P_s \\
 &= 2 \cdot 20,000 \cdot 1 \cdot 0.25 / (0.992964 \cdot 24 - 2 \cdot 0.25 \cdot (0.992964 - 0.1)) - 0.63 \\
 &= \underline{427} \text{ psi}
 \end{aligned}$$

Maximum allowable pressure, (New at 70 °F) Appendix 1-4(c)

$$\begin{aligned}
 P &= 2 \cdot S \cdot E \cdot t / (K \cdot D_o - 2 \cdot t \cdot (K - 0.1)) - P_s \\
 &= 2 \cdot 20,000 \cdot 1 \cdot 0.3125 / (1 \cdot 24 - 2 \cdot 0.3125 \cdot (1 - 0.1)) - 0 \\
 &= \underline{533.33} \text{ psi}
 \end{aligned}$$

% Extreme fiber elongation - UCS-79(d)

$$\begin{aligned}
 \text{EFE} &= (75 \cdot t / R_f) \cdot (1 - R_f / R_o) \\
 &= (75 \cdot 0.375 / 4.1613) \cdot (1 - 4.1613 / \infty) \\
 &= 6.7588\%
 \end{aligned}$$

The extreme fiber elongation exceeds 5 percent. Heat treatment per UCS-56 may be required. See UCS-79(d)(4) or (5).

SKIRT

ASME Section VIII Division 1, 2015 Edition			
Component	Support Skirt		
Skirt is Attached To	BTM HEAD		
Skirt Attachment Offset	3.4982" down from the top seam		
Material	SA-106 B Smls pipe (II-D p. 14, ln. 15)		
	Impact Tested¹	Normalized	Fine Grain Practice
	No	No	No
Design Temperature			
Internal	150°F		
Dimensions			
Inner Diameter	Top	23.25"	
	Bottom	23.25"	
Length (includes base ring thickness)	8.5"		
Nominal Thickness	0.375"		
Corrosion	Inner	0"	
	Outer	0"	
Weight			
New	64 lb		
Corroded	64 lb		
Insulation			
	Thickness	Density	Weight
Insulation	1"	22.5	8.69 lb
	Spacing	Individual Weight	Total Weight
Insulation Supports	0"	0 lb	0 lb
Joint Efficiency			
Top	0.55		
Bottom	0.8		

¹ Impact testing requirements are not checked for supports

Skirt design thickness, largest of the following + corrosion = 0.0031 in

The governing condition is due to seismic, compressive stress at the base, operating & new.

The skirt thickness of 0.3281 in is adequate.

Results Summary							
Loading	Condition	Tensile or Compressive Side	Governing Skirt Location	Temperature (°F)	Allowable Stress (psi)	Calculated Stress/E (psi)	Required thickness (in)
Wind	operating, corroded	Tensile	top	150	17,100	95.44	0.0021
		Compressive	bottom		16,469.34	128.16	0.0029
	operating, new	Tensile	top	150	17,100	90.88	0.002
		Compressive	bottom		16,469.34	132.58	0.003
	empty, corroded	Tensile	top	70	17,100	105.49	0.0023
		Compressive	bottom		16,469.34	118.95	0.0027
	empty, new	Tensile	top	70	17,100	100.8	0.0022
		Compressive	bottom		16,469.34	123.49	0.0028
Seismic	operating, corroded	Tensile	top	150	17,100	88.34	0.0019
		Compressive	bottom		16,469.34	120.09	0.0027
	operating, new	Tensile	top	150	17,100	98.88	0.0022
		Compressive	bottom		16,469.34	134.02	0.0031
	empty, corroded	Tensile	top	70	17,100	78.82	0.0017
		Compressive	bottom		16,469.34	97.57	0.0022
	empty, new	Tensile	top	70	17,100	89.17	0.002
		Compressive	bottom		16,469.34	111.61	0.0025

Loading due to seismic, operating & new

Tensile side

Required thickness, tensile stress at base:

$$\begin{aligned}
 t &= -(0.6 - 0.14 \cdot S_{DS}) \cdot W / (\pi \cdot D \cdot S_t \cdot E) + 48 \cdot M / (\pi \cdot D^2 \cdot S_t \cdot E) \\
 &= -(0.6 - 0.14 \cdot 0.7333) \cdot 1,193.56 / (\pi \cdot 23.625 \cdot 17,100 \cdot 0.8) + 48 \cdot 1,188.1 / (\pi \cdot 23.625^2 \cdot 17,100 \cdot 0.8) \\
 &= 0.0018 \text{ in}
 \end{aligned}$$

Required thickness, tensile stress at the top:

$$\begin{aligned}
 t &= -(0.6 - 0.14 \cdot S_{DS}) \cdot W_t / (\pi \cdot D_t \cdot S_t \cdot E) + 48 \cdot M_t / (\pi \cdot D_t^2 \cdot S_t \cdot E) \\
 &= -(0.6 - 0.14 \cdot 0.7333) \cdot 1,120.87 / (\pi \cdot 23.625 \cdot 17,100 \cdot 0.55) + 48 \cdot 1,019.3 / (\pi \cdot 23.625^2 \cdot 17,100 \cdot 0.55) \\
 &= 0.0022 \text{ in}
 \end{aligned}$$

Compressive side

Required thickness, compressive stress at base:

$$\begin{aligned}
 t &= (1 + 0.14 \cdot S_{DS}) \cdot W / (\pi \cdot D \cdot S_c \cdot E_c) + 48 \cdot M / (\pi \cdot D^2 \cdot S_c \cdot E_c) \\
 &= (1 + 0.14 \cdot 0.7333) \cdot 1,193.56 / (\pi \cdot 23.625 \cdot 16,469 \cdot 1) + 48 \cdot 1,188.1 / (\pi \cdot 23.625^2 \cdot 16,469 \cdot 1) \\
 &= 0.0031 \text{ in}
 \end{aligned}$$

Required thickness, compressive stress at the top:

$$t = (1 + 0.14 \cdot S_{DS}) \cdot W_t / (\pi \cdot D_t \cdot S_c \cdot E_c) + 48 \cdot M_t / (\pi \cdot D_t^2 \cdot S_c \cdot E_c)$$

$$= (1 + 0.14 \cdot 0.7333) \cdot 1,120.87 / (\pi \cdot 23.625 \cdot 16,469 \cdot 1) + 48 \cdot 1,019.3 / (\pi \cdot 23.625^2 \cdot 16,469 \cdot 1)$$
$$= 0.0027 \text{ in}$$

Skid 2 relocated from
UOPR Job 488 to 447

Skirt Buckling Check per ASCE 15.7.10.5

4.4.12.2.i Axial Compression, Bending Moment, and Shear		
$f_b = M / S$		(4.4.119)
$f_a = F / A$		(4.4.120)
$f_v = V \cdot \sin[\phi] / A$		(4.4.122)
$K_s = 1 - (f_v / F_{va})^2$		(4.4.105)
$F_e = \pi^2 \cdot E_y / (K_u \cdot L_u / r_g)^2$		(4.4.110)
$\Delta = C_m / (1 - f_a \cdot FS / F_e)$		(4.4.109)
$f_a / (K_s \cdot F_{ca}) + 8 \cdot \Delta \cdot f_b / (9 \cdot K_s \cdot F_{ba}) \leq 1$	for $f_a / (K_s \cdot F_{ca}) \geq 0.2$	(4.4.112)
$f_a / (2 \cdot K_s \cdot F_{ca}) + \Delta \cdot f_b / (K_s \cdot F_{ba}) \leq 1$	for $f_a / (K_s \cdot F_{ca}) < 0.2$	(4.4.113)
New / Corroded		
$r_g = 0.25 \cdot (23.9063^2 + 23.25^2)^{0.5} =$		8.3369"
$A = \pi \cdot (23.9063^2 - 23.25^2) / 4 =$		24.31 in ²
$S = \pi \cdot (23.9063^4 - 23.25^4) / (32 \cdot 23.9063) =$		141.3285 in ³
Operating Hot & Corroded		
Seismic ASCE 15.7.10.5	$f_b = 18,076.4 / 141.3285 =$	128 psi
	$f_a = 1,072.95 / 24.31 =$	44 psi
	$f_v = 308.26 \cdot \sin[90] / 24.31 =$	13 psi
	$K_s = 1 - (13 / 19,740)^2 =$	1
	$F_e = \pi^2 \cdot 29.03E+06 / (2.1 \cdot 92.1545 / 8.3369)^2 =$	531,740 psi
	$\Delta = 1 / (1 - 44 \cdot 1 / 531,740) =$	1.0001
	$f_a / (K_s \cdot F_{ca}) = 44 / (1 \cdot 32,160) =$	0.0014
	$44 / (2 \cdot 1 \cdot 32,160) + 1.0001 \cdot 128 / (1 \cdot 38,151) =$	0.004
Combined load check passes.		
Operating Hot & New		
Seismic ASCE 15.7.10.5	$f_b = 20,219.1 / 141.3285 =$	143 psi
	$f_a = 1,193.56 / 24.31 =$	49 psi
	$f_v = 341.43 \cdot \sin[90] / 24.31 =$	14 psi
	$K_s = 1 - (14 / 19,740)^2 =$	1
	$F_e = \pi^2 \cdot 29.03E+06 / (2.1 \cdot 92.1545 / 8.3369)^2 =$	531,740 psi
	$\Delta = 1 / (1 - 49 \cdot 1 / 531,740) =$	1.0001
	$f_a / (K_s \cdot F_{ca}) = 49 / (1 \cdot 32,160) =$	0.0015
	$49 / (2 \cdot 1 \cdot 32,160) + 1.0001 \cdot 143 / (1 \cdot 38,151) =$	0.0045
Combined load check passes.		

Empty Cold & Corroded		
Seismic ASCE 15.7.10.5	$f_b = 15,172.6 / 141.3285 =$	107 psi
	$f_a = 816.68 / 24.31 =$	34 psi
	$f_v = 237.79 * \sin[90] / 24.31 =$	10 psi
	$K_s = 1 - (10 / 21,000)^2 =$	1
	$F_e = \pi^2 * 29.4E+06 / (2.1 * 92.1545 / 8.3369)^2 =$	538,503 psi
	$\Delta = 1 / (1 - 34 * 1 / 538,503) =$	1.0001
	$f_a / (K_s * F_{ca}) = 34 / (1 * 34,161) =$	9.8359E-04
	$34 / (2 * 1 * 34,161) + 1.0001 * 107 / (1 * 40,162) =$	0.0032
	Combined load check passes.	
Empty Cold & New		
Seismic ASCE 15.7.10.5	$f_b = 17,311.8 / 141.3285 =$	122 psi
	$f_a = 940.38 / 24.31 =$	39 psi
	$f_v = 271.8 * \sin[90] / 24.31 =$	11 psi
	$K_s = 1 - (11 / 21,000)^2 =$	1
	$F_e = \pi^2 * 29.4E+06 / (2.1 * 92.1545 / 8.3369)^2 =$	538,503 psi
	$\Delta = 1 / (1 - 39 * 1 / 538,503) =$	1.0001
	$f_a / (K_s * F_{ca}) = 39 / (1 * 34,161) =$	0.0011
	$39 / (2 * 1 * 34,161) + 1.0001 * 122 / (1 * 40,162) =$	0.0036
	Combined load check passes.	

Skid 2 relocated from
 UOPR Job 408 to 447

BASE RING

Inputs	
Base configuration	single base plate without gussets
Base plate material	SA-516-70
Base plate allowable stress, S_p	20,000 psi
Foundation compressive strength	1,658 psi
Concrete ultimate 28-day strength	3,000 psi
Bolt circle, BC	28.5"
Base plate inner diameter, D_i	21"
Base plate outer diameter, D_o	32"
Base plate thickness, t_b	0.375"
Anchor Bolts	
Material	CS
Allowable stress, S_b	20,000 psi
Bolt size and type	0.75" coarse threaded
Number of bolts, N	4
Corrosion allowance (applied to root radius)	0"
Anchor bolt clearance	0.125"
Bolt root area (corroded), A_b	0.3 in ²
Diameter of anchor bolt holes, d_b	0.875"
Initial bolt preload	0% (0 psi)
Bolt at 0°	No

Skid 2 relocated from
 UOPR Job 488 to 447

Results Summary							
Load	Vessel condition	Base V (lb _f)	Base M (lb _f -ft)	W (lb)	Required bolt area (in ²)	t _r Base (in)	Foundation bearing stress (psi)
Wind	operating, corroded	314.9	1,227.5	1,121	0.0174	0.1965	16.09
Wind	operating, new	314.9	1,228.8	1,241.6	0.0166	0.197	16.18
Wind	empty, corroded	314.9	1,227.5	864.7	<u>0.0194</u>	0.1943	15.73
Wind	empty, new	314.9	1,228.8	988.4	0.0185	0.1957	15.95
Seismic	operating, corroded	215.8	1,062.7	1,121	0.0154	0.1986	16.43
Seismic	operating, new	239	1,188.1	1,241.6	0.0173	<u>0.2098</u>	<u>18.34</u>
Seismic	empty, corroded	166.5	893.4	864.7	0.0134	0.1807	13.61
Seismic	empty, new	190.3	1,018.5	988.4	0.0153	0.193	15.52

Anchor bolt load (governing)

$$\begin{aligned}
 P &= -0.6*W / N + 48 * M / (N*BC) \\
 &= -0.6*864.68 / 4 + 48 * 1,227.5 / (4*28.5) \\
 &= 387.15 \text{ lb}_f
 \end{aligned}$$

$$\text{Required area per bolt} = P / S_b = \underline{0.0194} \text{ in}^2$$

The area provided (0.302 in²) by the specified anchor bolt is adequate.

Support calculations (Jawad & Farr chapter 12, governing)

Base plate width, t_c: 5.5 in
 Average base plate diameter, d: 26.5 in
 Base plate elastic modulus, E_s: 29.0E+06 psi
 Base plate yield stress, S_y: 36,000 psi

$$E_c = 57,000 * \text{Sqr}(3,000) = 3,122,019 \text{ psi}$$

$$n = E_s / E_c = 29.0E+06 / 3,122,019 = 9.2889$$

$$\begin{aligned}
 t_s &= (N * A_b) / (\pi * d) \\
 &= (4 * 0.302) / (\pi * 26.5) \\
 &= 0.0145 \text{ in}
 \end{aligned}$$

From table 12.4 for k = 0.208063:

$$\begin{aligned}
 K_1 &= 2.6428, K_2 = 1.2437 \\
 L_1 &= 7.7348, L_2 = 16.1811, L_3 = 4.3835
 \end{aligned}$$

Total tensile force on bolting

$$\begin{aligned}
 T &= (12 * M - (0.6 - 0.14 * S_{DS}) * W * (L_1 + L_3)) / (L_2 + L_3) \\
 &= (12 * 1,188.1 - (0.6 - 0.14 * 0.7333) * 1,241.56 * (7.7348 + 4.3835)) / (16.1811 + 4.3835) \\
 &= 329.43 \text{ lb}_f
 \end{aligned}$$

Tensile stress in bolts use the larger of f_s or bolt preload = 0 psi

$$\begin{aligned}
 f_s &= T / (t_s * (d / 2) * K_1) \\
 &= 329.43 / (0.0145 * (26.5 / 2) * 2.6428) \\
 &= 648 \text{ psi}
 \end{aligned}$$

Total compressive load on foundation

$$\begin{aligned}
 C_c &= T + (1 + 0.14 * S_{DS}) * W + \text{Bolt Preload} \\
 &= 329.43 + (1 + 0.14 * 0.7333) * 1,241.56 + 0 \\
 &= 1,698.46 \text{ lb}_f
 \end{aligned}$$

Foundation bearing stress

$$\begin{aligned}
 f_c &= C_c / (((t_c - t_s) + n * t_s) * (d / 2) * K_2) \\
 &= 1,698.46 / (((5.5 - 0.0145) + 9.2889 * 0.0145) * (26.5 / 2) * 1.2437) \\
 &= 18 \text{ psi}
 \end{aligned}$$

As $f_c \leq 1,658$ psi the base plate width is satisfactory.

$$\begin{aligned}
 k &= 1 / (1 + f_s / (n * f_c)) \\
 &= 1 / (1 + 648 / (9.2889 * 18)) \\
 &= 0.208063
 \end{aligned}$$

Base plate required thickness (governing)

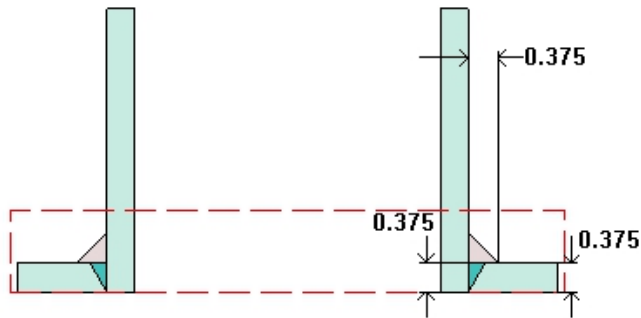
$$\begin{aligned}
 t_r &= (3 * f_c * L^2 / S_p)^{0.5} \\
 &= (3 * 18 * 4^2 / 20,000)^{0.5} \\
 &= 0.2098 \text{ in}
 \end{aligned}$$

The base plate thickness is satisfactory.

Skid 2 relocated from
UOPR Job 488 to 447

Inlet (A)

ASME Section VIII Division 1, 2015 Edition



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

Location and Orientation

Located on	SHELL #1
Orientation	270°
Nozzle center line offset to datum line	33"
End of nozzle to shell center	19"
Passes through a Category A joint	No

Nozzle

Description	NPS 4 Sch 80 (XS)
Access opening	No
Material specification	SA-106 B Smls pipe (II-D p. 14, ln. 15)
Inside diameter, new	3.826"
Pipe nominal wall thickness	0.337"
Pipe minimum wall thickness¹	0.2949"
Corrosion allowance	0.0625"
Projection available outside vessel, L_{pr}	4"
Projection available outside vessel to flange face, L_f	7"
Local vessel minimum thickness	0.3281"
Liquid static head included	0 psi
Longitudinal joint efficiency	1

Welds

Inner fillet, Leg₄₁	0.375"
Nozzle to vessel groove weld	0.375"

¹Pipe minimum thickness = nominal thickness times pipe tolerance factor of 0.875.

ASME B16.5-2013 Flange	
Description	NPS 4 Class 150 WN A105
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 344, ln. 31)
Blind included	No
Rated MDMT	-55 °F
Liquid static head	0 psi
MAWP rating	272.5 psi @ 150 °F
MAP rating	285 psi @ 70 °F
Hydrotest rating	450 psi @ 70 °F
PWHT performed	No
Impact Tested	No
Circumferential joint radiography	Full UW-11(a) Type 1
Gasket	
Description	Flexitallic Spiral Wound CG 304 S.S.
Notes	
Flange rated MDMT per UCS-66(b)(1)(b) = -55 °F (Coincident ratio = 0.5263) Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F	

UCS-66 Material Toughness Requirements Nozzle	
$t_r = 150 * 1.9755 / (17,100 * 1 - 0.6 * 150) =$	0.0174"
Stress ratio = $t_r * E^* / (t_n - c) = 0.0174 * 1 / (0.2949 - 0.0625) =$	0.075
Stress ratio ≤ 0.35 , MDMT per UCS-66(b)(3) =	-155 °F
Material is exempt from impact testing at the Design MDMT of -20 °F.	

Reinforcement Calculations for MAWP

The attached ASME B16.5 flange limits the nozzle MAWP.

UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 272.5 psi @ 150 °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}

0.7508	0.7615	0.2986	0.3223	--	--	0.1406	0.2525	0.2949
--------	--------	--------	--------	----	----	--------	--------	--------

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)	0.1859	0.2625	weld size is adequate

Reinforcement Calculations for MAP

The attached ASME B16.5 flange limits the nozzle MAP.

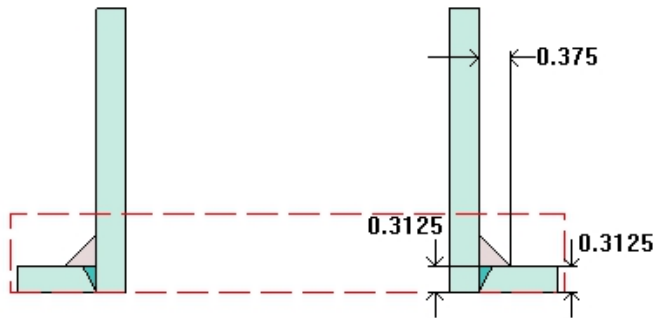
UG-37 Area Calculation Summary (in ²)							UG-45 Summary (in)	
For P = 285 psi @ 70 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
0.7602	1.1358	0.4952	0.5	--	--	0.1406	0.1987	0.2949

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)	0.2297	0.2625	weld size is adequate

Vapor Out/Inspection (B)

ASME Section VIII Division 1, 2015 Edition



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

Location and Orientation

Located on	TOP HEAD
Orientation	0°
End of nozzle to datum line	82"
Calculated as hillside	No
Distance to head center, R	0"
Passes through a Category A joint	No

Nozzle

Description	NPS 4 Sch 80 (XS)
Access opening	No
Material specification	SA-106 B Smls pipe (II-D p. 14, ln. 15)
Inside diameter, new	3.826"
Pipe nominal wall thickness	0.337"
Pipe minimum wall thickness ¹	0.2949"
Corrosion allowance	0.0625"
Projection available outside vessel, L _{pr}	4.9529"
Projection available outside vessel to flange face, L _f	7.9529"
Local vessel minimum thickness	0.3125"
Liquid static head included	0 psi
Longitudinal joint efficiency	1

Welds

Inner fillet, Leg ₄₁	0.375"
---------------------------------	--------

Nozzle to vessel groove weld	0.3125"
-------------------------------------	---------

¹Pipe minimum thickness = nominal thickness times pipe tolerance factor of 0.875.

ASME B16.5-2013 Flange	
Description	NPS 4 Class 150 WN A105
Bolt Material	SA-193 B7 Bolt <= 2 1/2 (II-D p. 344, ln. 31)
Blind included	No
Rated MDMT	-55°F
Liquid static head	0 psi
MAWP rating	272.5 psi @ 150°F
MAP rating	285 psi @ 70°F
Hydrotest rating	450 psi @ 70°F
PWHT performed	No
Impact Tested	No
Circumferential joint radiography	Full UW-11(a) Type 1
Gasket	
Description	Flexitallic Spiral Wound CG 304 S.S.
Notes	
Flange rated MDMT per UCS-66(b)(1)(b) = -55°F (Coincident ratio = 0.5263) Bolts rated MDMT per Fig UCS-66 note (c) = -55°F	

UCS-66 Material Toughness Requirements Nozzle	
$t_r = 150 * 1.9755 / (17,100 * 1 - 0.6 * 150) =$	0.0174"
$\text{Stress ratio} = t_r * E^* / (t_n - c) = 0.0174 * 1 / (0.2949 - 0.0625) =$	0.075
$\text{Stress ratio} \leq 0.35$, MDMT per UCS-66(b)(3) =	-155°F
Material is exempt from impact testing at the Design MDMT of -20°F.	

Reinforcement Calculations for MAWP

The attached ASME B16.5 flange limits the nozzle MAWP.

UG-37 Area Calculation Summary (in ²)	UG-45 Summary (in)
For P = 272.5 psi @ 150 °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}
0.5867	0.7839	0.4043	0.2594	--	--	0.1202	0.2229	0.2949

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)	0.175	0.2625	weld size is adequate

Reinforcement Calculations for MAP

The attached ASME B16.5 flange limits the nozzle MAP.

UG-37 Area Calculation Summary (in²)

UG-45 Summary (in)

For P = 285 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}
0.6004	1.1219	0.5945	0.4072	--	--	0.1202	0.1688	0.2949

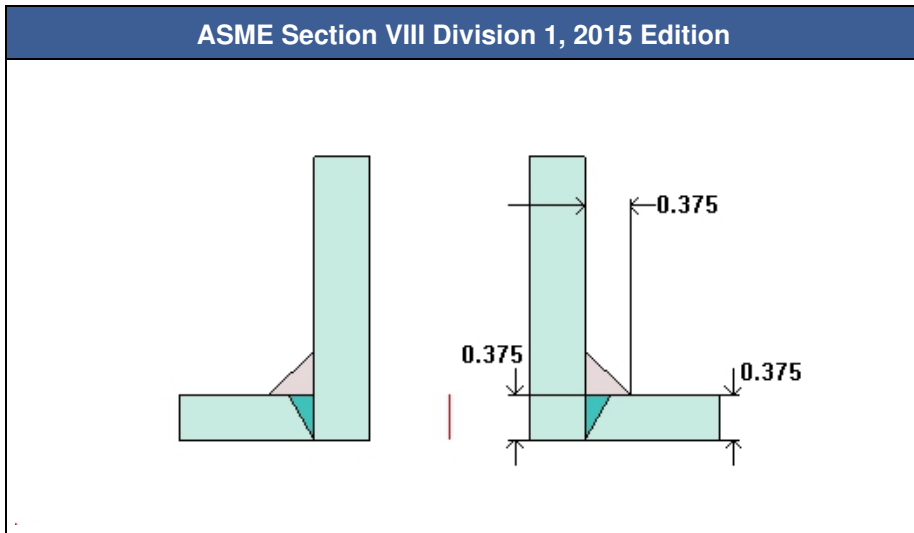
UG-41 Weld Failure Path Analysis Summary

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)	0.2188	0.2625	weld size is adequate

Liquid Out (C)



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

Location and Orientation	
Located on	SHELL #1
Orientation	45°
Nozzle center line offset to datum line	-3"
End of nozzle to shell center	13.5"
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. 23)
Inside diameter, new	1.315"
Nominal wall thickness	0.4675"
Corrosion allowance	0.0625"
Projection available outside vessel, L _{pr}	1.5"
Local vessel minimum thickness	0.3281"
Liquid static head included	0.45 psi
Longitudinal joint efficiency	1
Welds	
Inner fillet, Leg ₄₁	0.375"
Nozzle to vessel groove weld	0.375"

UCS-66 Material Toughness Requirements Nozzle At Intersection	
Governing thickness, $t_g =$	0.3281"
Exemption temperature from Fig UCS-66 Curve B =	-20 °F
$t_r = 150.45 \cdot 12 / (17,100 \cdot 1 + 0.4 \cdot 150.45) =$	0.1052"
Stress ratio = $t_r \cdot E^* / (t_n - c) = 0.1052 \cdot 1 / (0.3281 - 0.0625) =$	0.3961
Reduction in MDMT, T_R from Fig UCS-66.1 =	95.7 °F
MDMT = $\max[\text{MDMT} - T_R, -55] = \max[-20 - 95.7, -55] =$	-55 °F
Material is exempt from impact testing at the Design MDMT of -20 °F.	

UCS-66 Material Toughness Requirements Nozzle	
$t_r = 150.45 \cdot 0.72 / (20,000 \cdot 1 - 0.6 \cdot 150.45) =$	0.0054"
Stress ratio = $t_r \cdot E^* / (t_n - c) = 0.0054 \cdot 1 / (0.4675 - 0.0625) =$	0.0134
Stress ratio ≤ 0.35 , MDMT per UCS-66(b)(3) =	-155 °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 = 381.87 psi @ 150 °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)						0.125	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)	0.1859	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 = 472.71 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)							0.0625	0.4675

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

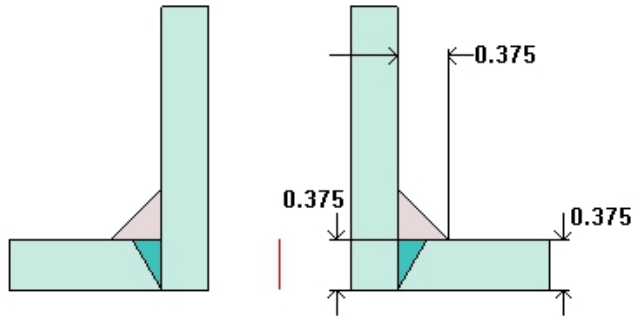
UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.2297	0.2625	weld size is adequate

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

Skin 2 relocated from UOPR Job 488 to 447

LG (D1)

ASME Section VIII Division 1, 2015 Edition



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

Location and Orientation

Located on	SHELL #1
Orientation	135°
Nozzle center line offset to datum line	27.5"
End of nozzle to shell center	13.5"
Passes through a Category A joint	No

Nozzle

Description	NPS 0.75 Class 6000 - threaded
Access opening	No
Material specification	SA-105 (II-D p. 18, ln. 23)
Inside diameter, new	1.05"
Nominal wall thickness	0.35"
Corrosion allowance	0.0625"
Projection available outside vessel, Lpr	1.5"
Local vessel minimum thickness	0.3281"
Liquid static head included	0 psi
Longitudinal joint efficiency	1

Welds

Inner fillet, Leg ₄₁	0.375"
Nozzle to vessel groove weld	0.375"

UCS-66 Material Toughness Requirements Nozzle At Intersection	
Governing thickness, $t_g =$	0.3281"
Exemption temperature from Fig UCS-66 Curve B =	-20 °F
$t_r = 150 \cdot 12 / (17,100 \cdot 1 + 0.4 \cdot 150) =$	0.1049"
Stress ratio = $t_r \cdot E^* / (t_n - c) = 0.1049 \cdot 1 / (0.3281 - 0.0625) =$	0.395
Reduction in MDMT, T_R from Fig UCS-66.1 =	96.6 °F
MDMT = $\max[\text{MDMT} - T_R, -55] = \max[-20 - 96.6, -55] =$	-55 °F
Material is exempt from impact testing at the Design MDMT of -20 °F.	

UCS-66 Material Toughness Requirements Nozzle	
$t_r = 150 \cdot 0.5875 / (20,000 \cdot 1 - 0.6 \cdot 150) =$	0.0044"
Stress ratio = $t_r \cdot E^* / (t_n - c) = 0.0044 \cdot 1 / (0.35 - 0.0625) =$	0.0154
Stress ratio ≤ 0.35 , MDMT per UCS-66(b)(3) =	-155 °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 = 381.87 psi @ 150 °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)							0.125	0.35

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)	0.1859	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 = 472.71 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)							0.0625	0.35

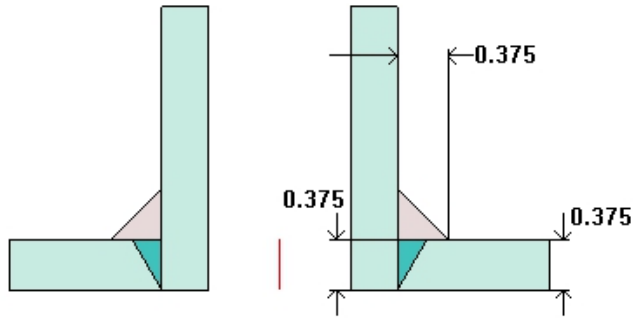
UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.2297	0.2625	weld size is adequate

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

LG (D2)

ASME Section VIII Division 1, 2015 Edition



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

Location and Orientation

Located on	SHELL #1
Orientation	135°
Nozzle center line offset to datum line	0"
End of nozzle to shell center	13.5"
Passes through a Category A joint	No

Nozzle

Description	NPS 0.75 Class 6000 - threaded
Access opening	No
Material specification	SA-105 (II-D p. 18, ln. 23)
Inside diameter, new	1.05"
Nominal wall thickness	0.35"
Corrosion allowance	0.0625"
Projection available outside vessel, L _{pr}	1.5"
Local vessel minimum thickness	0.3281"
Liquid static head included	0.39 psi
Longitudinal joint efficiency	1

Welds

Inner fillet, Leg ₄₁	0.375"
Nozzle to vessel groove weld	0.375"

UCS-66 Material Toughness Requirements Nozzle At Intersection	
Governing thickness, $t_g =$	0.3281"
Exemption temperature from Fig UCS-66 Curve B =	-20 °F
$t_r = 150.39 \cdot 12 / (17,100 \cdot 1 + 0.4 \cdot 150.39) =$	0.1052"
Stress ratio = $t_r \cdot E^* / (t_n - c) = 0.1052 \cdot 1 / (0.3281 - 0.0625) =$	0.396
Reduction in MDMT, T_R from Fig UCS-66.1 =	95.8 °F
MDMT = $\max[\text{MDMT} - T_R, -55] = \max[-20 - 95.8, -55] =$	-55 °F
Material is exempt from impact testing at the Design MDMT of -20 °F.	

UCS-66 Material Toughness Requirements Nozzle	
$t_r = 150.39 \cdot 0.5875 / (20,000 \cdot 1 - 0.6 \cdot 150.39) =$	0.0044"
Stress ratio = $t_r \cdot E^* / (t_n - c) = 0.0044 \cdot 1 / (0.35 - 0.0625) =$	0.0154
Stress ratio ≤ 0.35 , MDMT per UCS-66(b)(3) =	-155 °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 = 381.87 psi @ 150 °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)							0.125	0.35

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)	0.1859	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 = 472.71 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)							0.0625	0.35

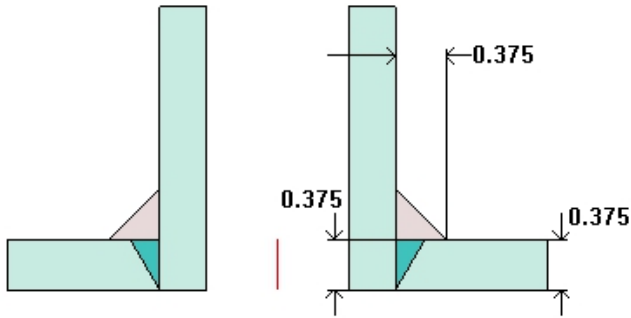
UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.2297	0.2625	weld size is adequate

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

TI (E)

ASME Section VIII Division 1, 2015 Edition



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

Location and Orientation

Located on	SHELL #1
Orientation	0°
Nozzle center line offset to datum line	6"
End of nozzle to shell center	13.5"
Passes through a Category A joint	No

Nozzle

Description	NPS 0.75 Class 6000 - threaded
Access opening	No
Material specification	SA-105 (II-D p. 18, ln. 23)
Inside diameter, new	1.05"
Nominal wall thickness	0.35"
Corrosion allowance	0.0625"
Projection available outside vessel, Lpr	1.5"
Local vessel minimum thickness	0.3281"
Liquid static head included	0.28 psi
Longitudinal joint efficiency	1

Welds

Inner fillet, Leg ₄₁	0.375"
Nozzle to vessel groove weld	0.375"

UCS-66 Material Toughness Requirements Nozzle At Intersection	
Governing thickness, $t_g =$	0.3281"
Exemption temperature from Fig UCS-66 Curve B =	-20 °F
$t_r = 150.28 \cdot 12 / (17,100 \cdot 1 + 0.4 \cdot 150.28) =$	0.1051"
Stress ratio = $t_r \cdot E^* / (t_n - c) = 0.1051 \cdot 1 / (0.3281 - 0.0625) =$	0.3957
Reduction in MDMT, T_R from Fig UCS-66.1 =	96 °F
MDMT = $\max[\text{MDMT} - T_R, -55] = \max[-20 - 96, -55] =$	-55 °F
Material is exempt from impact testing at the Design MDMT of -20 °F.	

UCS-66 Material Toughness Requirements Nozzle	
$t_r = 150.28 \cdot 0.5875 / (20,000 \cdot 1 - 0.6 \cdot 150.28) =$	0.0044"
Stress ratio = $t_r \cdot E^* / (t_n - c) = 0.0044 \cdot 1 / (0.35 - 0.0625) =$	0.0154
Stress ratio ≤ 0.35 , MDMT per UCS-66(b)(3) =	-155 °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 = 381.86 psi @ 150 °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)							0.125	0.35

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)	0.1859	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.

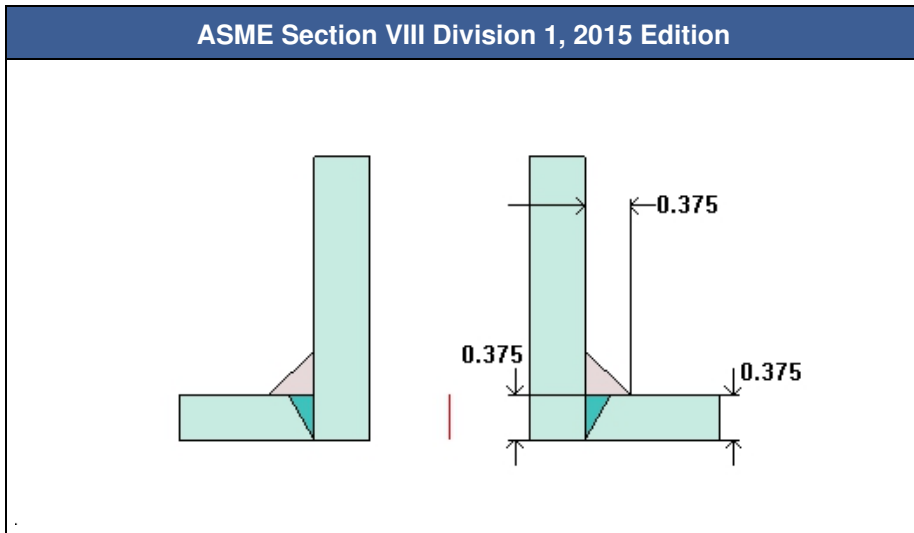
UG-37 Area Calculation Summary (in ²)							UG-44 Summary (in)	
For P = 472.71 psi @ 70 °F							The nozzle passes UG-44	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.0625	0.35

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)	0.2297	0.2625	weld size is adequate

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

LSHH (F1)



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

Location and Orientation	
Located on	SHELL #1
Orientation	90°
Nozzle center line offset to datum line	25.5"
End of nozzle to shell center	13.5"
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. 23)
Inside diameter, new	1.315"
Nominal wall thickness	0.4675"
Corrosion allowance	0.0625"
Projection available outside vessel, Lpr	1.5"
Local vessel minimum thickness	0.3281"
Liquid static head included	0 psi
Longitudinal joint efficiency	1
Welds	
Inner fillet, Leg ₄₁	0.375"
Nozzle to vessel groove weld	0.375"

UCS-66 Material Toughness Requirements Nozzle At Intersection	
Governing thickness, $t_g =$	0.3281"
Exemption temperature from Fig UCS-66 Curve B =	-20 °F
$t_r = 150 \cdot 12 / (17,100 \cdot 1 + 0.4 \cdot 150) =$	0.1049"
Stress ratio = $t_r \cdot E^* / (t_n - c) = 0.1049 \cdot 1 / (0.3281 - 0.0625) =$	0.395
Reduction in MDMT, T_R from Fig UCS-66.1 =	96.6 °F
MDMT = $\max[\text{MDMT} - T_R, -55] = \max[-20 - 96.6, -55] =$	-55 °F
Material is exempt from impact testing at the Design MDMT of -20 °F.	

UCS-66 Material Toughness Requirements Nozzle	
$t_r = 150 \cdot 0.72 / (20,000 \cdot 1 - 0.6 \cdot 150) =$	0.0054"
Stress ratio = $t_r \cdot E^* / (t_n - c) = 0.0054 \cdot 1 / (0.4675 - 0.0625) =$	0.0134
Stress ratio ≤ 0.35 , MDMT per UCS-66(b)(3) =	-155 °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 = 381.87 psi @ 150 °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)						0.125	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)	0.1859	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 = 472.71 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)							0.0625	0.4675

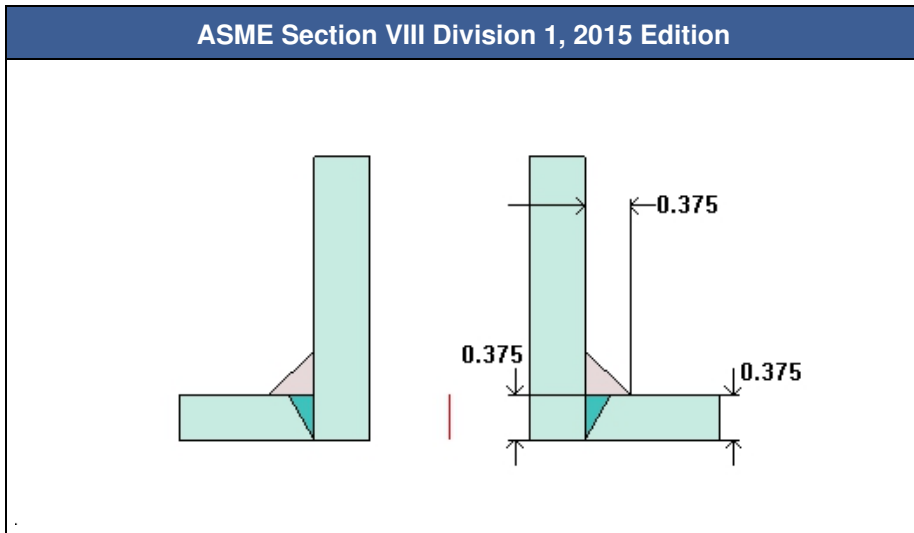
UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.2297	0.2625	weld size is adequate

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

Skin 2 relocated from UOPR Job 488 to 447

LSHH (F2)



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

Location and Orientation	
Located on	SHELL #1
Orientation	90°
Nozzle center line offset to datum line	11.5"
End of nozzle to shell center	13.5"
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. 23)
Inside diameter, new	1.315"
Nominal wall thickness	0.4675"
Corrosion allowance	0.0625"
Projection available outside vessel, L _{pr}	1.5"
Local vessel minimum thickness	0.3281"
Liquid static head included	0.18 psi
Longitudinal joint efficiency	1
Welds	
Inner fillet, Leg ₄₁	0.375"
Nozzle to vessel groove weld	0.375"

UCS-66 Material Toughness Requirements Nozzle At Intersection	
Governing thickness, $t_g =$	0.3281"
Exemption temperature from Fig UCS-66 Curve B =	-20°F
$t_r = 150.18 \cdot 12 / (17,100 \cdot 1 + 0.4 \cdot 150.18) =$	0.105"
Stress ratio = $t_r \cdot E^* / (t_n - c) = 0.105 \cdot 1 / (0.3281 - 0.0625) =$	0.3954
Reduction in MDMT, T_R from Fig UCS-66.1 =	96.2°F
MDMT = $\max[\text{MDMT} - T_R, -55] = \max[-20 - 96.2, -55] =$	-55°F
Material is exempt from impact testing at the Design MDMT of -20°F.	

UCS-66 Material Toughness Requirements Nozzle	
$t_r = 150.18 \cdot 0.72 / (20,000 \cdot 1 - 0.6 \cdot 150.18) =$	0.0054"
Stress ratio = $t_r \cdot E^* / (t_n - c) = 0.0054 \cdot 1 / (0.4675 - 0.0625) =$	0.0134
Stress ratio ≤ 0.35 , MDMT per UCS-66(b)(3) =	-155°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 = 381.86 psi @ 150 °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)						0.125	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)	0.1859	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 = 472.71 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)							0.0625	0.4675

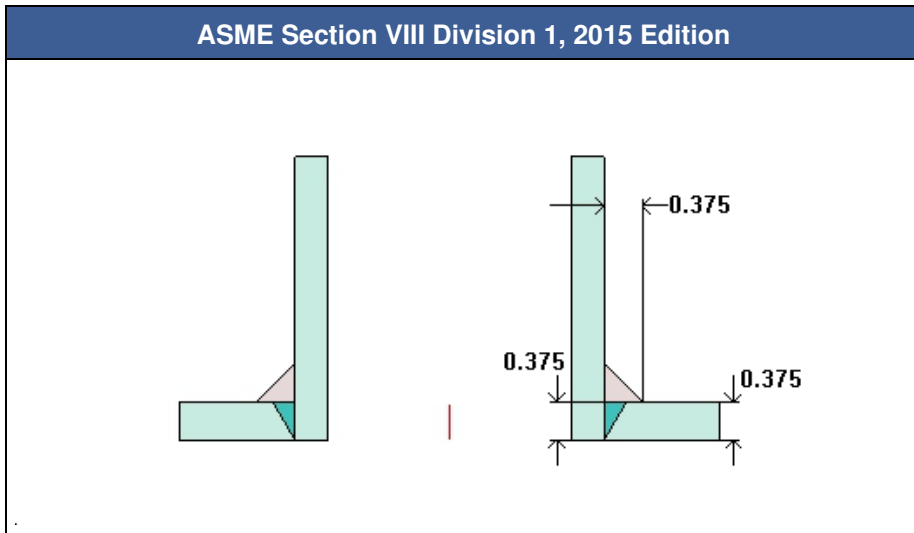
UG-41 Weld Failure Path Analysis Summary
The nozzle is exempt from weld strength calculations per UW-15(b)(2)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.2297	0.2625	weld size is adequate

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

Skin 2 relocated from UOPR Job 488 to 447

Inspection (G)



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

Location and Orientation	
Located on	SHELL #1
Orientation	270°
Nozzle center line offset to datum line	-3"
End of nozzle to shell center	13.5"
Passes through a Category A joint	No
Nozzle	
Description	NPS 2 Class 3000 - threaded
Access opening	No
Material specification	SA-105 (II-D p. 18, ln. 23)
Inside diameter, new	2.375"
Nominal wall thickness	0.3125"
Corrosion allowance	0.0625"
Projection available outside vessel, Lpr	1.5"
Local vessel minimum thickness	0.3281"
Liquid static head included	0.45 psi
Longitudinal joint efficiency	1
Welds	
Inner fillet, Leg ₄₁	0.375"
Nozzle to vessel groove weld	0.375"

UCS-66 Material Toughness Requirements Nozzle	
$t_r = 150.45 * 1.25 / (20,000 * 1 - 0.6 * 150.45) =$	0.0094"
Stress ratio = $t_r * E^* / (t_n - c) = 0.0094 * 1 / (0.3125 - 0.0625) =$	0.0378
Stress ratio ≤ 0.35 , MDMT per UCS-66(b)(3) =	-155°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 = 381.87 psi @ 150 °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)							0.125	0.3125

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)	0.175	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 = 472.71 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)							0.0625	0.3125

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

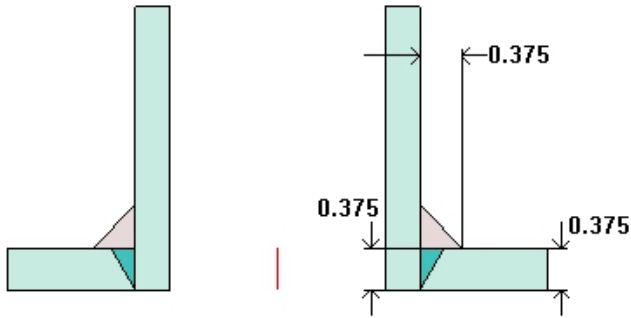
UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.2188	0.2625	weld size is adequate

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

Skid 2 relocated from UOPR Job 488 to 447

LC (Future) (H1)

ASME Section VIII Division 1, 2015 Edition



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

Location and Orientation

Located on	SHELL #1
Orientation	180°
Nozzle center line offset to datum line	22"
End of nozzle to shell center	13.5"
Passes through a Category A joint	No

Nozzle

Description	NPS 1.5 Class 3000 - threaded
Access opening	No
Material specification	SA-105 (II-D p. 18, ln. 23)
Inside diameter, new	1.9"
Nominal wall thickness	0.3"
Corrosion allowance	0.0625"
Projection available outside vessel, Lpr	1.5"
Local vessel minimum thickness	0.3281"
Liquid static head included	0 psi
Longitudinal joint efficiency	1

Welds

Inner fillet, Leg ₄₁	0.375"
Nozzle to vessel groove weld	0.375"

UCS-66 Material Toughness Requirements Nozzle	
$t_r = 150 * 1.0125 / (20,000 * 1 - 0.6 * 150) =$	0.0076"
Stress ratio = $t_r * E^* / (t_n - c) = 0.0076 * 1 / (0.3 - 0.0625) =$	0.0321
Stress ratio ≤ 0.35 , MDMT per UCS-66(b)(3) =	-155 °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 = 381.87 psi @ 150 °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)							0.125	0.3

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)	0.1662	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 = 472.71 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)							0.0625	0.3

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

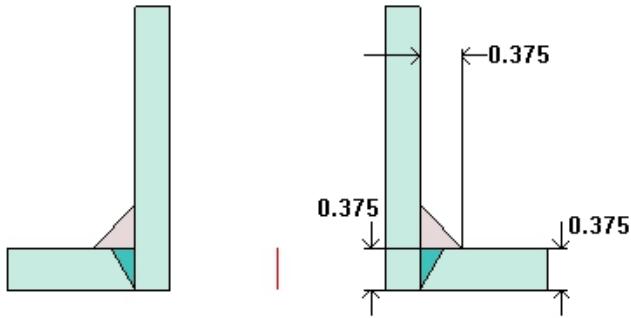
UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.21	0.2625	weld size is adequate

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

Skid 2 relocated from UOPR Job 488 to 447

LC (Future) (H2)

ASME Section VIII Division 1, 2015 Edition



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

Location and Orientation

Located on	SHELL #1
Orientation	180°
Nozzle center line offset to datum line	8"
End of nozzle to shell center	13.5"
Passes through a Category A joint	No

Nozzle

Description	NPS 1.5 Class 3000 - threaded
Access opening	No
Material specification	SA-105 (II-D p. 18, ln. 23)
Inside diameter, new	1.9"
Nominal wall thickness	0.3"
Corrosion allowance	0.0625"
Projection available outside vessel, Lpr	1.5"
Local vessel minimum thickness	0.3281"
Liquid static head included	0.25 psi
Longitudinal joint efficiency	1

Welds

Inner fillet, Leg ₄₁	0.375"
Nozzle to vessel groove weld	0.375"

UCS-66 Material Toughness Requirements Nozzle	
$t_r = 150.25 \times 1.0125 / (20,000 \times 1 - 0.6 \times 150.25) =$	0.0076"
Stress ratio = $t_r \times E^* / (t_n - c) = 0.0076 \times 1 / (0.3 - 0.0625) =$	0.0322
Stress ratio ≤ 0.35 , MDMT per UCS-66(b)(3) =	-155 °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 = 381.86 psi @ 150 °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)							0.125	0.3

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)	0.1662	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 = 472.71 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)							0.0625	0.3

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)	0.21	0.2625	weld size is adequate

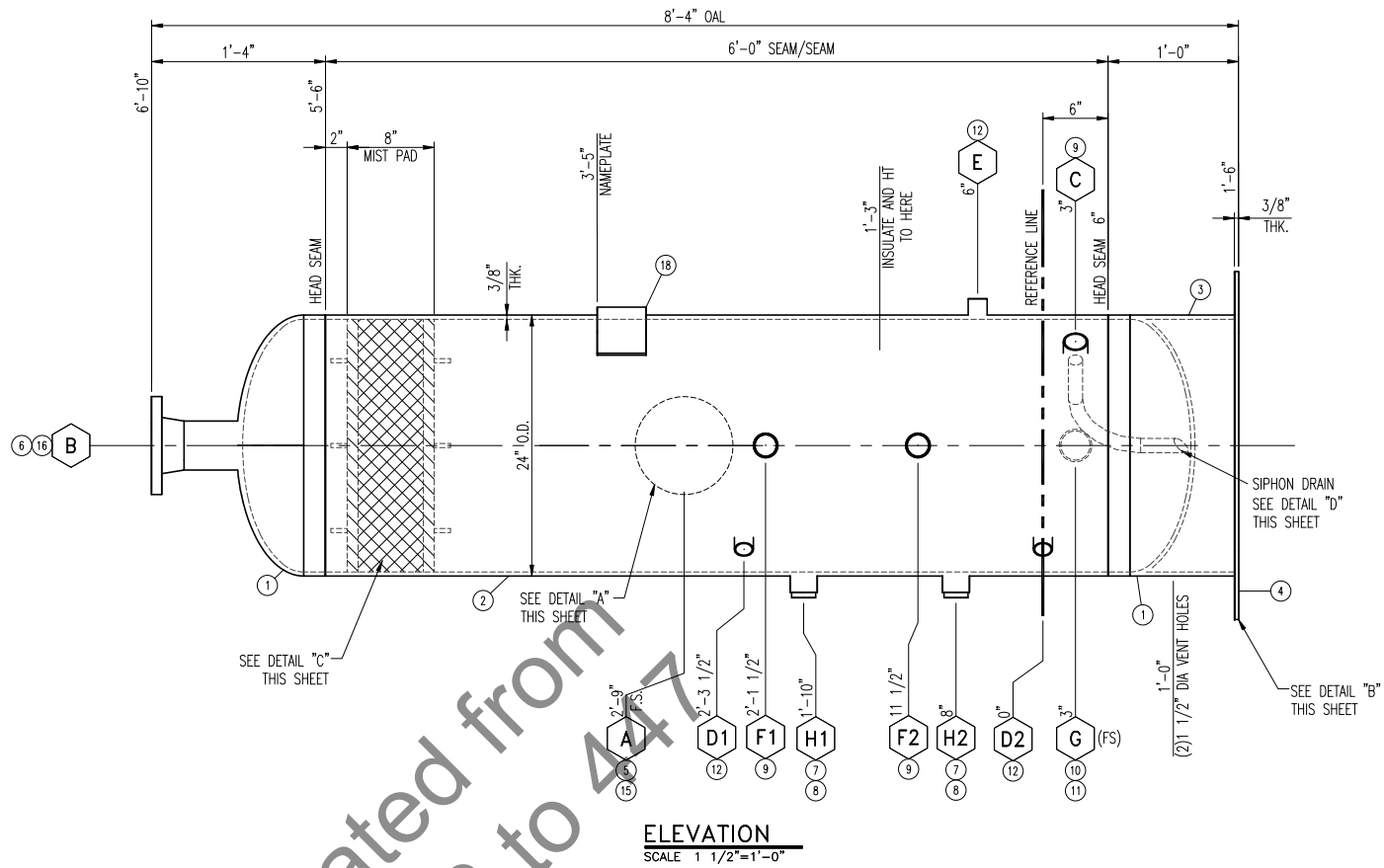
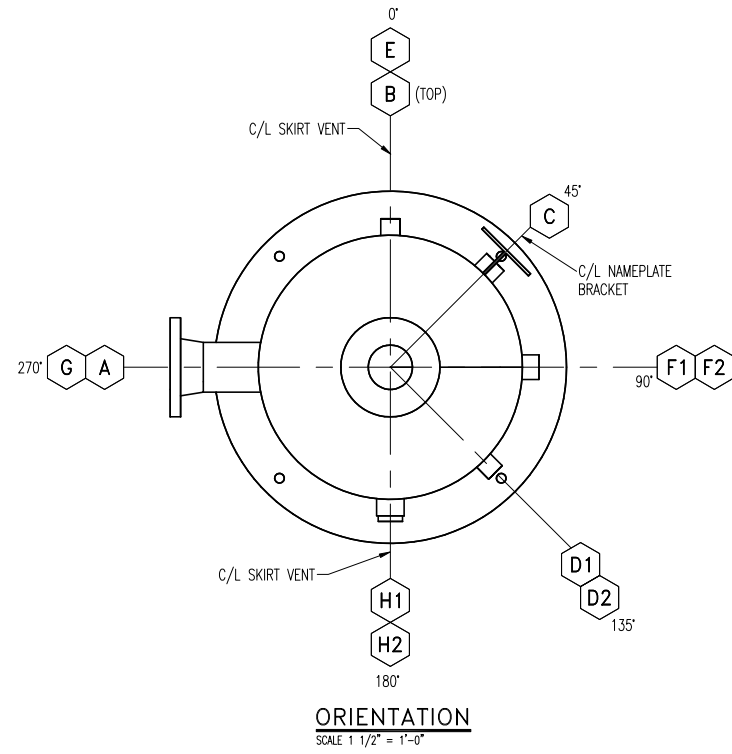
This opening does not require reinforcement per UG-36(c)(3)(a)

Skid 2 relocated from UOPR Job 488 to 447

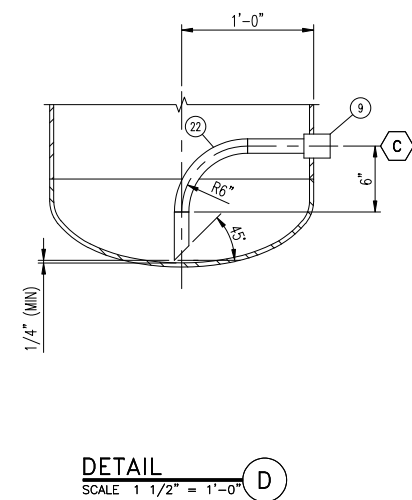
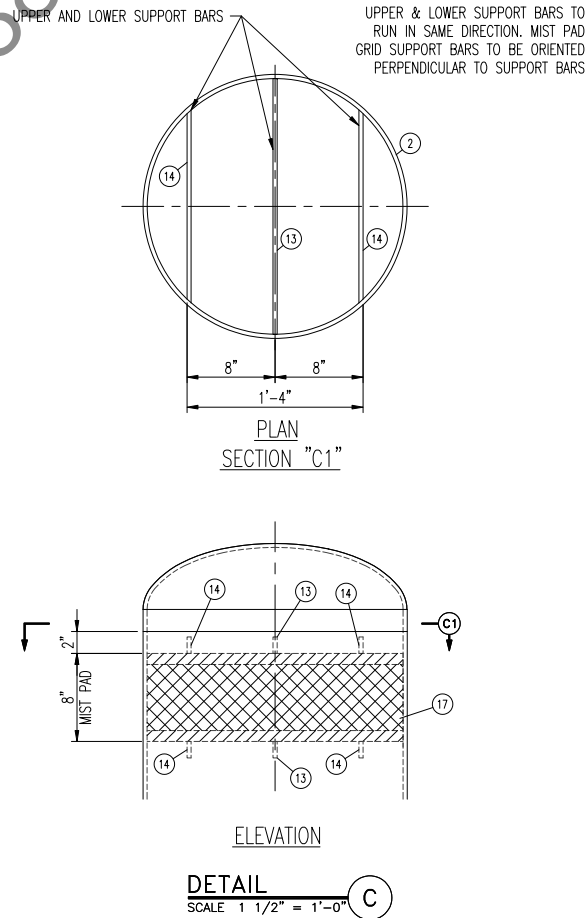
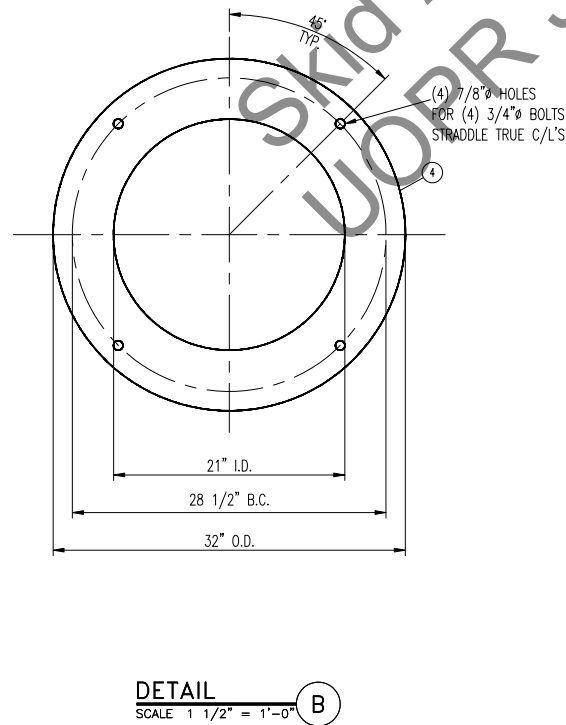
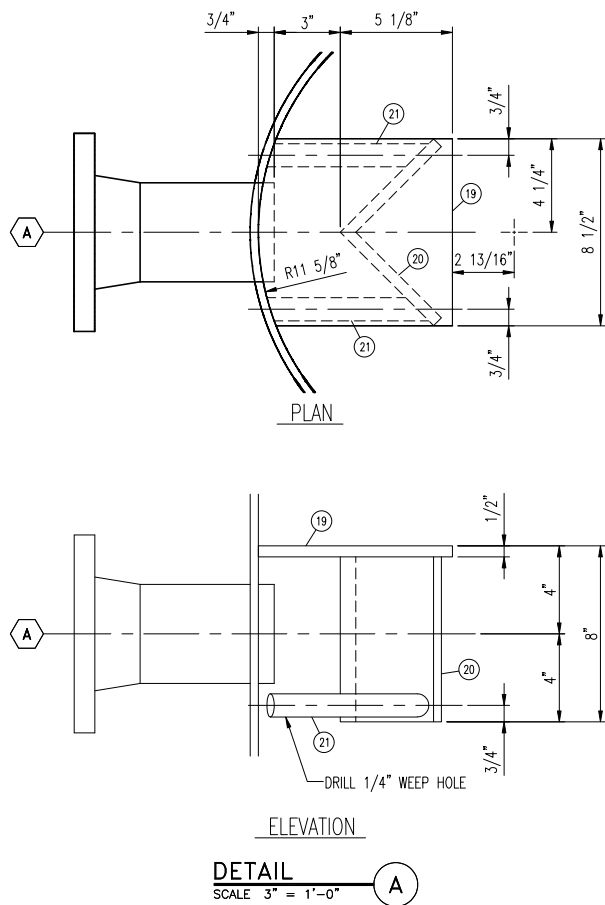
Mist Pad

ASME Section VIII Division 1, 2015 Edition	
Inputs	
Distance from Bottom of Bed to Datum	56"
Bed Depth	8"
Bed Diameter	23.25"
Bed Density	12.00 lb/ft ³
Liquid Holdup	2.00% of dry weight
Weight	
Estimated Bed Weight, Empty	23.6 lb
Estimated Bed Weight, Operating	24.1 lb
Loading Conditions	
Included in Vessel Lift & Shipping Weight	Yes
Present When Vessel is Empty	Yes
Present During Test	Yes

Skid 2 relocated from
UOPR Job 488 to 447



J-488
11/30/17
IFC



WY COM/04812-00
 TR P.E./ F-7531
UOP Russell
 7000 S. York, Suite 210
 Tulsa, Oklahoma 74138
 Phone: 918-481-3485
 Fax: 918-481-3427

REV.	DATE	BY	APP'D	DATE
0	11/20/17	AR		11/20/17
1	11/20/17	AR		11/20/17

UOP RUSSELL
 60 MMS/CD CRYO PLANT
 FABRICATION DETAILS
 V-481 - FUEL GAS SCRUBBER 24" O.D. x 6'-0" S/S
 SCALE NOTED
 File Name: 488-307A (V-481) Job 488 SCS RSJ (March 2016) V1.0 Drawings\172 Equipment
 Nov 30, 2017 - 10:35am