

## HISTORY DOCKET

CUSTOMER : ULTRAFAB INDUSTRIES LTD.,  
WO. NO. : 1173PQ  
A.W.C. SERIAL NO. : 7473  
ITEM : 48" O.D. VERTICAL INLET SEPARATOR TAG # 772-VESE-201

### CONTENTS OF BOOKLET

- 1) CERTIFICATE OF COMPLIANCE
- 2) FORM U-1A MANUFACTURER'S DATA REPORT FOR PRESSURE VESSELS C/W FORM U-4  
MANUFACTURER'S DATA REPORT SUPPLEMENTARY SHEET
- 3) TRAVELLER SHEETS 1&2
- 4) HYDROSTATIC TEST REPORTS/GAUGE CALIBRATION CERTIFICATE & WATER ANALYSIS  
REPORT
- 5) NAME PLATES (PHOTO IN IMPERIAL & METRIC) (STAMPED BY ABS)
- 6) KVI NDE REPORTS RT, UT, PT & HT C/W MAPS, RADIOGRAPH REVIEW FORM & NDE  
PERSONNEL CERTIFICATE
- 7) NON-CONFORMANCE REPORT N13-027, N13-037, N13-078, N13-080, N13-082 &  
N13-083
- 8) WPS/ PQR/ WELDING CONSUMABLES & WELDERS' QUALIFICATION RECORD C/W  
WELD MAP
- 9) HEAT NUMBER MAP AND MATERIAL TEST REPORTS
- 10) DESIGN CALCULATIONS AND AS BUILT DWGS C/W ABS APPROVED DWGS

# CERTIFICATE OF COMPLIANCE

I, THE UNDERSIGNED, DECLARE THAT YOUR VESSELS, IDENTIFIED AS

**CUSTOMER:** ULTRAFAB INDUSTRIES LTD  
**AWC W.O. NO.:** 1173 PQ  
**SERIAL NO'S:** 7473  
**ITEM:** 48" O D VERTICAL INLET SEPARATOR TAG 772-VESE-201

COMPLIES AND EXCEEDS THE QUALITY CONTROL LEVEL OF THE TECHNICAL STANDARDS AND SAFETY AUTHORITY OF ONTARIO AND THE CODES AND STANDARDS OF ASME CODES: SEC. VIII, DIV. 1 UW- 12(a) 2010 EDITION. 2011ADDEENDA

SIGNATURE



ROBERT C. BENTLEY, C.E.T.  
QUALITY ASSURANCE MANAGER

DATE

OCT 0 4 2013

## ALL-WELD

COMPANY LIMITED

*Engineer's Since 1920*

A TRADITION OF QUALITY

49 PASSMORE AVE., SCARBOROUGH, ONT., M1V 4T1 TEL (416) 299-3311 FAX (416)299-3387

CERTIFICATE OF COMPLIANCE -- EXCEL -- QUALITY

**(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**

**COPY**

1. Manufactured and certified by ALL-WELD COMPANY LIMITED., 49 PASSMORE AVE., SCARBOROUGH, ONT. M1V 4T1 CANADA  
(Name and address of Manufacturer)

2. Manufactured for ULTRA FAB INDUSTRIES LTD., 261088 WAGON WHEEL CRES., ROCKY VIEW, ALBERTA, T4A 0E2 CANADA

3. Location of Installation OFF THE COAST OF ANGOLA  
(Name and address)

4. Type VERTICAL 7473 M10135.5 1173-1-IN REV. 5 913 2013  
(Horizontal or vertical tank) (Manufacturer's serial number) (CRN) (Drawing number) (National Board number) (Year built)

5. The chemical and physical properties of all parts meet the requirements of material specifications of the ASME BOILER AND PRESSURE VESSEL CODE. The design, construction, and workmanship conform to ASME Rules, Section VIII, Division 1. 2010  
Year

to 2011a N/A LETHAL UW-2(a)  
[Addenda, if applicable (date)] (Code Case numbers) [Special service per UG-120(d)]

6. Shell: SA240-316 1.75" 0" 3'-8.5" 8'-0"  
(Material spec number, grade) (Nominal thickness) (Corr. allow.) (Inner diameter) (Length (overall))

7. Seams: TYPE 1 FULL 100% N/A N/A TYPE 1 FULL 100% 1  
[Long (welded, dbl. snlg., lap. buttl)] [R T (spot or full)] (Eff. %) (H.T temp.) (Time, hr) [Girth (welded, dbl. snlg. lap buttl)] [R T (spot or full)] (Eff. %) (No. of courses)

8. Heads: (a) Material SA 240 316 (b) Material SA 240 316  
(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	1.71"	0"	N/A	N/A	2:1	N/A	N/A	N/A	CONCAVE
(b)	BOTTOM	1.71"	0"	N/A	N/A	2:1	N/A	N/A	N/A	CONCAVE

If removable, bolts used (describe other fastenings) N/A  
(Material spec. number, grade, size, number)

9. MAWP 1378 PSI 15 PSI at max. temp. 140°F 140°F  
(Internal) (External) (Internal) (External)

Min. design metal temp -20° F at 1378 PSI Hydro., pneu., or comb. test pressure HYDRO 1792 PSI  
 Proof test N/A

10. Nozzles, inspection and safety valve openings:

Purpose (Inlet, Outlet, Drain etc.)	No.	Diameter or Size	Type	Material		Nominal Thickness		Reinforcement Material	Attachment Details		Location (Insp. Open.)
				Nozzle	Flange	Nom.	Corr.		Nozzle	Flange	
VENT (N14)	1	2" ID	Cl.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW-16.1 (e)	N/A	N/A
GAS OUTLET (N2)	1	8" ID	Cl.900 LWN	SA182 F316	SA182 F316	1.875"	0"	N/A	UW-16.1 (e)	N/A	N/A
LIQUID OUTLET (N3)	1	2" ID	Cl.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW-16.1 (e)	N/A	N/A
LEVEL BRIDLE (N8B)	1	2" ID	Cl.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW-16.1 (e)	N/A	N/A

11. Supports: Skirt YES Lugs N/A Legs N/A Other N/A 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: N/A

(1) SHOP TEST PERFORMED IN THE VERTICAL POSITION (2) IMPACT TESTED EXEMPTED PER UHA-51 (3) SEE ATTACHED U-4 FORM  
(Name of part, item number, Manufacturer's name and identifying stamp)

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 <u>21226</u> expires <u>MAY 07, 2016</u>	
Date <u>26 Sept 2013</u> Co. name <u>ALL-WELD COMPANY LIMITED.</u> Signed <u>[Signature]</u> <small>(Manufacturer) (Representative)</small>	
CERTIFICATE OF SHOP/FIELD INSPECTION	
Vessel constructed by <u>ALL-WELD COMPANY LIMITED</u> at <u>49 PASSMORE AVE. TORONTO, ONT.</u>	
I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and/or the State or Province of <u>ONTARIO</u> and employed by <u>T.S.S.A. OF ONTARIO</u>	
have inspected the component described in this Manufacturer's Data Report on <u>SEP 26, 2013</u> , 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 <u>SEP 26, 2013</u> Signed <u>[Signature]</u> Commissions <u>NB 13106A ONT 915</u> <small>(Authorized Inspector) (National Board (incl. endorsements), State, Province and number)</small>	

**As Required by the Provisions of the ASME Boiler and Pressure Vessel Code Rules, Section VIII, Division 1**

**COPY**

1. Manufactured and certified by ALL-WELD COMPANY LIMITED, 49 PASSMORE AVE., SCARBOROUGH, ONTARIO, M1V 4T1 CANADA  
(Name and address of Manufacturer)
2. Manufactured for ULTRA FAB INDUSTRIES LTD., 261088 WAGON WHEEL CRES., ROCKY VIEW, ALBERTA, T4A 0E2 CANADA  
(Name and address of Purchaser)
3. Location of installation OFF THE COAST OF ANGOLA  
(Name and address)
4. Type VERTICAL TANK 7473  
(Horizontal, vertical, or sphere) (Tank, separator, heat exch. etc.) (Manufacturer's serial number)  
M10135.5 1173-1-IN REV. 5 913 2013  
(CRN) (Drawing number) (National Board number) (Year built)

DATA REPORT ITEM NUMBER \_\_\_\_\_ REMARKS \_\_\_\_\_

ITEM 10:

Purpose (Inlet, Outlet, Drain etc.)	No.	Diameter or Size	Type	Material		Nominal Thickness		Reinforcement Material	Attachment Details		Location (Insp. Open.)
				Nozzle	Flange	Nom.	Corr.		Nozzle	Flange	
TEMPERATURE INDICATOR (N6)	1	2" ID	CI.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
P1 (N5)	1	2" ID	CI.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
PURGE (N12)	1	2" ID	CI.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
LEVEL BRIDAL(SAFE TY)(N9A)	1	2" ID	CI.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
MANWAY C/W BLIND FLANGE	1	24" ID	CI.900 V2/12	SA182 F316	SA182 F316	5.5"	0"	N/A	UW.16 1(e)	N/A	SHELL
PDI LOW (N7B)	1	2" ID	CI.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
LEVEL BRIDAL(PROCESS)(N8A)	1	2" ID	CI.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
PDI (HIGH) (N7A)	1	2" ID	CI.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
LEVEL BRIDLE (SAFETY) LOW (N9B)	1	2" ID	CI.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
LEVEL GAUGE HIGH (N10A)	1	2" ID	CI.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
INLET (N1)	1	8" ID	CI.900 LWN	SA182 F316	SA182 F316	1.875"	0"	N/A	UW.16 1(e)	N/A	N/A
SPARE (N11)	1	2" ID	CI.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
LEVEL GAUGE LOW (N10B)	1	2" ID	CI.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
PSV (N4)	1	2" ID	CI.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
INSP. C/W BLIND FLANGE (N15)	1	8" ID	CI.900 LWN	SA182 F316	SA182 F316	1.875"	0"	N/A	UW.16 1(e)	N/A	SHELL
BOTTOM DRAIN (N13)	1	NPS 2"	CI.900 WN	SA312 TP 316	SA182 F316	0.344"	0"	N/A	UW.16 1(e)	UW.16.1 (f2)	N/A

Certificate of Authorization: Type: U No.: 21226 Expires MAY 07, 2016

Date: 26 Sept 2013 Name: ALL-WELD COMPANY LIMITED Signed: R. Burt  
(Manufacturer) (Representative)  
Date: SEP 26, 2013 Name: [Signature] Commission: WB13106A, ONT915  
(Authorized Inspector) [National Board (incl. endorsements), State, Province, and number]

# ALL-WELD CO. LTD.

# TRAVELLER

(SUMMARY REPORT) Pg. 1 of 2

DATE 2013-02-06	WORK ORDER 1173PQ	CUSTOMER PO 11112	REVIEWED <i>[Signature]</i>	BY A.I. <i>[Signature]</i>
SERIAL NO. 7473	C.R.N. M10135.5	DATE 2013-02-06		SIGN FETS 07.13
NATIONAL BOARD NO. 913				
CUSTOMER ULTRAFAB		ULTIMATE OWNER		
FOR DRAWINGS & DOCUMENTS/REV./DATE ISSUED TO Q.C. SEE Q.C. DOCUMENT CONTROL FORM		ASME CODE 2010		
VESSEL TYPE/JOB DESCRIPTION		SECTION VIII DIV 1		
60" ID VERTICAL INLET SEPERATOR		ADD 2011		
<b>OPERATIONS, INSPECTIONS &amp; TEST POINTS</b>		H = HOLD R = REVIEW		
REVIEW APPVD DRWGS, CALCS,		R	H	H
REVIEW TRAVELLER AND REVIEW INSPECTION AND TEST PLAN		AWC QC	CUSTOMER	AI
REVIEW MATERIAL LIST		H		R
REVIEW W.P.S., P.Q.R SAW 3-2, 3-4, 9-4 + 2-1		H		R
INCOMING MATERIAL INSPECTION REPORT		H		R
CHECK ROUNDNESS OF VESSEL		H		
FIT-UP INSPECTION		H		
MAG PARTICLE / LIQUID PEN TEST		H		
APPROVAL OF RADIOGRAPH MAP BY AI		H		R
RADIOGRAPHIC TESTS - FULL		H		R
ULTRASONIC TEST		H		
HARDNESS TESTS		H		
REVIEW WELDERS QUALIFICATION		H		R
WELD MAP REPORT		H		R
FINAL INTERNAL INSPECTION		H		H
POST WELD HEAT TREATMENT		N/A		
FINAL (ALL NCR'S HAVE BEEN CLEARED)		H		R
FINAL COMPLETED VESSEL INSPECTION		H		H
FINAL HYDROSTATIC TEST		H		H
FINAL HYDROSTATIC TEST JACKET		N/A		
FINAL HYDROSTATIC TEST TUBE SIDE		N/A		
APPLICATION OF CODE STAMP + ATTACH NAMEPLATE		H		H
DATA REPORT SIGN OFF		H		H
GLASS BEAD BLASTING		N/A		
DATA PACKAGE SENT TO CUSTOMER		H		



# ALL-WELD HYDROSTATIC TEST REPORT

JOB NUMBER  
1173PQ

DATE  
SEPTEMBER 24, 2013

CUSTOMER  
ULTRA FAB INDUSTRIES LTD

SERIAL NO.  
7473

VESSEL DESCRIPTION  
48" OD VERTICAL OUTLET SEPARATOR TAG # 772-VESSE-201

TEST PRESSURE  
VESSEL  
1792 PSIG

TUBE

JACKET

TEST METAL TEMPERATURE  
50 F

HOLDING TIME  
1 HOUR MIN.

GAUGE #  
122 & 123  
LAST CALI. DATE  
12 - Jun - 13

GAUGE #  
LAST CALI. DATE

**REMARKS**

- 1) HYDROSTATIC TESTING SHALL BE PERFORMED IN ACCORDANCE WITH PARA UG-99 OF THE ASME CODE SECTION VIII, DIVISION 1.
- 2) THE METAL TEMPERATURE DURING HYDROSTATIC TEST IS RECOMMENDED TO BE HELD AT LEAST 30°F ABOVE THE MINIMUM DESIGN METAL TEMPERATURE TO A MAXIMUM OF 120°F BUT IN NO CASE LESS THAN THE MDMT.

COMMENTS: ACCEPTED

Witnessed by MSB  
Date: 9/25/13

Q.A. SIGNATURE *[Signature]*  
DATE: SEPTEMBER 24, 2013

MIKE KAMYAB  
REVIEWED   
WITNESSED   
FOR: SBM DATE: 9/25/13

646

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SBM OFFSHORE  
Print Name: CHAVESH SALLA  
Signature: *[Signature]*  
Date: SEP 25 13  
**Applus<sup>®</sup> VELOSI**  
Velosi America LLC

*M. A. Kamyab*









We're There.

Winters Instruments  
121 Railside Road  
Toronto, ON M3A 1B2  
Canada

Tel: 416-444-2345  
Fax: 416-444-8979  
1-800-WINTERS  
www.winters.com

# CALIBRATION TEST CERTIFICATE

Calibration Date: JUNE/27/13 Interval: 1 Year

Expiration: JUNE 27, 2014

<b>CUSTOMER: ALL WELD</b>		Winters Asset (Pressure)	ADT672
<b>PURCHASE ORDER: 13-0563</b>		Winters Serial # (Pressure)	27312420003
<b>DATE: JUNE 27, 2013</b>		Asset Accuracy (% FS): +/- 0.1%	
<b>TEST NUMBER: G13-0776</b>		Winters Asset (Vacuum)	
Customer Asset ID Number		Winters Serial # (Vacuum)	
Gauge Part Number	MARSH GAUGE	Asset Accuracy (% FS): +/-	
Gauge Serial Number	#45		
Gauge Range: 0-3000 PSI		Gauge Accuracy (% FS): N/A	Gauge Tolerance: N/A

Upscale		Downscale	
Above Gauge Reading	Reference Gauge Reading	Above Gauge Reading	Reference Gauge Reading
505	500		
1001	1000		
1498	1500		
2000	2000		
2497	2500		

Engineering Unit Used for Test: PSI  
Ambient Temp at Test: 29°C Relative Humidity: 56% Barometric Pressure: 99.3 KPA

Register Your Certificate at [www.winters.com/tc](http://www.winters.com/tc)

Technician: [Signature] Approved: [Signature]

NOTE: This instrument has been tested in accordance to ANSI/NCSS Z540-1 and complies with the relevant specifications/drawings of the above purchase order. All test equipment used in this certification is traceable to the National Institute of Standards and Technology.

F750-05 Rev 4 - Calibration Test Certificate-Gauges.doc / Last Revision: June 3, 2010

GCM  
JUL 03 2013



**Report For:** All-Weld Company Limited  
49 Passmore Avenue,  
SCARBOROUGH, Ontario  
M1V 4T1  
Phone: 416-299-3311  
Fax: 416-299-3387  
Email: mail@allweld.com

**Laboratory #:** 608638-12  
**Report Date:** May 14, 2012  
**Received Date:** May 9, 2012  
**Customer P.O. #:** N860-9764Q

**Specimen:** Water Sample

**TEST REPORT**

**RE: ANALYSIS OF WATER SAMPLE FOR HALOGEN AND SULPHUR RADICALS**

On May 9, 2012, CMTL received a water sample to determine the presence and relative concentration of halogen and sulphur radicals.

The submitted sample was analyzed using a DX-120 Ion Chromatogram as per ASTM D4327-11 and the following results were obtained:

HALOGEN RADICALS	CONCENTRATION (ppm)
Fluoride (F <sup>-</sup> )	0.5
Chloride (Cl <sup>-</sup> )	47.4
Bromide (Br <sup>-</sup> )	<0.5

SULPHUR RADICALS	CONCENTRATION (ppm)
Sulphate (SO <sub>4</sub> <sup>2-</sup> )	27.7

This report is subject to the following terms and conditions: 1. This report relates only to the specimen provided and there is no representation or warranty that it applies to similar substances or materials or the bulk of which the specimen is a part. 2. The content of this report is for the information of the customer identified above only and it shall not be reprinted, published or disclosed to any other party except in full. Prior written consent from Cambridge Materials Testing Limited is required. 3. The name Cambridge Materials Testing Limited shall not be used in connection with the specimen reported on or any substance or materials similar to that specimen without the prior written consent of Cambridge Materials Testing Limited. 4. Neither Cambridge Materials Testing Limited nor any of its employees shall be responsible or held liable for any claims, loss or damages arising in consequence of reliance on this report or any default, error or omission in its preparation or the tests conducted. 5. Specimens are retained 6 months, test reports and test data are retained 7 years from date of final test report and then disposed of, unless instructed otherwise in writing.

\* Cambridge Materials Testing Limited is accredited for tests listed on the scope of accreditation available for review at www.cambridgematerials.com.  
Test Report Template Revision March 2010

**Cambridge Materials Testing Limited**

Per Steve Brown QUALITY ASSURANCE

Per Rupinder Singh TECHNICIAN



11000  
11000

78			140	°F
15		AT	140	°F
20	F	AT	1378	PSI
N/A	PSI	AT	N/A	°F
N/A		AT	N/A	°F
N/A	PSI	AT	N/A	°F
N/A	°F	AT	N/A	PSI

SERIAL NO. 7A 76 YEAR BUILT 2013

CRN M 10138

TAG 772 SP-201

CERTIFIED BY  
**ALL-WELD**

COMPANY LIMITED  
SCARBOROUGH, ONTARIO  
ENGINEERS SINCE 1920

W.L.  
RT 1  
  
7/15

SHELL MAWP	9501	kPa AT	60	°C
SHELL MAEWP	103.5	kPa AT	60	°C
SHELL MDMT	-28.9	°C AT	9501	kPa
CHANNEL MAWP	N/A	kPa AT	N/A	°C
JACKET MAWP	N/A	kPa AT	N/A	°C
MAEWP	N/A	kPa AT	N/A	°C
MDMT	N/A	°C AT	N/A	kPa

SERIAL NO. 7473 YEAR BUILT 2013

C.R.N. M10135.5 10-296008

**TAG# 772-VESE-201**

## RADIOGRAPH REVIEW FORM

W.O. NO. 1173 PQ  
SERIAL NO. 7473

- 1) THE X-RAY MAP ATTACHED SHOWS THE LOCATION OF THE RADIOGRAPHS.
- 2) THE INFORMATION REQUIRED IN ASME SECTION V T-291 IS FOUND ON THE WELDING INSPECTION REPORT MADE OUT BY KV INSPECTION SERVICES.
- 3) EVALUATION AND DISPOSITION OF MATERIAL AND WELDS EXAMINED IS FOUND ON THE X-RAY MAP ATTACHED.
- 4) THE IDENTIFICATION OF THE MANUFACTURER'S REPRESENTATIVE WHO PERFORMED THE FINAL ACCEPTANCE OF THE RADIOGRAPHS IS IDENTIFIED BY HIS STAMP FOUND ON THE WELDING INSPECTION REPORT MADE OUT BY KV INSPECTION SERVICES ON THE LINE "MANUFACTURES REPRESENTATIVE".
- 5) THE DATE OF THE MANUFACTURES EVALUATION IS FOUND ON THE WELDING INSPECTION REPORTS MADE OUT BY KV INSPECTION SERVICES ON THE LINE "MANUFACTURES REPRESENTATIVE".



PREPARED BY: ROBERT C. BENTLEY  
Q.A. MANAGER

DATE: SEP 09 2013




# KV INSPECTION SERVICES LTD

Established 1980

1486 Wallace Road, Oakville, Ontario L6L 2Y2  
Office: (905) 844-9448 Fax: (905) 844-6697  
www.kvinspection.com Email: kvinsp1@aol.com

## EDWIN DUTSCHAEVER

	Natural Resources Canada	Ressources naturelles Canada
	Name Nom Edwin Dutschaever	Reg. No No matricule 515
	Issue Date Date d'émission 2011/11/28	
	This card does not identify the stated individual to be an employee or representative of Natural Resources Canada, Government of Canada. Cette carte n'identifie pas l'individu d'être un employé ou un représentant de Ressources naturelles Canada, Gouvernement du Canada.	
	Corrective lenses for <input checked="" type="checkbox"/> near     far vision Verres correctifs pour la vision de <input checked="" type="checkbox"/> pres     distance.	
	Signature	

	Natural Resources Canada	Ressources naturelles Canada			
Card No. / Carte de cert. : CAN-CCSE 48-9712		515			
Method Méthode	Level Niveau	Sector Secteur	Cert. Date Date cert.	Date recert. Date recert.	Expires Expiration
MT	2	EMC	1978/06/01		2014/12/31
PT	2	EMC	1980/07/01		2014/12/31
RT	2	EMC	1978/06/01		2014/12/31
For verification of certificate status, policies and detentions, visit website: http://nrc.certan.gc.ca/ Pour la vérification de la certification, les politiques, et les detentions, visitez le site web: http://nrc.certan.gc.ca/					
Manager, Certification Agency Gestionnaire, Organisme de certification					

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1486 Wallace Road, Oakville, Ontario L6L 2Y2

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www.kvinspection.com

Email: kvinsp1@aol.com

## CHRIS VEENEMAN

Natural Resources Canada		Ressources naturelles Canada	
	Name Nom	Christopher Veeneman	
	Rec. No. No. matricule	6651	
	Issue Date Date d'emission	2011/02/14	
	Corrective lenses for [X] near [X] far vision Verres correctifs pour la vision de [X] pres [X] distance		
	Signature		

Natural Resources Canada		Ressources naturelles Canada			
Qualified to / Qualifié(e) en		6651			
LEVEL 20607 Qualification					
Method Méthode	Level Niveau	Sector Secteur	Cert. Date Date cert.	Date recert Date recert	Expires Expiration
MT	2	EMC	1997/05/08		2013/12/31
PT	2	EMC	1997/11/07		2013/12/31
RT	2	EMC	2000/01/06		2013/12/31
UT	2	EMC	2010/06/03		2013/12/31



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Established 1980

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Office: (905) 844-9448 Fax: (905) 844-6697

www.kvinspection.com

Email: kvinsp1@aol.com

## FRANK MARUNDE



Natural Resources  
Canada

Ressources naturelles  
Canada



Name: **Frank Marunde**  
Nom:  
Reg. No. **8885**  
No. matricule  
Issue Date: **2012/11/29**  
Date d'emission

This card does not identify the stated individual to be an employee or representative of Natural Resources Canada, Government of Canada.  
Cette carte n'identifie pas l'individu d'être un employé ou un représentant de Ressources naturelles Canada, Gouvernement du Canada.

Corrective lenses for || near || far vision.  
Verres correctifs pour la vision de || près || distance.

Signature:



Natural Resources  
Canada

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Registered to Certifie selon CAR 1058 48 9712

8885

Method Methode	Level Niveau	Sector Secteur	Cert. Date Date cert.	Date recert. Date recert.	Expires Expiration
BT	2	EMC	1998/10/26		2015/12/31
PT	2	EMC	1998/10/26		2015/12/31
UT	2	EMC	2005/10/31		2015/12/31

The verification of certificates status, policies and directions, visit website:  
<http://nrc.can.ca> / Pour la vérification de la certification, les politiques, et les directives,  
visitez le site web: <http://nrc.can.ca>

Manager, Certifying Agency  
Gestionnaire, Organisme de certification

# KV INSPECTION SERVICES LTD

Established 1980

1486 Wallace Road, Oakville, Ontario L6L 2Y2

Office: (905) 844-9448 Fax: (905) 844-6697

www.kvinspection.com

Email: kvinsp1@aol.com

## JOHN MACDONALD



Natural Resources  
Canada

Ressources naturelles  
Canada



Name: **John D.E. MacDonald**  
Nom:  
Reg. No.: **10375**  
No. matricule:  
Issue Date: **2013/01/26**  
Date d'émission:

This card does not identify the stated individual to be an employee or representative of Natural Resources Canada, Government of Canada.  
Cette carte n'identifie pas l'individu d'être un employé ou un représentant de Ressources naturelles Canada, Gouvernement du Canada.

Corrective lenses for || near || far vision.  
Verres correctifs pour la vision de || pres || distance.

Signature | *John D.E. MacDonald* | 8 147 141 51



Natural Resources  
Canada

Ressources naturelles  
Canada

Certificat de Certebe selon CAN/CSB 48 9712

10375

Method Méthode	Level Niveau	Sector Secteur	Cert. Date Date cert.	Date recert. Date recert.	Expires Expiration
MT	2	EMC	2001/01/09		2015/12/31
PT	2	EMC	2000/11/27		2015/12/31
RT	1	EMC	2007/04/05		2015/12/31

For certifiers or certification status, policies and definitions, visit website:  
http://nrc.nrcan.gc.ca/ Pour la vérification de la certification, les politiques, et les définitions,  
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Manager, Certifying Agency  
Gestionnaire, Organisme de certification

# KV INSPECTION SERVICES LTD

Established 1980

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 www.kvinspection.com Email: kvinsp1@aol.com

## SHERWIN SUYOM



Natural Resources  
Canada

Ressources naturelles  
Canada



Name: **Sherwin Suyom**  
 Reg. No: **15133**  
 Issue Date: **2011/04/01**  
 Date d'émission:

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Signature:  (optional)



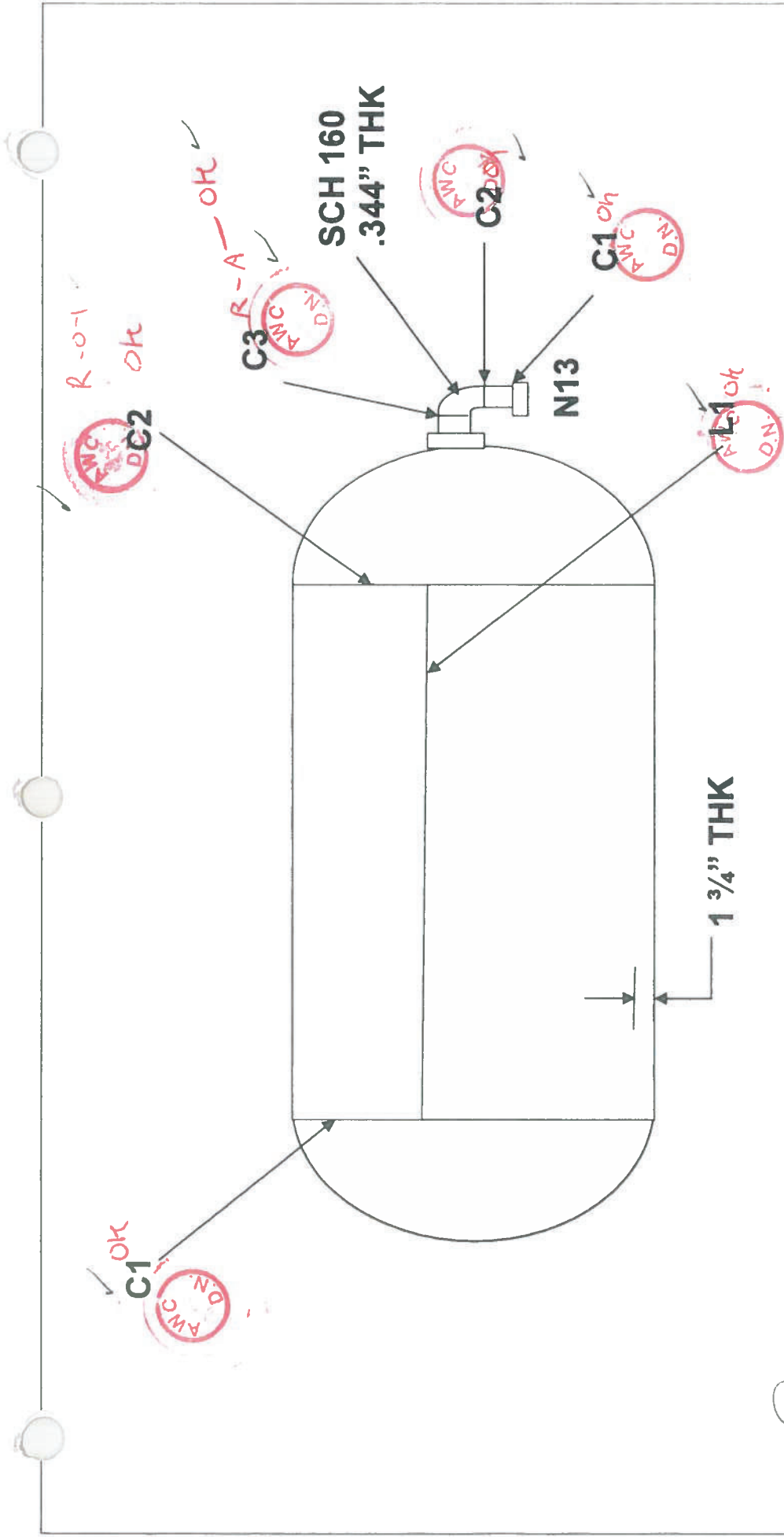
Natural Resources  
Canada

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Canada

Method Méthode	Level Niveau	Sector Secteur	Cert. Date Date cert.	Date recert. Date recert.	Expires Expiration
MT	2	EMC	2011/03/23		2013/12/31
PT	2	EMC	2010/12/23		2013/12/31

For more info on certification data, process and decisions, visit website:  
 http://www.nrcc.gc.ca. Pour la consultation de la certification, les conditions, et les décisions,  
 visitez le site web: http://www.nrcc.gc.ca

For more info on the Agency:  
 Pour plus d'infos sur le programme de certification



AI \_\_\_\_\_ Date MAR 15 13

**ALL-WELD CO. LTD. - RT MAP**  
 CLIENT: ULTRAFAB  
 WORK ORDER #: 1173PQ SN 7473  
 JOB DESCRIPTION: 48" O.D. VERTICAL SEPARATOR  
 DRAWING #: 1173-1  
 PREPARED BY: D.NESCI  
 DATE: FEB. 28/13

RT MAP - 1173PQ  
 ASME SECTION VIII. DIV. 1  
 100% (RT-1)  
 MATERIAL  
 SA-240 316/316L, SA-182 F316/316L, SA-312 TP316/TP316L, SA-403 316/316L  
 P.O. 13-0169-1173PQ

# Radiographic Examination Report RT

## Specification - Acceptance Criteria

ASME UW-51 UW-52 B31.1 B31.3NS CSA Other

### General Data

Customer	ALL WELD	Date	14 MARCH 2013
Location	SCARBOROUGH	P. O. #	
Project	VESSEL	Shop Order #	1173PQ SN 7473
Procedure	KV#5 REV 3	Worksheet #	36645
Technician	J. MacDonald	CGSB Reg #	10375 ASNT/SNT-TC-1A Level 1

### Technical Data Co 60

Material Type	Carbon <u>Alloys</u>	Isotope	IR 192 <u>Other</u>	Physical/Focal Size	.188"
Base Material Thickness	1 3/4"	Exposure	<u>Single Wall</u>	Double Wall	Film per Cassette 1
Weld Thickness	1 3/4"	View	<u>Single Wall</u>	Double Wall	PWHT Yes <u>No</u>
Reinforcement	1/4"	Number of Exposures	7		
Film Mfg.	KODAK	Minimum Source to Object Distance	24"		
Film Type	AA	Maximum Distance from Source Side of Object to Film	2"		

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
SN 7473										
LI	0-1								✓	
	1-2								✓	
	2-3								✓	
	3-4								✓	
	4-5								✓	
	5-6								✓	
	6- <del>END</del>								✓	

ACCEPTED/REVIEWED/RELEASED 046  
 for and on behalf of: SBM OFFSHORE CO  
 Print Name: ANESH SADA  
 Signature: [Signature]  
 Date: March 2013  
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 RT/MT/PT

KV Inspection Technician	<u>[Signature]</u>	Date	14 MARCH 2013
Customer Representative	<u>[Signature]</u>	Date	MAR 21 2013



1486 Wallace Road  
 Oakville, Ontario L6L 2Y2  
 Phone: 905-844-9448  
 Fax: 905-844-6697

# Radiographic Examination Report RT

## Specification - Acceptance Criteria

ASME  UW-51  UW-52 B31.1 B31.3NS CSA Other

### General Data

Customer	ALL WELD COMPANY	Date	08/06/13
Location	SCARBOROUGH ONT.	P. O. #	
Project	ULTRAFAB	Shop Order #	113PQ - 7473
Procedure	KW 75 REV 3	Worksheet #	37169
Technician	M. PERDON	CGSB Reg #	12283 ASNT/SNT-TC-1A Level 1

### Technical Data

Material Type	Carbon <input checked="" type="checkbox"/> Alloys <input checked="" type="checkbox"/>	Isotope	IR 192. <input checked="" type="checkbox"/> Other <input type="checkbox"/>	Physical/Focal Size	6x60
Base Material Thickness	1 3/4	Exposure	Single Wall <input checked="" type="checkbox"/> Double Wall <input type="checkbox"/>	Film per Cassette	1
Weld Thickness	1 3/4	View	Single Wall <input checked="" type="checkbox"/> Double Wall <input type="checkbox"/>	PWHT	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>
Reinforcement	1/8	Number of Exposures	PANORAMIC		
Film Mfg.	KODAK	Minimum Source to Object Distance			
Film Type	RA	Maximum Distance from Source Side of Object to Film	17/8		

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
C1	4-8									
	0-1								<input checked="" type="checkbox"/>	
	1-2								<input checked="" type="checkbox"/>	
	2-3								<input checked="" type="checkbox"/>	
	3-4								<input checked="" type="checkbox"/>	
	4-5								<input checked="" type="checkbox"/>	
	5-6								<input checked="" type="checkbox"/>	
	6-7								<input checked="" type="checkbox"/>	
	7-8								<input checked="" type="checkbox"/>	
	8-9								<input checked="" type="checkbox"/>	
	9-10								<input checked="" type="checkbox"/>	
	10-0								<input checked="" type="checkbox"/>	

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SAM DESSAONE  
 Print Name: GANESH SAHA  
 Signature: [Signature]  
 Date: 08/06/13  
 Applus® VELOSI  
 Velosi America LLC

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 CGSB LEVEL II, Reg # 515  
 RT/MT/PT  
 SNT-TC-1A, LEVEL II  
 RT/MT/PT

KV Inspection Technician	[Signature]	Date	08/06/13
Customer Representative	[Signature]	Date	AUG 13 2013



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 Oakville, Ontario L6L 2Y2  
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 Fax: 905-844-6697

## Radiographic Examination Report RT

### Specification - Acceptance Criteria

ASME UW-51 UW-52 B31.1 B31.3NS CSA Other

### General Data

Customer	Allweld	Date	04/04/13
Location	Toronto	P. O. #	
Project	Vessel Vertical Duplet	Shop Order #	1173 PQ ultrafab 7473
Procedure	KV5 Rev.3	Worksheet #	36784
Technician	MIRRON	CGSB Reg #	17883 ASNT/SNT-TC-1A Level 1

### Technical Data

Material Type	Carbon <u>Alloys</u>	Isotope	<u>Other</u>	Physical/Focal Size	188	
Base Material Thickness	1 3/4"	Exposure	<u>Single Wall</u>	Double Wall	Film per Cassette	1
Weld Thickness	1 3/4"	View	<u>Single Wall</u>	Double Wall	PWHT	Yes <u>No</u>
Reinforcement	1/2"	Number of Exposures	1			
Film Mfg.	Kodak	Minimum Source to Object Distance	DANORUMML			
Film Type	AA	Maximum Distance from Source Side of Object to Film	2 3/4"			

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
	48" Q									
(2)	0-1 (+3 4/4)							See Mirron		✓
	1-2								✓	
	2-3								✓	
	3-4								✓	
	4-5								✓	
	5-6								✓	
	6-7								✓	
	7-8								✓	
	8-9								✓	
	9-10								✓	
	10-0								✓	

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SAM OFFSHORE GIN 046  
 Print Name: GANESH SANA  
 Signature: [Signature]  
 Date: [Signature] 10/13  
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 SNT-TC-1A, LEVEL III  
 RT/MT/PT

KV Inspection Technician

Date 04/04/13

Customer Representative

Date APR 08 2013



**Radiographic Examination Report  
RT**

**Specification - Acceptance Criteria**

ASME UW-51 UW-52 B31.1 B31.3NS CSA Other

**General Data**

Customer	ALL WELD	Date	29 April 2013
Location	SCARBOROUGH	P. O. #	
Project	VESSEL	Shop Order #	1173PO - SN 7473
Procedure	KV #5 REV #3	Worksheet #	36928
Technician	J. MACDONALD	CGSB Reg # 10375	ASNT/SNT-TC-1A Level 1

**Technical Data 660**

Material Type	Carbon <input checked="" type="radio"/> Alloys	Isotope	IR 192 <input checked="" type="radio"/> Other	Physical/Focal Size	1188"
Base Material Thickness	3/4"	Exposure	Single Wall <input checked="" type="radio"/> Double Wall	Film per Cassette	1
Weld Thickness	1 3/4"	View	Single Wall <input checked="" type="radio"/> Double Wall	PWHT	Yes <input type="radio"/> No <input checked="" type="radio"/>
Reinforcement	1/8"	Number of Exposures	1		
Film Mfg.	KODAK	Minimum Source to Object Distance	Panoramic		
Film Type	AA	Maximum Distance from Source Side of Object to Film	17 1/2"		

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
C2R	O-1									✓

ACCEPTED/REVIEWED/RELEASED 046  
for and on behalf of: SAM OFFSHORE  
Print Name: GAMBISH SAHA  
Signature: [Signature]  
Date: [Date] 29 April 2013  
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CGSB LEVEL II, Reg # 515  
RT/MT/PT  
SNT-TC-1A, LEVEL III  
RT/MT/PT

KV Inspection Technician	[Signature]	Date	29 April 2013
Customer Representative	[Signature]	Date	MAY 06 2013





1486 Wallace Road  
Oakville, Ontario L6L 2Y2  
Phone: 905-844-9448  
Fax: 905-844-6697

# Radiographic Examination Report RT

## Specification - Acceptance Criteria

ASME  UW-51  UW-52 B31.1 B31.3NS CSA Other

### General Data

Customer	AM WELD LTD.	Date	Aug 13/13
Location	SCARBOROUGH ONT	P. O. #	
Project	ULTRAFAB.	Shop Order #	1173 PR - 7473
Procedure	KW #6 REV 2	Worksheet #	37436
Technician	C VENNEMAN	CGSB Reg #	6651 ASNT/SNT-TC-1A Level II

### Technical Data

Material Type	Carbon	Alloys <input checked="" type="checkbox"/>	Isotope	IR 192 <input checked="" type="checkbox"/> Other	Physical/Focal Size	.13	
Base Material Thickness	5/16		Exposure	Single Wall	Double Wall <input checked="" type="checkbox"/>	Film per Cassette	1
Weld Thickness	5/16		View	Single Wall	Double Wall <input checked="" type="checkbox"/>	PWHT	Yes No <input checked="" type="checkbox"/>
Reinforcement	.125		Number of Exposures				3/WELD
Film Mfg.	KODAK		Minimum Source to Object Distance				18"
Film Type	AA		Maximum Distance from Source Side of Object to Film				OD

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
N13	2"φ									
C1	A								<input checked="" type="checkbox"/>	
	B								<input checked="" type="checkbox"/>	
	C								<input checked="" type="checkbox"/>	
	2"φ									
C2	A								<input checked="" type="checkbox"/>	
	B								<input checked="" type="checkbox"/>	
	C								<input checked="" type="checkbox"/>	

046

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: S B M OFF SHORE

Print Name: GANESH SAHA

Signature: *[Signature]*

Date: Aug 22/13

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RT/MT/PT

KV Inspection Technician	<i>[Signature]</i>	Date	Aug 13/13
Customer Representative	<i>[Signature]</i>	Date	AUG 20 2013



# Radiographic Examination Report RT

**Inspection Services Ltd.**

1486 Wallace Road  
Oakville, Ontario L6L 2Y2  
Phone: 905-844-9448  
Fax: 905-844-6697

## Specification - Acceptance Criteria

ASME / UW-51 / UW-52 B31.1 B31.3NS CSA Other

### General Data

Customer: ALL WELD Co LTD Date: Aug 30/13  
 Location: SCARBOROUGH ONT P. O. #  
 Project: ULTRAFAB Shop Order #: 7473 - 1173  
 Procedure: KW AB RW 2 Worksheet #: 37542  
 Technician: B MONTAGNA CGSB Reg #: 439 ASNT/SNT-TC-1A Level: II

### Technical Data

Material Type: Carbon Alloys  Isotope: IR 192  Other Physical/Focal Size: 13  
 Base Material Thickness: 5/16 Exposure: Single Wall Double Wall Film per Cassette: 1  
 Weld Thickness: 5/16 View: Single Wall Double Wall PWHT: Yes  No   
 Reinforcement: 125 Number of Exposures: 3/weld  
 Film Mfg.: KODAK Minimum Source to Object Distance: 18"  
 Film Type: AA Maximum Distance from Source Side of Object to Film: 0.5

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
<u>N13</u>	<u>2nd</u>									
<u>C3</u>	<u>A</u>			<input checked="" type="checkbox"/>				<u>MT</u>		<input checked="" type="checkbox"/>
	<u>B</u>							<u>MT</u>	<input checked="" type="checkbox"/>	
	<u>C</u>							<u>MT</u>	<input checked="" type="checkbox"/>	

ACCEPTED/REVIEWED/RELEASED 046  
 for and on behalf of: SCIM OFI SHOPS  
 Print Name: GRANT S. HILL  
 Title: GRN  
 Date: SEP 1/2013  
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**RT/MT/PT**

KV Inspection Technician: [Signature] Date: Aug 31/13  
 Customer Representative: \_\_\_\_\_ Date: SEP 03 2013

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 Oakville, Ontario L6L 2Y2  
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 Fax: 905-844-6697

# Radiographic Examination Report RT

## Specification - Acceptance Criteria

ASME  UW-51  UW-52 B31.1 B31.3NS CSA Other

### General Data

Customer	Allweld	Date	09/05/13
Location	Scarborough	P. O. #	
Project	ultrafab	Shop Order #	7473 -1173
Procedure	KV6 Ver 2	Worksheet #	37561
Technician	MPewon	CGSB Reg #	12883
		ASNT/SNT-TC-1A Level	1

### Technical Data

Material Type	Carbon	Alloys <input checked="" type="checkbox"/>	Isotope	IR 192 <input checked="" type="checkbox"/> Other	Physical/Focal Size	.13	
Base Material Thickness	S160		Exposure	Single Wall	Double Wall <input checked="" type="checkbox"/>	Film per Cassette	1
Weld Thickness	S160		View	Single Wall	Double Wall <input checked="" type="checkbox"/>	PWHT	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>
Reinforcement	.125		Number of Exposures				3
Film Mfg.	Kodak		Minimum Source to Object Distance				18"
Film Type	AA		Maximum Distance from Source Side of Object to Film				OD


UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
	2" Q									
N13 C3R	A							REPAIRS	✓	
	B								✓	
	C								✓	

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 RT/MT/PT  
 SNT-TC-1A, LEVEL III  
 RT/MT/PT

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBM OFF SHORE  
 Print Name: CHRISTIE SAHWA  
 Signature: [Signature]  
 Date: SEP 10 2013  
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KV Inspection Technician

Customer Representative

~~CGSB LEVEL II, Reg# 515  
 RT/MT/PT  
 SNT-TC-1A, LEVEL III  
 RT/MT/PT~~  


Date 09/05/13

Date SEP 09 2013

# ULTRAFAB PROJECT

SC PER VISIT BY HOSNEY SHETEIWY JULY 4, 2013

## CS VESSELS

SERIAL #: 7468 & 7469  
REQUIREMENT: MAGNETIC PARTICLE EXAMINATION (MT) (ONE BOTTOM/ ONE TOP HEAD LOCATION)  
SCHEDULE: WEDNESDAY, JULY 10, 2013  
TEST CARRIED OUT BY: KVI  
WITNESSED BY: AWC INSPECTOR & ULTRAFAB INSPECTOR (HOSNY SHETEIWY)

## 1173 SS VESSELS

SERIAL #: 7473 & 7474 (HEADS WELDED TO SHELL)  
REQUIREMENT: LIQUID PENETRANT EXAMINATION (PT)  
POSITIVE MATERIAL IDENTIFICATION (PMI)  
ULTRASONIC EXAMINATION (UT)  
NOTE: Thickness reading, chemical analysis and LPI of external side only in way of knuckles  
SCHEDULE: WEDNESDAY, JULY 10, 2013  
TEST CARRIED OUT BY: KVI  
WITNESSED BY: AWC INSPECTOR & ULTRAFAB INSPECTOR (HOSNY SHETEIWY)

SERIAL #: 7473 ( HEAD ONLY)  
LIQUID PENETRANT EXAMINATION (PT)  
POSITIVE MATERIAL IDENTIFICATION (PMI)  
ULTRASONIC EXAMINATION (UT)  
NOTE: Thickness reading, chemical analysis and LPI of external side only in way of knuckles  
SCHEDULE: WEDNESDAY, JULY 10, 2013  
TEST CARRIED OUT BY: KVI  
WITNESSED BY: AWC INSPECTOR & ULTRAFAB INSPECTOR (HOSNY SHETEIWY)

### General Data

Customer	All-Weld Company	Date	July 10, 2013
Location	Scarborough, ON	P. O. #	
Project	1173 PQ ULTRA FAB	Shop Order #	
Procedure	PMI # 5 Rev. 04	Worksheet #	37218
Technician	Frank Marunde	PMI Certified	✓ CGSB Reg # 6651

### Test Method & Equipment

Technique	<input type="radio"/> Full Analysis <input checked="" type="radio"/> Main components <input type="radio"/> Material Verification			
Equipment	<input checked="" type="radio"/> Niton XLP 818 Alloy Analyzer- Ser # 11512	Source Details	<input checked="" type="radio"/> Americium 241	
Calibration	<input checked="" type="radio"/> To certified reference material			
CRM Used:	1 ARM 1¼ Cr ½ Mo	Readings	Cr% 1.16	Mo% 0.52
Like Sample:	316 G392	Readings:	Cr% 16.52	Mo% 2.13
			Ni% 9.89 ± 0.44	

### Inspection Results

#### Material Description:

Part/Drawing #	Description	Display	Cr%	Ni%	Mo%		
S/N 7473	Top Head	316	16.65	10.26	2.07		
	Bottom Head	316	16.61	10.37	2.05		
S/N 7474	Bottom Head	316	16.82	9.7 ±0.42	2.08		

ACCEPTED/REVIEWED/RELEASED 046  
 for and on behalf of: SBM OFFSHORE  
 Print Name: GABRIEL SAHA  
 Signature: [Signature]  
 Date: SEP 20 2013  
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KV Inspection Technician	<u>[Signature]</u>	Date	July 10, 2013
Customer Representative	<u>[Signature]</u>	Date	Jul. 11 2013



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 Oakville, Ontario L6L 2Y6  
 Phone: 905-844-9448  
 Fax: 905-844-6697

## Ultrasonic Thickness Testing Report

### Specification – Acceptance Criteria

- ASME Section V, Art. 5
- ASTM SE 797
- Customer Specifications
- Other:

### General Data

Customer	All-Weld Company	Date	July 10, 2013	
Location	Scarborough, Ontario	P. O. #		
Project	1173 PQ ULTRA FAB	Shop Order #	S/N 7473 Bottom Head	
Procedure	ASTM SE 797	Worksheet #	37218	
Technician	Frank Marunde	CGSB Reg #	8885	SNT-TC-IA Level III

### Technical Data

Material Type     Stainless Steel     Carbon Steel     Other

### Test Equipment

Ultrasonic Thickness Gauge     Panametrics MG2-DL Ser# 060296910     Other

Probe     Standard     Other

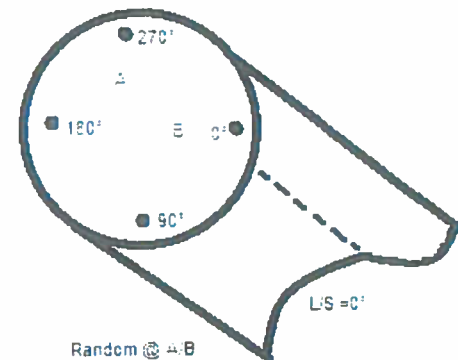
Couplant     Krautkramer ultrasonic gel     Other

Calibration    Test Specimen Micrometer Area of Head

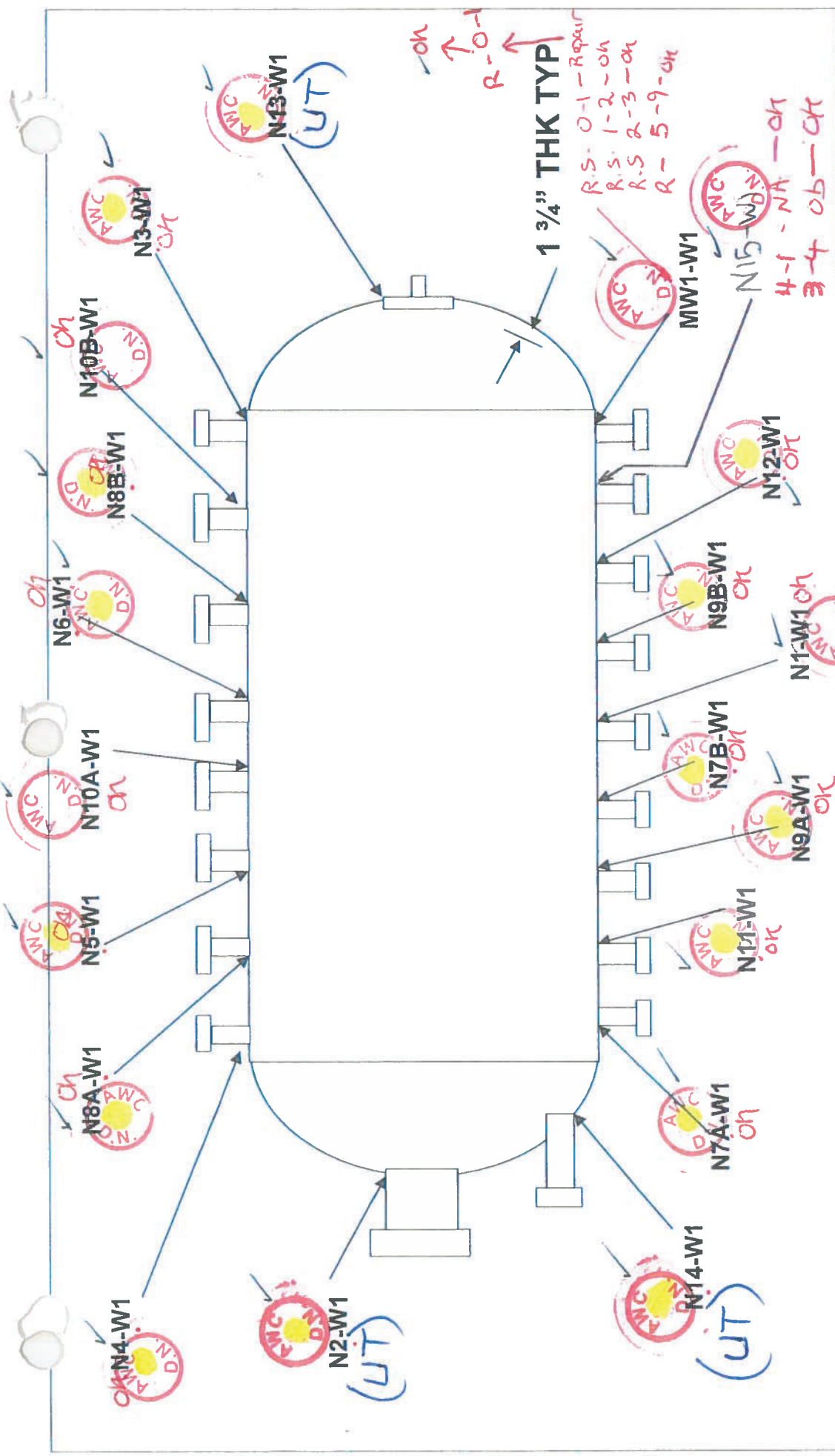
### Inspection

Description:    Measurements at knuckle area of head, plus random @ A and B

Item #	Point of Inspection	Readings	Interpretation	
Knuckle Area	0°	1.781		
	90°	1.77		
	180°	1.788		
	270°	1.778		
Random	A	1.761		
	B	1.767		
<div style="border: 2px solid red; padding: 5px; display: inline-block;"> <p style="margin: 0;">ACCEPTED/REVIEWED/RELEASED <span style="float: right;">046</span></p> <p style="margin: 0;">for and on behalf of: <u>SBM OFFSHORE</u></p> <p style="margin: 0;">Print Name: <u>CLAYTON SAHAI</u></p> <p style="margin: 0;">Signature: <u>[Signature]</u></p> <p style="margin: 0;">Date: <u>28/6/25/13</u></p> </div> <div style="margin-left: 20px; text-align: center;"> <p><b>Applus®</b></p> <p>VELOSI</p> <p>Velosi America LLC</p> </div>				
<p>Note: Representatives from ABS and SBM Offshore were present at time of inspection</p>				



KV Inspection Technician		Date	July 10, 2013
Customer Representative		Date	JUL 11 2013



**ALL-WELD CO. LTD. - UT MAP**

CLIENT: ULTRAFAB  
 WORK ORDER #: 1173PQ - SN 7473  
 JOB DESCRIPTION: 48" O.D. VERTICAL INLET  
 DRAWING #: 1173-1-IN  
 PREPARED BY: D.NESCI  
 DATE: March 6, 2013

UT MAP - 1173PQ

ASME SECTION VIII. DIV. 1

MATERIAL SA-240 316/316L, SA-182 F316/316L

P.O. 13-0225

RT shell  
 Conn's

1 3/4" THK TYP

R.S. 0-1 - Repair  
 R.S. 1-2 - oh  
 R.S. 2-3 - oh  
 R. 5-9 - oh

oh  
 ↑ 0-1  
 R-0-1

4-1 - NA - oh  
 3-4 05 - oh

(UT)

(UT)

(UT)

(UT)

1486 Wallace Road  
 Oakville, Ontario L6L 2Y2  
 Phone: 905-844-9448  
 Fax: 905-844-6697

## Ultrasonic Examination Report UT

### General Data

Customer	All-Weld Company	Date	April 5, 2013		
Shop Order	1173 PQ Serial # 7473	Project			
Component		P.O. #		Worksheet #:	36762
Drawing		Rev.	Technician	Frank Marunde	SNT-TC-1A Level III
NDT Specification	ASME Sec. VIII	Appendix	12	NDT Procedure	KV-UT# 1 R.02

### Technical Data – Ultrasonic Examination (UT)

Material Type	Stainless Steel	Technique	<input checked="" type="radio"/> Pulse Echo-Contact <input type="radio"/> Immersion <input type="radio"/> Dual		
Material Thickness	1 3/4"	Instrument Brand	<input checked="" type="radio"/> Olympus Epoch 1000i	Serial #	090054812
Weld Type	<input type="radio"/> Butt <input checked="" type="radio"/> T Joint <input type="radio"/> Fillet	Surface	<input checked="" type="radio"/> As Rolled <input type="radio"/> Ground <input type="radio"/> Machined <input type="radio"/> Shot Blasted		
Weld Thickness	1 3/4"	Couplant	<input checked="" type="radio"/> UT-X <input type="radio"/> Oil <input type="radio"/> Other	Temperature	
Heat Treated	<input type="radio"/> YES <input type="radio"/> NO	Sensitivity (PRL)	49 dB / 57 dB		
Heat Treatment		Surface Conditions			

### Transducers/Calibration Blocks

Diameter	Size	Beam Angle	Frequency	Manufacturer	Blocks
<input type="radio"/> 1/4" <input type="radio"/> 3/4"	<input checked="" type="radio"/> 5/8" x 3/4"	<input checked="" type="radio"/> 45°	<input type="radio"/> 1.00 MHz	<input type="radio"/> Techsonic	<input type="radio"/> IIW A2
<input type="radio"/> 3/8" <input type="radio"/> 1"	<input type="radio"/> 1/2" x 1"	<input checked="" type="radio"/> 60°	<input checked="" type="radio"/> 2.25 MHz	<input checked="" type="radio"/> Panametrics	<input type="radio"/> ASTM E164 MAB
<input type="radio"/> 1/2" <input type="radio"/> 1 1/8"	<input type="radio"/> 1" x 1"	<input checked="" type="radio"/> 70°	<input type="radio"/> 5.00 MHz	<input type="radio"/> Krautkramer	<input type="radio"/> Back Reflection
<input type="radio"/>	<input type="radio"/>	<input type="radio"/> Normal	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/> ASME

### Scope of Testing

1173 PQ-7473: Examination of category D nozzle attachment welds  
 N2-W1 & N14-W1


  
 APR 11 2013

ACCEPTED/REVIEWED/RELEASED 046  
 for and on behalf of: SBM OFFSHORE  
 Print Name: GANESH SAHAI  
 Signature: [Signature]  
 Date: April 5/13  
**Applus<sup>®</sup> VELOSI**  
 Velosi America LLC

### Scanning

Test Area	Disposition	From	Length	Depth	Amplitude

### Evaluation – Acceptance

Accepted	KV Inspection Services – Technician		Date	April 05, 2013
<input type="radio"/> Rejected	CGSB No. 48.9712-2000 Reg. No.	8885	Place	Scarborough, ON.



**General Data**

Customer	All-Weld Company	Date	April 30, 2013		
Shop Order	1173 PQ Serial # 7473	Project			
Component		P.O. #		Worksheet #:	36888
Drawing		Rev.	Technician	Frank Marunde	SNT-TC-1A Level III
NDT Specification	ASME Sec. VIII	Appendix	12	NDT Procedure	KV-UT# 1 R.02

**Technical Data – Ultrasonic Examination (UT)**

Material Type	Stainless Steel	Technique	<input checked="" type="radio"/> Pulse Echo-Contact <input type="radio"/> Immersion <input type="radio"/> Dual		
Material Thickness	1 3/4"	Instrument Brand	<input checked="" type="radio"/> Olympus Epoch 1000i	Serial #	090054812
Weld Type	<input type="radio"/> Butt <input checked="" type="radio"/> T Joint <input type="radio"/> Fillet	Surface	<input checked="" type="radio"/> As Rolled <input type="radio"/> Ground <input type="radio"/> Machined <input type="radio"/> Shot Blasted		
Weld Thickness	1 3/4"	Couplant	<input checked="" type="radio"/> UT-X <input type="radio"/> Oil <input type="radio"/> Other	Temperature	
Heat Treated	<input type="radio"/> YES <input type="radio"/> NO	Sensitivity (PRL)	47 dB / 57 dB		
Heat Treatment		Surface Conditions			

**Transducers/Calibration Blocks**

Diameter		Size	Beam Angle	Frequency	Manufacturer	Blocks
<input type="radio"/> 1/4"	<input type="radio"/> 3/4"	<input type="radio"/> 5/8" x 3/4"	<input checked="" type="radio"/> 45°	<input type="radio"/> 1.00 MHz	<input type="radio"/> Techsonic	<input type="radio"/> IIW A2
<input type="radio"/> 3/8"	<input type="radio"/> 1"	<input type="radio"/> 1/2" x 1"	<input type="radio"/> 60°	<input checked="" type="radio"/> 2.25 MHz	<input checked="" type="radio"/> Panametrics	<input type="radio"/> ASTM E164 MAB
<input checked="" type="radio"/> 1/2"	<input type="radio"/> 1 1/8"	<input type="radio"/> 1" x 1"	<input checked="" type="radio"/> 70°	<input type="radio"/> 5.00 MHz	<input type="radio"/> Krautkramer	<input type="radio"/> Back Reflection
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/> Normal	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/> ASME

**Scope of Testing**

1173 PQ-7473: Examination of category D attachment weld  
Nozzle: N14-W1

PER NCR N13-037

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBM OFFSHORE  
 Print Name: CLAUDE SAHN  
 Signature: [Signature]  
 Date: Aug 23/13  
**Applus<sup>®</sup> VELOSI**  
 Veloci America LLC



AUG 20 2013

**Scanning**

Test Area	Disposition	From	Length	Depth	Amplitude

**Evaluation – Acceptance**

<input checked="" type="radio"/> Accepted	KV Inspection Services – Technician	<u>[Signature]</u>	Date	April 30, 2013
<input type="radio"/> Rejected	CGSB No. 48.9712-2000 Reg. No.	8885	Place	Scarborough, ON.

### General Data

Customer	All-Weld Company		Date	August 26, 2013	
Shop Order	1173 PQ		Project		
Component			P.O. #	Worksheet #:	37490
Drawing	Rev.		Technician	Frank Marunde	SNT-TC-1A Level III
NDT Specification	ASME Sec. VIII		Appendix	12	NDT Procedure KV-UT# 1 R.02

### Technical Data - Ultrasonic Examination (UT)

Material Type	Stainless Steel	Technique	<input checked="" type="radio"/> Pulse Echo-Contact <input type="radio"/> Immersion <input type="radio"/> Dual		
Material Thickness	1 3/4"	Instrument Brand	Olympus Epoch 1000i	Serial #	090054812
Weld Type	<input type="radio"/> Butt <input checked="" type="radio"/> T Joint <input type="radio"/> Fillet	Surface	<input checked="" type="radio"/> As Rolled <input type="radio"/> Ground <input type="radio"/> Machined <input type="radio"/> Shot Blasted		
Weld Thickness	1 3/4"	Couplant	<input checked="" type="radio"/> UT-X <input type="radio"/> Oil <input type="radio"/> Other	Temperature	
Heat Treated	<input type="radio"/> YES <input type="radio"/> NO	Sensitivity (PRL)	49 dB / 58 dB		
Heat Treatment		Surface Conditions			

### Transducers/Calibration Blocks

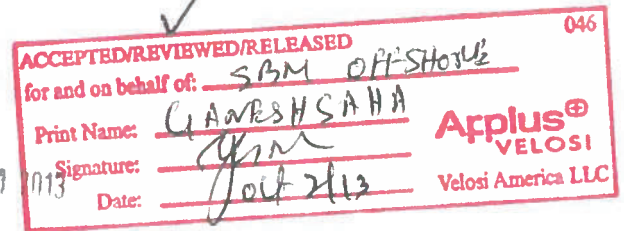
Diameter		Size	Beam Angle	Frequency	Manufacturer	Blocks
<input type="radio"/> 1/4"	<input type="radio"/> 3/4"	<input type="radio"/> 5/8" x 3/4"	<input checked="" type="radio"/> 45°	<input type="radio"/> 1.00 MHz	<input type="radio"/> Techsonic	<input type="radio"/> IIW A2
<input type="radio"/> 3/8"	<input type="radio"/> 1"	<input type="radio"/> 1/2" x 1"	<input type="radio"/> 60°	<input checked="" type="radio"/> 2.25 MHz	<input checked="" type="radio"/> Panametrics	<input type="radio"/> ASTM E164 MAB
<input checked="" type="radio"/> 1/2"	<input type="radio"/> 1 1/8"	<input type="radio"/> 1" x 1"	<input checked="" type="radio"/> 70°	<input type="radio"/> 5.00 MHz	<input type="radio"/> Krautkramer	<input type="radio"/> Back Reflection
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/> Normal	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/> ASME

### Scope of Testing

Ser# 7473: Examination of category D attachment welds  
Nozzle N13-W1



OCT 09 2013

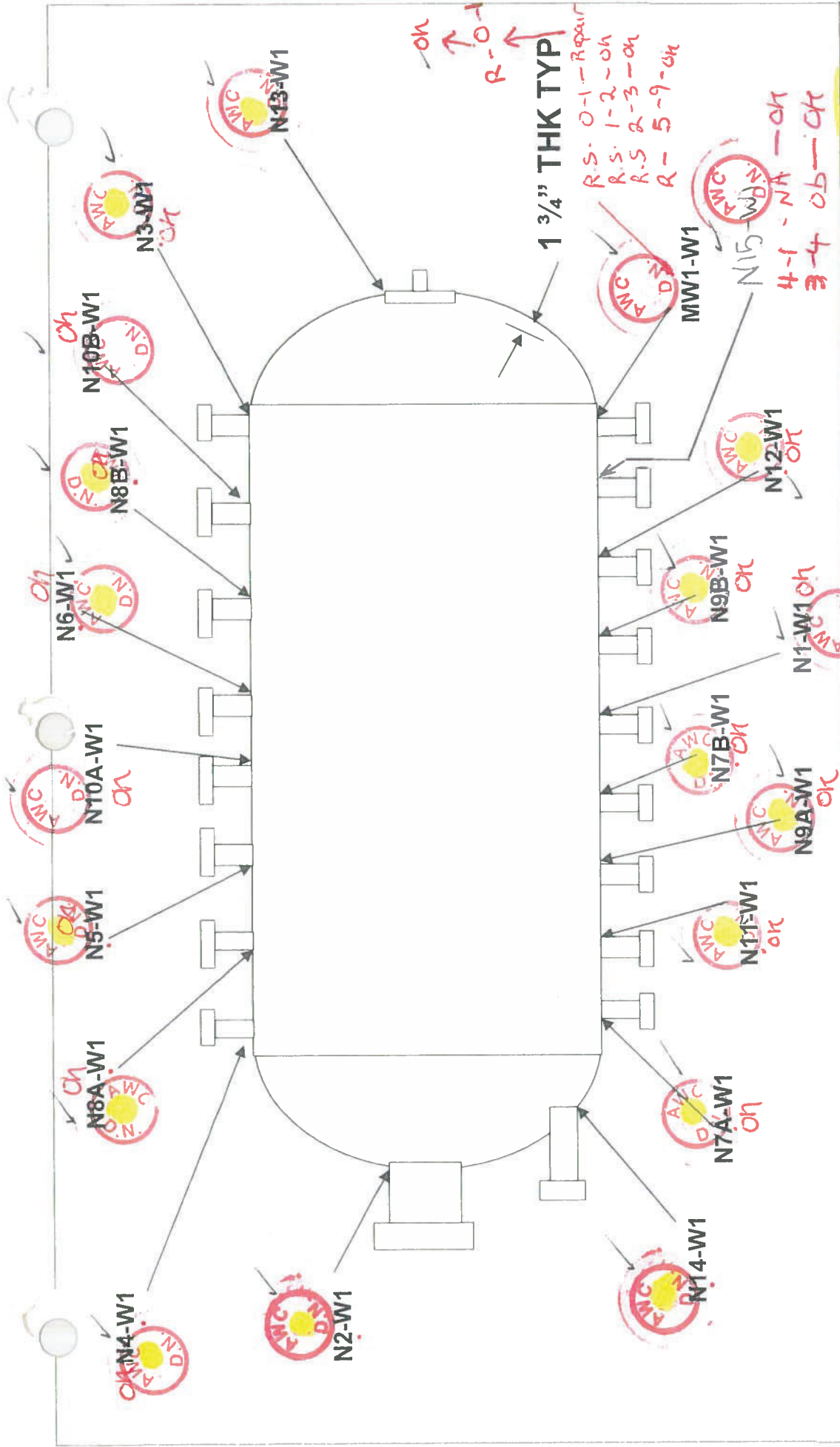


### Scanning

Test Area	Disposition	From	Length	Depth	Amplitude

### Evaluation - Acceptance

<input checked="" type="radio"/> Accepted	KV Inspection Services - Technician		Date	August 26, 2013
<input type="radio"/> Rejected	CGSB No. 48.9712-2000 Reg. No.	8885	Place	Scarborough, ON



**ALL-WELD CO. LTD. - UT MAP**

CLIENT: ULTRAFAB

WORK ORDER #: 1173PQ - SN 7473

JOB DESCRIPTION: 48" O.D. VERTICAL INLET

DRAWING #: 1173-1-IN

PREPARED BY: D.NESCI

DATE: March 6, 2013

UT MAP - 1173PQ

ASME SECTION VIII. DIV. 1

MATERIAL SA-240 316/316L, SA-182 F316/316L

P.O. 13-0225

RT shell  
Conn's

1486 Wallace Road  
 Oakville, Ontario L6L 2Y2  
 Phone: 905-844-9448  
 Fax: 905-844-6697

## Radiographic Examination Report RT

### Specification - Acceptance Criteria

ASME  UW-51  UW-52 B31.1 B31.3NS CSA Other

### General Data

Customer	Altweld	Date	09/05/13
Location	Scarborough	P. O. #	
Project	LV STAIRS	Shop Order #	1173 7473
Procedure	KV5 Lev 3	Worksheet #	37561
Technician	MPerron	CGSB Reg #	12283
		ASNT/SNT-TC-1A Level	1

### Technical Data

Material Type	Carbon <input type="checkbox"/> Alloys <input checked="" type="checkbox"/>	Isotope	IR 192 <input type="checkbox"/> Other <input checked="" type="checkbox"/>	Physical/Focal Size	100
Base Material Thickness	1 3/4	Exposure	Single Wall <input checked="" type="checkbox"/> Double Wall <input type="checkbox"/>	Film per Cassette	1
Weld Thickness	1 3/4	View	Single Wall <input checked="" type="checkbox"/> Double Wall <input type="checkbox"/>	PWHT	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>
Reinforcement	1/8" + fillet	Number of Exposures	4		
Film Mfg.	Kodak	Minimum Source to Object Distance	20"		
Film Type	AA	Maximum Distance from Source Side of Object to Film	2"		

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
NI W1	1-2								✓	
	2-3								✓	
	3-4								✓	
	4-1								✓	

046

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SMM OFFSHORE  
 Print Name: GABRIEL SAMIA  
 Signature: [Signature]  
 Date: SEP 11 2013

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 VELOSI  
 Velosi America LLC

ED DUTSCHAEVER  
 CGSB LEVEL II, Reg.# 515  
 RT/NT/PT  
 SNT-TC-1A LEVEL III  
 RT/NT/PT



KV Inspection Technician	<u>[Signature]</u>	Date	09/05/13
Customer Representative		Date	SEP 09 2013

1486 Wallace Road  
Oakville, Ontario L6L 2Y2  
Phone: 905-844-9448  
Fax: 905-844-6697

# Radiographic Examination Report RT

## Specification - Acceptance Criteria

ASME UW-51 UW-52 B31.1 B31.3NS CSA Other

### General Data

Customer	Allweld	Date	08/12/13
Location	Toronto	P. O. #	
Project		Shop Order #	1173 PQ 7473
Procedure	KVI 5 Rev 3	Worksheet #	37424
Technician	MPerron	CGSB Reg #	12803
		ASNT/SNT-TC-1A Level	1

### Technical Data

Material Type	Carbon <u>Alloys</u>	Isotope	<u>Other</u>	Physical/Focal Size	.199	
Base Material Thickness	1 3/4	Exposure	<u>Single Wall</u>	Double Wall	Film per Cassette	1
Weld Thickness	1 3/4	View	<u>Single Wall</u>	Double Wall	PWHT	Yes <u>No</u>
Reinforcement	1/8	Number of Exposures	4 per nozzle			
Film Mfg.	Kodak	Minimum Source to Object Distance	20			
Film Type	AA	Maximum Distance from Source Side of Object to Film	1 1/8			

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
N3	1-2								-	
	2-3								-	
	3-4								-	
	4-1								-	
N7A	1-2					-			-	
	2-3								-	
	3-4								-	
	4-1								-	
N7B	1-2								-	
	2-3								-	
	3-4								-	
	4-1								-	
N8A	1-2								-	
	2-3								-	
	3-4								-	
	4-1								-	

046

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SBM Offshore

Print Name: CHAMEL SAHA

Signature: [Signature]

Date: Aug 16 13

**Applus<sup>®</sup>**  
VELOSI  
Velosi America LLC

**ED DUTSCHAEVER**  
CGSB LEVEL II, Reg# 515  
RT/MT/PT  
SNT-TC-1A, LEVEL III  
RT/MT/PT

KV Inspection Technician	<u>[Signature]</u>	Date	08/12/13
Customer Representative		Date	AUG 14 2013

1486 Wallace Road  
 Oakville, Ontario L6L 2Y2  
 Phone: 905-844-9448  
 Fax: 905-844-6697

**Radiographic Examination Report  
 RT**

**Specification - Acceptance Criteria**

ASME  UW-51  UW-52 B31.1 B31.3NS CSA Other

**General Data**

Customer	<i>ARC WELD COMPANY</i>	Date	<i>Aug 8/13</i>
Location	<i>SLARBOROUGH ONT</i>	P. O. #	
Project	<i>ULTRAFAB</i>	Shop Order #	<i>1173PQ-7473</i>
Procedure	<i>W 8.5 REV 3</i>	Worksheet #	<i>37408</i>
Technician	<i>M PSLON</i>	CGSB Reg #	<i>12283</i> ASNT/SNT-TC-1A Level <i>1</i>

**Technical Data *W 60***

Material Type	Carbon <input type="checkbox"/> Alloys <input checked="" type="checkbox"/>	Isotope	IR 192 <input type="checkbox"/> Other <input checked="" type="checkbox"/>	Physical/Focal Size	<i>-199</i>
Base Material Thickness	<i>1 3/4</i>	Exposure	Single Wall <input checked="" type="checkbox"/> Double Wall <input type="checkbox"/>	Film per Cassette	<i>1</i>
Weld Thickness	<i>1 3/4</i>	View	Single Wall <input checked="" type="checkbox"/> Double Wall <input type="checkbox"/>	PWHT	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>
Reinforcement	<i>1/8" FILLER</i>	Number of Exposures	<i>9/NOZZLES</i>		
Film Mfg.	<i>KODAK</i>	Minimum Source to Object Distance	<i>18"</i>		
Film Type	<i>AA</i>	Maximum Distance from Source Side of Object to Film	<i>17/2</i>		

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
<i>N4</i>	<i>1-2</i>								<input checked="" type="checkbox"/>	
<i>TOSHEN</i>	<i>2-3</i>								<input checked="" type="checkbox"/>	
<i>W1</i>	<i>3-4</i>								<input checked="" type="checkbox"/>	
	<i>4-1</i>								<input checked="" type="checkbox"/>	
<i>N5</i>	<i>1-2</i>								<input checked="" type="checkbox"/>	
<i>TOSHEN</i>	<i>2-3</i>								<input checked="" type="checkbox"/>	
<i>W1</i>	<i>3-4</i>								<input checked="" type="checkbox"/>	
	<i>4-1</i>								<input checked="" type="checkbox"/>	
<i>N6</i>	<i>1-2</i>								<input checked="" type="checkbox"/>	
<i>TOSHEN</i>	<i>2-3</i>								<input checked="" type="checkbox"/>	
<i>W1</i>	<i>3-4</i>								<input checked="" type="checkbox"/>	
	<i>4-1</i>								<input checked="" type="checkbox"/>	

*NOZZLES MADE OF USS8C STEEL*

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: *SPM OFFSHORE*  
 Print Name: *WALTER SANDER*  
 Signature: *[Signature]*  
 Date: *Aug 8/13*  
 Appius® VELOSI  
 Veloci America LLC

**ED DUTSCHAEVER**  
 CGSB LEVEL II, Reg # 315  
 RT/MT/PT  
 SNT-TC-1A, LEVEL II  
 RT/MT/PT

*[Signature]*  
 AWC  
 D.N.

KV Inspection Technician	Date	<i>Aug 8/13</i>
Customer Representative	Date	<i>AUG 13 2013</i>

1486 Wallace Road  
Oakville, Ontario L6L 2Y2  
Phone: 905-844-9448  
Fax: 905-844-6697

## Radiographic Examination Report RT

### Specification - Acceptance Criteria

ASME UW-51 UW-52 B31.1 B31.3NS CSA Other

### General Data

Customer	Allweld	Date	08/12/13
Location	Toronto	P. O. #	
Project		Shop Order #	1173 PQ 7473
Procedure	K15 Lev 3	Worksheet #	37424
Technician	MPenon	CGSB Reg #	17283
		ASNT/SNT-TC-1A Level	1

### Technical Data

Material Type	Carbon <u>Alloys</u>	Isotope	<u>Other</u>	Physical/Focal Size	.199	
Base Material Thickness	1 3/4	Exposure	<u>Single Wall</u>	Double Wall	Film per Cassette	1
Weld Thickness	1 3/4	View	<u>Single Wall</u>	Double Wall	PWHT	Yes <u>No</u>
Reinforcement	1/8	Number of Exposures	4 per nozzle			
Film Mfg.	Kodak	Minimum Source to Object Distance	20"			
Film Type	DA	Maximum Distance from Source Side of Object to Film	1 7/8			

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
N88	1-2								✓	
	2-3								✓	
	3-4								✓	
	4-1								✓	

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SBM OFFSHORE  
Print Name: GANESH SAHA  
Signature: [Signature]  
Date: Aug 16 13  
046  
**Applus®**  
VELOSI  
Velosi America LLC

ED DUTSCHAEVER  
CGSB LEVEL II, Reg# 515  
RT/MT/PT  
SNT-TC-1A, LEVEL III  
RT/MT/PT

KV Inspection Technician

Date 08/12/13

Customer Representative

Date AUG 14 2013



# KV Inspection Services Ltd.

1486 Wallace Road  
Oakville, Ontario L6L 2Y2  
Phone: 905-844-9448  
Fax: 905-844-6697

## Radiographic Examination Report RT

### Specification - Acceptance Criteria

ASME UW-51 UW-52 B31.1 B31.3NS CSA Other

### General Data

Customer: ALL WELD Date: 21 AUGUST 2013  
 Location: SCARBOROUGH P. O. #  
 Project: VESSEL Shop Order # 1173PQ - SN7473  
 Procedure: KU#05 Rev 03 Worksheet # 37459  
 Technician: J. MacDONALD CGSB Reg # 10375 ASNT/SNT-TC-1A Level 1

### Technical Data

Material Type: Carbon Alloys Isotope: IR 192 Other Physical/Focal Size: .18"  
 Base Material Thickness: 1/4 Exposure: Single Wall Double Wall Film per Cassette: 1  
 Weld Thickness: 1/4 View: Single Wall Double Wall PWHT: Yes No  
 Reinforcement: 1/8 Number of Exposures: 4  
 Film Mfg.: KODAK Minimum Source to Object Distance: 20"  
 Film Type: AA Maximum Distance from Source Side of Object to Film: 1 3/8"

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
<u>N9A</u>										
<u>W1</u>	<u>1-2</u>								<input checked="" type="checkbox"/>	
	<u>2-3</u>								<input checked="" type="checkbox"/>	
	<u>3-4</u>								<input checked="" type="checkbox"/>	
	<u>4-1</u>								<input checked="" type="checkbox"/>	
<u>N9B</u>										
<u>W1</u>	<u>1-2</u>								<input checked="" type="checkbox"/>	
	<u>2-3</u>								<input checked="" type="checkbox"/>	
	<u>3-4</u>								<input checked="" type="checkbox"/>	
	<u>4-1</u>								<input checked="" type="checkbox"/>	

**CHRIS VEENEMAN**  
 CGSB LEVEL II, Reg# 6651  
 RT/MT/PT/UT  
 SNT-TC-1A, LEVEL II  
 RT/MT/PT/UT

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SAM OFF SHORE  
 Print Name: CHRISTY SAHA  
 Signature: [Signature]  
 Date: 21/8/13  
 Applus® VELOSI  
 Veloxi America LLC

KV Inspection Technician: [Signature] Date: 21 August 2013  
 Customer Representative: [Signature] Date: AUG 23 2013



# KV Inspection Services Ltd.

1486 Wallace Road  
Oakville, Ontario L6L 2Y2  
Phone: 905-844-9448  
Fax: 905-844-6697

## Radiographic Examination Report RT

### Specification - Acceptance Criteria

ASME  UW-5  UW-52 B31.1 B31.3NS CSA Other

### General Data

Customer: ARC Weld Co LTD Date: Aug 31/13  
Location: SCARBOROUGH ONT P. O. #  
Project: ULTRAFAB Shop Order # 1173-7473  
Procedure: W A-5 RW3 Worksheet # 37542  
Technician: B. MONTANA CGSB Reg # 939 ASNT/SNT-TC-1A Level IB

### Technical Data

Material Type: Carbon Alloys  Isotope: IR 192 Other  Physical/Focal Size: 128  
Base Material Thickness: 1 3/4 Exposure: Single Wall  Double Wall Film per Cassette: 1  
Weird Thickness: 1 3/4 View: Single Wall  Double Wall PWHT: Yes No  
Reinforcement: 1/8 + Fillet Number of Exposures: 4  
Film Mfg.: KODAK Minimum Source to Object Distance: 20"  
Film Type: AA Maximum Distance from Source Side of Object to Film: 2"

UNIT No.	SIZE/LOC	SLAG	L.O.F.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
<u>N10A</u>										
	<u>1-2</u>									
	<u>2-3</u>									
	<u>3-4</u>									
	<u>4-1</u>									

**ED-DUITSCHAEVER**  
CGSB LEVEL II, Reg# 515  
RT/MT/PT  
SNT-TC-1A, LEVEL III  
RT/MT/PT

ACCEPTED/REJECTED BASED ON  
for and on behalf of: SAM OFFSHORE  
Print Name: LANEY SAHN  
Signature: [Signature]  
Appius VELOSI  
Velosi America LLC

KV Inspection Technician [Signature]

Date Aug 31/13

Customer Representative



Date SEP 03 2013

1486 Wallace Road  
 Oakville, Ontario L6L 2Y2  
 Phone: 905-844-9448  
 Fax: 905-844-6697

# Radiographic Examination Report RT

## Specification - Acceptance Criteria

ASME / UW-51 ✓ UW-52 B31.1 B31.3NS CSA Other

### General Data

Customer	ALL WELDS CO	Date	Aug 31/13
Location	SCARBOROUGH ONT	P. O. #	
Project	ULTRAFAB	Shop Order #	1173 - 7473
Procedure	KW # 5 REV 3	Worksheet #	37542
Technician	B MONAGHAN	CGSB Reg #	439
		ASNT/SNT-TC-1A Level	II

### Technical Data

Material Type	Carbon ✓ Alloys	Isotope	IR 192 Other ✓	Physical/Focal Size	1
Base Material Thickness	1 3/4	Exposure	Single Wall ✓ Double Wall	Film per Cassette	1
Weld Thickness	1 3/4	View	Single Wall ✓ Double Wall	PWHT	Yes No ✓
Reinforcement	1/8" PLUS	Number of Exposures			4
Film Mfg.	KODAK	Minimum Source to Object Distance			20"
Film Type	AA	Maximum Distance from Source Side of Object to Film			2"

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
N10B										
	1-2								-	
	2-3								-	
	3-4								-	
	4-1								-	

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SAM OFFSHORE  
 Print Name: GAVESHI SAHNI  
 Signature: *[Signature]*  
 Date: Sep 3/13  
 045  
**Applus®**  
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 Veloci America LLC

ED DITSCHAEVER  
 CGSB LEVEL II, Reg# 515  
 RT/MT/PT  
 SNT-TC-1A, LEVEL III  
 RT/MT/PT



KV Inspection Technician	<i>[Signature]</i>	Date	Aug 31/13
Customer Representative		Date	SEP 03 2013

1486 Wallace Road  
 Oakville, Ontario L6L 2Y2  
 Phone: 905-844-9448  
 Fax: 905-844-6697

**Radiographic Examination Report  
 RT**

**Specification - Acceptance Criteria**

ASME  UW-51  UW-52 B31.1 B31.3NS CSA Other

**General Data**

Customer	<i>All Weld Company</i>	Date	<i>Aug 8/13</i>
Location	<i>Scarborough Ont.</i>	P. O. #	
Project	<i>ULTRAFAB</i>	Shop Order #	<i>1173PQ-7473</i>
Procedure	<i>KW X 5 R5 V 3</i>	Worksheet #	<i>37408</i>
Technician	<i>M Pylon</i>	CGSB Reg #	<i>12283</i>
		ASNT/SNT-TC-1A Level	<i>1</i>

**Technical Data**

Material Type	Carbon	Alloys <input checked="" type="checkbox"/>	Isotope	IR 192	Other <input checked="" type="checkbox"/>	Physical/Focal Size	<i>189</i>
Base Material Thickness	<i>1 3/4</i>		Exposure	Single Wall <input checked="" type="checkbox"/>	Double Wall	Film per Cassette	<i>1</i>
Weld Thickness	<i>1 3/4</i>		View	Single Wall <input checked="" type="checkbox"/>	Double Wall	PWHT	Yes No <input checked="" type="checkbox"/>
Reinforcement	<i>1/8" + Fillet</i>		Number of Exposures	<i>4/Nozzle</i>			
Film Mfg.	<i>KODAK</i>		Minimum Source to Object Distance	<i>18"</i>			
Film Type	<i>AA</i>		Maximum Distance from Source Side of Object to Film	<i>178"</i>			

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
<i>N11</i>	<i>1-2</i>								<input checked="" type="checkbox"/>	
<i>TOSHU</i>	<i>2-3</i>								<input checked="" type="checkbox"/>	
<i>11</i>	<i>3-4</i>								<input checked="" type="checkbox"/>	
	<i>4-1</i>								<input checked="" type="checkbox"/>	
<i>N12</i>	<i>1-2</i>								<input checked="" type="checkbox"/>	
<i>TOSHU</i>	<i>2-3</i>								<input checked="" type="checkbox"/>	
<i>W1</i>	<i>3-4</i>								<input checked="" type="checkbox"/>	
	<i>4-1</i>								<input checked="" type="checkbox"/>	

*NOZZLES PROUD OF VESSEL SHELL*

ACCEPTED/REVIEWED/RELEASED 046  
 for and on behalf of: *SBM OFFSHORE*  
 Print Name: *WALTER SAH*  
 Signature: *[Signature]*  
 Date: *Aug 16/13*  
**Applus<sup>®</sup> VELOSI**  
 Velosi America LLC

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 CGSB LEVEL II, Reg # 515  
 RT/MT/PT  
 SNT-TC-1A LEVEL II  
 RT/NT/PT



KV Inspection Technician	<i>[Signature]</i>	Date	<i>Aug 9/13</i>
Customer Representative		Date	<i>AUG 13 2013</i>

# KV Inspection Services Ltd.

1486 Wallace Road  
 Oakville, Ontario L6L 2Y2  
 Phone: 905-844-9448  
 Fax: 905-844-6697

## Radiographic Examination Report RT

### Specification - Acceptance Criteria

ASME  UW-51  UW-52 B31.1 B31.3NS CSA Other

### General Data

Customer	Alu Welds	Date	Aug 31/13
Location	SCARBOROUGH ONT.	P. O. #	
Project	ULTRA FAB	Shop Order #	1173-7473
Procedure	KW #5 KEV3	Worksheet #	3754
Technician	B. MONTAGNAN	CGSB Reg #	939
		ASNT/SNT-TC-1A Level	II

### Technical Data

Material Type	Carbon <input type="checkbox"/> Alloys <input checked="" type="checkbox"/>	Isotope	IR 192 <input type="checkbox"/> Other <input checked="" type="checkbox"/>	Physical/Focal Size	W60
Base Material Thickness	1 3/4	Exposure	Single Wall <input checked="" type="checkbox"/> Double Wall	Film per Cassette	1
Weld Thickness	1 3/4	View	Single Wall <input checked="" type="checkbox"/> Double Wall	PWHT	
Reinforcement	1/8" PLACES	Number of Exposures		Yes	No <input checked="" type="checkbox"/>
Film Mfg.	KODAK	Minimum Source to Object Distance			20"
Film Type	AA	Maximum Distance from Source Side of Object to Film			2"

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
N15										
W1										
	1-2									
	2-3									
	3-4									
	4-1									
								INT		
								OBSI		
								NA		

046

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBM OFF SHORE  
 Print Name: CAMERON SAH A  
 Signature: [Signature]  
 Date: SEP 13

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 RT/MT/PT  
 SNT-TC-1A, LEVEL III  
 RT/MT/PT

KV Inspection Technician	<u>[Signature]</u>	Date	Aug 31/13
Customer Representative	<u>[Signature]</u>	Date	SEP 03 2013



1486 Wallace Road  
Oakville, Ontario L6L 2Y2  
Phone: 905-844-9448  
Fax: 905-844-6697

## Radiographic Examination Report RT

### Specification - Acceptance Criteria

ASME  UW-51  UW-52 B31.1 B31.3NS CSA Other

### General Data

Customer	Almeld	Date	sept 5/13
Location	Scarborough	P. O. #	
Project	ultrafab	Shop Order #	1173 7473
Procedure	KV 5 Rev B	Worksheet #	37561
Technician	MPerron	CGSB Reg #	12203
		ASNT/SNT-TC-1A Level	I

### Technical Data

Material Type	Carbon <input checked="" type="checkbox"/> Alloys <input checked="" type="checkbox"/>	Isotope	IR 192 <input checked="" type="checkbox"/> Other <input checked="" type="checkbox"/>	Physical/Focal Size	0.60
Base Material Thickness	1 3/4	Exposure	Single Wall <input checked="" type="checkbox"/> Double Wall	Film per Cassette	1
Weld Thickness	1 3/4	View	Single Wall <input checked="" type="checkbox"/> Double Wall	PWHT	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>
Reinforcement	1/8" + fillet	Number of Exposures			2
Film Mfg.	Kodak	Minimum Source to Object Distance			20"
Film Type	AA	Maximum Distance from Source Side of Object to Film			2"

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
N15 W1	3-4								<input checked="" type="checkbox"/>	
	4-1								<input checked="" type="checkbox"/>	

046

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SDM OFF STORE  
Print Name: CHARLES SAH  
Signature: [Signature]  
Date: sep 14 13  
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Velos America LLC

ED DITSCHAEVER  
CGSB LEVEL II, Reg# 515  
RT/MT/PT  
SNT-TC-1A, LEVEL III  
RT/MT/PT

KV Inspection Technician		Date	09/05/13
Customer Representative		Date	SEP 09 2013



1486 Wallace Road  
Oakville, Ontario L6L 2Y2  
Phone: 905-844-9448  
Fax: 905-844-6697

## Radiographic Examination Report RT

### Specification - Acceptance Criteria

ASME  UW-51  UW-52 B31.1 B31.3NS CSA Other

### General Data

Customer	ALL WELD.	Date	22/8/2013
Location	SCARBOROUGH	P. O. #	
Project	MANWAY NOZZLE	Shop Order #	SN-7473-1173 PQ. + RT
Procedure	KV NDT #5 REV 3	Worksheet #	37461
Technician	D. McNEIL	CGSB Reg #	439
		ASNT/SNT-TC-1A Level	I

### Technical Data

Material Type	Carbon	Alloys <input checked="" type="checkbox"/>	Isotope	IR 192	Other <input checked="" type="checkbox"/>	Physical/Focal Size	18"
Base Material Thickness	1 3/4"		Exposure	Single Wall <input checked="" type="checkbox"/>	Double Wall	Film per Cassette	1
Weld Thickness	1 3/4"		View	Single Wall <input checked="" type="checkbox"/>	Double Wall	PWHT	Yes No <input checked="" type="checkbox"/>
Reinforcement	+ 1/4" +		Number of Exposures				12
Film Mfg.	KODAK		Minimum Source to Object Distance				25"
Film Type	400 AA		Maximum Distance from Source Side of Object to Film				2"

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
MANWAY NOZZLE.										
0-1									R/S	
1-2									R/S	
2-3									R/S	
3-4									✓	
4-5									✓	
5-9				@ 9-2"		-			✓	✓
9-10									✓	
10-11									✓	
11-12									✓	
12-13								F.M.	✓	
13-14									✓	
14-0								F.S.	✓	

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: S.M. OPT. SERVICES  
Print Name: CHRIS VEENEMAN  
Signature: [Signature]  
Date: SEP 3/13

**Applus**  
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Velosi America LLC  
**CHRIS VEENEMAN**  
CGSB LEVEL II, REG.# 6651  
MT/PT/RT/UT  
SNT-TC-1A LEVEL II  
MT/PT/RT/UT

KV Inspection Technician	<u>[Signature]</u>	Date	22/8/2013
Customer Representative	<u>[Signature]</u>	Date	SEP 03 2013



1486 Wallace Road  
Oakville, Ontario L6L 2Y2  
Phone: 905-844-9448  
Fax: 905-844-6697

**Radiographic Examination Report  
RT**

**Specification - Acceptance Criteria**

ASME  UW-51  UW-52 B31.1 B31.3NS CSA Other

**General Data**

Customer	ALL WELD LTD	Date	Aug 31/13
Location	SCARBOROUGH ONT.	P. O. #	
Project	WELDING FAB	Shop Order #	1173-7473
Procedure	W #5 RVS	Worksheet #	37542
Technician	B MONTGOMERY	CGSB Reg #	437 ASNT/SNT-TC-1A Level I

**Technical Data**

Material Type	Carbon	Alloys <input checked="" type="checkbox"/>	Isotope	IR 192	Other <input checked="" type="checkbox"/>	Physical/Focal Size	60
Base Material Thickness	1 3/4		Exposure	Single Wall <input checked="" type="checkbox"/>	Double Wall	Film per Cassette	1
Weld Thickness	1 3/4		View	Single Wall <input checked="" type="checkbox"/>	Double Wall	PWHT	Yes No <input checked="" type="checkbox"/>
Reinforcement	1/8" Jeld		Number of Exposures				3
Film Mfg.	KODAK		Minimum Source to Object Distance				20"
Film Type	AA		Maximum Distance from Source Side of Object to Film				2"

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
MWI										
1-1	0-1	4 1/2-7								<input checked="" type="checkbox"/>
1-2	1-2									<input checked="" type="checkbox"/>
1-3	2-3									<input checked="" type="checkbox"/>
MWI										
WR	5-9									<input checked="" type="checkbox"/>

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SBM OFFSHORE  
Print Name: CHARLES SAHA  
Signature: [Signature]  
Date: Sep 14/13  
046  
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Velosi America LLC

ED DUTSCHAEVER  
CGSB LEVEL II, Reg# 515  
RT/MT/PT  
SNT-TC-1A, LEVEL III  
RT/MT/PT

[Signature]  
D.N.

KV Inspection Technician	Date	Aug 31/13
Customer Representative	Date	SEP 03 2013

1486 Wallace Road  
 Oakville, Ontario L6L 2Y2  
 Phone: 905-844-9448  
 Fax: 905-844-6697

## Radiographic Examination Report RT

### Specification - Acceptance Criteria

ASME  UW-51  UW-52 B31.1 B31.3NS CSA Other

### General Data

Customer	Allweld	Date	09/05/13
Location	Scarborough	P. O. #	
Project	ULTRAFAB	Shop Order #	1173 7273
Procedure	KV5 Dev3	Worksheet #	37561
Technician	MPerron	CGSB Reg #	12285
		ASNT/SNT-TC-1A Level	I

### Technical Data

Material Type	Carbon	Alloys <input checked="" type="checkbox"/>	Isotope	IR 192	Other <input checked="" type="checkbox"/>	Physical/Focal Size	60 .188
Base Material Thickness	1 3/4		Exposure	Single Wall <input checked="" type="checkbox"/>	Double Wall	Film per Cassette	1
Weld Thickness	1 3/4		View	Single Wall <input checked="" type="checkbox"/>	Double Wall	PWHT	Yes No <input checked="" type="checkbox"/>
Reinforcement	1/8" fillet		Number of Exposures	1			
Film Mfg.	Kodak		Minimum Source to Object Distance	20"			
Film Type	AA		Maximum Distance from Source Side of Object to Film	2"			

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSIY	U.C.	OTHERS	ACC	REJ
MW/1	0-1							7/2-8 3/4		
IR								check surface		<input checked="" type="checkbox"/>
								Lin-Ind		

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SAM OFFSHORE  
 Print Name: G. HARRIS SA # 4  
 Signature: [Signature]  
 Date: sep 11 13  

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 SNT-TC-1A, LEVEL III  
 RT/MT/PT

KV Inspection Technician		Date	09/05/13
Customer Representative		Date	SEP 09 2013





# KV Inspection Services Ltd.

1486 Wallace Road  
Oakville, Ontario L6L 2Y2  
Phone: 905-844-9448  
Fax: 905-844-6697

## Radiographic Examination Report RT

### Specification - Acceptance Criteria

ASME UW-51 UW-52 B31.1 B31.3NS CSA Other

### General Data

Customer	ALL WELD	Date	SOPT. 7/13
Location	SCARBOROUGH	P. O. #	
Project	ULTRAFAB	Shop Order #	1173-7473
Procedure	KV5 REV 3	Worksheet #	
Technician	C. Veeneman	CGSB Reg #	6651
		ASNT/SNT-TC-1A Level	II

### Technical Data C-60

Material Type	Carbon	Alloys	Isotope	IR 192	Other	Physical/Focal Size	199"	
Base Material Thickness	1 3/4"		Exposure	Single Wall	Double Wall	Film per Cassette	1	
Weld Thickness	"		View	Single Wall	Double Wall	PWHT	Yes <u>NO</u>	
Reinforcement	1/4"		Number of Exposures					1
Film Mfg.	KODAK		Minimum Source to Object Distance					20"
Film Type	AA		Maximum Distance from Source Side of Object to Film					2"

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
MM-WLR 0-1									✓	

046

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SIPM OFF SHORE  
Print Name: LIANESH SAHAI  
Signature: [Signature]  
Date: 7 SEP 2013  
**Applus<sup>+</sup> VELOSI**  
Velosi America LLC

**CHRIS VEENEMAN**  
CGSB LEVEL II, REG.# 6651  
MT/PT/RT/UT  
SNT-TC-1A LEVEL II  
MT/PT/RT/UT

KV Inspection Technician	<u>[Signature]</u>	Date	SOPT. 7/13
Customer Representative	<u>[Signature]</u>	Date	SEP 09 2013



# KV Inspection Services Ltd.

1486 Wallace Road  
Oakville, Ontario L6L 2Y2  
Phone: 905-844-9448  
Fax: 905-844-6697

## Liquid Dye Penetrant Inspection Report PT

### Specification - Acceptance Criteria

As per ASME Sec. VIII Div. 1 Appx. 8

### General Data

Customer	All-Weld Company	Date	July 10, 2013		
Location	Scarborough, Ontario	P. O. #			
Project	1173PQ Ultra FAB	Shop Order #	Ser# 7473		
Procedure	KV# 16 Rev. 03	Worksheet #	37218		
Technician	Frank Marunde	CGSB Level II, Reg #	8885	ASNT/SNT-TC-1A Level	II

### Technical Data - Liquid Dye Penetrant (PT)

Material Type	<input type="radio"/> Carbon Steel	<input checked="" type="radio"/> Stainless Steel	<input type="radio"/> Other	Material Thickness	
---------------	------------------------------------	--	-----------------------------	--------------------	--

### Equipment & Method

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter	
	<input type="radio"/> Chemetall Oakite 996			
	<input type="radio"/> Chemetall Oakite 970P25E		<input type="radio"/> Fluorescent	
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<input checked="" type="radio"/> Water Washable	Serial #: 07076803	
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable	Intensity: 1400	Lx

Lighting Equipment Description: Flashlight

### Inspection

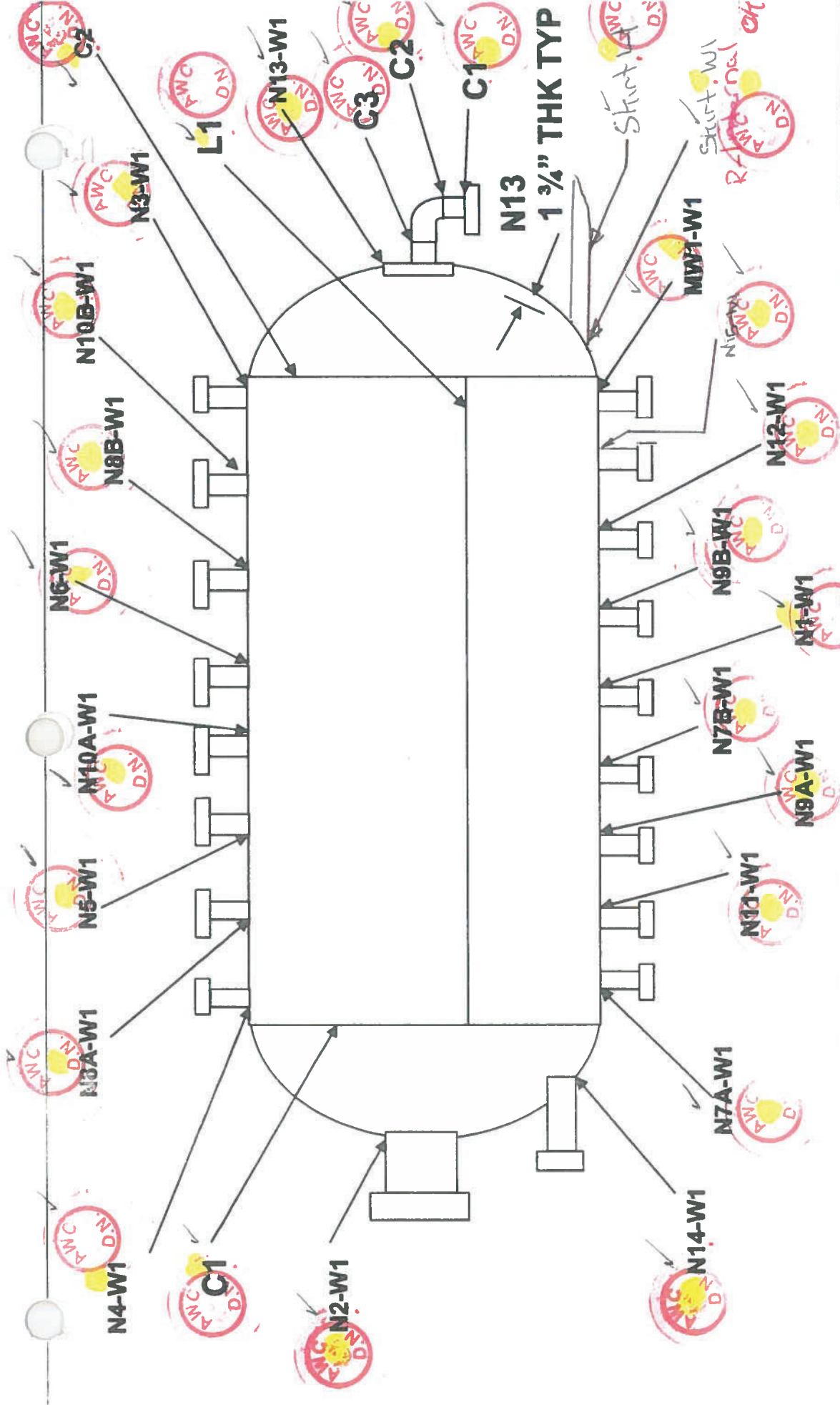
Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
	Knuckle area of top head (exterior)		Acceptable to specifications

ACCEPTED/REVIEWED/RELEASED 046  
 for and on behalf of: SBM OFFSHORE  
 Print Name: LA MESH SAH A  
 Signature: [Signature] **Applus<sup>®</sup> VELOSI**  
 Date: July 25/13 **Velosi America LLC**

Note: Representatives from ABS and SBM Offshore were present at time of inspection

KV Inspection Technician	<u>[Signature]</u>	Date	July 10, 2013
Customer Representative	<u>[Signature]</u>	Date	JUL 11 2013



**ALL-WELD CO. LTD. - PT MAP**

CLIENT: ULTRAFAB  
 WORK ORDER #: 1173PQ / SN 7473  
 JOB DESCRIPTION: 48" O.D. VERTICAL INLET  
 DRAWING #: 1173-1-IN  
 PREPARED BY: D.NESCI  
 DATE: March 6, 2013

**PT MAP - 1173PQ**

ASME SECTION VIII. DIV. 1  
 ALL WELDS INTERNAL / EXTERNAL EXCEPT WHERE NOTED  
 N13- C1, C2, C3 EXTERNAL ONLY  
 MATERIAL SA-240 316/316L, SA-182 F316/316L

P.O. 13-0227

**Liquid Dye Penetrant Inspection Report**  
**PT**

**Specification – Acceptance Criteria**

As per ASME Sec. VIII Div. 1 Appx. 8

**General Data**

Customer	All-Weld Company	Date	March 14, 2013		
Location	Scarborough, ON.	P. O. #			
Project	Vessel	Shop Order #	1173 PQ		
Procedure	KV# 16 Rev. 03	Worksheet #	36645		
Technician	John MacDonald	CGSB Level II, Reg #	10375	ASNT/SNT-TC-1A Level	II

**Technical Data – Liquid Dye Penetrant (PT)**

Material Type	<input type="radio"/> Carbon Steel	<input checked="" type="radio"/> Stainless Steel	<input type="radio"/> Other	Material Thickness	1 3/4"
---------------	------------------------------------	--	-----------------------------	--------------------	--------

**Equipment & Method**

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter	
	<input type="radio"/> Chemetall Oakite 996		Type: EA31	
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 970P25E	<input type="radio"/> Fluorescent	Serial #: 070706809	
	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<input checked="" type="radio"/> Water Washable	Intensity: 1200 Lx	
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable		


Lighting Equipment Description: Flashlight

**Inspection**

Description: Long seam weld

Item #	Description of Weld/Test Area	Defect Location	Interpretation
Serial # 7473	Long seam weld – L1 Inside & out		Acceptable to specification

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SIM OFFSHORE GR  
Print Name: GAMBHIR SAHIL  
Signature: [Signature]  
Date: Apr 14 2013  
046  
**Applus®**  
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Velosi America LLC

KV Inspection Technician		Date	March 14, 2013
Customer Representative		Date	MAR 15 2013

## Liquid Dye Penetrant Inspection Report PT

### Specification - Acceptance Criteria

As per ASME Sec. VIII Div. 1 Appx. 8

### General Data

Customer	All-Weld Company	Date	August 6, 2013		
Location	Scarborough, Ontario	P. O. #			
Project	1173 PQ	Shop Order #	7473		
Procedure	KV# 16 Rev. 03	Worksheet #	37169		
Technician	Sherwin Suyom	CGSB Level II, Reg #	15133	ASNT/SNT-TC-1A Level	II

### Technical Data - Liquid Dye Penetrant (PT)

Material Type	<input type="radio"/> Carbon Steel	<input checked="" type="radio"/> Stainless Steel	<input type="radio"/> Other	Material Thickness	
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### Equipment & Method

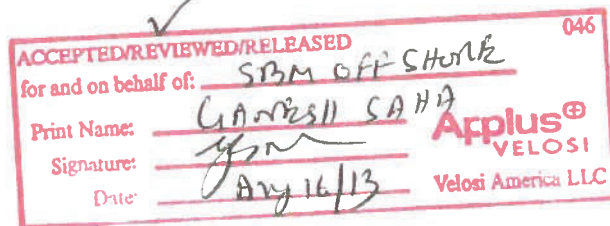
Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter Type: EA31	
	<input type="radio"/> Chemetall Oakite 996	<input type="radio"/> Fluorescent		
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<input checked="" type="radio"/> Water Washable	Serial #: 80613518	
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable	Intensity: 1100	Lx

Lighting Equipment Description: Flashlight/Floodlight

### Inspection

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
SN# 7473	C1 (external and internal) 100%		Acceptable to specification
	Skirt L1 (external and internal) 100%		Acceptable to specification
	Skirt W1 (external)		Acceptable to specification
	Skirt W1 (internal)	See photo	Unacceptable to specification



KV Inspection Technician		Date	August 6, 2013
Customer Representative		Date	AUG 07 2013

**Liquid Dye Penetrant Inspection  
Report  
PT**

**Specification – Acceptance Criteria**

**As per ASME Sec. VIII Div. 1 Appx. 8**

**General Data**

Customer	All-Weld Company	Date	August 26, 2013		
Location	Scarborough, ON	P. O. #			
Project	Vessel	Shop Order #	1173 PQ		
Procedure	KV# 16 Rev. 03	Worksheet #	37490		
Technician	Frank Marunde	CGSB Level II, Reg #	8885	ASNT/SNT-TC-1A Level	II

**Technical Data – Liquid Dye Penetrant (PT)**

Material Type	<input type="radio"/> Carbon Steel	<input checked="" type="radio"/> Stainless Steel	<input type="radio"/> Other	Material Thickness	
---------------	------------------------------------	--	-----------------------------	--------------------	--

**Equipment & Method**

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter	
	<input type="radio"/> Chemetall Oakite 996		<input type="radio"/> Fluorescent	Type: EA31
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 970P25E	<input checked="" type="radio"/> Water Washable	Serial #: 07076802	
	<input type="radio"/> Chemetall Oakite 9PR50		<input type="radio"/> Solvent Removable	Intensity: 1400
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B			

Lighting Equipment Description: Flashlight



**Inspection**

Description:

item #	Description of Weld/Test Area	Defect Location	Interpretation
Ser#7473	N13-W1 attachment weld (interior and exterior)		Acceptable to specification.
	Skirt-W1 attachment weld (interior)		Acceptable to specification.

046

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SBM off-shore  
Print Name: WAVEH SAHA  
Signature: [Signature]  
Date: Aug 27/13  
**Applus<sup>®</sup> VELOSI**  
Veloci America LLC

KV Inspection Technician		Date	August 26, 2013
Customer Representative		Date	AUG 28 2013

# KV Inspection Services Ltd.

1486 Wallace Road  
Oakville, Ontario L6L 2Y2  
Phone: 905-844-9448  
Fax: 905-844-6697

## Liquid Dye Penetrant Inspection Report PT

Specification - Acceptance Criteria

As per ASME Sec. VIII Div. 1 Appx. 8

### General Data

Customer	All-Weld Company	Date	April 04, 2013		
Location	Scarborough, ON.	P. O. #			
Project	Vessel	Shop Order #	1173 PQ		
Procedure	KV# 16 Rev. 03	Worksheet #	36784		
Technician	Sherwin Suyom	CGSB Level II, Reg #	15133	ASNT/SNT-TC-1A Level	II

### Technical Data - Liquid Dye Penetrant (PT)

Material Type	<input type="radio"/> Carbon Steel	<input checked="" type="radio"/> Stainless Steel	<input type="radio"/> Other	Material Thickness	1 3/4"
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### Equipment & Method

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter	
	<input type="radio"/> Chemetall Oakite 996	<input type="radio"/> Fluorescent	Type: EA31	
	<input type="radio"/> Chemetall Oakite 970P25E		Serial #: 80613518	
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<input checked="" type="radio"/> Water Washable	Intensity: 2500 Lx	
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable		

Lighting Equipment Description: Flashlight & Shop lighting

### Inspection

Description: 48" OD Vertical Inlet

Item #	Description of Weld/Test Area	Defect Location	Interpretation
Ser# 7473	C2 100% -external and internal		Acceptable to specification.

✓

ACCEPTED/REVIEWED/RELEASED 046

for and on behalf of: SVBM OFFSHORE GIL

Print Name: GANESH SAHAI

Signature: [Signature] **Applus® VELOSI**

Date: April 10/13 **Velosi America LLC**

KV Inspection Technician		Date	April 04, 2013
Customer Representative		Date	APR 05 2013

1486 Wallace Road  
 Oakville, Ontario L6L 2Y2  
 Phone: 905-844-9448  
 Fax: 905-844-6697

## Liquid Dye Penetrant Inspection Report PT

### Specification – Acceptance Criteria

As per ASME Sec. VIII Div. 1 Appx. 8

### General Data

Customer	All-Weld Company	Date	April 29, 2013		
Location	Scarborough, ON.	P. O. #			
Project	Vessel	Shop Order #	1173 PQ		
Procedure	KV# 16 Rev. 03	Worksheet #	36928		
Technician	Sherwin Suyom	CGSB Level II, Reg #	15133	ASNT/SNT-TC-1A Level	II

### Technical Data – Liquid Dye Penetrant (PT)

Material Type	<input type="radio"/> Carbon Steel <input checked="" type="radio"/> Stainless Steel <input type="radio"/> Other	Material Thickness	
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### Equipment & Method

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906 <input type="radio"/> Chemetall Oakite 996 <input type="radio"/> Chemetall Oakite 970P25E	<input checked="" type="radio"/> Visible <input type="radio"/> Fluorescent	Light meter
			Type: EA31
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<input checked="" type="radio"/> Water Washable	Serial #: 07076863
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable	Intensity: 2000      Lx

Lighting Equipment Description: Headlamp & Shoplighting

### Inspection

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
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Ser# 7473	Internal and external inspection of C2R (0-1)		Acceptable to specification.
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ACCEPTED/REVIEWED/RELEASED 046  
 for and on behalf of: SBM OFF STORE  
 Print Name: GANESH SAHA  
 Signature: [Signature]  
 Date: JUN 5 13  
**Applus®**  
**VELOSI**  
 Velosi America LLC

KV Inspection Technician		Date	April 29, 2013
Customer Representative		Date	MAY 01 2013



**Liquid Dye Penetrant Inspection Report**  
**PT**

**Specification - Acceptance Criteria**

**As per ASME Sec. VIII Div. 1 Appx. 8**

**General Data**

Customer	All-Weld Company	Date	August 19, 2013		
Location	Scarborough, ON	P. O. #			
Project	Nozzles	Shop Order #	1173 PQ 7473		
Procedure	KV# 16 Rev. 03	Worksheet #	37397		
Technician	Frank Marunde	CGSB Level II, Reg #	8885	ASNT/SNT-TC-1A Level	II

**Technical Data - Liquid Dye Penetrant (PT)**

Material Type	<input type="radio"/> Carbon Steel <input checked="" type="radio"/> Stainless Steel <input type="radio"/> Other	Material Thickness	
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**Equipment & Method**

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter	
	<input type="radio"/> Chemetall Oakite 996	<input type="radio"/> Fluorescent	Type: EA31	
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 970P25E	<input checked="" type="radio"/> Water Washable	Serial #: 070706869	
	<input type="radio"/> Chemetall Oakite 9PR50	<input type="radio"/> Solvent Removable	Intensity: 1300	Lx
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B			



Lighting Equipment Description: Shop & Exterior Lighting

**Inspection**

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
SN# 7473	Nozzle attachment welds: N1-W1, N3-W1, N4-W1, N5-W1 N6-W1, N7A-W1, N7B-W1, N8A-W1, N8B-W1, N9A-W1, N9B-W1, N10A-W1, N10B-W1, N11-W1, N12-W1 & N15-W1 (Interior & Exterior)		Acceptable to specification

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SBM OFFSHORE 046  
Print Name: GANESH SAHA  
Signature: [Signature] **Applus® VELOSI**  
Date: Aug 23/13 Velosi America LLC

KV Inspection Technician		Date	August 19, 2013
Customer Representative		Date	AUG 22 2013

1486 Wallace Road  
 Oakville, Ontario L6L 2Y2  
 Phone: 905-844-9448  
 Fax: 905-844-6697

## Liquid Dye Penetrant Inspection Report PT

Specification - Acceptance Criteria

As per ASME Sec. VIII Div. 1 Appx. 8

### General Data

Customer	All-Weld Company	Date	April 05, 2013		
Location	Scarborough, ON.	P. O. #			
Project	Vessel	Shop Order #	1173 PQ		
Procedure	KV# 16 Rev. 03	Worksheet #	36762		
Technician	Frank Marunde	CGSB Level II, Reg #	8885	ASNT/SNT-TC-1A Level	II

### Technical Data - Liquid Dye Penetrant (PT)

Material Type	<input type="radio"/> Carbon Steel <input checked="" type="radio"/> Stainless Steel <input type="radio"/> Other	Material Thickness	
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### Equipment & Method

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter	
	<input type="radio"/> Chemetall Oakite 996			
	<input type="radio"/> Chemetall Oakite 970P25E		Type: EA31	
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<input checked="" type="radio"/> Water Washable	Serial #: 80613518	
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable	Intensity: 1400	Lx

Lighting Equipment Description: Flashlight

### Inspection

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
Ser# 7473	N2-W1 -nozzle attachment weld (exterior and interior)		Acceptable to specification.
	N14-W1 -nozzle attachment weld (exterior and interior)		Acceptable to specification.

✓

AUTHORIZED/REVIEWED/RELEASED  
 for and on behalf of: SAM OFFSHORE CORP 046  
 Print Name: GANESH SAHA  
 Signature: [Signature]  
 Date: APR 10 2013  
**Applus®**  
**VELOSI**  
 Velosi America LLC

KV Inspection Technician		Date	April 05, 2013
Customer Representative		Date	APR 09 2013

## Liquid Dye Penetrant Inspection Report PT

Specification - Acceptance Criteria

As per ASME Sec. VIII Div. 1 Appx. 8

### General Data

Customer	All-Weld Company	Date	April 30, 2013		
Location	Scarborough, ON.	P. O. #			
Project	Vessel	Shop Order #	1173 PQ		
Procedure	KV# 16 Rev. 03	Worksheet #	36888		
Technician	Frank Marunde	CGSB Level II, Reg #	8885	ASNT/SNT-TC-1A Level	II

### Technical Data - Liquid Dye Penetrant (PT)

Material Type	<input type="radio"/> Carbon Steel	<input checked="" type="radio"/> Stainless Steel	<input type="radio"/> Other	Material Thickness	
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### Equipment & Method

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter Type: EA31	
	<input type="radio"/> Chemetall Oakite 996	<input type="radio"/> Fluorescent		
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<input checked="" type="radio"/> Water Washable	Serial #: 07076863	
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable	Intensity: 1400	Lx

Lighting Equipment Description: Flashlight

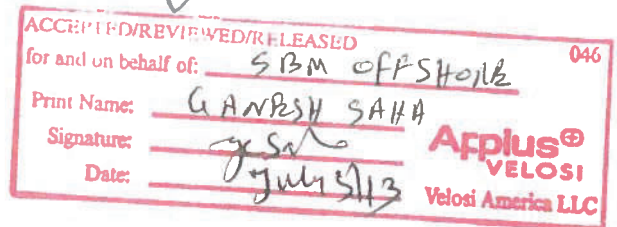
### Inspection

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
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Ser# 7473	N14-W1 attachment weld (interior and exterior)		Acceptable to specification.
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Per NCR N13-037



KV Inspection Technician		Date	April 30, 2013
Customer Representative		Date	

## Liquid Dye Penetrant Inspection Report PT

### Specification – Acceptance Criteria

As per ASME Sec. VIII Div. 1 Appx. 8

### General Data

Customer	All-Weld Company	Date	August 13, 2013
Location	@ KV Inspection, Oakville, ON	P. O. #	
Project	Ultrafab	Shop Order #	1173 PQ - 7473
Procedure	KV# 16 Rev. 03	Worksheet #	37436
Technician	Ed Duitschaever	CGSB Level II, Reg #	515 ASNT/SNT-TC-1A Level III

### Technical Data – Liquid Dye Penetrant (PT)

Material Type	<input type="radio"/> Carbon Steel <input checked="" type="radio"/> Stainless Steel <input type="radio"/> Other	Material Thickness	
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### Equipment & Method

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter	
	<input type="radio"/> Chemetall Oakite 996			Type: EA31
	<input type="radio"/> Chemetall Oakite 970P25E			
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<input checked="" type="radio"/> Water Washable	Serial #: 80613518	
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable	Intensity: 1100 Lx	

Lighting Equipment Description: Shop & Exterior Lighting

### Inspection

Description: **Nozzle 13**

Item #	Description of Weld/Test Area	Defect Location	Interpretation
SN# 7473	C1 – 2"Ø Butt weld		Acceptable to specification
	C2 – 2"Ø Butt Weld		Acceptable to specification

✓

ACCEPTED/REVIEWED/RELEASED 046

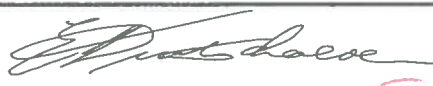

for and on behalf of: SBM OFF SHORE

Print Name: GANESH SAHA

Signature: [Signature] **Applus®**

Date: Aug 16/13 **VELOSI**

**Velosi America LLC**

KV Inspection Technician		Date	August 13, 2013
Customer Representative		Date	AUG 14 2013

1486 Wallace Road  
 Oakville, Ontario L6L 2Y2  
 Phone: 905-844-9448  
 Fax: 905-844-6697

## Liquid Dye Penetrant Inspection Report PT

### Specification – Acceptance Criteria

As per ASME Sec. VIII Div. 1 Appx. 8

### General Data

Customer	All-Weld Company	Date	September 3, 2013		
Location	Scarborough, ON	P. O. #			
Project	Vessel	Shop Order #	1173 PQ S/N 7473		
Procedure	KV# 16 Rev. 03	Worksheet #	37495		
Technician	Frank Marunde	CGSB Level II, Reg #	8885	ASNT/SNT-TC-1A Level	II

### Technical Data – Liquid Dye Penetrant (PT)

Material Type	<input type="radio"/> Carbon Steel <input checked="" type="radio"/> Stainless Steel <input type="radio"/> Other	Material Thickness	
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### Equipment & Method

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible <input type="radio"/> Fluorescent	Light meter	
	<input type="radio"/> Chemetall Oakite 996		Type: EA31	
	<input type="radio"/> Chemetall Oakite 970P25E		Serial #: 07076803	
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<input checked="" type="radio"/> Water Washable	Intensity: 1400	
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable	Lx	

Lighting Equipment Description: Flashlight


### Inspection

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
1)	Nozzle N13 Weld C3		Acceptable to specifications
2)	Vortex breaker assembly welds (loose)		Acceptable to specifications

✓

ACCEPTED/REVIEWED/RELEASED 046  
 for and on behalf of: SRM OFFSHORE  
 Print Name: GANESH SAIJI  
 Signature: [Signature]  
 Date: SEP 10 2013  
**Applus®**  
 VELOSI  
 Velosi America LLC

KV Inspection Technician	<u>[Signature]</u>	Date	September 3, 2013
Customer Representative		Date	SEP 09 2013

**Liquid Dye Penetrant Inspection  
Report  
PT**

**Specification – Acceptance Criteria**

**As per ASME Sec. VIII Div. 1 Appx. 8**

**General Data**

<b>Customer</b>	All-Weld Company	<b>Date</b>	August 22, 2013		
<b>Location</b>	Scarborough, ON	<b>P. O. #</b>			
<b>Project</b>		<b>Shop Order #</b>	1173PQ-7473		
<b>Procedure</b>	KV# 16 Rev. 03	<b>Worksheet #</b>	37488		
<b>Technician</b>	Frank Marunde	<b>CGSB Level II, Reg #</b>	8885	<b>ASNT/SNT-TC-1A Level</b>	II

**Technical Data – Liquid Dye Penetrant (PT)**

<b>Material Type</b>	<input type="radio"/> Carbon Steel	<input checked="" type="radio"/> Stainless Steel	<input type="radio"/> Other	<b>Material Thickness</b>	
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**Equipment & Method**

<b>Penetrant</b>	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	<b>Light meter</b>		
	<input type="radio"/> Chemetall Oakite 996				<input type="radio"/> Fluorescent
	<input type="radio"/> Chemetall Oakite 970P25E		<b>Type: EA31</b>		
<b>Cleaner</b>	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<input checked="" type="radio"/> Water Washable	<b>Serial #: 07076803</b>		
<b>Developer</b>	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable	<b>Intensity: 1400</b>	<b>Lx</b>	

**Lighting Equipment Description: Flashlight**



**Inspection**

**Description:**

Item #	Description of Weld/Test Area	Defect Location	Interpretation
SN# 7473	Manway: MW1-W1 Attachment weld (Interior & Exterior)		Acceptable to specification

046

ACCEPTED/REVIEWED/RELEASED ✓  
for and on behalf of: SPM OFF SHORE  
Print Name: CLAUDETTE SABA  
Signature: [Signature]  
Date: Aug 22/13  
**Applus<sup>®</sup> VELOSI**  
Velosi America LLC

<b>KV Inspection Technician</b>		<b>Date</b>	August 22, 2013
<b>Customer Representative</b>		<b>Date</b>	AUG 27 2013

1486 Wallace Road  
 Oakville, Ontario L6L 2Y2  
 Phone: 905-844-9448  
 Fax: 905-844-6697

## Liquid Dye Penetrant Inspection Report PT

### Specification – Acceptance Criteria

As per ASME Sec. VIII Div. 1 Appx. 8

### General Data

Customer	All-Weld Company	Date	August 29, 2013		
Location	Scarborough, ON	P. O. #			
Project	Vessel	Shop Order #	1173 PQ		
Procedure	KV# 16 Rev. 03	Worksheet #	37493		
Technician	Frank Marunde	CGSB Level II, Reg #	8885	ASNT/SNT-TC-1A Level	II

### Technical Data – Liquid Dye Penetrant (PT)

Material Type	<input type="radio"/> Carbon Steel <input checked="" type="radio"/> Stainless Steel <input type="radio"/> Other	Material Thickness	
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### Equipment & Method

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906 <input type="radio"/> Chemetall Oakite 996 <input type="radio"/> Chemetall Oakite 970P25E	<input checked="" type="radio"/> Visible <input type="radio"/> Fluorescent	Light meter
			Type: EA31
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<input checked="" type="radio"/> Water Washable	Serial #: 07076803
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable	Intensity: 1400 Lx

Lighting Equipment Description: Flashlight

### Inspection

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
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Ser#7473	MW1-W1 repair area (exterior)		Acceptable to specification.
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✓

ACCEPTED/REVIEWED/RELEASED 046

for and on behalf of: SBM OFF SHORE

Print Name: C. AMBUSH SAH

Signature: [Signature]

Date: SEP 20 2013

**Applus<sup>®</sup>**  
**VELOSI**  
 Velosi America LLC

KV Inspection Technician		Date	August 29, 2013
Customer Representative		Date	SEP 18 2013

**Liquid Dye Penetrant Inspection  
Report  
PT**

**Specification - Acceptance Criteria**

**As per ASME Sec. VIII Div. 1 Appx. 8**

**General Data**

Customer	All-Weld Company	Date	September 06, 2013		
Location	Scarborough, ON	P. O. #			
Project	Vessel	Shop Order #	1173 PQ S/N 7473		
Procedure	KV# 16 Rev. 03	Worksheet #	37498		
Technician	Frank Marunde	CGSB Level II, Reg #	8885	ASNT/SNT-TC-1A Level	II

**Technical Data - Liquid Dye Penetrant (PT)**

Material Type	<input type="radio"/> Carbon Steel <input checked="" type="radio"/> Stainless Steel <input type="radio"/> Other	Material Thickness	
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**Equipment & Method**

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible <input type="radio"/> Fluorescent	Light meter	
	<input type="radio"/> Chemetall Oakite 996		Type: EA31	
	<input type="radio"/> Chemetall Oakite 970P25E		Serial #: 07076802	
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<input checked="" type="radio"/> Water Washable	Intensity: 1400 Lx	
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable		

Lighting Equipment Description: Flashlight

**Inspection**

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
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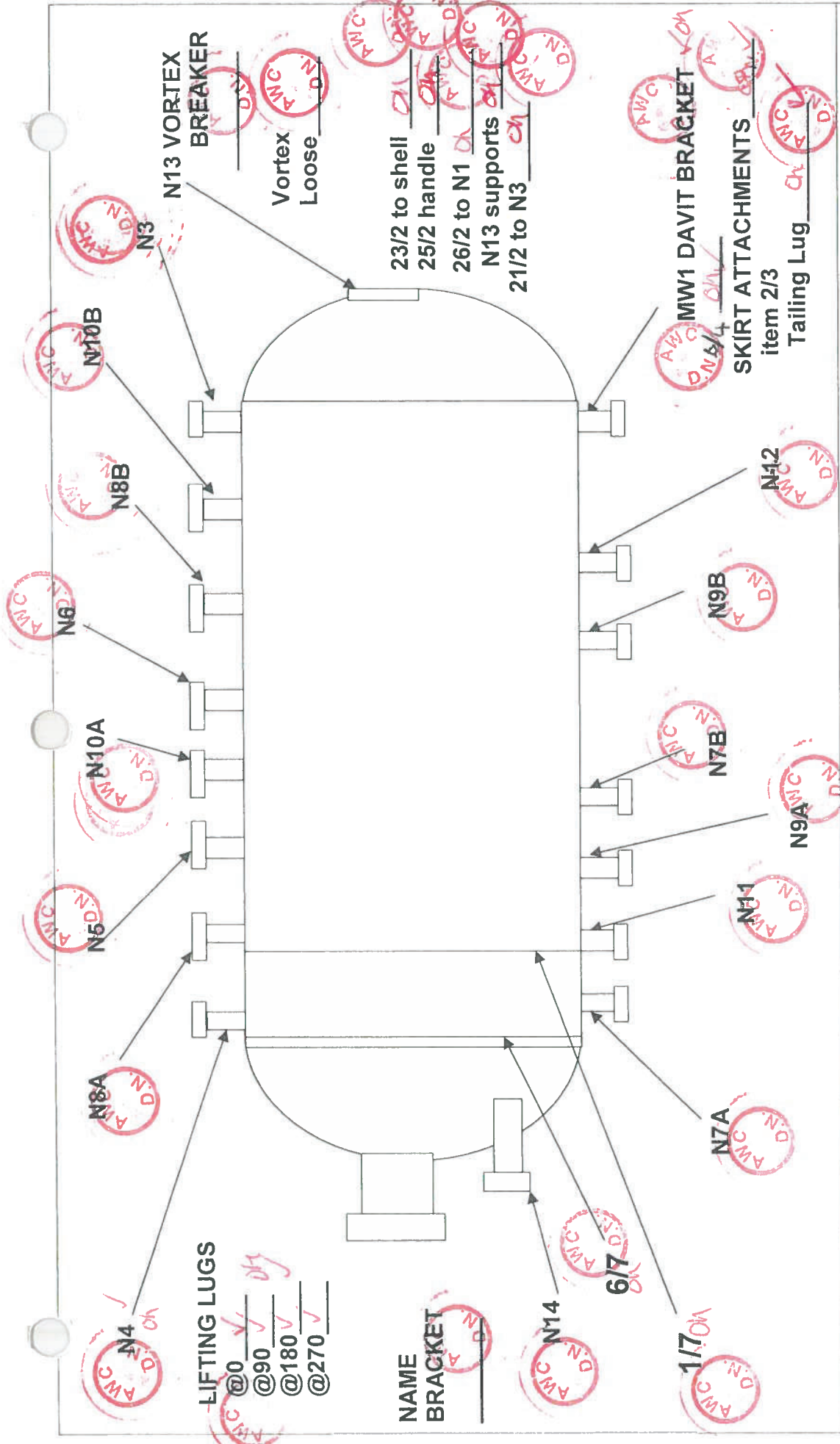
Ser# 7473 MW1-W1 repair area (see RT report) Acceptable to specifications

✓

ACCEPTED/REVIEWED/RELEASED 046  
for and on behalf of: SBM CFP SIKING  
Print Name: CHANDRASEKHAR SAHA  
Signature: [Signature]  
Date: SEP 20 2013  
**Applus<sup>®</sup> VELOSI**  
Velosi America LLC

KV Inspection Technician		Date	September 06, 2013
Customer Representative		Date	SEP 18 2013





**ALL-WELD CO. LTD. - PT MAP  
 ATTACHMENTS / BRACKETS**

PT MAP - 1173PQ  
 ASME SECTION VIII. DIV. 1  
 ALL WELDS INTERNAL / EXTERNAL EXCEPT WHERE NOTED  
 ATTACHMENTS / BRACKETS  
 MATERIAL SA-240 316/316L  
 P.O.

CLIENT: ULTRAFAB
WORK ORDER #: 1173PQ / SN 7473
JOB DESCRIPTION: 48" O.D. VERTICAL INLET
DRAWING #: 1173-1-IN
PREPARED BY: D.NESCI
DATE: March 6, 2013

**Liquid Dye Penetrant Inspection  
Report  
PT**

**Specification - Acceptance Criteria**

**As per ASME Sec. VIII Div. 1 Appx. 8**

**General Data**

<b>Customer</b>	All-Weld Company	<b>Date</b>	September 11, 2013		
<b>Location</b>	Scarborough, ON	<b>P. O. #</b>			
<b>Project</b>	Ultrafab	<b>Shop Order #</b>	1173 PQ S/N 7473		
<b>Procedure</b>	KV# 16 Rev. 03	<b>Worksheet #</b>	37629		
<b>Technician</b>	John MacDonald	<b>CGSB Level II, Reg #</b>	10375	<b>ASNT/SNT-TC-1A Level</b>	II

**Technical Data - Liquid Dye Penetrant (PT)**

<b>Material Type</b>	<input type="radio"/> Carbon Steel <input checked="" type="radio"/> Stainless Steel <input type="radio"/> Other	<b>Material Thickness</b>	Various		
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**Equipment & Method**

<b>Penetrant</b>	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	<b>Light meter</b>		
	<input type="radio"/> Chemetall Oakite 996				
<b>Cleaner</b>	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<input checked="" type="radio"/> Water Washable	Serial #: 07076802		
<b>Developer</b>	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable	<b>Intensity:</b>	1400	Lx

**Lighting Equipment Description:** Flashlight

**Inspection**

**Description:** Nozzle Attachments/Brackets

Item #	Description of Weld/Test Area	Defect Location	Interpretation
N3	Bracket attachment welds		Acceptable to specification
N7A	Bracket attachment welds		Acceptable to specification
N7B	Bracket attachment welds		Acceptable to specification
N12	Bracket attachment welds		Acceptable to specification

046

ACCEPTED/REVIEWED/RELEASED ✓  
for and on behalf of: SBM OFFSHORE  
Print Name: GAMBISH SAHAI  
Signature: [Signature] **Applus®**  
Date: Sept 24 13 **VELOSI**  
Velosi America LLC

<b>KV Inspection Technician</b>		<b>Date</b>	September 11, 2013
<b>Customer Representative</b>		<b>Date</b>	SEP 13 2013

1486 Wallace Road  
 Oakville, Ontario L6L 2Y2  
 Phone: 905-844-9448  
 Fax: 905-844-6697

## Liquid Dye Penetrant Inspection Report PT

### Specification – Acceptance Criteria

As per ASME Sec. VIII DIV.1 Appx 8

#### General Data

Customer	All-Weld Company	Date	September 17, 2013		
Location	Scarborough, ON	P. O. #			
Project		Shop Order #	1176 S/N 7473		
Procedure	KV# 16 Rev. 03	Worksheet #	37644		
Technician	Frank Marunde	CGSB Level II, Reg #	8885	ASNT/SNT-TC-1A Level	II

#### Technical Data – Liquid Dye Penetrant (PT)

Material Type	<input type="radio"/> Carbon Steel <input checked="" type="radio"/> Stainless Steel <input type="radio"/> Other	Material Thickness	
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#### Equipment & Method

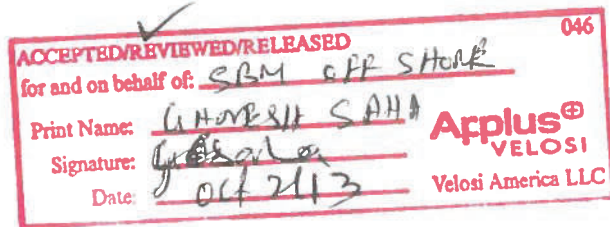
Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter	
	<input type="radio"/> Chemetall Oakite 996			
	<input type="radio"/> Chemetall Oakite 970P25E		<input type="radio"/> Fluorescent	Serial #: 07076802
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<input checked="" type="radio"/> Water Washable	Intensity: 1400 Lx	
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable		

Lighting Equipment Description: Flashlight

#### Inspection

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
1)	Lifting lug attachment welds (x4)		Acceptable to specifications
2)	Tailing lug attachment weld		Acceptable to specifications
3)	MW1 davit bracket attachment weld		Acceptable to specifications
4)	Item 2/3 to skirt attachment weld		Acceptable to specifications
5)	Item 6/4 attachment welds		Acceptable to specifications
6)	N4 support attachment welds		Acceptable to specifications



KV Inspection Technician		Date	September 17, 2013
Customer Representative		Date	SEP 20 2013

**Liquid Dye Penetrant Inspection  
Report  
PT**

**Specification – Acceptance Criteria**

**As per ASME Sec. VIII Div. 1 Appx. 8**

**General Data**

Customer	All-Weld Company	Date	September 04, 2013		
Location	Scarborough, ON	P. O. #			
Project	Vessel	Shop Order #	1173 PQ		
Procedure	KV# 16 Rev. 03	Worksheet #	37560		
Technician	John MacDonald	CGSB Level II, Reg #	10375	ASNT/SNT-TC-1A Level	II

**Technical Data – Liquid Dye Penetrant (PT)**

Material Type	<input type="radio"/> Carbon Steel	<input checked="" type="radio"/> Stainless Steel	<input type="radio"/> Other	Material Thickness	
---------------	------------------------------------	--	-----------------------------	--------------------	--

**Equipment & Method**

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter	
	<input type="radio"/> Chemetall Oakite 996			
	<input type="radio"/> Chemetall Oakite 970P25E		Type: EA31	
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<input checked="" type="radio"/> Water Washable	Serial #: 07076802	
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable	Intensity: 1400	Lx

Lighting Equipment Description: Flashlight

**Inspection**

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
--------	-------------------------------	-----------------	----------------

Ser#7473	Nozzle bracket attachment welds N5, N6, N8A, N8B & N9A		Acceptable to specification.
----------	---	--	------------------------------

✓

**ACCEPTED/REVIEWED/RELEASED** 046  
for and on behalf of: SBM OFF SHORE  
Print Name: CA AMBESH SAHA  
Signature: [Signature] **Applus®**  
Date: Sept 24 2013 **VELOSI**  
Velosi America LLC

KV Inspection Technician		Date	September 04, 2013
Customer Representative		Date	SEP 10 2013

1486 Wallace Road  
 Oakville, Ontario L6L 2Y2  
 Phone: 905-844-9448  
 Fax: 905-844-6697

## Liquid Dye Penetrant Inspection Report PT

### Specification - Acceptance Criteria

As per ASME Sec. VIII Div. 1 Appx. 8

### General Data

Customer	All-Weld Company	Date	September 11, 2013		
Location	Scarborough, ON	P. O. #			
Project		Shop Order #	1173 PQ S/N 7473		
Procedure	KV# 16 Rev. 03	Worksheet #	37591		
Technician	Frank Marunde	CGSB Level II, Reg #	8885	ASNT/SNT-TC-1A Level	II

### Technical Data - Liquid Dye Penetrant (PT)

Material Type	<input type="radio"/> Carbon Steel	<input checked="" type="radio"/> Stainless Steel	<input type="radio"/> Other	Material Thickness	Various
---------------	------------------------------------	--	-----------------------------	--------------------	---------

### Equipment & Method

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter	
	<input type="radio"/> Chemetall Oakite 996			
	<input type="radio"/> Chemetall Oakite 970P25E		Type: EA31	
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<input checked="" type="radio"/> Water Washable	Serial #: 07076803	
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable	Intensity: 1400	Lx

Lighting Equipment Description: Flashlight



### Inspection

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
	Nameplate bracket attachment welds.		Acceptable to specification
	Nozzle support welds N9B, N10A, N10B & N11		Acceptable to specification

✓

ACCEPTED/REVIEWED/RELEASED 046  
 for and on behalf of: SBM OFFSHORE  
 Print Name: GANESH SANA  
 Signature: [Signature]  
 Date: 09/11/13  
**Applus<sup>®</sup> VELOSI**  
 Velosi America LLC

KV Inspection Technician		Date	September 11, 2013
Customer Representative		Date	SEP 13 2013

**Liquid Dye Penetrant Inspection  
Report  
PT**

**Specification – Acceptance Criteria**

**As per ASME Sec. VIII Div. 1 Appx. 8**

**General Data**

Customer	All-Weld Company	Date	September 04, 2013		
Location	Scarborough, ON	P. O. #			
Project	Vessel	Shop Order #	1173 PQ		
Procedure	KV# 16 Rev. 03	Worksheet #	37496		
Technician	Frank Marunde	CGSB Level II, Reg #	8885	ASNT/SNT-TC-1A Level	II

**Technical Data – Liquid Dye Penetrant (PT)**

Material Type	<input type="radio"/> Carbon Steel <input checked="" type="radio"/> Stainless Steel <input type="radio"/> Other	Material Thickness	
---------------	---	--------------------	--

**Equipment & Method**

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter	
	<input type="radio"/> Chemetall Oakite 996			
	<input type="radio"/> Chemetall Oakite 970P25E		Type: EA31	
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<input checked="" type="radio"/> Water Washable	Serial #: 07076802	
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable	Intensity: 1400	Lx

Lighting Equipment Description: Flashlight

**Inspection**



Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
--------	-------------------------------	-----------------	----------------

Ser#7473	N13 support welds		Acceptable to specification.
	MW1-W1 repair area (See RT reports)		Acceptable to specification.

✓

**ACCEPTED/REVIEWED/RELEASED** 046  
for and on behalf of: SBM OFFSHORE  
Print Name: GANESH SAHA  
Signature: [Signature]  
Date: 09-04-2013  
**Applus<sup>®</sup> VELOSI**  
Velosi America LLC

KV Inspection Technician		Date	September 04, 2013
Customer Representative		Date	SEP 10 2013



1486 Wallace Road  
 Oakville, Ontario L6L 2Y2  
 Phone: 905-844-9448  
 Fax: 905-844-6697

## Liquid Dye Penetrant Inspection Report PT

### Specification – Acceptance Criteria

As per ASME Sec. VIII Div. 1 Appx. 8

### General Data

Customer	All-Weld Company	Date	September 12, 2013		
Location	Scarborough, ON	P. O. #			
Project		Shop Order #	1173 PQ S/N 7473		
Procedure	KV# 16 Rev. 03	Worksheet #	37592		
Technician	Frank Marunde	CGSB Level II, Reg #	8885	ASNT/SNT-TC-1A Level	II

### Technical Data – Liquid Dye Penetrant (PT)

Material Type	<input type="radio"/> Carbon Steel <input checked="" type="radio"/> Stainless Steel <input type="radio"/> Other	Material Thickness	Various		
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### Equipment & Method

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter		
	<input type="radio"/> Chemetall Oakite 996				
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<input checked="" type="radio"/> Water Washable	Serial #: 07076803		
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable	Intensity: 1400	Lx	

Lighting Equipment Description: Flashlight


### Inspection

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
	N14 Support attachment welds.		Acceptable to specification
	Vortex breaker attachment weld		Acceptable to specification
	Item 21/2 to N3 weld		Acceptable to specification
	Item 25/2 to shell attachment welds		Acceptable to specification

✓

**ACCEPTED/REVIEWED/RELEASED** 046  
 for and on behalf of: SBM OFFSHORE  
 Print Name: LAWESHA SAHA  
 Signature: [Signature]  
 Date: Sept 2013  
**Applus<sup>®</sup> VELOSI**  
 Velosi America LLC

KV Inspection Technician	<u>[Signature]</u>	Date	September 12, 2013
Customer Representative		Date	SEP 13 2013

1486 Wallace Road  
 Oakville, Ontario L6L 2Y2  
 Phone: 905-844-9448  
 Fax: 905-844-6697

## Liquid Dye Penetrant Inspection Report PT

### Specification – Acceptance Criteria

As per ASME Sec. VIII Div. 1 Appx. 8

### General Data

Customer	All-Weld Company	Date	September 13, 2013		
Location	Scarborough, ON	P. O. #			
Project	Vessel	Shop Order #	1173 PQ S/N 7473		
Procedure	KV# 16 Rev. 03	Worksheet #	37593		
Technician	Frank Marunde	CGSB Level II, Reg #	8885	ASNT/SNT-TC-1A Level	II

### Technical Data – Liquid Dye Penetrant (PT)

Material Type	<input type="radio"/> Carbon Steel	<input checked="" type="radio"/> Stainless Steel	<input type="radio"/> Other	Material Thickness	Various
---------------	------------------------------------	--	-----------------------------	--------------------	---------

### Equipment & Method

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter	
	<input type="radio"/> Chemetall Oakite 996			
	<input type="radio"/> Chemetall Oakite 970P25E		Type: EA31	
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<input checked="" type="radio"/> Water Washable	Serial #: 07076802	
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable	Intensity: 1400	Lx

Lighting Equipment Description: Flashlight

### Inspection

Description:

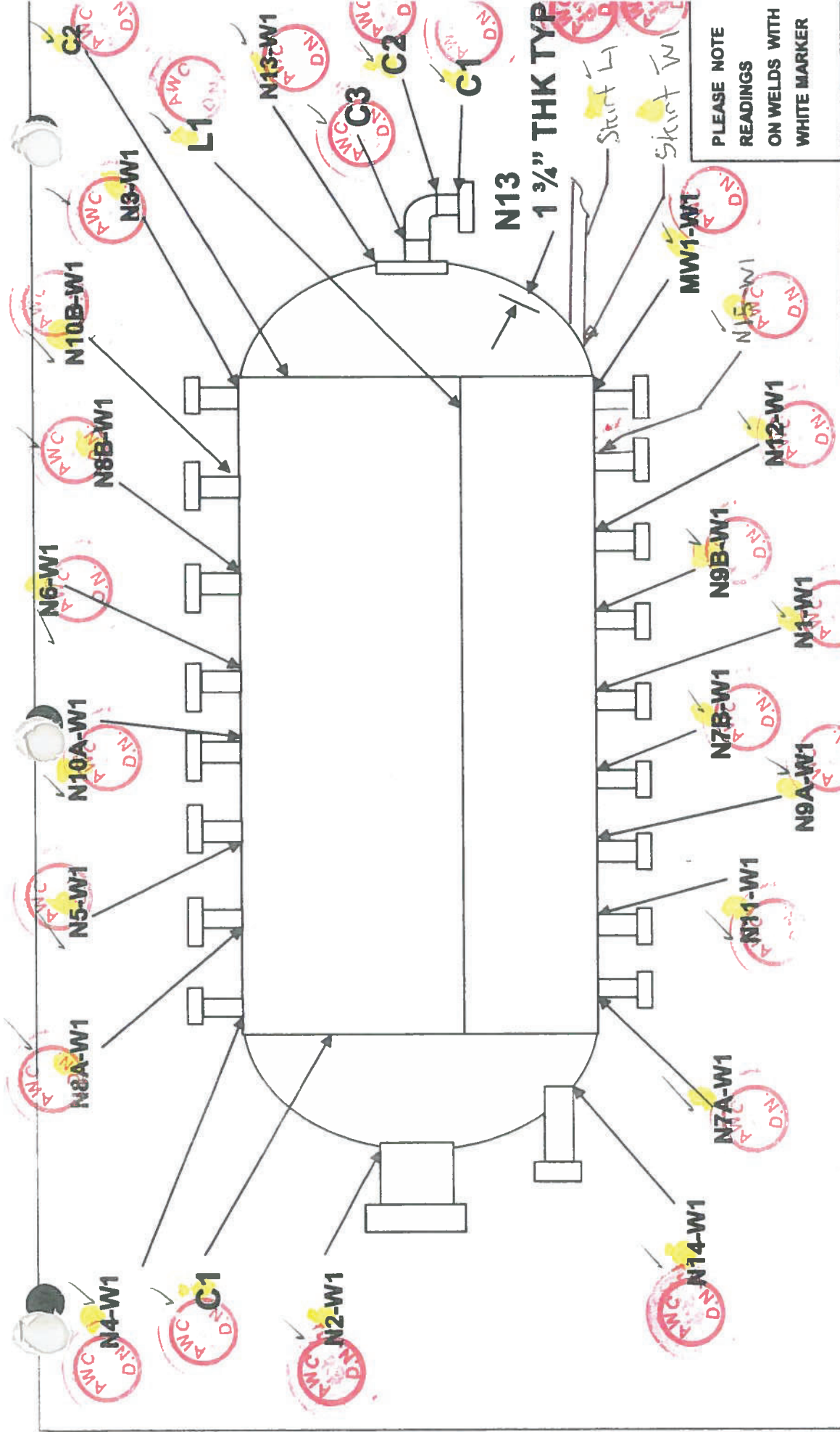
Item #	Description of Weld/Test Area	Defect Location	Interpretation
Ser#7473	Item 23/2 to shell weld		Acceptable to specification
	Item 26/2 to N1 weld		Acceptable to specification
	Item 1/7 attachment weld		Acceptable to specification
	Item 6/7 attachment weld		Acceptable to specification

✓

ACCEPTED/REVIEWED/RELEASED 046  
 for and on behalf of: SBM OFF SHORE  
 Print Name: GABRIEL SATHA  
 Signature: [Signature]  
 Date: Sept 24/13 **Applus® VELOSI**  
 Velosi America LLC

KV Inspection Technician		Date	September 13, 2013
Customer Representative		Date	OCT 02 2013





PLEASE NOTE  
 READINGS  
 ON WELDS WITH  
 WHITE MARKER

**ALL-WELDED CO. LTD. - HT MAP**

**HT MAP - 1173PQ**  
**ASME SECTION VIII. DIV. 1**

MATERIAL SA-240 316/316L, SA-182 F316/316L

1 SET OF READINGS PER WELD (BM, HAZ, W, HAZ, BM)  
 248 HV10 MAX.

P.O. 13-0228

CLIENT: ULTRAFAB  
 WORK ORDER #: 1173PQ SN 7473  
 JOB DESCRIPTION: 48" O.D. VERTICAL INLET  
 DRAWING #: 1173-1-IN  
 PREPARED BY: D.NESCI  
 DATE: March 6, 2013

1486 Wallace Road  
 Oakville, Ontario L6L 2Y6  
 Phone: 905-844-9448  
 Fax: 905-844-6697

## Hardness Testing Report HT

### Specification - Acceptance Criteria

248 HV MAX

### General Data

Customer	All-Weld Company	Date	March 14, 2013
Location	Scarborough, Ontario	P. O. #	
Project	Vessel	Shop Order #	1173 PQ
Procedure	KV HT# 50	Worksheet #	36645
Technician	John MacDonald	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 10375

### Technical Data - Hardness Testing (HT)

Material	Stainless Steel
----------	-----------------

### Test Method & Equipment

Technique	<input checked="" type="radio"/> Ultrasonic Contact Impedance (UCI)
Equipment	<input checked="" type="radio"/> GE Inspection Technologies MIC 10 DL Type # 34101 Ser# 8483
Readings Taken	<input type="radio"/> Average of 5 readings <input type="radio"/> Average of 3 readings <input checked="" type="radio"/> Other
Scale	<input type="radio"/> Brinell Hardness <input checked="" type="radio"/> Other


### Inspection

Description:

Item #	Description of Test Area	Readings
Serial # 7473 - L1	Parent Material	217
	H.A.Z	193
	Weld	225
	H.A.Z	237
	Parent Material	219

046

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBM OFFSHORE LTD  
 Print Name: LIANPESHA SAHA  
 Signature: [Signature]  
 Date: April 10/13  
**Applus<sup>®</sup> VELOSI**  
 Velosi America LLC

KV Inspection Technician		Date	March 14, 2013
Customer Representative		Date	MAR 15 2013

1486 Wallace Road  
 Oakville, Ontario L6L 2Y6  
 Phone: 905-844-9448  
 Fax: 905-844-6697

## Hardness Testing Report HT

### Specification – Acceptance Criteria

248 Max ✓

General Data			
Customer	All-Weld Company	Date	August 12, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ Ser#7473
Procedure	KV HT# 35 Rev. 00	Worksheet #	37393
Technician	Frank Marunde	HT Certified	✓ CGSB Reg # 8885

Technical Data – Hardness Testing (HT)	
Material	Stainless Steel
Test Method & Equipment	
Technique	<input checked="" type="radio"/> Impact Load – Digital Readout <input type="radio"/> Impact Load – Ocular Viewing
Equipment	<input checked="" type="radio"/> Equotip D Impact Device
Readings Taken	<input type="radio"/> Average of 5 readings <input checked="" type="radio"/> Average of 3 readings <input type="radio"/> Other
Scale	<input type="radio"/> Brinell Hardness <input checked="" type="radio"/> Other: HV    Unit Setting: S.S.

Inspection						
Description:						
Item #	Description of Test Area	Weld	HAZ	HAZ	Parent Material	Parent Material
Ser# 7473	C1	172	190	168	180	172
	C2	180	169	170	167	171

046

**ACCEPTED/REVIEWED/RELEASED**

for and on behalf of: SBM OFF SHORE

Print Name: LIANFESH SAMA

Signature: [Signature]

Date: Aug 16/13

**Applus<sup>®</sup>**  
VELOSI  
Velosi America LLC

KV Inspection Technician		Date	August 12, 2013
Customer Representative		Date	AUG 14 2013

**Hardness Testing Report  
HT**

**Specification - Acceptance Criteria**

**General Data**

Customer	All-Weld Company	Date	August 22, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ Ser#7473
Procedure	KV HT# 35 Rev.00	Worksheet #	37488
Technician	Frank Marunde	HT Certified	✓ CGSB Reg # 8885

**Technical Data - Hardness Testing (HT)**

Material	Stainless Steel
----------	-----------------

**Test Method & Equipment**

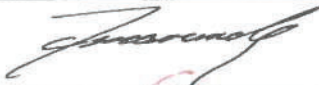

Technique	<input checked="" type="radio"/> Impact Load - Digital Readout <input type="radio"/> Impact Load - Ocular Viewing
Equipment	<input checked="" type="radio"/> Equotip D Impact Device
Readings Taken	<input type="radio"/> Average of 5 readings <input checked="" type="radio"/> Average of 3 readings <input type="radio"/> Other
Scale	<input type="radio"/> Brinell Hardness <input checked="" type="radio"/> Other: HV         Unit Setting: S.S.

**Inspection**

Description:

Item #	Description of Test Area	Weld	HAZ	HAZ	Parent Material	Parent Material
Ser# 7473	MW1	163	172	180	205	178

✓  
 ACCEPTED/REVIEWED/RELEASED 046  
 for and on behalf of: SMM OFFSHORE  
 Print Name: CHRISTOPHER SAHA  
 Signature: [Signature]  
 Date: Aug 22/13  
**Applus®**  
**VELOSI**  
 Velosi America LLC

KV Inspection Technician		Date	August 22, 2013
Customer Representative		Date	AUG 27 2013

1486 Wallace Road  
 Oakville, Ontario L6L 2Y6  
 Phone: 905-844-9448  
 Fax: 905-844-6697

## Hardness Testing Report HT

### Specification - Acceptance Criteria

#### General Data

Customer	All-Weld Company	Date	April 11, 2013
Location	Scarborough, Ontario	P. O. #	
Project	Vessel	Shop Order #	1173 PQ
Procedure	KV HT# 35 Rev. 00	Worksheet #	36766
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

#### Technical Data - Hardness Testing (HT)

Material	Stainless Steel
----------	-----------------

#### Test Method & Equipment



Technique	<input checked="" type="radio"/> Impact Load - Digital Readout
Equipment	<input checked="" type="radio"/> Equotip D Impact Device
Readings Taken	<input type="radio"/> Average of 5 readings <input checked="" type="radio"/> Average of 3 readings <input type="radio"/> Other
Scale	<input type="radio"/> Brinell Hardness <input checked="" type="radio"/> HV

#### Inspection

##### Description:

Item #	Description of Test Area	Parent Mat'l	HAZ	Weld	HAZ	Parent Mat'l
Ser# 7473	N2-W1	186	171	143	178	172
	N14-W1	191	190	173	182	189
	Skirt-W1	196	177	162	164	169
	Skirt-L1	171	162	125	169	173

ACCEPTED/REVIEWED/RELEASED 046  
 for and on behalf of: SBM OFFSHORE  
 Print Name: GANESH SAHA  
 Signature: [Signature] **Applus<sup>®</sup> VELOSI**  
 Date: April 11, 2013 **Velosi America LLC**

KV Inspection Technician		Date	April 11, 2013
Customer Representative		Date	APR 15 2013

1486 Wallace Road  
 Oakville, Ontario L6L 2Y6  
 Phone: 905-844-9448  
 Fax: 905-844-6697

## Hardness Testing Report HT

### Specification – Acceptance Criteria

248 HV Max

### General Data

Customer	All-Weld Company	Date	April 30, 2013
Location	Scarborough, Ontario	P. O. #	
Project	Vessel	Shop Order #	1173 PQ
Procedure	KV HT# 35 Rev. 00	Worksheet #	36888
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

### Technical Data – Hardness Testing (HT)

Material	Stainless Steel
----------	-----------------

### Test Method & Equipment


Technique	<input checked="" type="radio"/> Impact Load – Digital Readout
Equipment	<input checked="" type="radio"/> Equotip D Impact Device
Readings Taken	<input type="radio"/> Average of 5 readings <input checked="" type="radio"/> Average of 3 readings <input type="radio"/> Other
Scale	<input type="radio"/> Brinell Hardness <input checked="" type="radio"/> HV

### Inspection

Description:

Item #	Description of Test Area	Parent Mat'l	HAZ	Weld	HAZ	Parent Mat'l
Ser# 7473	N14-W1	189	197	169	188	183
Per NCR N13-037						

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SVM OFFSHORE  
 Print Name: GANESH SAHA  
 Signature: [Signature]  
 Date: July 21/13  
046  
**Applus®**  
 VELOSI  
 Velosi America LLC

KV Inspection Technician		Date	April 30, 2013
Customer Representative		Date	

1486 Wallace Road  
 Oakville, Ontario L6L 2Y6  
 Phone: 905-844-9448  
 Fax: 905-844-6697

## Hardness Testing Report HT

### Specification – Acceptance Criteria

#### General Data

Customer	All-Weld Company	Date	August 19, 2013
Location	Scarborough, ON	P. O. #	
Project	Nozzles	Shop Order #	1173 PQ Ser#7473
Procedure	KV HT# 35 Rev.00	Worksheet #	37397
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

#### Technical Data – Hardness Testing (HT)

Material	Stainless Steel
----------	-----------------

#### Test Method & Equipment

Technique	<input checked="" type="radio"/> Impact Load – Digital Readout <input type="radio"/> Impact Load – Ocular Viewing
Equipment	<input checked="" type="radio"/> Equotip D Impact Device
Readings Taken	<input type="radio"/> Average of 5 readings <input checked="" type="radio"/> Average of 3 readings <input type="radio"/> Other
Scale	<input checked="" type="radio"/> Brinell Hardness <input type="radio"/> Other

#### Inspection

##### Description:

Item #	Description of Test Area	Weld	HAZ	HAZ	Parent Material	Parent Material
Ser# 7473	N1	143	160	160	154	192
	N3	136	177	164	202	190
	N4	149	169	181	182	185
	N5	155	197	192	188	208
	N6	148	197	170	181	172
	N7A	153	202	189	204	195
	N7B	145	191	200	202	219
	N8A	149	169	171	162	195
	N8B	167	191	179	204	175

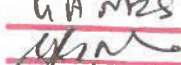
KV Inspection Technician		Date	August 19, 2013
Customer Representative		Date	AUG 22 2013



ACCEPTED/REVIEWED/RELEASED 046

for and on behalf of: CISM OPS HOLD

Print Name: W A MESH SAHA

Signature: 

Date: Aug 23/13

Applus<sup>®</sup>  
VELOSI  
Velosi America LLC

**Hardness Testing Report  
HT**

**Specification – Acceptance Criteria**

**General Data**

Customer	All-Weld Company	Date	August 19, 2013
Location	Scarborough, ON	P. O. #	
Project	Nozzles	Shop Order #	1173 PQ Ser#7473
Procedure	KV HT# 35 Rev.00	Worksheet #	37397
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

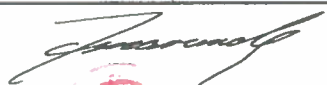

**Technical Data – Hardness Testing (HT)**

Material	Stainless Steel
<b>Test Method &amp; Equipment</b>	
Technique	<input checked="" type="radio"/> Impact Load – Digital Readout <input type="radio"/> Impact Load – Ocular Viewing
Equipment	<input checked="" type="radio"/> Equotip D Impact Device
Readings Taken	<input type="radio"/> Average of 5 readings <input checked="" type="radio"/> Average of 3 readings <input type="radio"/> Other
Scale	<input checked="" type="radio"/> Brinell Hardness <input type="radio"/> Other

**Inspection**

Description:

Item #	Description of Test Area	Weld	HAZ	HAZ	Parent Material	Parent Material
Ser# 7473	N9A	157	208	198	217	207
	N9B	167	165	202	185	202
	N10A	157	188	197	170	190
	N10B	143	207	186	210	172
	N11	166	191	219	204	215
	N12	195	205	169	197	153
	N15	137	189	173	206	173

KV Inspection Technician		Date	August 19, 2013
Customer Representative		Date	AUG 22 2013

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SAH OFFSHORE  
Print Name: LAMBESH SAH A  
Signature: [Signature]  
Date: Aug 23/13  
**Applus® VELOSI**  
Velosi America LLC



1486 Wallace Road  
 Oakville, Ontario L6L 2Y6  
 Phone: 905-844-9448  
 Fax: 905-844-6697

## Hardness Testing Report HT

### Specification – Acceptance Criteria

General Data			
Customer	All-Weld Company	Date	August 26, 2013
Location	Scarborough, ON	P. O. #	
Project	Vessel	Shop Order #	1173 PQ
Procedure	KV HT# 35 Rev.00	Worksheet #	37490
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

Technical Data – Hardness Testing (HT)	
Material	Carbon Steel
Test Method & Equipment	
Technique	<input checked="" type="radio"/> Impact Load – Digital Readout <input type="radio"/> Impact Load – Ocular Viewing
Equipment	<input checked="" type="radio"/> Equotip D Impact Device
Readings Taken	<input type="radio"/> Average of 5 readings <input checked="" type="radio"/> Average of 3 readings <input type="radio"/> Other
Scale	<input type="radio"/> Brinell Hardness <input checked="" type="radio"/> HV

Inspection						
Description:						
Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7473	N13 - WI	167	179	161	183	169

046

ACCEPTED/REVIEWED/RELEASED

for and on behalf of: SBM OFFSHORE

Print Name: GABRIELA SALLA

Signature: [Signature]

Date: Aug 29/13

**Applus®**  
VELOSI

Velosi America LLC

KV Inspection Technician		Date	August 26, 2013
Customer Representative		Date	AUG 28 2013

1486 Wallace Road  
 Oakville, Ontario L6L 2Y6  
 Phone: 905-844-9448  
 Fax: 905-844-6697

## Hardness Testing Report HT

### Specification - Acceptance Criteria

248 Max ✓

General Data			
Customer	All-Weld Company	Date	August 13, 2013
Location	@ KVI, Oakville, ON	P. O. #	
Project	Vessel	Shop Order #	1176 PQ Ser#7473
Procedure	KV HT# 35 Rev.00	Worksheet #	37440
Technician	Ed Duitschaever	HT Certified	✓ CGSB Reg # 515

Technical Data - Hardness Testing (HT)	
Material	Stainless Steel
Test Method & Equipment	
Technique	<input checked="" type="radio"/> Impact Load - Digital Readout <input type="radio"/> Impact Load - Ocular Viewing
Equipment	<input checked="" type="radio"/> Equotip D Impact Device
Readings Taken	<input type="radio"/> Average of 5 readings <input checked="" type="radio"/> Average of 3 readings <input type="radio"/> Other
Scale	<input checked="" type="radio"/> Brinell Hardness <input type="radio"/> Other

Inspection						
Description:						
Item #	Description of Test Area	Parent Material Flange	HAZ	Weld	HAZ	Parent Material
Ser# 7473	N13 - C1	137	152	159	160	153
	N13 - C2	150	162	150	148	160

ACCEPTED/REVIEWED/RELEASED 046



for and on behalf of: SBM OPP SHD&E

Print Name: GANESH SANA

Signature: [Signature]

Date: Aug 14/13

**Applus®**  
VELOSI  
Velosi America LLC

KV Inspection Technician		Date	August 13, 2013
Customer Representative		Date	AUG 14 2013

1486 Wallace Road  
 Oakville, Ontario L6L 2Y6  
 Phone: 905-844-9448  
 Fax: 905-844-6697

## Hardness Testing Report HT

**Specification – Acceptance Criteria**

2UB Max

### General Data

Customer	All-Weld Company	Date	August 30, 2013
Location	Scarborough, ON	P. O. #	
Project	Vessel	Shop Order #	1173 PQ
Procedure	KV HT# 35 Rev.00	Worksheet #	37494
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

### Technical Data – Hardness Testing (HT)

Material	Stainless Steel
----------	-----------------

### Test Method & Equipment

Technique	<input checked="" type="radio"/> Impact Load – Digital Readout	<input type="radio"/> Impact Load – Ocular Viewing
Equipment	<input checked="" type="radio"/> Equotip D Impact Device	
Readings Taken	<input type="radio"/> Average of 5 readings <input checked="" type="radio"/> Average of 3 readings <input type="radio"/> Other	
Scale	<input type="radio"/> Brinell Hardness <input checked="" type="radio"/> HV	

### Inspection

Description:

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7473	N13-C3	143	147	158	169	163

046

ACCEPTED/REVIEWED/RELEASED

for and on behalf of: SBM CFF SHOPS

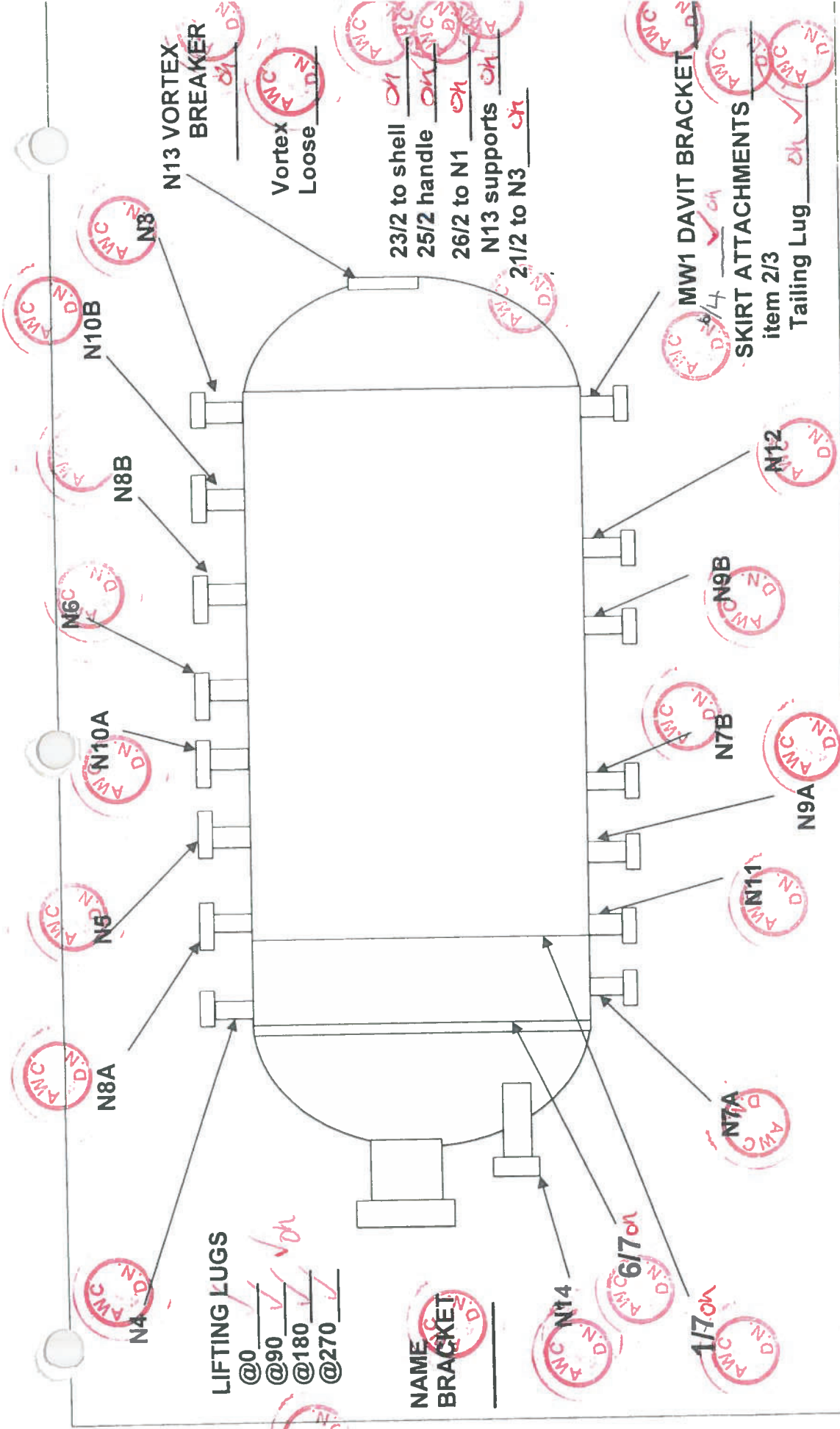
Print Name: CHRISTIAN SAH

Signature: [Signature]

Date: SEP 10 2013

Appius®  
VELOSI  
Velosi America LLC

KV Inspection Technician		Date	August 30, 2013
Customer Representative		Date	SEP 04 2013



N13 VORTEX BREAKER

Vortex Loose

23/2 to shell  
 25/2 handle  
 26/2 to N1  
 N13 supports  
 21/2 to N3

MW1 DAVIT BRACKET  
 SKIRT ATTACHMENTS  
 item 2/3  
 Tailing Lug

LIFTING LUGS  
 @0 ✓  
 @90 ✓  
 @180 ✓  
 @270 ✓

NAME BRACKET

**ALL-WELD CO. LTD. - HT MAP  
 ATTACHMENTS / BRACKETS**

HT MAP - 1173PQ  
 ASME SECTION VIII. DIV. 1  
 ALL WELDS INTERNAL / EXTERNAL EXCEPT WHERE NOTED  
 ATTACHMENTS / BRACKETS  
 MATERIAL SA-240 316/316L

CLIENT: ULTRAFAB  
 WORK ORDER #: 1173PQ SN 7473  
 JOB DESCRIPTION: 48" O.D. VERTICAL INLET  
 DRAWING #: 1173-1-IN  
 PREPARED BY: D.NESCI  
 DATE: March 6, 2013

P.O.

1486 Wallace Road  
 Oakville, Ontario L6L 2Y6  
 Phone: 905-844-9448  
 Fax: 905-844-6697

## Hardness Testing Report HT

### Specification – Acceptance Criteria

#### General Data

Customer	All-Weld Company	Date	September 13, 2013
Location	Scarborough, ON	P. O. #	
Project	Vessel	Shop Order #	1173 PQ S/N 7473
Procedure	KV HT# 35 Rev.00	Worksheet #	37593
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

#### Technical Data – Hardness Testing (HT)

Material	Stainless Steel
----------	-----------------

#### Test Method & Equipment

Technique	<input checked="" type="radio"/> Impact Load – Digital Readout	<input type="radio"/> Impact Load – Ocular Viewing	
Equipment	<input checked="" type="radio"/> Equotip D Impact Device		
Readings Taken	<input type="radio"/> Average of 5 readings	<input checked="" type="radio"/> Average of 3 readings	<input type="radio"/> Other
Scale	<input type="radio"/> Brinell Hardness	<input checked="" type="radio"/> HV	Unit Setting:

#### Inspection

Description:

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7473	N3 Support Welds					
	Weld #1	115	147	140	149	145
	Weld #2	109	146	140	144	143
	Weld #3	122	142	132	149	174
	Weld #4	198	148	165	145	164
	N7A Support Welds					
	Weld #1	129	145	159	163	119
	Weld #2	164	133	121	131	107
	Weld #3	158	182	150	189	121
	Weld #4	110	161	138	159	159

046  
 ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: S. B. M. OFFSHORE INC.  
 Print Name: G. MARUNDE  
 Signature: [Signature]  
 Date: 13 Sep 2013  
**Applus®**  
**VELOSI**  
 Velocity America LLC

KV Inspection Technician	<u>[Signature]</u>	Date	September 13, 2013
Customer Representative	<u>[Signature]</u>	Date	SEP 18 2013

**Hardness Testing Report  
HT**

**Specification – Acceptance Criteria**

**General Data**

Customer	All-Weld Company	Date	September 4, 2013
Location	Scarborough, ON	P. O. #	
Project	Vessel	Shop Order #	1173 PQ
Procedure	KV HT# 35 Rev.00	Worksheet #	37560
Technician	John MacDonald	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 10375

**Technical Data – Hardness Testing (HT)**

Material	Stainless Steel
----------	-----------------

**Test Method & Equipment**


Technique	<input checked="" type="radio"/> Impact Load – Digital Readout <input type="radio"/> Impact Load – Ocular Viewing
Equipment	<input checked="" type="radio"/> Equotip D Impact Device
Readings Taken	<input type="radio"/> Average of 5 readings <input checked="" type="radio"/> Average of 3 readings <input type="radio"/> Other
Scale	<input type="radio"/> Brinell Hardness <input checked="" type="radio"/> HV

**Inspection**

Description:

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7473	N4					
	0° to shell	160	168	110	179	102
		201	162	129	158	168
	0° to nozzle	170	119	165	185	190
		185	161	147	132	117
	90° to shell	137	182	127	155	110
		162	162	162	121	104
	90° to nozzle	162	213	179	190	173
		185	189	183	174	131

ACCEPTED/REVIEWED/REI BASED  
 for and on behalf of:  
 Print Name: John MacDonald  
 Signature: [Signature]  
 Date: 09/11/13  
 046  
**Applus**  
**VELOSI**  
 Velosi America LLC

KV Inspection Technician		Date	September 4, 2013
Customer Representative		Date	SEP 10 2013

**Hardness Testing Report  
HT**

**Specification – Acceptance Criteria**

**General Data**

Customer	All-Weld Company	Date	September 4, 2013
Location	Scarborough, ON	P. O. #	
Project	Vessel	Shop Order #	1173 PQ
Procedure	KV HT# 35 Rev.00	Worksheet #	37560
Technician	John MacDonald	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 10375

**Technical Data – Hardness Testing (HT)**

Material	Stainless Steel
----------	-----------------

**Test Method & Equipment**


Technique	<input checked="" type="radio"/> Impact Load – Digital Readout <input type="radio"/> Impact Load – Ocular Viewing
Equipment	<input checked="" type="radio"/> Equotip D Impact Device
Readings Taken	<input type="radio"/> Average of 5 readings <input checked="" type="radio"/> Average of 3 readings <input type="radio"/> Other
Scale	<input type="radio"/> Brinell Hardness <input checked="" type="radio"/> HV

**Inspection**

Description:

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7473	N5					
	0° to shell	130	146	173	170	138
		107	172	104	156	123
	0° to nozzle	108	111	160	172	190
		191	157	143	183	107
	90° to shell	146	165	123	138	180
		172	155	117	171	174
	90° to nozzle	190	108	164	176	127
		156	199	173	173	138

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBM OFFSHORE HOLDINGS  
 Print Name: GAMESH SHAH  
 Signature: *[Signature]*  
 Date: Oct 11/13  
 Applus®  
 VELOSI  
 Velosi America LLC  
 046

KV Inspection Technician		Date	September 4, 2013
Customer Representative		Date	SEP 10 2013

1486 Wallace Road  
 Oakville, Ontario L6L 2Y6  
 Phone: 905-844-9448  
 Fax: 905-844-6697

## Hardness Testing Report HT

### Specification – Acceptance Criteria

General Data			
Customer	All-Weld Company	Date	September 4, 2013
Location	Scarborough, ON	P. O. #	
Project	Vessel	Shop Order #	1173 PQ
Procedure	KV HT# 35 Rev.00	Worksheet #	37560
Technician	John MacDonald	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 10375

Technical Data – Hardness Testing (HT)	
Material	Stainless Steel

Test Method & Equipment	
Technique	<input checked="" type="radio"/> Impact Load – Digital Readout <input type="radio"/> Impact Load – Ocular Viewing
Equipment	<input checked="" type="radio"/> Equotip D Impact Device
Readings Taken	<input type="radio"/> Average of 5 readings <input checked="" type="radio"/> Average of 3 readings <input type="radio"/> Other
Scale	<input type="radio"/> Brinell Hardness <input checked="" type="radio"/> HV

### Inspection

Description:

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7473	N6					
	0° to shell	147	185	128	161	119
		109	126	198	138	172
	0° to nozzle	175	178	132	129	183
		160	199	181	178	156
	90° to shell	139	115	210	189	156
		172	137	171	190	167
	90° to nozzle	185	174	139	190	190
		172	185	186	107	186

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: S&M OF S&H


Print Name: LAURENCE SHIH

Signature: [Signature]

Date: 09/11/13

**Applus**  
VELIOSI  
Velosi America LLC

045

KV Inspection Technician		Date	September 4, 2013
Customer Representative		Date	SEP 10 2013



1486 Wallace Road  
 Oakville, Ontario L6L 2Y6  
 Phone: 905-844-9448  
 Fax: 905-844-6697

## Hardness Testing Report HT

### Specification – Acceptance Criteria

#### General Data

Customer	All-Weld Company	Date	September 13, 2013
Location	Scarborough, ON	P. O. #	
Project	Vessel	Shop Order #	1173 PQ S/N 7473
Procedure	KV HT# 35 Rev.00	Worksheet #	37593
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

#### Technical Data – Hardness Testing (HT)

Material	Stainless Steel
----------	-----------------

#### Test Method & Equipment

Technique	<input checked="" type="radio"/> Impact Load – Digital Readout <span style="margin-left: 100px;"><input type="radio"/> Impact Load – Ocular Viewing</span>
Equipment	<input checked="" type="radio"/> Equotip D Impact Device
Readings Taken	<input type="radio"/> Average of 5 readings <span style="margin-left: 20px;"><input checked="" type="radio"/> Average of 3 readings</span> <span style="margin-left: 20px;"><input type="radio"/> Other</span>
Scale	<input type="radio"/> Brinell Hardness <span style="margin-left: 20px;"><input checked="" type="radio"/> HV</span> <span style="margin-left: 20px;">Unit Setting:</span>

#### Inspection

Description:

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7473	N7B Support Welds					
	Weld #1	172	160	136	152	134
	Weld #2	160	145	132	141	115
	Weld#3	168	197	151	156	173
	Weld#4	157	126	134	149	139
	N12 Support Welds					
	Weld #1	188	160	152	180	116
	Weld #2	178	179	150	175	132
	Weld#3	160	194	130	175	138
	Weld#4	158	156	136	137	154
	Item 2/3 to Skirt	143	160	157	127	118

046

ACCEPTED/REVIEWED/RELEASED

for and on behalf of: BOB OFFSHORE

Print Name: G. A. WELLS SA HT

Signature: [Signature]

Date: SEP 24 13

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Velosi America LLC

KV Inspection Technician		Date	September 13, 2013
Customer Representative		Date	SEP 18 2013

1486 Wallace Road  
Oakville, Ontario L6L 2Y6  
Phone: 905-844-9448  
Fax: 905-844-6697

**Hardness Testing Report  
HT**

**Specification – Acceptance Criteria**

**General Data**

Customer	All-Weld Company	Date	September 4, 2013
Location	Scarborough, ON	P. O. #	
Project	Vessel	Shop Order #	1173 PQ
Procedure	KV HT# 35 Rev.00	Worksheet #	37560
Technician	John MacDonald	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 10375

**Technical Data – Hardness Testing (HT)**


Material	Stainless Steel
<b>Test Method &amp; Equipment</b>	
Technique	<input checked="" type="radio"/> Impact Load – Digital Readout <input type="radio"/> Impact Load – Ocular Viewing
Equipment	<input checked="" type="radio"/> Equotip D Impact Device
Readings Taken	<input type="radio"/> Average of 5 readings <input checked="" type="radio"/> Average of 3 readings <input type="radio"/> Other
Scale	<input type="radio"/> Brinell Hardness <input checked="" type="radio"/> HV

**Inspection**

Description:

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7473	N8A					
	0° to shell	116	172	180	152	192
		179	194	155	140	109
	0° to nozzle	101	147	176	176	185
		136	189	201	152	172
	90° to shell	142	180	126	163	183
		132	179	180	137	126
	90° to nozzle	121	139	186	152	184
		173	130	170	173	172

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SRM OFFSHORE  
 Print Name: John MacDonald  
 Signature: [Signature]  
 Date: 09-11-13  
**Applus**  
**VELOSI**  
 Veloci America LLC

KV Inspection Technician		Date	September 4, 2013
Customer Representative		Date	SEP 10 2013

**Hardness Testing Report  
HT**

**Specification – Acceptance Criteria**

**General Data**

Customer	All-Weld Company	Date	September 4, 2013
Location	Scarborough, ON	P. O. #	
Project	Vessel	Shop Order #	1173 PQ
Procedure	KV HT# 35 Rev.00	Worksheet #	37560
Technician	John MacDonald	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 10375

**Technical Data – Hardness Testing (HT)**

Material	Stainless Steel
----------	-----------------

**Test Method & Equipment**

Technique	<input checked="" type="radio"/> Impact Load – Digital Readout <input type="radio"/> Impact Load – Ocular Viewing
Equipment	<input checked="" type="radio"/> Equotip D Impact Device
Readings Taken	<input type="radio"/> Average of 5 readings <input checked="" type="radio"/> Average of 3 readings <input type="radio"/> Other
Scale	<input type="radio"/> Brinell Hardness <input checked="" type="radio"/> HV

**Inspection**

Description:

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7473	N8B					
	0° to shell	140	180	210	165	190
		120	149	171	143	139
	0° to nozzle	141	172	108	137	186
		138	105	172	175	117
	90° to shell	181	129	180	180	132
		199	167	160	185	200
	90° to nozzle	147	183	173	179	186
		135	200	189	212	189

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SPM O.F.F. Shell  
 Print Name: W. AMESIA SAHJI  
 Signature: [Signature]  
 Date: SEP 11 2013  
**Applus®**  
**VELOSI**  
 Veloxi America LLC  
 006

KV Inspection Technician		Date	September 4, 2013
Customer Representative		Date	SEP 10 2013



## Hardness Testing Report HT

### Specification – Acceptance Criteria

#### General Data

Customer	All-Weld Company	Date	September 4, 2013
Location	Scarborough, ON	P. O. #	
Project	Vessel	Shop Order #	1173 PQ
Procedure	KV HT# 35 Rev.00	Worksheet #	37560
Technician	John MacDonald	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 10375

#### Technical Data – Hardness Testing (HT)

Material	Stainless Steel
<b>Test Method &amp; Equipment</b>	
Technique	<input checked="" type="radio"/> Impact Load – Digital Readout <input type="radio"/> Impact Load – Ocular Viewing
Equipment	<input checked="" type="radio"/> Equotip D Impact Device
Readings Taken	<input type="radio"/> Average of 5 readings <input checked="" type="radio"/> Average of 3 readings <input type="radio"/> Other
Scale	<input type="radio"/> Brinell Hardness <input checked="" type="radio"/> HV

#### Inspection

##### Description:

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7473	N9A					
	0° to shell	183	143	105	185	162
		201	170	147	184	185
	0° to nozzle	213	148	185	176	190
		165	105	170	148	172
	90° to shell	145	143	167	166	186
		190	197	182	200	177
	90° to nozzle	171	149	199	170	187
		164	155	183	150	193

ACCEPTED FOR RELEASED  
 for and on behalf of: SAM OFF SHELL  
 Print Name: LAWRENCE SAM  
 Signature: *[Signature]*  
 Date: 09/11/13  
 Applus®  
 VELOSI  
 Veloci America LLC  
 046



KV Inspection Technician		Date	September 4, 2013
Customer Representative		Date	SEP 10 2013

1486 Wallace Road  
 Oakville, Ontario L6L 2Y6  
 Phone: 905-844-9448  
 Fax: 905-844-6697

## Hardness Testing Report HT

### Specification - Acceptance Criteria

#### General Data

Customer	All-Weld Company	Date	September 11, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7473
Procedure	KV HT# 35 Rev.00	Worksheet #	37591
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

#### Technical Data - Hardness Testing (HT)

Material	Stainless Steel
----------	-----------------

#### Test Method & Equipment

Technique	<input checked="" type="radio"/> Impact Load - Digital Readout	<input type="radio"/> Impact Load - Ocular Viewing	
Equipment	<input checked="" type="radio"/> Equotip D Impact Device		
Readings Taken	<input type="radio"/> Average of 5 readings	<input checked="" type="radio"/> Average of 3 readings	<input type="radio"/> Other
Scale	<input type="radio"/> Brinell Hardness	<input checked="" type="radio"/> HV	Unit Setting: <input type="text"/>

#### Inspection

Description: Ser# 7473

Item #	Description of Test Area	Weld	HAZ	HAZ	Parent Material	Parent Material
N9B	Support Weld # 1	170	163	141	165	116
	Support Weld # 2	186	139	139	156	135
	Support Weld # 3	172	176	147	151	148
	Support Weld # 4	167	148	--	146	--
N10A	Support Weld # 1	124	157	169	190	132
	Support Weld # 2	132	171	167	163	122
	Support Weld # 3	157	182	166	170	121
	Support Weld # 4	154	133	139	153	158
	Name plate bracket	139	169	No Access	164	155

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of:  
 Print Name: CHARLES SAHA  
 Signature: [Signature]  
 Date: Sept 11 13  
 Applis®  
 VELLOSI  
 Veloci America LLC  
 096

KV Inspection Technician	<u>[Signature]</u>	Date	September 11, 2013
Customer Representative	<u>[Signature]</u>	Date	SEP 13 2013



1486 Wallace Road  
 Oakville, Ontario L6L 2Y6  
 Phone: 905-844-9448  
 Fax: 905-844-6697

## Hardness Testing Report HT

### Specification – Acceptance Criteria

General Data			
Customer	All-Weld Company	Date	September 11, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ
Procedure	KV HT# 35 Rev.00	Worksheet #	37591
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

Technical Data – Hardness Testing (HT)	
Material	Stainless Steel

Test Method & Equipment			
Technique	<input checked="" type="radio"/> Impact Load – Digital Readout <input type="radio"/> Impact Load – Ocular Viewing		
Equipment	<input checked="" type="radio"/> Equotip D Impact Device		
Readings Taken	<input type="radio"/> Average of 5 readings <input checked="" type="radio"/> Average of 3 readings <input type="radio"/> Other		
Scale	<input type="radio"/> Brinell Hardness <input checked="" type="radio"/> HV	Unit Setting:	

### Inspection

Description: Ser# 7473

Item #	Description of Test Area	Weld	HAZ	HAZ	Parent Material	Parent Material
N10B	Support Weld # 1	141	191	178	171	154
	Support Weld # 2	157	151	163	168	130
	Support Weld # 3	163	163	181	172	143
	Support Weld # 4	154	173	167	176	121
N11	Support Weld # 1	127	190	149	203	135
	Support Weld # 2	126	124	163	124	110
	Support Weld # 3	140	181	129	211	133
	Support Weld # 4	143	173	144	171	136
	Davit Bracket	148	190	196	210	208

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of:

Print Name: \_\_\_\_\_  
 Signature: \_\_\_\_\_  
 Date: \_\_\_\_\_

046

KV Inspection Technician		Date	September 11, 2013
Customer Representative		Date	SEP 13 2013

**Hardness Testing Report  
HT**

**Specification – Acceptance Criteria**

**General Data**

Customer	All-Weld Company	Date	September 4, 2013
Location	Scarborough, ON	P. O. #	
Project	Vessel	Shop Order #	1173 PQ
Procedure	KV HT# 35 Rev.00	Worksheet #	37496
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

**Technical Data – Hardness Testing (HT)**

Material	Stainless Steel
<b>Test Method &amp; Equipment</b>	
Technique	<input checked="" type="radio"/> Impact Load – Digital Readout <input type="radio"/> Impact Load – Ocular Viewing
Equipment	<input checked="" type="radio"/> Equotip D Impact Device
Readings Taken	<input type="radio"/> Average of 5 readings <input checked="" type="radio"/> Average of 3 readings <input type="radio"/> Other
Scale	<input type="radio"/> Brinell Hardness <input checked="" type="radio"/> HV

**Inspection**

Description:

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7473	MW1-W1 repair (See RT report)	155	174	148	190	172
	N13 support weld					
	#1	152	138	144	133	145
	#2	120	156	136	150	153
	#3	130	148	126	137	133
	#4	129	152	143	141	136

ACCEPTED/REVIEWED/RELEASED 046  
for and on behalf of: SAM OFFSHORE  
Print Name: ANUPESH SAHAI  
Signature: [Signature]  
Date: 09/11/13  
**Applus<sup>®</sup> VELOSI**  
Velosi America LLC

KV Inspection Technician	<u>[Signature]</u>	Date	September 4, 2013
Customer Representative	<u>[Signature]</u>	Date	SEP 10 2013



1486 Wallace Road  
 Oakville, Ontario L6L 2Y6  
 Phone: 905-844-9448  
 Fax: 905-844-6697

## Hardness Testing Report HT

### Specification - Acceptance Criteria

#### General Data

Customer	All-Weld Company	Date	September 12, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7473
Procedure	KV HT# 35 Rev.00	Worksheet #	37592
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

#### Technical Data - Hardness Testing (HT)

Material	Stainless Steel
----------	-----------------

#### Test Method & Equipment

Technique	<input checked="" type="radio"/> Impact Load - Digital Readout	<input type="radio"/> Impact Load - Ocular Viewing	
Equipment	<input checked="" type="radio"/> Equotip D Impact Device		
Readings Taken	<input type="radio"/> Average of 5 readings	<input checked="" type="radio"/> Average of 3 readings	<input type="radio"/> Other
Scale	<input type="radio"/> Brinell Hardness	<input checked="" type="radio"/> HV	Unit Setting: <input type="text"/>

#### Inspection

##### Description:

Item #	Description of Test Area	Weld	HAZ	HAZ	Parent Material	Parent Material
Ser# 7473						
N14	Support Weld #1	160	106	135	132	102
	Support Weld #2	149	152	157	179	128
	Support Weld #3	147	149	No Access	130	144
	Support Weld #4	156	146	156	135	154

✓

ACCEPTED/REVIEWED/RELEASED 046

for and on behalf of: SBM OFFSHORE

Print Name: CHANDSIT SAHA

Signature: [Signature]

Date: Sept 11/13

**Applus®**  
**VELOSI**  
 Velosi America LLC

KV Inspection Technician	<u>[Signature]</u>	Date	September 12, 2013
Customer Representative		Date	SEP 13 2013



1486 Wallace Road  
 Oakville, Ontario L6L 2Y6  
 Phone: 905-844-9448  
 Fax: 905-844-6697

## Hardness Testing Report HT

### Specification – Acceptance Criteria

Max 248 V

### General Data

Customer	All-Weld Company	Date	September 11, 2013
Location	Scarborough, ON	P. O. #	
Project	Ultrafab	Shop Order #	1173 PQ S/N 7473
Procedure	KV HT# 35 Rev.00	Worksheet #	37629
Technician	John MacDonald	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 10375

### Technical Data – Hardness Testing (HT)

Material: 316 L

### Test Method & Equipment

Technique	<input checked="" type="radio"/> Impact Load – Digital Readout <input type="radio"/> Impact Load – Ocular Viewing		
Equipment	<input checked="" type="radio"/> Equotip D Impact Device		
Readings Taken	<input type="radio"/> Average of 5 readings <input checked="" type="radio"/> Average of 3 readings <input type="radio"/> Other		
Scale	<input type="radio"/> Brinell Hardness <input checked="" type="radio"/> Vickers	Unit Setting:	

### Inspection

Description:

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7473	MW1 Bracket	220	146	128	149	180
	Skirt Attachment Item 2/3					
	Inside	112	141	137	132	136
	Outside	131	150	114	117	162

046

ACCEPTED/REVIEWED/RELEASED

for and on behalf of: SBA OFFSHORE

Print Name: GANESH SAHA

Signature: [Signature]

Date: SEP 11 2013

**Applus®**  
 VELOSI  
 Velosi America LLC

KV Inspection Technician		Date	September 11, 2013
Customer Representative		Date	SEP 13 2013

1486 Wallace Road  
 Oakville, Ontario L6L 2Y6  
 Phone: 905-844-9448  
 Fax: 905-844-6697

## Hardness Testing Report HT

### Specification – Acceptance Criteria

#### General Data

Customer	All-Weld Company	Date	September 17, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7473
Procedure	KV HT# 35 Rev.00	Worksheet #	37644
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

#### Technical Data – Hardness Testing (HT)


Material	Stainless Steel		
<b>Test Method &amp; Equipment</b>			
Technique	<input checked="" type="radio"/> Impact Load – Digital Readout <input type="radio"/> Impact Load – Ocular Viewing		
Equipment	<input checked="" type="radio"/> Equotip D Impact Device		
Readings Taken	<input type="radio"/> Average of 5 readings <input checked="" type="radio"/> Average of 3 readings <input type="radio"/> Other		
Scale	<input type="radio"/> Brinell Hardness <input checked="" type="radio"/> HV	Unit Setting:	

#### Inspection

Description:

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7473	Lifting Lug @ 0°	175	154	135	135	145
	Lifting Lug @ 90°	141	181	112	143	142
	Lifting Lug @ 180°	133	159	133	169	141
	Lifting Lug @ 270°	172	135	169	197	172
	Tailing Lug	103	142	157	134	113
	Item 6/4 Attachment					
	Weld #1	189	171	158	196	176
	Weld #2	205	191	149	191	168
	Weld #3	189	163	133	211	182
	Weld #4	218	175	142	203	164

ACCEPTED FOR RELEASE  
 for and on behalf of: SAM OFFSHORE  
 Print Name: CHANESH SANA  
 Signature: *[Signature]*  
 Date: Sep 17 11:13  
 096  
 Atplus®  
 VELOSI  
 Velocity America LLC

KV Inspection Technician	<i>[Signature]</i>	Date	September 17, 2013
Customer Representative		Date	SEP 20 2013

1486 Wallace Road  
 Oakville, Ontario L6L 2Y6  
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 Fax: 905-844-6697

## Hardness Testing Report HT

### Specification - Acceptance Criteria

#### General Data

Customer	All-Weld Company	Date	September 12, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7473
Procedure	KV HT# 35 Rev.00	Worksheet #	37592
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

#### Technical Data - Hardness Testing (HT)

Material	Stainless Steel		
<b>Test Method &amp; Equipment</b>			
Technique	<input checked="" type="radio"/> Impact Load - Digital Readout <input type="radio"/> Impact Load - Ocular Viewing		
Equipment	<input checked="" type="radio"/> Equotip D Impact Device		
Readings Taken	<input type="radio"/> Average of 5 readings <input checked="" type="radio"/> Average of 3 readings <input type="radio"/> Other		
Scale	<input type="radio"/> Brinell Hardness <input checked="" type="radio"/> HV	Unit Setting:	

#### Inspection

Description:

Item #	Description of Test Area	Weld	HAZ	HAZ	Parent Material	Parent Material
Ser# 7473	Item 1/7	118	184	194	189	174
	Item 6/7	154	166	138	161	179
	Item 23/2 to shell	125	167	135	198	133
	Item 22/2 to shell	135	152	145	207	203
	Item 25/2 to shell	131	138	137	183	197
	Item 26/2 N1	133	147	149	148	165
	Item 21/2 to N3	121	156	171	178	157
	Vortex breaker to shell	117	170	129	119	130

ACCEPTED FOR RELEASED  
 for and on behalf of: SAW OFFSHORE  
 Print Name: CHRISTINA SAHNI  
 Signature: [Signature]  
 Date: Sept 11/13  
 046  
 Applus®  
 VELOSI  
 Velosi America LLC

KV Inspection Technician	<u>[Signature]</u>	Date	September 12, 2013
Customer Representative	<u>[Signature]</u>	Date	SEP 13 2013



1486 Wallace Road  
 Oakville, Ontario L6L 2Y6  
 Phone: 905-844-9448  
 Fax: 905-844-6697

### Specification – Acceptance Criteria

### General Data

Customer	All-Weld Company	Date	September 3, 2013
Location	Scarborough, ON	P. O. #	
Project	Vessel	Shop Order #	1173 PQ S/N 7473
Procedure	KV HT# 35 Rev.00	Worksheet #	37495
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

### Technical Data – Hardness Testing (HT)

Material	Stainless Steel
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### Test Method & Equipment

Technique	<input checked="" type="radio"/> Impact Load – Digital Readout <input type="radio"/> Impact Load – Ocular Viewing
Equipment	<input checked="" type="radio"/> Equotip D Impact Device
Readings Taken	<input type="radio"/> Average of 5 readings <input checked="" type="radio"/> Average of 3 readings <input type="radio"/> Other
Scale	<input type="radio"/> Brinell Hardness <input checked="" type="radio"/> HV

### Inspection

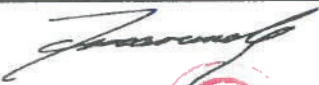

Description:

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7473	N13-C3	158	158	133	174	163
	Vortex breaker loose	104	131	110	143	111

046

ACCEPTED/REVIEWED/RELEASED ✓  
 for and on behalf of: SBM OFF SHORE  
 Print Name: GAURPESH SAHA  
 Signature: [Signature]  
 Date: SEP 10 2013

**Applus<sup>®</sup>**  
**VELOSI**  
 Velosi America LLC

KV Inspection Technician		Date	September 3, 2013
Customer Representative		Date	SEP 09 2013

<b>NON-CONFORMANCE REPORT</b>				NCR No N13-083
Work Order 1173	Serial Number 7473 & 7474	Customer Ultrafab	NCR Author DN	NCR Date 6-Sep-13

**NCR Background**

Discovered By	Customer	AWC		DN		Other
Nature of NCR	Product <input checked="" type="checkbox"/>	System	Document	Vendor	Other	

**Description**

SN 7373 Item 33/2 supports on conns N10A & N10B were coped, not as shown on dwg to avoid long seam.(welded)  
 SN 7474 item 33/2 supports on conns N9A, N9B, & N10 were coped, not as shown on dwg to avoid long seam.(fitted)

Immediate Action	
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**NCR Disposition**

Decision	Scrap	Rework	Repair	Return to Supplier	Use As Is <input checked="" type="checkbox"/>	Other	Assigned to
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**Description**

1. USE AS-IS
2. UPDATE DRAWING TO 'AS-BUILT.'

See supplementary file for further Disposition File Name

Contract Adjustment (ECN Only)	Quote	Extra Amount	AWC Rep	Notes	Submitted	Dates
					Approved	

<input checked="" type="checkbox"/>	Approvals Required - (Sign and Date)	<b>NCR Approvals</b>			
	Customer	Engineer	ISO		
	Sales	QA <i>DN</i> <i>Sept 6/13</i>	Other -		
<input checked="" type="checkbox"/>	Proj. Mgr <i>[Signature]</i> <i>Sept 6/13</i>	AI	Other -		

<input checked="" type="checkbox"/>	Dwgs/Calcs <i>[Signature]</i> <i>Sept 19/13</i>	Prod-CPS	ISO		
	Purchasing	QA <i>DN</i> <i>Sept 17/13</i>	Other -		
	Prod-AWC	AI	Other -		

**Follow-Up Required**

<input type="checkbox"/> No Follow-Up Required	<input type="checkbox"/> Corrective Action Investigation	<input type="checkbox"/> Employee Review	<input type="checkbox"/> Other -
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# NON-CONFORMANCE REPORT

NCR No  
N13-082

Work Order 11/3PQ	Serial Number 7473	Customer Ultrafab	NCR Author DN	NCR Date 6-Sep-13
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### NCR Background

Discovered By	Customer	AWC	DN	Other KVI
Nature of NCR	Product <input checked="" type="checkbox"/>	System	Document	Vendor
				Other

### Description

RT repair in MW1-W1 film 0-1 ( hard edge / internal blending )

Immediate Action

### NCR Disposition

Decision	Scrap	Rework	Repair <input checked="" type="checkbox"/>	Return to Supplier	Use As Is	Other	Assigned to
----------	-------	--------	--	--------------------	-----------	-------	-------------

### Description

Groove out hard edge with grinder

Weld with WPS 3-4

3) QA Inspect

4) PT / RT repair

See suplimentary file for further Disposition File Name

Contract Adjustment (ECN Only)	Quote	Extra Amount	AWC Rep	Notes	Submitted	Approved	Dates

<input checked="" type="checkbox"/>	Approvals Required - (Sign and Date)	<b>NCR Approvals</b>		
	Customer	Engineer	ISO	
	Sales	QA <i>DN</i> Sept 6/13	Other -	
<input checked="" type="checkbox"/>	Proj. Mgr <i>Quar</i> Sept 6/13	AI	Other -	

	(Sign and Date)	<b>Disposition Verification</b>		
	Dwgs/Calcs	Prod-CPS	ISO	
	Purchasing	QA <i>DN</i> Sept 17/13	Other -	
	Prod-AWC	AI	Other -	

### Follow-Up Required

No Follow-Up Required  
  Corrective Action Investigation  
  Employee Review  
  Other -

# NON-CONFORMANCE REPORT

NCR No  
N13-080

Work Order 1173PQ	Serial Number 7473	Customer Ultrafab	NCR Author DN	NCR Date 3-Sep-13
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## NCR Background

Discovered By	Customer	AWC	DN	Other	KVI
Nature of NCR	Product <input checked="" type="checkbox"/>	System	Document	Vendor	Other

### Description

- 1) MW1-W1 reshoot found RT repair @ 0-1 slag. Welder # 90
- 2) N13-C3 RT repair @ "A" (L.O.F.) Welder # 16

Immediate Action	
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## NCR Disposition

Decision	Scrap	Rework	Repair	Return to Supplier	Use As Is	Other	Assigned to
----------	-------	--------	--------	--------------------	-----------	-------	-------------

### Description

- 1) Grind out repairs
- 2) PT repair area
- 3) Weld with WPS 3-4 on MW1, WPS 9-4 on N13
- 4) QA Inspect
- 5) PT / HT / & RT repairs

See supplementary file for further Disposition File Name

Contract Adjustment (ECN Only)	Quote	Extra Amount	AWC Rep	Notes		Submitted	Dates
						Approved	

<input checked="" type="checkbox"/>	Approvals Required - (Sign and Date)	<b>NCR Approvals</b>	
	Customer	Engineer	ISO
	Sales	<input checked="" type="checkbox"/> QA <i>DT</i> <i>Sept 3/13</i>	Other -
<input checked="" type="checkbox"/>	Proj. Mgr <i>[Signature]</i> <i>3/26/13</i>	<input checked="" type="checkbox"/> AI <i>[Signature]</i> <i>SEP 12 13</i>	Other -

	Disposition Verification		
	Dwgs/Calcs	Prod-CPS	ISO
	Purchasing	QA <i>[Signature]</i> <i>Sept 17/13</i>	Other -
	Prod-AWC	AI <i>[Signature]</i> <i>SEP 19.13</i>	Other -

### Follow-Up Required

<input type="checkbox"/> No Follow-Up Required	<input type="checkbox"/> Corrective Action Investigation	<input type="checkbox"/> Employee Review	<input type="checkbox"/> Other -
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## NON-CONFORMANCE REPORT

NCR No  
N13-0/8

Work Order 1173PQ	Serial Number 7473	Customer Ultrafab	NCR Author DN	NCR Date 23 Aug-13
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### NCR Background

Discovered By	Customer	AWC	DN	Other	KVI
Nature of NCR	Product <input checked="" type="checkbox"/>	System	Document	Vendor	Other

### Description

RT repair in MW1 category 'D' weld, film 5-9 @ 9 minus 2" (L.O.F) welder # 90 & 83

Note: films 0-1, 1-2, & 2-3 are required re-shoots per KVInspection

Immediate Action

### NCR Disposition

Decision	Scrap	Rework	Repair <input checked="" type="checkbox"/>	Return to Supplier	Use As Is	Other	Assigned to
----------	-------	--------	--	--------------------	-----------	-------	-------------

### Description

- 1) Grind out repair
- 2) PT repair area
- 3) Weld with WPS 3-4
- 4) QA inspect
- 5) PT, HT & RT repair
- 6) Re-shoot films 0-1, 1-2 & 2-3

See supplementary file for further Disposition File Name

Contract Adjustment (ECN Only)	Quote	Extra Amount	AWC Rep	Notes	Submitted	Dates
					Approved	

<input checked="" type="checkbox"/>	Approvals Required - (Sign and Date)	<b>NCR Approvals</b>			
	Customer	Engineer	ISO		
	Sales	QA <i>DN</i> <i>Aug 26/13</i>	Other -		
<input checked="" type="checkbox"/>	Proj. Mgr <i>Man</i> <i>Aug 25</i>	AI	Other -		

	(Sign and Date)	<b>Disposition Verification</b>			
	Dwgs/Calcs	Prod-CPS	ISO		
	Purchasing	QA <i>DN</i> <i>Sept 17/13</i>	Other -		
	Prod-AWC	AI	Other -		

### Follow-Up Required

No Follow-Up Required  
  Corrective Action Investigation  
  Employee Review  
  Other -



<b>NON-CONFORMANCE REPORT</b>				NCR No N13-037
Work Order 1173PQ	Serial Number 7473	Customer Ultrafab	NCR Author DN	NCR Date 12-Apr-13

**NCR Background**

Discovered By	Customer	AWC	DN	Other
Nature of NCR	Product <b>X</b>	System	Document	Vendor
				Other

**Description**

N14 conn out of level 0.6 degrees max per ASME & SBM spec is 0.5

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**Immediate Action**

**NCR Disposition**

<b>Decision</b>	Scrap	Rework	Repair	Return to Supplier	Use As Is	Other -	Assigned to
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**Description**

• Apply slight items of JACK INTO POSITION

• RENO PT, UT, & HT

- Repair if required

See supplementary file for further Disposition File Name

<b>Contract Adjustment (ECN Only)</b>	Quote	Extra Amount	AWC Rep	Notes	Submitted	Dates
					Approved	

Approvals Required - (Sign and Date) **NCR Approvals**

Customer	Engineer	ISO
Sales	QA <i>DN</i> Apr 19/13	Other -
<input checked="" type="checkbox"/> Proj. Mgr <i>DN</i> Apr 19/13	AI	Other -

(Sign and Date) **Disposition Verification**

Dwgs/Calcs	Prod-CPS	ISO
Purchasing	QA <i>DN</i> 1/05/13	Other -
Prod-AWC	AI	Other -

**Follow-Up Required**

No Follow-Up Required  
  Corrective Action Investigation  
  Employee Review  
  Other -

QA COPY

## NON-CONFORMANCE REPORT

NCR No. N13-027

Work Order 1173PQ	Serial Number 7473	Customer Ultrafab	NCR Author DN	NCR Date 5-Apr-13
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### NCR Background

Discovered By	Customer	AWC	DN	Other KVInspection
Nature of NCR	Product <input checked="" type="checkbox"/>	System	Document	Vendor
				Other

### Description

X-ray repair in C2 @ +3 to 4 1/4" slag inclusion.

Immediate Action

### NCR Disposition

Decision	Scrap	Rework	Repair <input checked="" type="checkbox"/>	Return to Supplier	Use As Is	Other -	Assigned to
----------	-------	--------	--	--------------------	-----------	---------	-------------

### Description

- Grind out repair area.
- 2) PT repair area.
- 3) Weld with WPS 3-4
- 4) QA Inspect
- 5) RT repair.

See supplementary file for further Disposition File Name

Contract Adjustment (ECN Only)	Quote	Extra Amount	AWC Rep	Notes	Submitted	Dates
					Approved	

### NCR Approvals

<input checked="" type="checkbox"/>	Approvals Required - (Sign and Date)		Engineer	ISO	
	Customer				
	Sales		QA <i>[Signature]</i> B/4/13	Other -	
	Proj. Mgr <i>[Signature]</i> 15.4.13		AI <i>[Signature]</i> MAY 29.13	Other -	

### Disposition Verification

	Dwgs/Calcs		Prod-CPS	ISO	
	Purchasing		QA <i>[Signature]</i> MAY 29/13	Other -	
	Prod-AWC <i>[Signature]</i> 15.4.13		AI <i>[Signature]</i> MAY 29.13	Other -	

### Follow-Up Required

No Follow-Up Required   
  Corrective Action Investigation   
  Employee Review   
  Other -

# Welding Procedure Specification (WPS)

CARBON STEEL

<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="text-align: center;"><b>1</b></td> <td style="text-align: center;"><b>Company</b></td> </tr> <tr> <td colspan="2">Name: <b>ALL-WELD COMPANY LIMITED</b></td> </tr> <tr> <td colspan="2">Address: <b>49 PASSMORE AVE. PLANT 1</b>      <b>14 PASSMORE AVE. PLANT 2</b></td> </tr> <tr> <td colspan="2" style="text-align: center;"><b>SCARBOROUGH, ONTARIO</b></td> </tr> <tr> <td>Postal Code ( PLANT 1 ) <b>M1V-4T1</b></td> <td>Postal Code ( PLANT 2 ) <b>M1V-2R6</b></td> </tr> </table>	<b>1</b>	<b>Company</b>	Name: <b>ALL-WELD COMPANY LIMITED</b>		Address: <b>49 PASSMORE AVE. PLANT 1</b> <b>14 PASSMORE AVE. PLANT 2</b>		<b>SCARBOROUGH, ONTARIO</b>		Postal Code ( PLANT 1 ) <b>M1V-4T1</b>	Postal Code ( PLANT 2 ) <b>M1V-2R6</b>	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="text-align: center;"><b>2</b></td> <td><b>Provincial Registration</b></td> <td><b>WP</b> D700.5 R2363.5 / R2060.5</td> </tr> <tr> <td style="text-align: center;"><b>3</b></td> <td colspan="2" style="text-align: center;"><b>Procedure Identification</b></td> </tr> <tr> <td>WPS NO.</td> <td style="text-align: center;"><b>1-1</b></td> <td>Revision No. <b>6</b></td> </tr> <tr> <td>Code Section</td> <td style="text-align: center;"><b>IX</b></td> <td>Date <b>14 April, 07</b></td> </tr> <tr> <td>PQR No.</td> <td colspan="2" style="text-align: center;"><b>1, 1A &amp; 78</b></td> </tr> </table>	<b>2</b>	<b>Provincial Registration</b>	<b>WP</b> D700.5 R2363.5 / R2060.5	<b>3</b>	<b>Procedure Identification</b>		WPS NO.	<b>1-1</b>	Revision No. <b>6</b>	Code Section	<b>IX</b>	Date <b>14 April, 07</b>	PQR No.	<b>1, 1A &amp; 78</b>	
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PQR No.	<b>1, 1A &amp; 78</b>																									

<b>4</b>	Welding Process(es)	<b>1</b>	<b>SMAW</b>	Manual	<b>X</b>	Semi-auto.		Auto.	
		<b>2</b>		Manual		Semi-auto.		Auto.	
		<b>3</b>		Manual		Semi-auto.		Auto.	

<b>5</b>	<b>Joints (QW-402)</b>				
Design	<b>SINGLE &amp; DOUBLE V GROOVE</b>			Backing Material	<b>WELD METAL</b>
Backing	Yes	No	<b>X</b>	NOTE	<b>SMAW SHALL BE USED WITH BACKING ONLY</b>
Sketch					
<b>ALL FILLET WELDS</b>					

<b>6</b>	<b>Base Metals (QW-403)</b>	P. No. <u>1</u> Gr. No. <u>1 &amp; 2</u> to P. No. <u>1</u> Gr. No. <u>1 &amp; 2</u>
or Specifications type and grade <b>SA-36, 53, 105, 106, 181, 234WPB, 285 &amp; 516</b> to <b>SA-36, 53, 105, 106, 181, 234WPB, 285 &amp; 516</b>		
or Chemical Analysis and Mech. Prop. <b>NONE</b>		
Thickness Range Qualified	Total 1) <b>1/16" to 1 1/2"</b>	
Other	1) <b>NO SINGLE PASS TO BE GREATER THAN 1/2"</b>	

<b>7</b>	<b>Filler Metals (QW-404)</b>									
1. AWS No.	<b>E7018-1H4</b>	<b>RETURN LOW HYDROGEN ELECTRODES TO THE OVEN EVERY 4 HOURS</b>	SFA	<b>5.1</b>	F-No	<b>4</b>	A-No.	<b>1</b>	Dia.	<b>3/32" &amp; 1/8"</b>
2. AWS No.	<b>E7018-1H4</b>		SFA	<b>5.1</b>	F-No	<b>4</b>	A-No.	<b>1</b>	Dia.	<b>5/32"</b>
3. AWS No.	<b>E7018-1H4</b>		SFA	<b>5.1</b>	F-No	<b>4</b>	A-No.	<b>1</b>	Dia.	<b>3/16" &amp; 1/4"</b>
Flux Tradename	<b>NONE</b>		Electrode Flux Classification			<b>NONE</b>				
Consumable Insert	<b>NONE</b>		Other			<b>MAX DEPOSITED METAL 1 1/2"</b>				

<b>8</b>	<b>Positions (QW-405)</b>
Position(s) of Groove	<b>ALL</b>
Welding Progression	<b>UP</b>
Position(s) of Fillet	<b>ALL</b>
Other	<b>NONE</b>

<b>10</b>	<b>Postweld Heat Treatment (QW-407)</b>
Temperature Range	<b>NONE</b>
Time Range	<b>NONE</b>
Other	<b>NONE</b>

9	<b>Preheat (QW-406)</b>		
Preheat Temperature	Min.	SEE 'OTHER'	
Interpass Temperature	Max.	350° F	
Preheat Maintenance	SEE 'OTHER'		
Other	NONE		


11	<b>Gas (QW-408)</b>	
Shielding Gas Composition	NONE	
Gas Flow Rate	NONE	
Backing Gas Composition	NONE	
Trailing Shield Gas Composition	NONE	
Other	NONE	

**12 Electrical Characteristics and Technique (QW-409)-(QW-410)**

Weld Layer(s)	Process	Filler Metal		Current				Travel Speed Range
		Classification	Diameter	Type	Polarity	Amp. Range	Volt Range	
ROOT	SMAW	E7018-1H4	3/32"	DC	RP	70-120	20-22	N/A
ROOT	SMAW	E7018-1H4	1/8"	DC	RP	70-150	22-24	N/A
FILL	SMAW	E7018-1H4	3/32"	DC	RP	70-120	22-24	N/A
FILL	SMAW	E7018-1H4	1/8"	DC	RP	70-150	22-24	N/A
FILL	SMAW	E7018-1H4	5/32"	DC	RP	120-200	22-24	N/A
FILL	SMAW	E7018-1H4	3/16"	DC	RP	200-275	22-24	N/A
FILL	SMAW	E7018-1H4	1/4"	DC	RP	300-400	24-26	N/A

Tungsten Electrode Size and Type	NONE
Mode of Metal Transfer for GMAW	NONE
String or Weave Bead	STRING
Method of Back Gouging	GRINDING OR ARC AIR GOUGING AND GRINDING
Initial and Interpass Cleaning (Brushing, Grinding, etc.)	WIRE BRUSH OR GRINDING
Orifice or Gas Cup Size	NONE
Oscillation	NONE
Width	NONE
Frequency	NONE
Contact Tube to Work Distance	NONE
Multiple or Single Pass (per side)	MULTIPLE
Multiple or Single Electrode	SINGLE
Electrode Wire feed speed range	NONE
Other	Preheat Requirements: When welding to or together for the thickness noted below the preheat requirements must be followed. Thickness and minimum temperature 0 to 3/4" thick preheat to 50° F. 1" thick and up 200° F

1	<b>Supplementary Comments</b>
NONE	

14	Company Representative Signature		Date	14 April, 07
		Robert C. Bentley C.E.T.		

Registration of this Welding Procedure (Specification plus Qualification Record) is required pursuant to the provisions of Section 36 (1) of the Boilers and Pressure Vessels Act of Ontario.  
 The registration becomes invalid when any essential variable changes, or any requirement of the ASME Code Section IX, affecting this procedure, is altered.



Ministry of  
Consumer and  
Commercial  
Relations

Boilers and  
Pressure Vessels  
Branch  
Technical Standards Division

Tel. (416) 965-4121

400 University Avenue  
Toronto, Ontario  
M5G 1S5  
PRESSURE  
VESSELS BRANCH

**COPY**

**PROCEDURE QUALIFICATION RECORD**

**PQR - 1**

Date APR 23, 1979

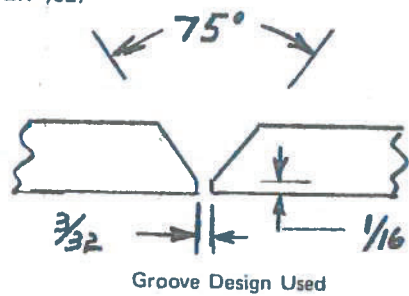
ALL-WELD COMPANY LIMITED  
(Manufacturer)

2/15/90 49 PASSMORE AVE SCARBOROUGH M1V 4T1  
24 CARLAW AVENUE, TORONTO, M4M 2R7.  
(Address)

Weld Proc. Spec. No. WPSI-1

Weld Process(es) SMAW

Types MANUAL  
(Manual, Automatic)

<p>JOINTS (QW-402)</p>  <p>Groove Design Used</p>	<p>BASE METALS (QW-403)</p> <p>Material Spec. <u>Carbon Steel</u></p> <p>Type or Grade <u>SA53 GR.B</u></p> <p>P No. <u>1</u> to P No. <u>1</u></p> <p>Thickness <u>0.432"</u></p> <p>Diameter <u>6" Pipe</u></p> <p>Other <u>N/A</u> <del>NO SINGLE PASS GREATER THAN 1/2" THICK</del> <u>VOID</u> <i>10/24 3/3/95 (PQR) 3/3/95 @ 14/3/95</i></p>
<p>FILLER METALS (QW-404)</p> <p>Weld Metal Analysis A No. <u>A1</u></p> <p>Size of Electrode <u>3/32 1/8</u></p> <p>Filler Metal F No. <u>F4</u></p> <p>SFA Specification <u>5.1</u></p> <p>AWS Classification <u>E7018</u></p> <p>Other <u>N/A</u></p>	<p>POSITION (QW-405)</p> <p>Position of Groove <u>A11</u></p> <p>Weld Progression <u>UP</u> (Uphill, Downhill)</p> <p>Other <u>N/A</u></p> <p>PREHEAT (QW-406)</p> <p>Preheat Temp. <u>NONE 50°F</u> <i>JUL 23/79</i></p> <p>Interpass Temp. <u>N/A</u></p> <p>Other <u>N/A</u></p>
<p>POSTWELD HEAT TREATMENT (QW-407)</p> <p>Temperature <u>None</u></p> <p>Time <u>N/A</u></p> <p>Other <u>N/A</u></p>	<p>GAS (QW-408)</p> <p>Type of Gas or Gases <u>N/A</u></p> <p>Composition of Gas Mixture <u>N/A</u></p> <p>Other <u>N/A</u></p>
<p>ELECTRICAL CHARACTERISTICS (QW-409)</p> <p>Current <u>DC</u></p> <p>Polarity <u>Reverse</u></p> <p>Amps. <u>12() - 150</u> Volts <u>22-24</u></p> <p>Travel Speed <u>N/A</u></p> <p>Other <u>N/A</u></p>	<p>TECHNIQUE (QW-410)</p> <p>String or Weave Bead <u>String</u></p> <p>Oscillation <u>N/A</u></p> <p>Multipass or Single Pass <u>Multipass</u> (per side)</p> <p>Single or Multiple Electrodes <u>Single</u></p>

TENSILE TEST (QW-150)

PQR-1

SPECIMEN NO.	WIDTH	THICKNESS	AREA	ULTIMATE TOTAL LOAD LB.	ULTIMATE UNIT STRESS PSI	CHARACTER FAILURE LOCAT.
13-47-T1	0.759	0.367	0.279	18,950	67,900	Parent Metal
13-47-T2	0.773	0.359	0.278	18,600	66,900	Parent Metal

GUIDED BEND TESTS (QW-160)

TYPE AND FIGURE NO.	RESULT	TYPE AND FIGURE NO.	RESULT
FB 1	Satisfactory	RB 1	Satisfactory
FB 2	Satisfactory	RB 2	Satisfactory

TOUGHNESS TESTS (QW-170)

SPECIMEN NO.	NOTCH LOCATION	NOTCH TYPE	TEST TEMP.	IMPACT VALUES	LATERAL EXP.		DROPWEIGHT	
					% SHEAR	MILS	BREAK	NO BREAK

Type of Test \_\_\_\_\_  
 Deposit Analysis \_\_\_\_\_  
 Other \_\_\_\_\_

Weld Test Witnessed By \_\_\_\_\_  
 H.L.P. Wright <sup>Authorized Inspector</sup>

Tensile Test Made By Vern W. Jones C.E.T.

Laboratory Test No. 282-0170

Warnock Hersey Professional Service L

BOILERS AND PRESSURE VESSELS BRANCH

**ACCEPTED**

W.P. No. D.700-5 P1 x F4-01

Date 12-7-79

Examiner [Signature]  
 MINISTRY OF CONSUMER & COMMERCIAL RELATIONS  
 PROVINCE OF ONTARIO

We certify that the Statements in this record are correct and the test welds were prepared, welded and tested in accordance with ASME Boiler and Pressure Vessel Code Section IX.

Signed ALL-WELD COMPANY LIMITED  
 (Manufacturer)

By [Signature]  
 R. J. McIntyre,  
 Q.A. Supervisor.



Ministry of  
Consumer and  
Commercial  
Relations

Ministère de la  
Consommation  
et du  
Commerce

Pressure  
Vessels  
Safety  
Branch

Résultat de méthode de soudage (RMS)

(Reference: ASME Section IX/Référence: ASME, Section IX)

Company/Entreprise

Name/Nom: ALL-WELD COMPANY LIMITED  
Address/Adresse: 49 PASSMORE AVE  
SCARBOROUGH ONTARIO  
Postal Code/Code postal: M1H 1Y1

4 Welding Process(es)/Procédé(s) de soudage  
1 SMAW Type MANUAL  
2  
3

6 Base Metals/Métaux de base (QW-403)  
P No. 1 Gr No. 1+2 to/a P. N° 1 Gr N° 1+2  
SA-516-GR70 70,000  
SA-516-GR70 70,000  
Thickness/Épaisseur 1/4" Diameter/Diamètre

Other/Autre NO SINGLE PASS TO BE GREATER THAN 1/2" TH

7 Filler Metals/Métaux d'apport (QW-404)

Classification (AWS)	SFA-No.	F - No.	A - No.
E7018	5.1	4	1

Other/Autre MAX DEPOSITED METAL QUALIFIED 1/2"

8 Positions/Positions (QW-405)  
Position(s) of Groove/Position(s) du joint: 1 G  
Welding Progression/Progression du soudage: Up/Montant  Down/Descendant

9 Preheat/Préchauffage (QW-406)  
Preheat Temperature/Temperature de préchauffage: 50°F MIN.  
Interpass Temperature/Température de l'interpasse: 350°F MAX

13 Electrical Characteristics and Technique/Caractéristiques électriques et techniques (QW-409) + (QW-410)

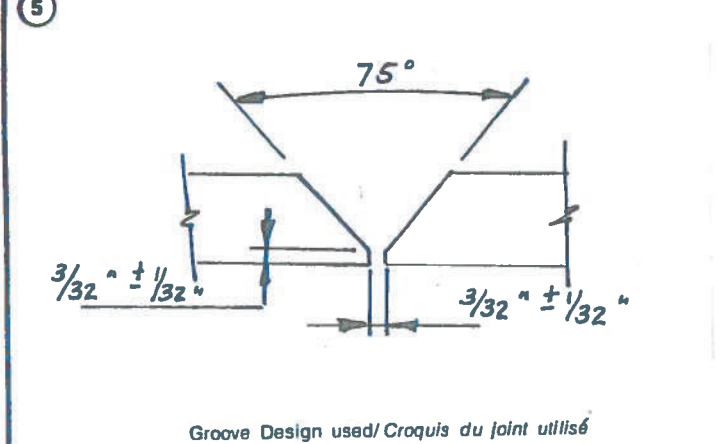
Weld Layer(s) Couche(s) de soudure	Process Procédé	Filler Metal Métal d'apport		Current Courant				Travel Speed Vitesse
		Classification	Diameter Diamètre	Type Type	Polarity Polarité	Amp Ampérage	Volt Voltage	
ROOT	SMAW	E7018	1/8"	DC	RP	100-150	22-24	7-10
FILL	SMAW	E7018	1/8"	DC	RP	100-150	22-24	7-10

2 Provincial Registration/Enregistrement provincial WP # 2R 2363-5

3 Record Identification/Désignation du résultat

PQR No. RMS N° 1-A

WPS No. DMS N° 1A-1



10 Postweld Heat Treatment/Traitement thermique postsoudage (QW-407)

Temperature/Température: NONE

Time/Durée: -- --

Other/Autre: -- --

11 Gas/Gaz (QW-408)

Shielding Gas Composition/Composition du gaz de protection: NONE

Gas Flow Rate/Débit du gaz: -- --

Backing Gas Composition/Composition du gaz de soutien: -- --

Gas Flow Rate/Débit du gaz: -- --

Other/Autre: -- --

12 Technique/Technique (QW-410)

String or Weave Bead/Cordon droit ou oscillant: STRING

Oscillation/Oscillation: N/A

Multipass or Single Pass (per side)/Passe unique ou multiple (par côté): MULTIPLE

Single or Multiple Electrode/Électrode unique ou multiple: SINGLE

Other/Autre









# Welding Procedure Specification (WPS)

STAINLESS TO  
CARBON STEEL

**Customer  
Work Order #**

<b>1</b>	<b>Company</b>
Name/	ALL-WELD COMPANY LIMITED
Address /	49 PASSMORE AVE. , 14 PASSMORE AVE. PLANT 1 PLANT 2
	SCARBOROUGH, ONTARIO
Postal Code ( PLANT 1 )	Postal Code ( PLANT 2 )
M1V-4T1	M1V-2R6

<b>2</b>	<b>Provincial Registration</b>	WP G186.5
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<b>3</b>	<b>Procedure Identification</b>	
WPS NO.	2-1	Revision No. 4
Code Section	IX	Date 14 April, 07
PQR No.	2	

<b>4</b>	<b>1 SMAW</b>	Manual	<input checked="" type="checkbox"/>	Semi-auto.	<input type="checkbox"/>	Auto.	<input type="checkbox"/>
Welding Process(es)	<b>2</b>	Manual	<input type="checkbox"/>	Semi-auto.	<input type="checkbox"/>	Auto.	<input type="checkbox"/>
	<b>3</b>	Manual	<input type="checkbox"/>	Semi-auto.	<input type="checkbox"/>	Auto.	<input type="checkbox"/>

<b>5</b>	<b>Joints (QW-402)</b>	
Design	SINGLE & DOUBLE V GROOVE	Backing Material WELD METAL
Backing	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> Other <input type="checkbox"/>	NONE
Sketch		
<b>ALL FILLET WELDS</b>		

<b>6</b>	<b>Base Metals (QW-403)</b>	P. No. 8 Gr. No. 1 to P. No. 1 Gr. No. 1 & 2
or Specifications type and grade SA-240, 304, 304L, 316, 316L & 310 + 321 to SA-36, 53, 105, 106, 181, 234WPB, 285 & 516		
or Chemical Analysis and Mech. Prop. NONE		
Thickness Range Qualified	Total 1) 3/16" to 1 1/2"	
Other 1) NO SINGLE PASS TO BE GREATER THAN 1/2"		

<b>7</b>	<b>Filler Metals (QW-404)</b>	
1. AWS No. E309-16	RETURN ELECTRODES TO THE OVEN EVERY 4 HOURS	SFA 5.4 F-No 5 A-No. 8 Dia. 3/32" & 1/8"
2. AWS No. E309-16		SFA 5.4 F-No 5 A-No. 8 Dia. 5/32" & 3/16"
3. AWS No.		SFA F-No A-No. Dia.
Flux Tradename	NONE	Electrode Flux Classification NONE
Consumable Insert	NONE	Other MAX DEPOSITED METAL 1 1/2"

<b>8</b>	<b>Positions (QW-405)</b>
Position(s) of Groove	ALL
Welding Progression	UP
Position(s) of Fillet	ALL
Other	NONE

<b>10</b>	<b>Postweld Heat Treatment (QW-407)</b>
Temperature Range	NONE
Time Range	NONE
Other	NONE





Ministry of  
Consumer and  
Commercial  
Relations

Boilers and  
Pressure Vessels  
Branch  
Technical Standards Division

Tel (416) 965-4121

400 University Avenue  
Toronto, Ontario  
M5G 1S5

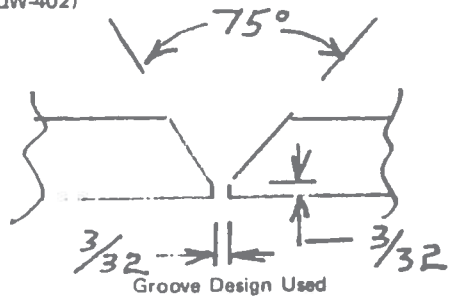
PROCEDURE QUALIFICATION RECORD

PQR-2

Date December 1, 1981

All-Weld Company Limited (Manufacturer) 49 Passmore Avenue, Scarborough, Ontario (Address)

Weld Proc. Spec. No. P8XPlxF5 Weld Process(es) SMAW Types MANUAL  
(Manual, Automatic)

<p>JOINTS (QW-402)</p>  <p>Groove Design Used</p>	<p>BASE METALS (QW-403)</p> <p>Material Spec. <u>SA240 &amp; SA 285C</u></p> <p>Type or Grade <u>304 &amp; C.S.</u></p> <p>P No. <u>8</u> to P No. <u>1</u></p> <p>Thickness <u>3/4"</u></p> <p>Diameter <u>FLAT</u></p> <p>Other <u>N/A</u> <del>NO WELD PASS GREATER THAN 1/2 INCH THICK.</del> <u>3/3/95</u> <u>THICK. HOLD @ 14/3/95</u></p>
<p>FILLER METALS (QW-404)</p> <p>Weld Metal Analysis A No. <u>A8</u></p> <p>Size of Electrode <u>1/8 x 5/32</u></p> <p>Filler Metal F No. <u>F5</u></p> <p>SFA Specification <u>SFA 5.4</u></p> <p>AWS Classification <u>E308-16</u></p> <p>Other <u>N/A</u></p>	<p>POSITION (QW-405)</p> <p>Position of Groove <u>FLAT</u></p> <p>Weld Progression <u>N/A</u> (Uphill, Downhill)</p> <p>Other _____</p> <hr/> <p>PREHEAT (QW-406)</p> <p>Preheat Temp. <u>50° F. MIN</u></p> <p>Interpass Temp. <u>350° F. MAX</u></p> <p>Other <u>N/A</u></p>
<p>POSTWELD HEAT TREATMENT (QW-407)</p> <p>Temperature <u>NONE</u></p> <p>Time <u>N/A</u></p> <p>Other <u>N/A</u></p>	<p>GAS (QW-408)</p> <p>Type of Gas or Gases <u>N/A</u></p> <p>Composition of Gas Mixture <u>N/A</u></p> <p>Other <u>N/A</u></p>
<p>ELECTRICAL CHARACTERISTICS (QW-409)</p> <p>Current <u>D.C.</u></p> <p>Polarity <u>REVERSE</u></p> <p>Amps. <u>120</u> Volts <u>25</u></p> <p>Travel Speed <u>7-10</u> <u>1PM</u></p> <p>Other <u>N/A</u></p>	<p>TECHNIQUE (QW-410)</p> <p>String or Weave Bead <u>STRING</u></p> <p>Oscillation <u>N/A</u></p> <p>Multipass or Single Pass <u>MULTIPASS</u> (per side)</p> <p>Single or Multiple Electrodes <u>SINGLE</u></p>

G 186.5

**TENSILE TEST (QW-150)**

SPECIMEN NO.	WIDTH	THICKNESS	AREA	ULTIMATE TOTAL LOAD LB.	ULTIMATE UNIT STRESS PSI	CHARACTER OF FAILURE & LOCATION
AW-7-5	.755	.370	.280		64,000	PARENT METAL
AW-7-6	.755	.350	.264		63,000	PARENT METAL

**GUIDED BEND TESTS (QW-160)**

TYPE AND FIGURE NO.	RESULT	TYPE AND FIGURE NO.	RESULT
AW-7-1	SATISFACTORY	AW-7-3	SATISFACTORY
AW-7-2	SATISFACTORY	AW-7-4	SATISFACTORY

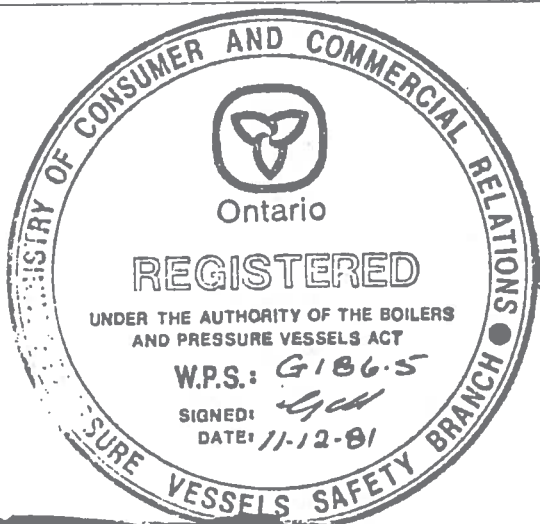
**TOUGHNESS TESTS (QW-170)**

SPECIMEN NO.	NOTCH LOCATION	NOTCH TYPE	TEST TEMP.	IMPACT VALUES	LATERAL EXP.		DROPWEIGHT	
					% SHEAR	MILS	BREAK	NO BREAK

Type of Test \_\_\_\_\_  
 Deposit Analysis \_\_\_\_\_  
 Other \_\_\_\_\_

Weld Test Witnessed By Mr. J. Clark  
Authorized Inspector

Tensile Test Made By The Warnock Hersey Co. Ltd  
 Laboratory Test No. 7735/TP63/TP96



We certify that the Statements in this record are correct and the test welds were prepared, welded and tested in accordance with ASME Boiler and Pressure Vessel Code Section IX.

Signed ALL-WELD COMPANY LIMITED  
(Manufacturer)  
 By R. J. McIntyre  
 R. J. MCINTYRE  
 Q.A. SUPERVISOR/

**Customer Work Order #**

1 <b>Company</b>	
name/ ALL-WELD COMPANY LIMITED	
Address /	49 PASSMORE AVE. / 14 PASSMORE AVE. PLANT 1 / PLANT 2
SCARBOROUGH, ONTARIO	
Postal Code ( PLANT 1 )	Postal Code ( PLANT 2 )
M1V-4T1	M1V-2R6

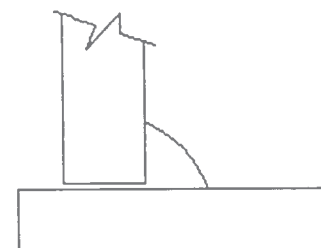
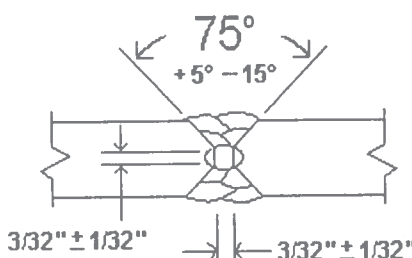
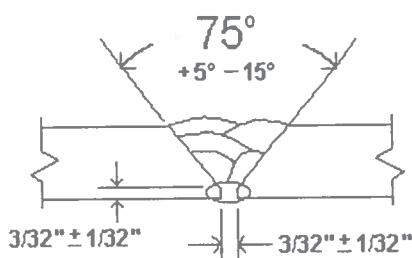
2 <b>Provincial Registration</b>	WP T4628.5
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3 <b>Procedure Identification</b>			
WPS NO.	3-4	Revision No.	1
Code Section	IX	Date	27 March, 2013
PQR No.	3-3X		

4 <b>Welding Process(es)</b>	1	<b>SMAW</b>		Manual	<input checked="" type="checkbox"/>	Semi-auto.	<input type="checkbox"/>	Auto.	<input type="checkbox"/>
	2			Manual	<input type="checkbox"/>	Semi-auto.	<input type="checkbox"/>	Auto.	<input type="checkbox"/>
	3			Manual	<input type="checkbox"/>	Semi-auto.	<input type="checkbox"/>	Auto.	<input type="checkbox"/>

5 <b>Joints (QW-402)</b>			
Design	<b>SINGLE &amp; DOUBLE V GROOVE</b>	Backing Material	<b>WELD METAL</b>
Backing	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	Other	<b>NONE</b>

**Sketch**



**ALL FILLET WELDS**

6 <b>Base Metals (QW-403)</b>		P. No.	8	Gr. No.	1	to P. No.	8	Gr. No.	1
or Specifications type and grade		SA-479, 312, 240 & 182 - 316L		to		SA-479, 312, 240 & 182 - 304, 304L, 316 & 316L			
or Chemical Analysis and Mech. Prop.		<b>NONE</b>							
Thickness Range Qualified		Total 1) 5/8 " to 8" for Impact use 2) Non Impact use 3/16 " to 8"							
Other		1) NO SINGLE PASS TO BE GREATER THAN 1/2"							

7 <b>Filler Metals (QW-404)</b>										
1. AWS No.	E316L-16	RETURN ELECTRODES TO THE OVEN EVERY 4 HOURS	SFA	5.4	F-No	5	A-No.	8	Dia.	3/32"
2. AWS No.	E316L-16		SFA	5.4	F-No	5	A-No.	8	Dia.	1/8" 5/32"
3. AWS No.	E316L-16		SFA	5.4	F-No	5	A-No.	8	Dia.	3/16"
Flux Tradename		<b>NONE</b>		Electrode Flux Classification		<b>NONE</b>				
Consumable Insert		<b>NONE</b>		Other		<b>MAX DEPOSITED METAL 8 " &amp; SEE SECTION # 12</b>				

8 <b>Positions (QW-405)</b>	
Position(s) of Groove	For Impact use 1G & 2G Only / Non impact use all
Welding Progression	Horiz and Flat for Impact Use / Up non impact use
Position(s) of Fillet	<b>ALL</b>
Other	<b>NONE</b>

90 <b>Postweld Heat Treatment (QW-407)</b>	
Temperature Range	<b>NONE</b>
Time Range	<b>NONE</b>
Other	<b>NONE</b>

10	Preheat (QW-406)	
Preheat Temperature	Min.	50° F
Interpass Temperature	Max.	350° F
Preheat Maintenance		50° F
Other	NONE	

Gas (QW-408)	
Shielding Gas Composition	NONE
Gas Flow Rate	NONE
Backing Gas Composition	NONE
Trailing Shield Gas Composition	NONE
Other	NONE

12 **Electrical Characteristics and Technique (QW-409)-(QW-410)**

Weld Layer(s)	Process	Filler Metal		Current				Travel Speed Range
		Classification	Diameter	Type	Polarity	Amp. Range	Volt Range	
ROOT	SMAW	E316L-16	3/32"	DC	RP	65-95	20-25	4" TO 8"
FILL	SMAW	E316L-16	1/8"	DC	RP	90-120	20-25	4" TO 8"
FILL	SMAW	E316L-16	5/32"	DC	RP	120-160	20-25	4" TO 8"
FILL	SMAW	E316L-16	3/16"	DC	RP	155-195	20-25	4" TO 8"
		<b>Heat Input ( Per QW-409.1 ) = 45,000 j / in Maximum</b>						
		<b>Per QW 409.1 only 3/32 ' and 1/8 " Electrode used for Impact welding</b>						
Tungsten Electrode Size and Type		NONE						
Mode of Metal Transfer for GMAW		NONE						
String or Weave Bead		STRING						
Method of Back Gouging		GRINDING OR ARC AIR GOUGING AND GRINDING TO SOUND METAL						
Initial and Interpass Cleaning (Brushing, Grinding, etc.)		WIRE BRUSH OR GRINDING						
Orifice or Gas Cup Size		NONE						
Oscillation	NONE	Width	NONE	Frequency	NONE			
Contact Tube to Work Distance		NONE						
Multiple or Single Pass (per side)		MULTIPLE						
Multiple or Single Electrode		SINGLE						
Electrode Wire feed speed range		NONE						
Other								

13 **Supplementary Comments**

1) CHARPY V NOTCH IMPACT TESTED TO -50 F 2) MACROETCH TO ASTM E3-11

3) VICKERS HARDNESS TEST TO NACE MR0175/ISO 15156-2:2009/CIR. 1 : 2011

14 Company Representative Signature Robert C. Bentley Date 27 March , 2013  
 Robert C. Bentley C.E.T.

Registration of this Welding Procedure (Specification plus Qualification Record) is required pursuant to the provisions of Section 36 (1) of the Boilers and Pressure Vessels Act of Ontario.  
 The registration becomes invalid when any essential variable changes, or any requirement of the ASME Code Section IX, affecting this procedure, is altered.





14 Tensile Tests				Reference:		
Specimen	Dimensions in Inches		Area in Inches <sup>2</sup>	Ultimate Total Load in Foot Pounds	Ultimate Unit Stress in PSI	Character and Location of Failure
	Width	Thickness				
T2A	0.756 "	0.865 "	0.654 "	55,409	84,500	T2B FRACTURED IN WELD ZONE & T2A, T5B IN THE BASE METAL ALL IN A DUCTILE MANNER
T2B	0.755 "	0.905 "	0.683 "	57,283	84,000	
T5A	0.753 "	0.842 "	0.634 "	52,974	83,500	
T5B	0.755 "	0.790 "	0.596 "	50,353	84,500	

15 Guided Bend Tests					Reference:				
Specimen	Face	Root	Side	Result	Specimen	Face	Root	Side	Result
S1			X	ACCEPTED	S3			X	ACCEPTED
S2			X	ACCEPTED	S4			X	ACCEPTED

16 Toughness Tests							Reference:	
Specimen	Notch Location	Notch Type	Specimen Temperature	Impact Value	Lateral Expansion		Drop Weight	
					Shear	Mills	Break	No Break
1	Weld ( 1/6" below )	V Notch	-50 F	49 ft -lbf	100	36		
2	Weld ( 1/6" below )	V Notch	-50 F	52 ft -lbf	100	44		
3	Weld ( 1/6" below )	V Notch	-50 F	49 ft -lbf	100	37		
1	HAZ	V Notch	-50 F	125 ft -lbf	100	58		
2	HAZ	V Notch	-50 F	127 ft -lbf	100	66		
3	HAZ	V Notch	-50 F	114 ft -lbf	100	50		
1	Weld ( 1/4" below )	V Notch	-50 F	44 ft -lbf	100	22		
2	Weld ( 1/4" below )	V Notch	-50 F	50 ft -lbf	100	31		
3	Weld ( 1/4" below )	V Notch	-50 F	48 ft -lbf	100	30		

17 Fillet Weld Test				Reference:			
Result - Satisfactory	Yes <input type="checkbox"/>	No <input type="checkbox"/>	Penetration Into Parent Metal	Yes <input type="checkbox"/>	No <input type="checkbox"/>		

Macro - Passed , Nace 228 HV 10 Max and Heat Input ( j / in ) = 45,000

18 Other Tests		Reference:	
MACROETCH EXAMINATION PER LAB REPORT 634805-13 ( REVISED )			
VICKERS HARDNESS TEST PER LAB REPORT 634805-13			

19 Welder's Name STEVE LEW Stamp No. 90

636411-2013, 636412-2013, 636413-2013  
 CAMBRIDGE MATERIAL TESTING LTD. 634851-2013, 634803-2013, 634805-13  
 Tests conducted by \_\_\_\_\_ Laboratory Test No. 634805-13 ( REVISED )

We certify that the statements in this record are correct and that the test welds were prepared, welded and tested in accordance with the requirements of section IX of the ASME Code.

20 Company Representative's Signature Robert C. Bentley Date 18 MARCH 2013

ROBERT C. BENTLEY, C.E.T. **Boilers and Pressure Vessels Safety Program**

21 Department Use only	
Samples Welded on	Inspector
Record verified on	Inspector

W.P.S.: .....  
 Signed: S. Lew  
 Date: MAR 26, 2013

PQR: 3-3X  
 WPS: 3-3B

**REGISTERED**  
 WP-T4628.5  
**W.P.S.:** .....  
 Signed: S. Lew  
 Date: MAR 26, 2013

**Customer Work Order #**

<b>1</b>	<b>Company</b>
Name/ <b>ALL-WELD COMPANY LIMITED</b>	
Address / <b>49 PASSMORE AVE. PLANT 1      14 PASSMORE AVE. PLANT 2</b>	
<b>SCARBOROUGH, ONTARIO</b>	
Postal Code ( PLANT 1 ) <b>M1V-4T1</b>	Postal Code ( PLANT 2 ) <b>M1V-2R6</b>

<b>2</b>	<b>Provincial Registration</b>	<b>WP</b> <b>R3578.5 , R4056.5 R7674.5, D852.5</b>
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<b>3</b>	<b>Procedure Identification</b>	
WPS NO.	<b>9-4</b>	Revision No. <b>7</b>
Code Section	<b>IX</b>	Date <b>09 April, 13</b>
PQR No.	<b>9, 9AB , 54 &amp; 105</b>	

<b>4</b>	<b>1 GTAW</b>	Manual	<input checked="" type="checkbox"/>	Semi-auto.	<input type="checkbox"/>	Auto.	<input type="checkbox"/>
Welding Process(es)	<b>2</b>	Manual	<input type="checkbox"/>	Semi-auto.	<input type="checkbox"/>	Auto.	<input type="checkbox"/>
	<b>3</b>	Manual	<input type="checkbox"/>	Semi-auto.	<input type="checkbox"/>	Auto.	<input type="checkbox"/>

<b>5</b>	<b>Joints (QW-402)</b>	
Design	<b>SINGLE V GROOVE</b>	Backing Material <b>WELD METAL</b>
Backing	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> <b>X</b>	Other <b>NONE</b>
Sketch		
<p style="text-align: center;"><b>ALL FILLET WELDS</b></p>		

<b>6</b>	<b>Base Metals (QW-403)</b>	P. No. <u>8</u> Gr. No. <u>1</u> to P. No. <u>8</u> Gr. No. <u>1</u>
or Specifications type and grade		
<b>SA-182, 240, 312, 403, 479-316L</b>		<b>to SA-182, 240, 312, 403, 479, 304, 304L, 316 &amp; 316L</b>
or Chemical Analysis and Mech. Prop.		<b>NONE</b>
Thickness Range Qualified	Total 1) 0.035" TO 1 1/2" NON IMPACT 2) 1/16" TO 1/2" IMPACT TESTED	
Other	1) NO SINGLE PASS TO BE GREATER THAN 1/2"	

<b>7</b>	<b>Filler Metals (QW-404)</b>	
1. AWS No. <b>ER316L</b>	<b>Product Form - Solid</b>	SFA <b>5.9</b> F-No <b>6</b> A-No. <b>8</b> Dia <b>1/16"</b>
2. AWS No. <b>ER316L</b>		SFA <b>5.9</b> F-No <b>6</b> A-No. <b>8</b> Dia. <b>3/32"</b>
3. AWS No.		SFA F-No A-No. Dia.
Flux Tradename	<b>NONE</b>	Electrode Flux Classification <b>NONE</b>
Consumable Insert	<b>NONE</b>	Other <b>MAX. DEPOSITED METAL 1 1/2" THICK NON Impact &amp; 1/2" Impact</b>

<b>8</b>	<b>Positions (QW-405)</b>
Position(s) of Groove	<b>ALL</b>
Welding Progression	<b>UP</b>
Position(s) of Fillet	<b>ALL</b>
Other	<b>NONE</b>

<b>10</b>	<b>Postweld Heat Treatment (QW-407)</b>
Temperature Range	<b>NONE</b>
Time Range	<b>NONE</b>
Other	<b>NONE</b>

9	Preheat (QW-406)		
Preheat Temperature	Min.	50° F	
Interpass Temperature	Max.	350° F	
Preheat Maintenance	50° F		
Other	NONE		

Gas (QW-408)	
Shielding Gas Composition	ARGON 99%
Gas Flow Rate	25 CFH
Backing Gas Composition	ARGON 99%
Trailing Shield Gas Composition	ARGON 99%
Other	NONE

12 Electrical Characteristics and Technique (QW-409)-(QW-410)

Weld Layer(s)	Process	Filler Metal		Current				Travel Speed Range
		Classification	Diameter	Type	Polarity	Amp. Range	Volt Range	
ROOT	GTAW	ER316L	1/16"	DC	SP	80-110	8-11	7-8 IPM
FILL	GTAW	ER316L	3/32"	DC	SP	130-200	11-18	7-8 IPM
For - 200 F IMPACT TEST APPLICATION SEE BELOW per PQR 105 WP-R4056.5								
Heat Input ( Per QW-409.1 ) = 16,800 j / in								
ROOT	GTAW	ER316L	1/16"	DC	SP	80 - 110	8 - 11	7 - 8 IPM
FILL	GTAW	ER316L	1/16"	DC	SP	110 - 140	8 - 14	7 - 8 IPM

Tungsten Electrode Size and Type	1/8" & 3/32" 2% THORIATED TUNGSTEN ( ZIRCONIUM TUNGSTEN )		
Mode of Metal Transfer for GMAW	NONE		
String or Weave Bead	STRING		
Method of Back Gouging	GRINDING OR ARC AIR GOUGING AND GRINDING TO SOUND METAL		
Initial and Interpass Cleaning (Brushing, Grinding, etc.)	WIRE BRUSH OR GRINDING		
Orifice or Gas Cup Size	1/2 TO 5/8		
Oscillation	NONE	Width	NONE
		Frequency	NONE
Contact Tube to Work Distance	1/2 TO 3/4		
Multiple or Single Pass (per side)	MULTIPLE		
Multiple or Single Electrode	SINGLE		
Electrode Wire feed speed range	NONE		

13 Supplementary Testing Done

1) Vickers Hardness per NACE MR0175/ISO 15156-1:2009(E) Lab Report 637323- 13 Report A

2) Macroetch Evaluation Test Per ASTM E3-11 Lab Report 637323-13 Report B

Comments
NONE

14 Company Representative Signature Robert C. Bentley Date 09-Apr  
 Robert C. Bentley C.E.T.

Registration of this Welding Procedure (Specification plus Qualification Record) is required pursuant to the provisions of Section 36 (1) of the Boilers and Pressure Vessels Act of Ontario.  
 The registration becomes invalid when any essential variable changes, or any requirement of the ASME Code Section IX, affecting



Ministry of  
Consumer and  
Commercial  
Relations

Boilers and  
Pressure Vessels  
Branch  
Technical Standards Division

Tel. (416) 965-4100  
400 University Avenue  
Toronto, Ontario  
M5G 1S5  
RECORDED  
PRESSURE VESSEL  
SAFETY DIVISION

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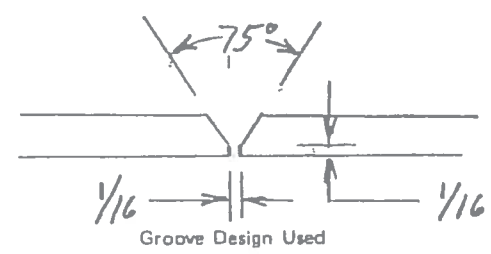
8:10:02

PROCEDURE QUALIFICATION RECORD

PQR 9

Date October 10, 19

All-Weld Company Limited 2/15/90 49 PASSMORE AVE., SCARBOROUGH, ONTARIO M1V 4T1  
(Manufacturer) (Address)  
Weld Proc. Spec. No. WPS 9-1 Weld Process(es) GTAW Types MANUAL  
D852.5 (Manual, Automatic)

<p>JOINTS (QW-402)</p>  <p>Groove Design Used</p>	<p>BASE METALS (QW-403)</p> <p>Material Spec. <u>SA 312</u></p> <p>Type or Grade <u>304 Stainless Steel</u></p> <p>P No. <u>8</u> to P No. <u>8</u></p> <p>Thickness <u>.218</u></p> <p>Diameter <u>2" Pipe</u></p> <p>Other <u>N/A</u></p>
<p>FILLER METALS (QW-404)</p> <p>Weld Metal Analysis A No. <u>8</u></p> <p>Size of Electrode <u>3/32</u></p> <p>Filler Metal F No. <u>6</u></p> <p>SFA Specification <u>5.9</u></p> <p>AWS Classification <u>ER316</u></p> <p>Other <u>N/A</u></p>	<p>POSITION (QW-405)</p> <p>Position of Groove <u>ALL POSITIONS</u></p> <p>Weld Progression <u>UPHILL</u> (Uphill, Downhill)</p> <p>Other <u>N/A</u></p> <p>PREHEAT (QW-406)</p> <p>Preheat Temp. <u>N/A</u></p> <p>Interpass Temp. <u>N/A</u></p> <p>Other <u>N/A</u></p>
<p>POSTWELD HEAT TREATMENT (QW-407)</p> <p>Temperature <u>N/A</u></p> <p>Time <u>N/A</u></p> <p>Other <u>N/A</u></p>	<p>GAS (QW-408)</p> <p>Type of Gas or Gases <u>ARGON</u></p> <p>Composition of Gas Mixture <u>N/A</u></p> <p>Other <u>N/A</u></p>
<p>ELECTRICAL CHARACTERISTICS (QW-409)</p> <p>Current <u>D.C.</u></p> <p>Polarity <u>STRAIGHT</u></p> <p>Amps. <u>110-140</u> Volts</p> <p>Travel Speed <u>7" - 8" I.P.M.</u></p> <p>Other <u>N/A</u></p>	<p>TECHNIQUE (QW-410)</p> <p>String or Weave Bead <u>STRING</u></p> <p>Oscillation <u>N/A</u></p> <p>Multipass or Single Pass <u>MULTIPASS</u> (per side)</p> <p>Single or Multiple Electrodes <u>SINGLE</u></p>

TENSILE TEST (QW-150)

PQR-9

SPECIMEN NO.	WIDTH	THICKNESS	AREA	ULTIMATE TOTAL LOAD LB.	ULTIMATE UNIT STRESS PSI	CHARACTER OF FAILURE & LOCATION
TS-1	.494	.192	.0948	7830	82600	WELD
TS-2	.515	.211	.109	8990	82500	WELD

GUIDED BEND TESTS (QW-160)

TYPE AND FIGURE NO.	RESULT	TYPE AND FIGURE NO.	RESULT
NO. 1 RB	SATISFACTORY	NO. 2 FB	SATISFACTORY
NO. 3 RB	SATISFACTORY	NO. 4 FB	SATISFACTORY

TOUGHNESS TESTS (QW-170)

SPECIMEN NO.	NOTCH LOCATION	NOTCH TYPE	TEST TEMP.	IMPACT VALUES	LATERAL EXP.		DROPWEIGHT	
					% SHEAR	MILS	BREAK	NO BREAK

Type of Test \_\_\_\_\_  
 Deposit Analysis \_\_\_\_\_  
 Other \_\_\_\_\_

Warnock Hersey

Weld Test Witnessed By \_\_\_\_\_  
 Authorized Inspector  
**G. EWING**

Tensile Test Made By Professional Service Ltd  
 Laboratory Test No. 282-388

BOILERS AND PRESSURE VESSELS BRANCH

**ACCEPTED**

W.P. No. D. 252:5.....P. 21:02

Date.....17:10:79.....

Examiner.....G. Ewing  
 MINISTRY OF CONSUMER & COMMERCIAL RELATIONS  
 PROVINCE OF ONTARIO

We certify that the Statements in this record are correct and the test welds were prepared, welded and tested in accordance with ASME Boiler and Pressure Vessel Code Section IX.

Signed ALL-WELD COMPANY LIMITED  
 (Manufacturer)

By R. J. McIntyre  
**R. J. MCINTYRE**  
 Q. A. SUPERVISOR



14 Tensile Tests/Essais à la traction						Reference: Référence:
Specimen Eprouvette	Dimensions Dimensions		Area Surface	Ultimate Total Load Charge limite	Ultimate Unit Stress Contrainte limite	Character and Location of Failure Nature et endroit de la rupture
	Width Largeur	Thickness Épaisseur				
T1	0.250	0.0350"	0.0236	1987 lbf	84000 PSI	BOTH FRACTURE BASE METAL
T2	0.249"	0.0350"	0.0235"	1975 lbf	84000 PSI	" "

15 Guided Bend Tests/Essais de pilage guidé						Reference: Référence:			
Specimen Eprouvette	Face Face	Root Racine	Side Côté	Result Résultat	Specimen Eprouvette	Face Face	Root Racine	Side Côté	Result Résultat
B1	X			ACCEPTED	B3	X			ACCEPTED
B2		X		ACCEPTED	B4		X		ACCEPTED

16 Toughness Tests/Essais de résilience						Reference: Référence:		
Specimen Eprouvette	Notch Location Endroit de l'entaille	Notch Type Forme de l'entaille	Specimen Temperature Température de l'éprouvette	Impact Value Énergie de rupture	Lateral Expansion Expansion latérale		Drop Weight Essai en chute libre	
					Shear % cisaillement	Mills Millimètres	Break Cassé	No Break Non cassé

17 Fillet Weld Test/Essai de soudure d'angle				Reference: Référence:
Result - Satisfactory Résultat satisfaisant	Yes <input type="checkbox"/>	No <input type="checkbox"/>	Penetration into Parent Metal Pénétration dans métal de base	Yes <input type="checkbox"/> No <input type="checkbox"/>
Macro - Results Résultats macroscopiques				

18 Other Tests/Autres essais		Reference: Référence:

19 Welder's Name Nom du soudeur	ROBIN GREER	Stamp No. N° de symbole	9
Tests conducted by Essais effectués par	CAMBRIDGE MATERIALS TESTING LTD.	Laboratory Test No. Essai de laboratoire n°	305909-2002

We certify that the statements in this record are correct and that the test welds were prepared, welded and tested in accordance with the requirements of section IX of the ASME Code.

Nous certifions que les renseignements concernant ce résultat sont exacts et que les essais de soudage ont été préparés, soudés et exécutés conformément aux exigences de la section IX du Code ASME.

REGISTERED

20 Company Representative's Signature		Date	18, APRIL, 2002
Signature du représentant de l'entreprise	ROBERT C. BENTLEY		

W.P.S.:... W.P.R.76.7A.5...  
Signed:   
Date: ... 2002.04.15 ...

Department Use Only/Réservé au ministère	
Samples Welded on Pièces soudées le	Inspector Inspecteur
Record verified on Résultats vérifiés le	Inspector Inspecteur

9-A





14) **Tensile Tests/Essais à la traction** Reference: SECT IX ASME CODE

Specimen Éprouvette	Dimensions Dimensions		Area Surface	Ultimate Total Load Charge limite	Ultimate Unit Stress Contrainte limite	Character and Location of Failure Nature et endroit de la rupture
	Width Largeur	Thickness Épaisseur				
T2	0.746	0.750	0.5595	49340	88184	FRACTURED IN WE
T3	0.751	0.751	0.5640	49630	87990	FRACTURED IN

5) **Guided Bend Tests/Essais de pliage guidé** Reference: SECT IX Q.W. 462:2

Specimen Éprouvette	Face Face	Root Racine	Side Côté	Result Résultat	Specimen Éprouvette	Face Face	Root Racine	Side Côté	Result Résultat
S1			✓	ACCEPTED	S3			✓	ACCEPTED
S2			✓	— v —	S4			✓	— n —

18) **Toughness Tests/Essais de résilience** Reference:

Specimen Éprouvette	Notch Location Endroit de l'entaille	Notch Type Forme de l'entaille	Specimen Temperature Température de l'éprouvette	Impact Value Énergie de rupture	Lateral Expansion Expansion latérale		Drop Weight Essai en chute libre	
					Shear % cisaillement	Mills Millimètres	Break Cassé	No Break Non cassé

17) **Fillet Weld Test/Essai de soudure d'angle** Reference:

Result - Satisfactory  Yes  No  Penetration into Parent Metal  Yes  No

Résultat satisfaisant  Oui  Non  Pénétration dans métal de base  Oui  Non

18) **Other Tests/Autres essais** Reference:

19) Welder's Name: ROBIN GREER Stamp No. 9

Tests conducted by: CAMBRIDGE MATERIALS TESTING LTD Laboratory Test No. 152211-1996

Essais effectués par: CAMBRIDGE MATERIALS TESTING LTD Essai de laboratoire n° 152211-1996

We certify that the statements in this record are correct and that the test welds were prepared, welded and tested in accordance with the requirements of section IX of the ASME Code.

Nous certifions que les renseignements concernant ce résultat sont exacts et que les essais de soudage ont été préparés, soudés et exécutés conformément aux exigences de la section IX du Code ASME.

20) Company Representative's Signature: Robert C Bentley Date: 4 Oct 1996

Signature du représentant de l'entreprise

Department Use Only/Réserve au ministère	
Samples Welded on Pièces soudées le	Inspector Inspecteur
Record verified on Résultats vérifiés le	Inspector Inspecteur

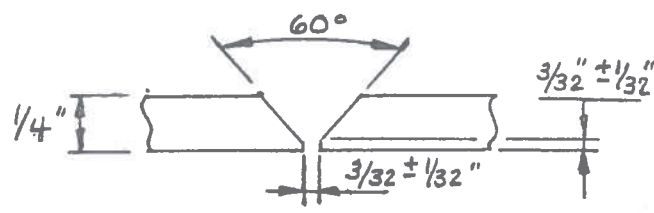
WP-R35  
ya  
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54-1

# Résultat de méthode de soudage (RMS)

(Reference: ASME Section IX/Référence: ASME, Section IX)

<b>Company/Entreprise</b>			
ALL-WELD COMPANY LTD			
<b>Address/Adresse</b>			
49 PASSMORE AVE			
SCARBOROUGH			
Postal Code/Code postal	M11 1Y4T11		
<b>4 Welding Process(es)/Procédé(s) de soudage</b>			
1	GTA W MANUAL		
2			
3			
<b>6 Base Metals/Métaux de base (QW-403)</b>			
P No. 8	Gr No. 1		
P. No. 8	Gr No. 1		
<b>Specification/Spécification</b>			
SA-240-316L TO 70,000			
SA-240-316L 70000			
Thickness/Épaisseur	Diameter/Diamètre		
1/4"			
<b>Other/Autre</b>			
NO SINGLE PASS > 1/2"			
<b>7 Filler Metals/Métaux d'apport (QW-404)</b>			
Classification (AWS)	SFA-No.	F - No.	A - No.
ER316L	5.9	6	8
<b>Other/Autre</b>			
MAX DEPOSITED METAL 1/2"			
<b>8 Positions/Positions (QW-405)</b>			
Position(s) of Groove/Position(s) du joint: 1G THROUGH GG			
Welding Progression/Progression du soudage		Up/Montant <input checked="" type="checkbox"/>	Down/Descendant <input type="checkbox"/>
<b>9 Preheat/Préchauffage (QW-406)</b>			
Preheat Temperature/Temperature de préchauffage		50°F	
Interpass Temperature/Temperature de l'interpassage		300°F MAX	

<b>2 Provincial Registration/Enregistrement provincial</b>	WP MS WP-R40505
<b>3 Record Identification/Désignation du résultat</b>	
POR No. RMS N°	105
WPS No. DMS N°	105-1
<b>5</b>	



Groove Design used/Croquis du joint utilisé

<b>10 Postweld Heat Treatment/Traitement thermique postsoudage (QW-407)</b>	
Temperature/Température	NONE
Time/Durée	
Other/Autre	
<b>11 Gas/Gaz (QW-408)</b>	
Shielding Gas Composition/Composition du gaz de protection	ARGON 98% + OXY 2%
Gas Flow Rate/Débit du gaz	25 CFH
Backing Gas Composition/Composition du gaz de soutien	NONE
Gas Flow Rate/Débit du gaz	
Other/Autre	
<b>12 Technique/Technique (QW-410)</b>	
String or Weave Bead/Cordon droit ou oscillant	STRING
Oscillation/Oscillation	N/A
Multipass or Single Pass (per side)/Passe unique ou multiple (par côté)	MULTI PASS
Single or Multiple Electrode/Électrode unique ou multiple	SINGLE
Other/Autre	

<b>13 Electrical Characteristics and Technique/Caractéristiques électriques et techniques (QW-409) + (QW-410)</b>								
Weld Layer(s)/Couche(s) de soudure	Process/Procédé	Filler Metal/Métal d'apport			Current/Courant			Travel Speed/Vitesse
		Classification	Diameter/Diamètre	Type	Polarity/Polarité	Amp/Amperage	Volt/Voltage	
	GTA W	ER316L	1/16	DC	SP	80-110	11	7-8 IP
FILL	GTA W	ER316L	1/16"	DC	SP	110-140	14	7-8 IPM

14 Tensile Tests/Essais à la traction						Reference: Référence:
Specimen Eprouvette	Dimensions Dimensions		Area Surface	Ultimate Total Load Charge limite	Ultimate Unit Stress Contrainte limite	Character and Location of Failure Nature et endroit de la rupture
	Width Largeur	Thickness Épaisseur				
1	0.748	0.249	0.1863	16560	88924	FRACTURED IN BASE METAL
16	0.754	0.247	0.1862	16840	90440	FRACTURED BASE METAL

15 Guided Bend Tests/Essais de pliage guidé						Reference: Référence:			
Specimen Eprouvette	Face Face	Root Racine	Side Côté	Result Résultat	Specimen Eprouvette	Face Face	Root Racine	Side Côté	Result Résultat
S1	✓			ACCEPTED	S3	✓			ACCEPTED
S2		✓		ACCEPTED	S4		✓		ACCEPTED

16 Toughness Tests/Essais de résilience						Reference: Référence:		
Specimen Eprouvette	Notch Location Endroit de l'entaille	Notch Type Forme de l'entaille	Specimen Temperature Température de l'éprouvette	Impact Value Énergie de rupture	Lateral Expansion Expansion latérale		Drop Weight Essai en chute libre	
					Shear % cisaillement	Mills Millimètres	Break Cassé	No Break Non cassé
1	WELD	CHARPY V-NOTCH	-200°F	94	100	80		
2	WELD			96		86		
3	WELD			94		78		
4	HAZ			89		78		
5	HAZ			70		70		
6	HAZ			82		72		
7	BASE			89		74		
8	BASE			100		75		
	BASE			96		75		


17 Fillet Weld Test/Essai de soudure d'angle				Reference: Référence:
Result - Satisfactory Résultat satisfaisant	Yes Oui <input type="checkbox"/>	No Non <input type="checkbox"/>	Penetration Into Parent Metal Pénétration dans métal de base	Yes Oui <input type="checkbox"/> No Non <input type="checkbox"/>

Macro - Results Résultats macroscopiques

18 Other Tests/Autres essais		Reference: Référence:

9 Welder's Name Nom du soudeur <u>ROBIN GREER</u>	Stamp No. N° de symbole <u>9</u>
Tests conducted by Essais effectués par <u>CAMBRIDGE MATERIALS TESTING LTD</u>	Laboratory Test No. Essai de laboratoire n° <u>169712-1997</u>

We certify that the statements in this record are correct and that the test welds were prepared, welded and tested in accordance with the requirements of section IX of the ASME Code.  
 Nous certifions que les renseignements concernant ce résultat sont exacts et que les essais de soudage ont été préparés, exécutés et vérifiés conformément aux exigences de la section IX du Code ASME.



Boilers and Pressure Vessels Safety Division

REGISTERED

W.P.S.: WP-R4056.5

Signed: ya

Date: 97.06.17

10 Company Representative's Signature Signature du représentant de l'entreprise	Date Date
<u>Robert Bentley</u>	<u>13 JUNE 1997</u>

11 Department Use Only/Réservé au ministère	Inspector Inspecteur
Welds Verified on Records Vérifiés les	Inspector Inspecteur

**Customer Work Order #**

<b>1 Company</b>	
Name/	ALL-WELD COMPANY LIMITED
Address /	49 PASSMORE AVE. PLANT 1      14 PASSMORE AVE. PLANT 2
SCARBOROUGH, ONTARIO	
Postal Code ( PLANT 1 )	Postal Code ( PLANT 2 )
M1V-4T1	M1V-2R6

<b>2 Provincial Registration</b>	WP T4646.5
----------------------------------	------------

<b>3 Procedure Identification</b>			
WPS NO.	50-3A	Revision No.	0
Code Section	IX	Date	23 March, 13
PQR No.	50X		

<b>4</b>	Welding Process(es)	1	<b>FCAW</b>	Manual		Semi-auto.	<input checked="" type="checkbox"/>	Auto.	
		2		Manual		Semi-auto.		Auto.	
		3		Manual		Semi-auto.		Auto.	

<b>5 Joints (QW-402)</b>			
Design	<b>DOUBLE V GROOVE &amp; FILLETS</b>	Backing Material	WELD METAL
Backing	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	Other	NONE



<b>6 Base Metals (QW-403)</b>	P. No. <u>8</u> Gr. No. <u>1</u> to P. No. <u>8</u> Gr. No. <u>1</u>
or Specifications type and grade	SA-240, 316L to SA-240, 316L, 316, 304L & 304
or Chemical Analysis and Mech. Prop.	
Thickness Range Qualified	Total 1) 5/8 " to 8 " for Impact use 2) 3/16" to 8" Non Impact use
Other 1) NO SINGLE PASS TO BE GREATER THAN 1/2" 2) IMPACT TEST QUALIFIED TO - 50 F	

<b>7 Filler Metals (QW-404)</b>									
1. AWS No	E316LTO-1	SFA	5.22	F-No	6	A-No.	8	Dia.	0.045"
2. AWS No.		Product Form : Flux Core		SFA		F-No		A-No.	
3. AWS No.				SFA		F-No		A-No.	
Flux Tradename	NONE	No Supplementary filler metal is allowed to be used							
Electrode Flux Classification	NONE								
Consumable Insert	NONE	Other	MAX DEPOSITED METAL 8 "						

<b>8 Positions (QW-405)</b>	
Position(s) of Groove	1G TO 6G
Welding Progression	UP
Position(s) of Fillet	ALL
Other	NONE

<b>10 Postweld Heat Treatment (QW-407)</b>	
Temperature Range	NONE
Time Range	NONE
Other	NONE

9	<b>Preheat (QW-406)</b>	
Preheat Temperature	Min.	50° F
Interpass Temperature	Max.	350° F
Preheat Maintenance		50° F
Other	NONE	

11	<b>Gas (QW-408)</b>
Shielding Gas Composition	CO2
Gas Flow Rate	45 CFH
Backing Gas Composition	NONE
Trailing Shield Gas Composition	NONE
Other	NONE

**12 Electrical Characteristics and Technique (QW-409)-(QW-410)**

Weld Layer(s)	Process	Filler Metal		Current				Travel Speed Range
		Classification	Diameter	Type	Polarity	Amp. Range	Volt Range	
ROOT	FCAW	E316TO-1	0.045"	DC	RP	290 - 330	27-30	10-15 IPM
FILL	FCAW	E316TO-1	0.045"	DC	RP	290 - 330	27-30	10-15 IPM
<b>Heat Input ( Per QW-409.1 ) = 59,400 j / in</b>								

Tungsten Electrode Size and Type	NONE							
Mode of Metal Transfer for GMAW	SPRAY							
String or Weave Bead	STRING							
Method of Back Gouging	GRINDING OR ARC AIR GOUGING AND GRINDING							
Initial and Interpass Cleaning (Brushing, Grinding, etc.)	WIRE BRUSH OR GRINDING							
Orifice or Gas Cup Size	1/2"							
Oscillation	NONE	Width	NONE	Frequency	NONE			
Contact Tube to Work Distance	3/4"							
Multiple or Single Pass (per side)	MULTIPLE							
Multiple or Single Electrode	SINGLE							
Electrode Wire feed speed range	400 IPM							
Other	NONE							

**1 Supplementary Comments**

NONE

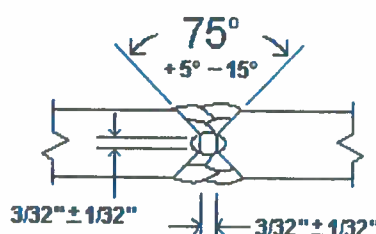
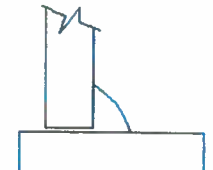
**10** Company Representative Signature Robert C. Bentley Date 23 March, 2013  
 Robert C. Bentley C.E.T.

Registration of this Welding Procedure (Specification plus Qualification Record) is required pursuant to the provisions of Section 36 (1) of the Boilers and Pressure Vessels Act of Ontario.  
 The registration becomes invalid when any essential variable changes, or any requirement of the ASME Code Section IX, affecting this procedure, is altered.

# PROCEDURE QUALIFICATION RECORD (PQR)

(Reference: ASME Section IX)

<b>1 Company</b>			
Name / ALL-WELD COMPANY LIMITED			
Address / 49 PASSMORE AVENUE			
SCARBOROUGH, ONTARIO			
			Postal Code M   1   V   4   T   1
<b>4 Welding Process(es)</b>			
1	FCAW	Type	MANUAL
2		Type	
3		Type	
<b>6 Base Metals (QW-403)</b>			
P No.	8	Gr No.	1 to P. No. 8 Gr No. 1
Specification		Tensile	
SA-240-316L		70,000 psi	
Thickness		Diameter	
1 3/4 "		N/A	
Other NONE			
<b>7 Filler Metals (QW-405)</b>			
Classification (AWS)	SFA-No.	F - No.	A - No.
E316LTO-1	5.22	6	8
Product Form - Flux Core			
No Supplementary filler metal is allowed to be used			
Other No Single Pass Greater than 1/2 "			
<b>8 Positions QW-405</b>			
Position(s) of Groove 3G			
Welding Progression Up <input type="checkbox"/> Down <input type="checkbox"/>			
Other NONE			
<b>9 Preheat (QW-406)</b>			
Preheat Temperature 50°F			
Interpass Temperature 350°F			
Other NONE			

<b>2 Provincial Registration</b>		WP <b>T4646.5</b>
<b>3 Record Identification</b>		
PQR No.		50-X
WPS No.		50-3A
<b>5 Groove Design used</b>		
		
ALL FILLET WELDS		
<b>10 Postweld Heat Treatment /</b>		
Temperature		NONE
Time		NONE
Other		NONE
<b>11 Gas (QW-408)</b>		
Shielding Gas Composition		CO2
Gas Flow Rate		45 CFH
Backing Gas composition		NONE
Gas Flow Rate		NONE
Other		NONE
<b>12 Technique (QW-410)</b>		
String or Weave Bead		STRING
Oscillation		NONE
Multipass or Single Pass (per side)		MULTIPLE
Single or Multiple Electrode		SINGLE
Other		Transfer : Spray

<b>13 Electrical Characteristics and Technique (QW-409) + (QW-410)</b>								
Weld Layers	Process	Filler Metal		Current				Travel Speed
		Classification	Diameter	Type	Polarity	Amp	Volt	
ROOT	FCAW	E316LTO-1	0.045 "	DC	RP	330	30	10
FILL	FCAW	E316LTO-1	0.045 "	DC	RP	330	30	10

14 Tensile Tests				Reference:		
Specimen	Dimensions in Inches		Area in Inches <sup>2</sup>	Ultimate Total Load in Foot Pounds	Ultimate Unit Stress in PSI	Character and Location of Failure
	Width	Thickness				
T2A	0.754"	0.810"	0.611"	49,863	81,500	All coupons failed ductile manner in base metal
T2B	0.756"	0.820"	0.620"	51,094	82,500	
T5A	0.754"	0.885"	0.667"	57,278	86,000	
T5B	0.756"	0.908"	0.686"	56,013	81500	

15 Guided Bend Tests					Reference:				
Specimen	Face	Root	Side	Result	Specimen	Face	Root	Side	Result
S1			X	ACCEPTED	S3			X	ACCEPTED
S2			X	ACCEPTED	S4			X	ACCEPTED

16 Toughness Tests					Reference:			
Specimen	Notch Location	Notch Type	Specimen Temperature	Impact Value	Lateral Expansion		Drop Weight:	
					Shear	Mills	Break	No Break
1	Weld ( 1/16" below )	V NOTCH	- 50 F	26 ft-lbf	100	22		
2	Weld ( 1/16" below )	V NOTCH	- 50 F	26 ft-lbf	100	24		
3	Weld ( 1/16" below )	V NOTCH	- 50 F	26 ft-lbf	100	20		
1	HAZ	V NOTCH	- 50 F	85 ft-lbf	100	37		
2	HAZ	V NOTCH	- 50 F	43 ft-lbf	100	28		
3	HAZ	V NOTCH	- 50 F	63 ft-lbf	100	30		
1	Weld ( 1/4 t opposite )	V NOTCH	- 50 F	25 ft-lbf	100	20		
2	Weld ( 1/4 t opposite )	V NOTCH	- 50 F	25 ft-lbf	100	19		
3	Weld ( 1/4 t opposite )	V NOTCH	- 50 F	27 ft-lbf	100	23		

17 Fillet Weld Test			Reference:	
Result - Satisfactory	Yes <input type="checkbox"/>	No <input type="checkbox"/>	Penetration Into Parent Metal	Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>
HEAT INPUT = 59,400 j / in Maximum			W.P.S.: WP-146465	
			Signed: [Signature]	

18 Other Tests		Reference:
1) MACROETCH EXAMINATION PER LAB REPORT 636455-13 ( Report A )		Date: April 11, 2013
2) NACE MR0175/ISO 15156-2:2009/CIR..2011(E) VICKERS HARDNESS PER LAB REPORT 636455-13 ( Report B )		

19 Welder's Name	Steve Liew	Stamp No.	WPS-# 50-3A 90
Tests conducted by		CAMBRIDGE MATERIAL TESTING LTD.	
We certify that the statements in this record are correct and that the test welds were prepared, welded and tested in accordance with the requirements of section IX of the ASME Code.		636448-2013, 636450-2013, 636452-2013, 636453-2013, 636454-2013, 636455-13(Report A) Laboratory Test No. 636455-13(Report B)	

20 Company Representative's Signature	[Signature]	Date	23 March, 2013
ROBERT C. BENTLEY, C.E.T.			

21 Department Use only	
Samples Welded on	Inspector
Record verified on	Inspector



# Welding Procedure Specification (WPS)

STAINLESS  
STEEL

**Customer  
Work Order #**

<b>1</b>	<b>Company</b>
Name/	ALL-WELD COMPANY LIMITED
Address/	49 PASSMORE AVE. , 14 PASSMORE AVE. PLANT 1 PLANT 2
	SCARBOROUGH, ONTARIO
Postal Code ( PLANT 1 )	Postal Code ( PLANT 2 )
M1V-4T1	M1V-2R6

<b>2</b>	<b>Provincial Registration</b>	WP R4428.5
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<b>3</b>	<b>Procedure Identification</b>	
WPS NO.	SAW-W-2-4	Revision No. 0
Code Section	IX	Date 21-Mar-13
PQR No.	SAW-2A1	

<b>4</b>	<b>1</b>	<b>SAW</b>	Manual	<input type="checkbox"/>	Semi-auto.	<input type="checkbox"/>	Auto.	<input checked="" type="checkbox"/>
Welding Process(es)	<b>2</b>		Manual	<input type="checkbox"/>	Semi-auto.	<input type="checkbox"/>	Auto.	<input type="checkbox"/>
	<b>3</b>		Manual	<input type="checkbox"/>	Semi-auto.	<input type="checkbox"/>	Auto.	<input type="checkbox"/>

<b>5</b>	<b>Joints (QW-402)</b>	
Design	DOUBLE V GROOVE	Backing Material WELD METAL
Backing	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> X	Other NONE
Sketch		
<b>FLAT POSITION FILLET WELDS</b>		

<b>6</b>	<b>Base Metals (QW-403)</b>	P. No. <u>8</u> Gr. No. <u>1</u> to P. No. <u>8</u> Gr. No. <u>1</u>
or Specifications type and grade		SA-240, 316L to SA-240, 304, 304L, 316 & 316L
or Chemical Analysis and Mech. Prop.		NONE
Thickness Range Qualified	Total	5/8" TO 8" for Impact Test and 3/16" to 8" for Non Impact test
Other 1) NO SINGLE PASS TO BE GREATER THAN 1/2"		

<b>7</b>	<b>Filler Metals (QW-404)</b>	
1. AWS No	ER316L	SFA 5.9 F-No 6 A-No. 8 Dia. 0.125
2. AWS No.		SFA F-No A-No. Dia.
3. AWS No.		SFA F-No A-No. Dia.
Flux Tradename	LINCONWELD ST100	Electrode Flux Classification NONE
Consumable Insert	NONE	Other MAX DEPOSITED METAL 8"

<b>8</b>	<b>Positions (QW-405)</b>
Position(s) of Groove	1G
Welding Progression	UP
Position(s) of Fillet	1F
Other	NONE

<b>10</b>	<b>Postweld Heat Treatment (QW-407)</b>
Temperature Range	NONE
Time Range	NONE
Other	NONE

9	<b>Preheat (QW-406)</b>		
Preheat Temperature	Min.	60° F	
Interpass Temperature	Max.	350 ° F	
Preheat Maintenance		350 ° F	
Other	NONE		

11	<b>Gas (QW-408)</b>	
Shielding Gas Composition	NONE	
Gas Flow Rate	NONE	
Backing Gas Composition	NONE	
Trailing Shield Gas Composition	NONE	
Other	NONE	

12		<b>Electrical Characteristics and Technique (QW-409)-(QW-410)</b>							
Weld Layer(s)	Process	Filler Metal		Current				Travel Speed Range	
		Classification	Diameter	Type	Polarity	Amp. Range	Volt Range		
ROOT	SAW	ER316L	0.125	DC	RP	350-500	30-32	16-24 IPM	
FILL	SAW	ER316L	0.125	DC	RP	350-500	30-32	16-24 IPM	
		<b>Heat input ( Per QW-409.1 ) = 60,000 J / in</b>						<b>Maximum</b>	
Tungsten Electrode Size and Type		NONE							
Mode of Metal Transfer for GMAW		NONE							
String or Weave Bead		STRING							
Method of Back Gouging		GRINDING OR ARC AIR GOUGING AND GRINDING							
Initial and Interpass Cleaning (Brushing, Grinding, etc.)		WIRE BRUSH OR GRINDING							
Orifice or Gas Cup Size		3/4"							
Oscillation	NONE	Width	NONE	Frequency	NONE				
Contact Tube to Work Distance		1"							
Multiple or Single Pass (per side)		MULTIPLE							
Multiple or Single Electrode		SINGLE							
Electrode Wire feed speed range		55 IPM							
Other		NONE							

13 **Supplementary Comments**

1) Impact Testing to - 50 F per Laboratory No 636543-2013

2) NACE MR0175 / ISO 1516-2:2009 / Cir.1:2011 ( E ) per Laboratory No 636546--13 ( Report B )

3) Macroetch per ASTM E3-11 per Laboratory No 636546-13 ( Report A )

14 Company Representative Signature Robert Bentley Date 21 March, 13  
**Robert Bentley QCM**

Registration of this Welding Procedure (Specification plus Qualification Record) is required pursuant to the provisions of Section 36 (1) of the Boilers and Pressure Vessels Act of Ontario.  
 The registration becomes invalid when any essential variable changes, or any requirement of the ASME Code Section IX, affecting this procedure, is altered.



Specimen Epreuve	Dimensions Dimensions		Area Surface	Ultimate Total Load Charge limite	Ultimate Unit Stress Contrainte limite	Character and Location of Failure Nature et endroit de la rupture
	Width Largeur	Thickness Epaisseur				
	0.755"	1.504"	1.1355	99,440	87,573	FRACTURED BASE
	0.750"	1.507"	1.1302	99,950	88,433	FRACTURED BA

**15 Guided Bend Tests/Essais de pliage guidé** Reference: Réference:

Specimen Epreuve	Face Face	Root Racine	Side Côté	Result Résultat	Specimen Epreuve	Face Face	Root Racine	Side Côté	Result Résultat
B1			X	ACCEPTED	B3			X	ACCEPTED
B2			X	ACCEPTED	B4			X	ACCEPTED

**16 Toughness Tests/Essais de résilience** Reference: Réference:

Specimen Epreuve	Notch Location Endroit de l'entaille	Notch Type Forme de l'entaille	Specimen Temperature Température de l'éprouvette	Impact Value Énergie de rupture	Lateral Expansion Expansion latérale		Drop Weight Essai en chute libre	
					Shear % cisaillement	Mills Millimètres	Break Cassé	No Break Non cassé

**17 Fillet Weld Test/Essai de soudure d'angle** Reference: Réference:

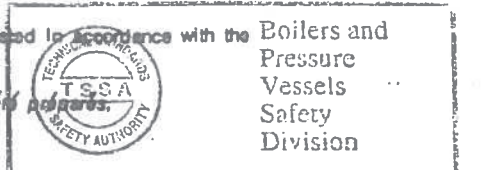
Result - Satisfactory Résultat satisfaisant Yes  No   
 Penetration into Parent Metal Pénétration dans métal de base Yes  No   
 Macro - Results Résultats macroscopiques

**18 Other Tests/Autres essais** Reference: Réference:

Blank area for other tests.

19 Welder's Name VITTORIO VITRANO Stamp No. 38  
 Nom du soudeur  
 Tests conducted by CAMBRIDGE MATERIALS TESTING LTD. Laboratory Test No. 183506-1998  
 Essais effectués par

We certify that the statements in this record are correct and that the test welds were prepared, welded and tested in accordance with the requirements of section IX of the ASME Code.  
 Nous certifions que les renseignements concernant ce résultat sont exacts et que les essais de soudage ont été préparés, soudés et exécutés conformément aux exigences de la section IX du Code ASME.



20 Company Representative's Signature Robert C Bentley Date 7 JAN. 1998  
 Signature du représentant de l'entreprise ROBERT C. BENTLEY

21 Department Use Only/Réservé au ministère  
 Samples Welded on Pièces soudées le Inspector inspecteur  
 Record verified on Résultats vérifiés le Inspector inspecteur

**REGISTERED**  
 W.P.S.: WR-R4428.5  
 Signed: \_\_\_\_\_  
 Date: 98.01.15.

WPS 2-1  
W-0-1173 PQ

PO# 13-0765

5

# HOBART BROTHERS

McKay

## CERTIFICATE OF ANALYSIS

CUSTOMER:	EXOCOR C/O USF HOLLAND BUFFALO	P.O. #:	021702
MARKED FOR:		DATE:	5/7/2013 2:14:00 PM
PACK SLIP/ORDER #:	A503500	WORK ORDER:	
LBS SHIPPED:	60		
PRODUCT TYPE:	STERL AP 309/309L 1/8 10 CAN	STOCK NUMBER:	S483944-033
LOT NO:	23R058	HEAT NO:	743678
SPECIFICATION:	AWS A5.4, ASME SFA 5.4	CLASS:	E309/309L-16

### ACTUAL CHEMICAL ANALYSIS (%)

C	0.028	✓
Mn	1.060	✓
P	0.034	✓
S	0.007	✓
Si	0.534	✓
Cu	0.114	✓
Cr	22.859	✓
Ni	12.983	✓
Mo	0.120	✓

This material has not come in contact with mercury or mercury containing compounds.

Measured FN : 9  
 Delong FN : 13  
 Schaeffler : 9

### TYPICAL MECHANICAL PROPERTIES

Tensile 83,000 psi ( 575 Mpa)  
 Yield 66,000 psi ( 455 Mpa)  
 Elongation 46

Filler Metals Quality Assurance  
 Hobart Brothers  
 400 Trade Square  
 Troy, Ohio 45373

Authorized Signature :

Brian Simpson, Q.A. Technician

Certification and Limited Warranty - Data for the above supplied product are those obtained when welded and tested in accordance with the above specification. All tests for the above classification were satisfied. Other tests and procedures may produce different results. Hobart Brothers produces welding consumables under continuing quality assurance programs audited and approved by the American Bureau of Shipping ("ABS").



**HOBART BROTHERS**

McKay

W.O.N' 1173 PG  
WPS 2-1

**CERTIFICATE OF ANALYSIS**

CUSTOMER:	EXOCOR % USF HOLLAND BUFFALO	P.O. #:	021769
MARKED FOR:		DATE:	5/21/2013 7:33:39 AM
PACK SLIP/ORDER #:	A7841/00	WORK ORDER:	
LBS SHIPPED:	60		
PRODUCT TYPE:	STERL AP 309/309L 1/8 10 CAN	STOCK NUMBER:	S483944-033
LOT NO:	24R046 ✓	HEAT NO:	744973 ✓
SPECIFICATION:	AWS A5.4, /ASME SFA 5.4 ✓	CLASS:	E309/309L-16 ✓

**ACTUAL CHEMICAL ANALYSIS (%)**

C 0.032 ✓  
Mn 1.068 ✓  
P 0.020 ✓  
S 0.008 ✓  
Si 0.574 ✓  
Cu 0.070 ✓  
Cr 22.722 ✓  
Ni 12.735 ✓  
Mo 0.147 ✓

This material has not come in contact with mercury or mercury containing compounds.

Measured FN : 10  
DeLong FN : 13  
Schaeffler : 9

**TYPICAL MECHANICAL PROPERTIES**

Tensile 83,000 psi (575 Mpa)  
Yield 66,000 psi (455 Mpa)  
Elongation 46

Filter Metals Quality Assurance  
Hobart Brothers  
400 Trade Square  
Troy, Ohio 45373



Authorized Signature :

Tim Wagner, Q.A. Technician

Certification and Limited Warranty - Data for the above supplied product are those obtained when welded and tested in accordance with the above specification. All tests for the above classification were satisfied. Other tests and procedures may produce different results. Hobart Brothers produces welding consumables under continuing quality assurance programs audited and approved by the American Bureau of Shipping ("ABS").



**CERTIFICATE OF ANALYSIS**

CUSTOMER:	CPG	P.O.#:	59751
MARKED FOR:		DATE:	7/24/2012 8:42:12 AM
PACK SLIP/ORDER #:	44941/01	WORK ORDER:	
LBS SHIPPED:	180		
PRODUCT TYPE:	STERL AP 309/309L 5/32 10 CAN	STOCK NUMBER:	S483951-033
LOT NO:	26P006	HEAT NO:	740749
SPECIFICATION:	AWS A5.4,/ASME SFA 5.4	CLASS:	E309/309L-16

**ACTUAL CHEMICAL ANALYSIS (%)**

C	0.028
Mn	1.102
P	0.021
S	0.005
Si	0.647
Cu	0.048
Cr	22.454
Ni	12.309
Mo	0.070

This material has not come in contact with mercury or mercury containing compounds .

Measured FN :	9
DeLong FN :	14
Schaeffler :	10

**TYPICAL MECHANICAL PROPERTIES**

Tensile	83,000 psi ( 575 Mpa)
Yield	66,000 psi ( 455 Mpa)
Elongation	46

Filler Metals Quality Assurance  
Hobart Brothers  
100 Trade Square  
Troy, Ohio 45373



Authorized Signature :

Brian Simpson, Q.A. Technician

Certification and Limited Warranty - Data for the above supplied product are those obtained when welded and tested in accordance with the above specification. All tests for the above classification were satisfied. Other tests and procedures may produce different results. Hobart Brothers produces welding consumables under continuing quality assurance programs audited and approved by the American Bureau of Shipping ("ABS").

**HOBART BROTHERS**

McKay

**CERTIFICATE OF ANALYSIS**

CUSTOMER:  
MARKED FOR  
PACK SLIP/ORDER #  
LBS SHIPPED:

P.O. #:  
DATE: 1/19/2013 5:26:19 AM  
WORK ORDER:

PRODUCT TYPE  
LOT NO  
SPECIFICATION

STERL AP 316/316L 1/8 10 CAN  
21R006  
AWS A5.4, ASME SFA 5.4 EN10204 3.1 CLASS:

STOCK NUMBER: S482944-033  
HEAT NO: 741891  
E316L-16 E316-16

**ACTUAL CHEMICAL ANALYSIS (%)**

C 0.04  
Mn 1.08  
P 0.028  
S 0.009  
Si 0.65  
Cu 0.28  
Cr 17.30  
Ni 13.41  
Mo 2.27

This material has not come in contact with mercury or mercury containing compounds .

Measured FN : 1  
Schaeffler : 2

**TYPICAL MECHANICAL PROPERTIES**

Tensile 81,000 psi ( 559 Mpa)  
Yield 58,000 psi ( 398 Mpa)  
Elongation 39

Filler Metals Quality Assurance  
Hobart Brothers  
400 Trade Square  
Troy, Ohio 45373



Authorized Signature :

Brian Simpson, Q.A. Technician

Certification and Limited Warranty - Data for the above supplied product are those obtained when welded and tested in accordance with the above specification. All tests for the above classification were satisfied. Other tests and procedures may produce different results. Hobart Brothers produces welding consumables under continuing quality assurance programs audited and approved by the American Bureau of Shipping ("ABS").

W.I.O.N' 1  
1173 P&Q

SMAW  
WPS 3-4

6



SMCW

(6)

WPS. 3-4

# HOBART BROTHERS

McKay

## CERTIFICATE OF ANALYSIS

CUSTOMER:  
MARKED FOR  
PACK SLIP/ORDER #  
LBS SHIPPED:

P.O. #:  
DATE: 12/5/2012 12:57:15 PM  
WORK ORDER:

PRODUCT TYPE:  
LOT NO  
SPECIFICATION:

STERL AP 316/316L 5/32 10 CAN  
31P050  
AWS A5.4, ASME SFA 5.4 EN10204 3.1 CLASS:

STOCK NUMBER: S482951-033  
HEAT NO: 741891  
E316L-16 E316-16

### ACTUAL CHEMICAL ANALYSIS (%)

C 0.03  
Mn 1.02  
P 0.022  
S 0.009  
Si 0.44  
Cu 0.25  
Cr 17.68  
Ni 12.87  
Mo 2.14

This material has not come in contact with mercury or mercury containing compounds.

Measured FN : 2  
DeLong FN : 1  
Schaeffler : 3

### TYPICAL MECHANICAL PROPERTIES

Tensile 81,000 psi ( 559 Mpa)  
Yield 58,000 psi ( 398 Mpa)  
Elongation 39

Filler Metals Quality Assurance  
Hobart Brothers  
400 Trade Square  
Troy, Ohio 45373



Authorized Signature :

Brian Simpson, Q.A. Technician

Certification and Limited Warranty - Data for the above supplied product are those obtained when welded and tested in accordance with the above specification. All tests for the above classification were satisfied. Other tests and procedures may produce different results. Hobart Brothers produces welding consumables under continuing quality assurance programs audited and approved by the American Bureau of Shipping ("ABS").

GTAW 9.4

PO#13-0511

(7)

**Inspection Certificate**  
**Schedule F**  
**As Per: AWS/ASME SFA.5.01**  
**Certificate No: EXP1320157 24**

**Bohler Welding Group USA, Inc.**  
 10401 Greenbough Drive  
 Stafford, TX 77477  
 Tel: 281-499-1212; 800-527-0791  
 Fax: 281-499-4347

**Böhler Welding GROUP**

Test Object: welding wire for GTAW ✓  
 Dimensions: 3.2mm(1/8") x 914mm(36") x 4.5kg(10 lb)  
 Trade Designation: AVESTA ER316/316L ✓  
 Lot No: E48111 ✓  
 Marking of Product: Delivery Qty:

Standard Designation: AWS A5.9/ASME SFA5.9 ER316L

Chemical Composition in %

Lot/Heat	C	Mn	Si	P	S	Cu	Ni	Cr	Mo	N	WRC-92
E48111	0.013 ✓	1.54 ✓	0.64 ✓	0.023 ✓	0.003 ✓	0.20 ✓	11.26 ✓	18.23 ✓	2.54 ✓	0.074	7.5FN
Test Result											

All weld metal

As per Test Temp. T °C	ASTM E8 Yield Point ReH MPa	Specimen Preparation Tensile Strength Rp MPa	AWS B4.0 Elongation A % Lo=4d	RA %	Note
As per Test Temp. T °C	ASTM E23 Absorbed Energy Minimum Values KV	Specimen Preparation Average	AWS B4.0 Lateral Expansion MM	Shear Fracture %	
Minimum:					
Maximum:					
Impact Test:					

Note:  
 This product meets the requirements of the filler metal specifications when tested in accordance with that specification. This certificate was issued by DP-equipment and does not require signature.  
 Authorized inspection representative:  
 Russel Fuchs  
 Loc: Houston, TX  
 Date:



CW.O.NI 1173 PR  
50-3A

**INSPECTION**

**INSPECTION CERTIFICATE**

PURCHASER: **FLUX CORED WIRE**  
 CERTIFICATE No. **Z20121197**  
 DATE OF ISSUE **2012.09.18**

TRADE DESIGNATION	DIMENSION	WFS No.	APPLICABLE SPECIFICATION AND CLASSIFICATION										
DW-316L	0.045 inch	F2G2315	ANS A5.22 E316LT0-1 AWS A5.22 E316LT0-4 ASME SFA-5.22 E316LT0-1 ASME SFA-5.22 E316LT0-4										
CHEMICAL COMPOSITION (%) ACCORDING TO EN10204 TYPE 3.1													
ELEMENTS	C	SI	MN	P	S	CU	NI	CR	MO	NB	IN	FN	FS
DEPOSITED METAL ELEMENTS	0.023	0.67	1.41	0.018	0.003	0.10	12.12	18.42	2.28	0.01	0.022	10	7
	FS												
DEPOSITED METAL	7												
MECHANICAL PROPERTY ACCORDING TO EN10204 TYPE 3.1													
TENSILE TEST OF DEPOSITED METAL													
YIELD POINT	YIELD STRENGTH AT 0.2% OFFSET	TENSILE STRENGTH	ELONGATION	TEST TEMP.	IMPACT TEST OF DEPOSITED METAL				HARDNESS TEST				
- ksi	- ksi	81 ksi	28 %	- F	AVG. - ft-lbf				ABSORBED ENERGY				

POSTFIELD HEAT TREATMENT: - F X - h

WELDING CONDITIONS:

TYPE OF CURRENT	DCEP	SHIELDING GAS	CO2 100%
AMPERAGE	200 A		
ARC VOLTAGE	29 V		

BISMUTH(BI) CONTENT IN DEPOSIT METAL IS NO LESS THAN 0.002%. **QC-B**

WE HEREBY CERTIFY THAT THE ABOVE TEST RESULTS ARE AS DESCRIBED HEREIN AND SATISFY THE REQUIREMENTS OF THE APPLICABLE SPECIFICATION.

→ KOBEL STEEL, LTD.  
 WELDING BUSINESS FUJISAWA PLANT  
**H. Sugawara**  
 APPROVED BY CHIEF INSPECTOR

**CERTIFICATE OF CONFORMANCE**  
 (APPLIES ONLY TO U.S. PRODUCTS)



Product: Lincolnweld® 316/316L  
 Classification: ER316, ER316L  
 Specification: AWS A5.9:2008, ASME SFA-5.9  
 Date: March 06, 2012

This is to certify that the product named above and supplied on the referenced order number is of the same classification, manufacturing process, and material requirements as the material which was used for the test that was concluded on the date shown, the results of which are shown below. All tests required by the specifications shown for classification were performed at that time and the material tested met all requirements. It was manufactured and supplied according to the Quality System Program of the Lincoln Electric Company, Cleveland, Ohio, U.S.A., which meets the requirements of ISO9001, NCA3800, AWS A5.01, and other specification and Military requirements, as applicable. The Quality System Program has been approved by ASME, ABS, and VdTUV.

Electrode composition (weight %)	ER316 Requirements	ER316L Requirements	3/32 Electrode RESULTS
C	0.08 max.	0.03 max.	0.02
Mn	1.0 - 2.5	1.0 - 2.5	1.4
Si	0.30 - 0.65	0.30 - 0.65	0.39
S	0.03 max.	0.03 max.	0.00
P	0.03 max.	0.03 max.	0.02
Cr	18.0 - 20.0	18.0 - 20.0	19.1
Ni	11.0 - 14.0	11.0 - 14.0	12.3
Mo	2.0 - 3.0	2.0 - 3.0	2.4
Cu	0.75 max.	0.75 max.	0.08
N	Not Required	Not Required	0.04
Nb	Not Required	Not Required	0.01
WRC-1992 (C)	Not Required	Not Required	8.10
WRC-Delong (C)	Not Required	Not Required	9.80

1. This certificate complies with the requirements of EN 10204, Type 2.2.
2. All other diameters manufactured will also meet these requirements
3. Results below the detection limits of the instrument or lower than the precision required by the specification are reported as zero.

*Toronto Cunningham* March 06, 2012  
 Toronto Cunningham, Certification Supervisor Date

*David R. Fink* March 07, 2012  
 Dave Fink, Manager, Compliance Date  
 Engineering, Consumable R&D

WPS SAW-W-2-Y J-LUX

W.O.N. 1173PQ

22801 St. Clair Avenue  
Cleveland, Ohio 44117-1199 U.S.A.  
(216) 481-8100



# THE LINCOLN ELECTRIC COMPANY

## PRODUCT CERTIFICATE

### ST-100 FLUX

The product named above and supplied on the referenced order number is of the same manufacturing process, and material requirements as the material which was used for the tests and calculations, the results of which are shown below. This certificate complies to the requirements of EN 10204, Type 2.2.

• Basicity Index

B.I.\* = 1.2

\*Calculated using Boniszewski formula shown below

$$B.I. = \frac{0.5 (FeO + MnO) + CaO + MgO + Na_2O + K_2O + CaF_2}{SiO_2 + 0.5 (TiO_2 + ZrO_2 + Al_2O_3)}$$

• Flux Sizing Distribution\*

+20 MESH	32%	Maximum
-20 +100 MESH	64%	Minimum
-100 MESH	4%	Maximum

\*U.S. sieve number per ASTM E11-04

• Flux Composition (Based on Elemental Values Determined by X-Ray Fluorescence)

Na <sub>2</sub> O	2%	SiO <sub>2</sub>	19%	MnO	7%	Cr	5%
MgO	28%	CaO	1%	FeO	1%		
Al <sub>2</sub> O <sub>3</sub>	8%	TiO <sub>2</sub>	1%	CaF <sub>2</sub>	8%		
ZrO <sub>2</sub>	24%						

• Density (g/cm<sup>3</sup>): 1.4

• Flux Classification: EN 760 – S A AS 2  
EN 760 – S A ZS 2

*Philip J. Woodring* February 19, 2013  
Philip J. Woodring, Certification Supervisor, Date



Technical Standards and Safety Authority

14th Floor - Centre Tower  
3300 Bloor Street West  
Toronto, Ontario M8X 2X4  
Web site: www.tssa.org

# Welder/Welding Operator Certificate

Technical Standards and Safety Act  
Boilers and Pressure Vessels Regulation

No. 258822

Welder's Last Name <b>GREER</b>		Initial	First Name <b>ROBIN</b>	Signature <i>Robin Greer</i>	Stamp No. <b>9</b>
Res. Address <b>835 MOUNTAIN ASH ROAD, PETERBOROUGH, ONTARIO</b>				Postal Code <b>K 9 J 8 K 2</b>	Provincial Registration No. <b>R3578.5, D852.5 &amp; R764.5</b>
Employer Name <b>ALL - WELD COMPANY LIMITED</b>				Company PQR No. <b>54, 9, 9AB</b>	
Street Address <b>49 PASSMORE AVE</b>				Postal Code <b>M 1 V 4 T 1</b>	Company WPS No used <b>9-3</b>
Location <b>SCARBOROUGH, ONT</b>				Welding Process(es) Used <b>GTAW</b>	
Base Material(s) <b>SA-312-316</b>				Thickness(es) <b>0.188"</b>	<input checked="" type="checkbox"/> Test Coupon <input type="checkbox"/> Production Weld
Variables for All Processes		Actual Values		Range Qualified	
Backing material (with/without)		WITHOUT		WITH OR WITHOUT	
Base Metal P-Number to P-Number		<b>8</b> to <b>8</b>		<b>P1 THRU P15F, P34, &amp; P4X PLATE AND PIPE 1/2" OD AND UP</b>	
( ) Plate ( <input checked="" type="checkbox"/> ) Pipe (enter diameter if pipe)		<b>1/2" SCH 160</b>			
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)		<b>5.9 ER 316</b>			
Consumable Insert for GTAW or PAW (QW-404)		<b>NONE</b>			
Welding Position (1G, 5G, etc.) (QW-405)		<b>6G</b>		<b>6G</b>	
Manual or Semi-automatic Variables (QW-350)		Actual Values		Range Qualified	
Filler Metal F-No (QW-404)		<b>F6</b>		<b>F6</b>	
Filler Metal Product Form for GTAW, PAW (QW-404)		<b>SOLID</b>		<b>SOLID</b>	
Weld deposit thickness for each welding process (QW-404)		<b>0.188"</b>		<b>0.376" MAX PLATE GROOVE + PIPE 1/2" OD + UP</b>	
Process 1: _____ 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No		<b>3</b>		<b>+ ALL FILLETS</b>	
Process 2: _____ 3 layers minimum <input type="checkbox"/> Yes <input type="checkbox"/> No		<b>NONE</b>		<b>NONE</b>	
Vertical progression (uphill/downhill) (QW-405)		<b>UPHILL</b>		<b>NONE</b>	
GTAW, PAW or GMAW backing gas; or OFW fuel gas (QW-408)		<b>ARGON 99.9%</b>		<b>ARGON 99.9%</b>	
GMAW transfer mode (spray/globular or pulse to short circuit) (QW-409)		<b>NONE</b>		<b>NONE</b>	
GTAW welding current type & polarity (AC, DCEP, DCEN) (QW-409)		<b>DC / SP</b>		<b>DC / SP</b>	
Machine Welding Variables (QW-361.2)		Actual Values		Range Qualified	
Direct or remote visual control		<b>NONE</b>			
Automatic arc voltage control (GTAW)		<b>NONE</b>			
Automatic joint tracking		<b>NONE</b>			
Multiple or single pass per side		<b>NONE</b>			
Automatic Welding Variables (QW-361.1)		Actual Values		Range Qualified	
Filler Metal (EBW or LBW)		<b>NONE</b>			
Laser type for LBW (CO <sub>2</sub> to YAG etc.)		<b>NONE</b>			
Continuous drive or inertia welding (FW)		<b>NONE</b>			
Vacuum or out of vacuum (EBW)		<b>NONE</b>			

Note: Values in "Range Qualified" are valid only when used with a Qualified Welding Procedure.

### RESULTS

Visual Examination of Completed Weld (QW-302.4) ACCEPTED

Transverse root and face [QW-462.3(a)];  Longitudinal root and face [QW-462.3(b)];  Side [QW-462.2];

Pipe bend specimen, corrosion-resistant overlay [QW-462.5(c)];  Plate bend specimen, corrosion-resistant overlay [QW-462.5(d)];

Pipe specimen, macro test for fusion [QW-462.5(b)];  Plate specimen, macro test for fusion [QW-462.5(e)]

Type	Result	Type	Result	Type	Result	Type	Result
QW-462.3 (a)	ACCEPTED	QW-462.3 (a)	ACCEPTED	QW-462.3 (a)	ACCEPTED	QW-462.3 (a)	ACCEPTED
(Face)		(ROOT)		(Face)		(ROOT)	

Alternative radiographic examination results (QW-191) NONE

Fillet weld - fracture test (QW-181.2) NONE Length and percent of defects NONE

Fillet welds in plate [QW-462.4(b)];  Fillet welds in pipe [QW-462.4(c)]

Macro examination (QW-184) NONE Fillet size (in.) NONE x NONE Concavity/convexity (in.) NONE

Other tests NONE

Film or specimens evaluated by NONE Company NONE

Mechanical tests conducted by ALL - WELD COMPANY LIMITED Laboratory test no. NONE

Welding supervised by (Print name) ANDREW LEWIS

Test requested by (Print name) ROBERT BENTLEY Tested at (Print address) 49 PASSMORE AVE, SCARBOROUGH, ONT

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Boiler and Pressure Vessel Code.

Organization ALL - WELD COMPANY LIMITED Signature *Robert Bentley* Date 03-06-2012  
(mm-dd-yyyy)

### FOR TSSA INSPECTOR USE ONLY

The Welder named above has passed the welding test required under Ontario's *Technical Standards and Safety Act*, Boilers and Pressure Vessels Regulation and is hereby authorized, subject to the limitations of this certificate.

Check  applicable box below.

To weld for the Employer named above only

For seeking employment only.

This Certificate expires: PER ASME SECTION IX  
(mm dd yyyy)

WOSTICA ROSE ONT 915  
Inspector Name and Number (Print)

*[Signature]* MAR 07, 2012  
Inspector Signature and Date



Technical Standards and Safety Authority

14th Floor - Centre Tower  
3300 Bloor Street West  
Toronto, Ontario M8X 2X4  
Web site: www.tssa.org

# Welder/Welding Operator Certificate

Technical Standards and Safety Act  
Boilers and Pressure Vessels Regulation

No. 258823

Welder's Last Name <b>PARKIN</b>	Initial <b>P</b>	First Name <b>LAUGHTON</b>	Signature <i>Andrew Laughton</i>	Stamp No. <b>18</b>
Res. Address <b>38 MUSCAT CRESCENT, AJAX, ONTARIO</b>		Postal Code <b>L1Z0B9</b>	Provincial Registration No. <b>R3578.5, D852.5 &amp; R764.5</b>	
Employer Name <b>ALL - WELD COMPANY LIMITED</b>		Company PQR No. <b>54, 9, 9AB</b>		
Street Address <b>49 PASSMORE AVE</b>		Company WPS No used <b>9-3</b>		
SCARBOROUGH, ONT		Postal Code <b>M1V4T1</b>		
Welding Process(es) Used <b>GTAW</b>		Type(s)	<input checked="" type="checkbox"/> manual <input type="checkbox"/> machine <input type="checkbox"/> semi-automatic <input type="checkbox"/> automatic	
Base Material(s) <b>SA-312-318</b>		Thickness(es) <b>0.188"</b>	<input checked="" type="checkbox"/> Test Coupon <input type="checkbox"/> Production Weld	
Variables for All Processes		Actual Values	Range Qualified	
Backing material (with/without)		<b>WITHOUT</b>	<b>WITH OR WITHOUT</b>	
Base Metal P-Number to P-Number		<b>8 to 8</b>	<b>P1 THRU P15F, P34, &amp; P4X PLATE AND PIPE 1/2" OD AND UP</b>	
( ) Plate ( X ) Pipe (enter diameter if pipe)		<b>1 1/2" SCH 160</b>		
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)		<b>5.9 ER 316</b>		
Consumable Insert for GTAW or PAW (QW-404)		<b>NONE</b>		
Welding Position (1G, 5G, etc.) (QW-405)		<b>6G</b>	<b>6G</b>	
Manual or Semi-automatic Variables (QW-350)		Actual Values	Range Qualified	
Filler Metal F-No. (QW-404)		<b>F8</b>	<b>F8</b>	
Filler Metal Product Form for GTAW, PAW (QW-404)		<b>SOLID</b>	<b>SOLID</b>	
Weld deposit thickness for each welding process (QW-404)		<b>0.188"</b>	<b>0.376" MAX PLATE GROOVE + PIPE 1/2" OD + UP</b>	
Process 1: _____ 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No		<b>3</b>	<b>+ ALL FILLETS</b>	
Process 2: _____ 3 layers minimum <input type="checkbox"/> Yes <input type="checkbox"/> No		<b>NONE</b>	<b>NONE</b>	
Vertical progression (uphill/downhill) (QW-405)		<b>UPHILL</b>	<b>NONE</b>	
GTAW, PAW or GMAW backing gas; or OFW fuel gas (QW-406)		<b>ARGON 99.9%</b>	<b>ARGON 99.9%</b>	
GMAW transfer mode (spray/globular or pulse to short circuit) (QW-409)		<b>NONE</b>	<b>NONE</b>	
GTAW welding current type & polarity (AC, DCEP, DCEN) (QW-409)		<b>DC / SP</b>	<b>DC / SP</b>	
Machine Welding Variables (QW-361.2)		Actual Values	Range Qualified	
Direct or remote visual control		<b>NONE</b>		
Automatic arc voltage control (GTAW)		<b>NONE</b>		
Automatic joint tracking		<b>NONE</b>		
Multiple or single pass per side		<b>NONE</b>		
Automatic Welding Variables (QW-361.1)		Actual Values	Range Qualified	
Filler Metal (EBW or LBW)		<b>NONE</b>		
Laser type for LBW (CO <sub>2</sub> to YAG etc.)		<b>NONE</b>		
Continuous drive or inertia welding (FW)		<b>NONE</b>		
Vacuum or out of vacuum (EBW)		<b>NONE</b>		

Note: Values in "Range Qualified" are valid only when used with a Qualified Welding Procedure.  
RESULTS

Visual Examination of Completed Weld (QW-302.4) **ACCEPTED**

Transverse root and face (QW-462.3(a));  Longitudinal root and face (QW-462.3(b));  Side (QW-462.2);  
 Pipe bend specimen, corrosion-resistant overlay (QW-462.5(c));  Plate bend specimen, corrosion-resistant overlay (QW-462.5(d));  
 Pipe specimen, macro test for fusion (QW-462.5(b));  Plate specimen, macro test for fusion (QW-462.5(e))

Type	Result	Type	Result	Type	Result	Type	Result
QW-462.3 (a)	ACCEPTED	QW-462.3 (a)	ACCEPTED	QW-462.3 (a)	ACCEPTED	QW-462.3 (a)	ACCEPTED
(Face)		(ROOT)		(Face)		(ROOT)	

Alternative radiographic examination results (QW-191) **NONE**

Fillet weld — fracture test (QW-181.2) **NONE** Length and percent of defects **NONE**

Fillet welds in plate (QW-462.4(b))  Fillet welds in pipe (QW-462.4(c))

Macro examination (QW-184) **NONE** Fillet size (in.) **NONE** x **NONE** Concavity/convexity (in.) **NONE**

Other tests **NONE**

Film or specimens evaluated by **NONE** Company **NONE**

Mechanical tests conducted by **ALL - WELD COMPANY LIMITED** Laboratory test no. **NONE**

Welding supervised by (Print name) **ANDREW LEWIS**

Test requested by (Print name) **ROBERT BENTLEY** Tested at (Print address) **49 PASSMORE AVE, SCARBOROUGH, ONT**

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Boiler and Pressure Vessel Code.

Organization **ALL - WELD COMPANY LIMITED** Signature *Robert Bentley* Date **03 - 06 - 2012**  
(mm-dd-yyyy)

### FOR TSSA INSPECTOR USE ONLY

The Welder named above has passed the welding test required under Ontario's *Technical Standards and Safety Act*, Boilers and Pressure Vessels Regulation and is hereby authorized, subject to the limitations of this certificate.

Check (✓) applicable box below:

- To weld for the Employer named above only.  
 For seeking employment only.

This Certificate expires: **PER ASME SECTION IX**  
(mm-dd-yyyy)

**COSETCA ROSU 001915**  
Inspector Name and Number (Print)

*[Signature]* : **MAR 07, 2012**  
Inspector Signature and Date



Technical Standards and Safety Authority

14th Floor - Centre Tower  
3300 Bloor Street West  
Toronto, Ontario M8X 2X4  
Web site: www.tssa.org

# Welder/Welding Operator Certificate

Technical Standards and Safety Act  
Boilers and Pressure Vessels Regulation

No. 262465

Welder's Last Name <b>GABIDON</b>	Initial <b>AL</b>	First Name <b>PHONSO</b>	Signature 	Stamp No. <b>25</b>
Res. Address <b>49 HAVAGAL CRES MARKHAM, ONT</b>		Postal Code <b>L 3 P 7 G 6</b>	Provincial Registration No. <b>R4428.5</b>	
Employer Name <b>ALL - WELD COMPANY LIMITED</b>		Company PQR No. <b>SAW - W-2-A1</b>		Company WPS No. used <b>SAW - W - 2 - 4</b>
Street Address <b>49 PASSMORE AVE</b>		Postal Code <b>M 1 V 4 T 1</b>	Type(s) <input type="checkbox"/> manual <input type="checkbox"/> machine <input type="checkbox"/> semi-automatic <input checked="" type="checkbox"/> automatic	
SCARBOROUGH, ONT		Thickness(es) <b>1 3/4"</b>		<input checked="" type="checkbox"/> Test Coupon <input type="checkbox"/> Production Weld
Welding Process(es) Used <b>SAW</b>		Variables for All Processes		
Base Material(s) <b>SA - 240 - 318L</b>		Actual Values		
Backing material (with/without)		Range Qualified		
Base Metal P-Number to P-Number		BASE & WELD METAL		
( X ) Plate ( ) Pipe (enter diameter if pipe)		BASE & WELD METAL		
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)		P8 to P8 P1 THRU P15F, P34 & P4X PLATE AND PIPE 2 7/8" OD AND UP		
Consumable Insert for GTAW or PAW (QW-404)		1 3/4"		
Welding Position (1G, 5G, etc.) (QW-405)		5.9 ER316L		
Manual or Semi-automatic Variables (QW-350)		NONE		
Filler Metal F-No. (QW-404)		1G		
Filler Metal Product Form for GTAW, PAW (QW-404)		Actual Values		
Weld deposit thickness for each welding process (QW-404)		Range Qualified		
Process 1: _____ 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No		6		
Process 2: _____ 3 layers minimum <input type="checkbox"/> Yes <input type="checkbox"/> No		NONE		
Vertical progression (uphill/downhill) (QW-405)		1 3/4"		
GTAW, PAW or GMAW backing gas; or OFW fuel gas (QW-408)		MAX TO BE WELDED		
GMAW transfer mode (spray/globular or pulse to short circuit) (QW-409)		14		
GTAW welding current type & polarity (AC, DCEP, DCEN) (QW-409)		NONE		
Machine Welding Variables (QW-361.2)		Actual Values		
Direct or remote visual control		Range Qualified		
Automatic arc voltage control (GTAW)		NONE		
Automatic joint tracking		NONE		
Multiple or single pass per side		NONE		
Automatic Welding Variables (QW-361.1)		Actual Values		
Filler Metal (EBW or LBW)		Range Qualified		
Laser type for LBW (CO <sub>2</sub> to YAG etc.)		NONE		
Continuous drive or Inertia welding (FW)		NONE		
Vacuum or out of vacuum (EBW)		NONE		

Note: Values in "Range Qualified" are valid only when used with a Qualified Welding Procedure.

## RESULTS

Visual Examination of Completed Weld (QW-302.4) ACCEPTED

- Transverse root and face [QW-462.3(a)];  Longitudinal root and face [QW-462.3(b)];  Side [QW-462.2];  
 Pipe bend specimen, corrosion-resistant overlay [QW-462.5(c)];  Plate bend specimen, corrosion-resistant overlay [QW-462.5(d)];  
 Pipe specimen, macro test for fusion [QW-462.5(b)];  Plate specimen, macro test for fusion [QW-462.5(e)]

Type	Result	Type	Result	Type	Result	Type	Result
QW-462.2.2	ACCEPTED	QW-462.2.2	ACCEPTED				

Alternative radiographic examination results (QW-191) NONE

Fillet weld - fracture test (QW-181.2) NONE Length and percent of defects NONE

- Fillet welds in plate [QW-462.4(b)]  Fillet welds in pipe [QW-462.4(c)]

Macro examination (QW-184) NONE Fillet size (In.) NONE x NONE Concavity/convexity (In.) NONE

Other tests NONE

Film or specimens evaluated by NONE Company NONE

Mechanical tests conducted by ALL - WELD COMPANY LIMITED Laboratory test no. NONE

Welding supervised by (Print name) ANDREW LEWIS

Test requested by (Print name) ROBERT BENTLEY Tested at (Print address) 49 PASSMORE AVE, SCARBOROUGH, ONT

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Boiler and Pressure Vessel Code.

Organization ALL - WELD COMPANY LIMITED Signature Date 03 - 04 - 2013  
(mm-dd-yyyy)

### FOR TSSA INSPECTOR USE ONLY

The Welder named above has passed the welding test required under Ontario's *Technical Standards and Safety Act*, Boilers and Pressure Vessels Regulation and is hereby authorized, subject to the limitations of this certificate.

Check (✓) applicable box below:

- To weld for the Employer named above only.  
 For seeking employment only.

This Certificate expires: PER ASME SECTION IX  
(mm-dd-yyyy)

COSTICA ROYU 047915  
Inspector Name and Number (Print)

Inspector Signature and Date MARCH 19, 2013





Standards and Safety Authority

3000 SHEPPARD AVENUE EAST  
Toronto, Ontario M8X 2X4  
Web site www.tssa.org

Technical Standards and Safety Act  
Boilers and Pressure Vessels Regulation

No. 164471

Welder's Last Name: **YANG** Initial: **FAN** First Name: **FAN** Signature: *Fan Yang* Stamp No: **83**

Res Address: **39 - 1050 BRISTOL RD., W., MISSISSAUGA, ONT.** Postal Code: **L5V 2E8** Provincial Registration No: **OW2142.5R & R2180.5**

Company Name: **ALL-WELD COMPANY LIMITED** Company POR No: **3**

Street Address: **49 PASSMORE AVE.** Company WPS No used: **3-1**

Postal Code: **M1V 4T1**

Welding Process(es) Used: **SMAW** Type(s):  manual  machine  semi-automatic  automatic

Base Material(s): **SA 516-70 / SA 516-70** Thickness(es): **5/16"**

Variables for All Processes	Actual Values	Range Qualified
Backing material (metal, weld metal, welded from both sides, flux, etc.)	<b>WITHOUT</b>	<b>WITH OR WITHOUT</b>
ASME P or S No. to ASME P or S No.	<b>P1</b> to <b>P1</b>	<b>P1 THRU P11 &amp; P4X PLATE &amp;</b>
( <input checked="" type="checkbox"/> ) Plate ( ) Pipe (enter diameter if pipe)	<b>5/16"</b>	<b>PIPE 2 7/8" O.D. &amp; UP</b>
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)	<b>(5.4) E308-16</b>	
Consumable Insert for GTAW or PAW (QW-404)	<b>--</b>	
Welding Position (1G, 5G, etc.) (QW-405)	<b>2G</b>	<b>2G</b>
Manual or Semi-automatic Variables (QW-350)	Actual Values	Range Qualified
Filler Metal F-No. (QW-404)	<b>F5</b>	<b>F5</b>
Filler Metal Product Form for GTAW, PAW (QW-404)	<b>--</b>	<b>--</b>
Weld deposit thickness for each welding process (QW-404)	<b>5/16"</b>	<b>5/8" MAX.</b>
Progression (uphill/downhill) (QW-405)	<b>--</b>	<b>--</b>
GTAW, PAW or GMAW backing gas, or OFW fuel gas (QW-408)	<b>--</b>	<b>--</b>
GMAW transfer mode (QW-409)	<b>--</b>	<b>--</b>
GTAW welding current type & polarity (QW-409)	<b>--</b>	<b>--</b>
Machine Welding Variables (QW-361-2)	Actual Values	Range Qualified
Direct or remote visual control	<b>--</b>	<b>--</b>
Automatic voltage control (GTAW)	<b>--</b>	<b>--</b>
Automatic joint tracking	<b>--</b>	<b>--</b>
Multiple or single pass per side	<b>--</b>	<b>--</b>
Automatic Welding Variables (QW-361-1)	Actual Values	Range Qualified
Filler metal (EBW or LBW)	<b>--</b>	<b>--</b>
Laser type for LBW (CO <sub>2</sub> to YAG etc.)	<b>--</b>	<b>--</b>
Continuous drive or inertia welding (FW)	<b>--</b>	<b>--</b>
Vacuum or out of vacuum (EBW)	<b>--</b>	<b>--</b>

Manufacturer's Copy

Note: Values in "Range Qualified" are valid only when used with a Qualified Welding Procedure.

**RESULTS**

Visual Examination of Completed Weld (QW-302.4) ACCEPTED

Bend test;  Transverse root and face [QW-462.3(a)];  Longitudinal root and face [QW-462.3(b)];  Side [QW-462.2];

Pipe bend specimen, corrosion-resistant overlay [QW-462.5(c)];  Plate bend specimen, corrosion-resistant overlay [QW-462.5(d)];

Macro test for fusion [QW-462.5(b)];  Macro test for fusion [QW-462.5(e)]

Type	Result	Type	Result	Type	Result
QW462.3(a)	ACCEPTED	QW462.3(a)	ACCEPTED		
ROOT		FACE			

Alternative radiographic examination results (QW-191) **--**

Fillet weld — fracture test (QW-180) **--** Length and percent of defects **--**

Macro examination (QW-184) **--** Fillet size (in.) **--** x **--** Concavity/convexity (in.) **--**

Other tests **--**

Film or specimens evaluated by **--** Company **--**

Mechanical tests conducted by **ALL-WELD COMPANY LIMITED** Laboratory test no. **--**

Welding supervised by **ANDREW LEWIS**

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Code

Organization **ALL-WELD COMPANY LIMITED** Signature *Robert Bentley* Date **FEB. 23, 2006**



Issued under Ontario's **Technical Standards and Safety Act**  
Boilers and Pressure Vessels Regulation

**PER ASME**  
Expiry Date **SECT. IX**

**FAN YANG**  
Welder

**83**  
Symbol

Has passed the welding test required under Ontario's **Technical Standards and Safety Act**, Boilers and Pressure Vessels Regulation and is hereby authorized to weld for:

**ALL-WELD COMPANY LIMITED**

Subject to the limitations of this certificate

*[Signature]*  
Authorized Examiner

Director

**Office Use Only**

Test Requested By **ROBERT BENTLEY**  
(Print Person's Name)

**ALL-WELD COMPANY LIMITED**  
49 PASSMORE AVE., SCARBOROUGH, ONT.  
(Print Address)

Tasted At **49 PASSMORE AVE., SCARBOROUGH, ONT.**

District # **13** Inspector # **011.037** Fee **105,-**



Standards and Safety Authority

Toronto, Ontario M8X 2X4  
Web site: www.tssa.orgTechnical Standards and Safety Act  
Boilers and Pressure Vessels Regulation

No. 169441

Welder's Last Name <b>YANG</b>		Initial <b>FAN</b>	First Name <b>FAN</b>	Signature <i>Fan Yang</i>	Stamp No. <b>83</b>
Address <b>1050 BRISTOL RD. W. MISSISSAUGA, ONTARIO</b>			Postal Code <b>L5V2E8</b>	Provincial/Registration No. <b>D852.5 + R3578.5 R7674.5</b>	
Company Name <b>ALL-WELD COMPANY LIMITED</b>			Company PQR No. <b>9</b>		
Street Address <b>49 PASSMORE AVENUE</b>			Company WPS No. used <b>9-1</b>		
SCARBOROUGH, ONTARIO			Postal Code <b>M1V4T1</b>		
Welding Process(es) Used <b>GTAW</b>			Type(s) <input checked="" type="checkbox"/> manual <input type="checkbox"/> machine <input type="checkbox"/> semi-automatic <input type="checkbox"/> automatic		
Base Material(s) <b>SA 312-304 / SA 312-304</b>			Thickness(es) <b>0.218"</b>		

Variables for All Processes	Actual Values	Range Qualified
Backing material (metal, weld metal, welded from both sides, flux, etc.)	<b>WITHOUT</b>	<b>WITH OR WITHOUT</b>
ASME P or S No. to ASME P or S No.	<b>P 8 to P 8</b>	<b>P1 THRU P11 &amp; P4X PLATE &amp; ALL</b>
( ) Plate ( <input checked="" type="checkbox"/> ) Pipe (enter diameter if pipe)	<b>2 3/8" O.D.</b>	<b>PIPE 1" O.D. &amp; UP</b>
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)	<b>(5.9) ER308</b>	
Consumable Insert for GTAW or PAW (QW-404)	<b>NONE</b>	
Welding Position (1G, 5G, etc.) (QW-405)	<b>6G</b>	<b>6G</b>
Manual or Semi-automatic Variables (QW-360)	Actual Values	Range Qualified
Filler Metal F- No. (QW-404)	<b>F6</b>	<b>F6</b>
Filler Metal Product Form for GTAW, PAW (QW-404)	<b>SOLID</b>	<b>SOLID</b>
Weld deposit thickness for each welding process (QW-404)	<b>0.218"</b>	<b>1/16" TO 0.436" MAX</b>
Progression (uphill/downhill) (QW-405)	<b>UPHILL</b>	
GTAW, PAW or GMAW backing gas; or OFW fuel gas (QW-408)	<b>ARGON 99%</b>	<b>ARGON 99%</b>
G transfer mode (QW-409)	<b>N/A</b>	<b>N/A</b>
GTAW welding current type & polarity (QW-409)	<b>DC/SP</b>	<b>DC/SP</b>
Machine Welding Variables (QW-361-2)	Actual Values	Range Qualified
Direct or remote visual control	<b>---</b>	<b>---</b>
Automatic voltage control (GTAW)	<b>---</b>	<b>---</b>
Automatic joint tracking	<b>---</b>	<b>---</b>
Multiple or single pass per side	<b>---</b>	<b>---</b>
Automatic Welding Variables (QW-361-1)	Actual Values	Range Qualified
Filler metal (EBW or LBW)	<b>---</b>	<b>---</b>
Laser type for LBW (CO <sub>2</sub> to YAG etc.)	<b>---</b>	<b>---</b>
Continuous drive or inertia welding (FW)	<b>---</b>	<b>---</b>
Vacuum or out of vacuum (EBW)	<b>---</b>	<b>---</b>

Note: Values in "Range Qualified" are valid only when used with a Qualified Welding Procedure.

## RESULTS

Visual Examination of Completed Weld (QW-302.4) ACCEPTED

Bend test;  Transverse root and face [QW-462.3(a)];  Longitudinal root and face [QW-462.3(b)];  Side [QW-462.2];  
 Pipe bend specimen, corrosion-resistant overlay [QW-462.5(c)];  Plate bend specimen, corrosion-resistant overlay [QW-462.5(d)];  
 Macro test for fusion [QW-462.5(b)];  Macro test for fusion [QW-462.5(e)]

Type	Result	Type	Result	Type	Result
(ROOT)	ACCEPTED	(FACE)	ACCEPTED		
(ROOT)	ACCEPTED	(FACE)	ACCEPTED		

Alternative radiographic examination results (QW-191) ---

Fillet weld — fracture test (QW-180) --- Length and percent of defects ---

Macro examination (QW-184) --- Fillet size (in.) --- x --- Concavity/convexity (in.) ---

Other tests ---

Film or specimens evaluated by --- Company ---

Mechanical tests conducted by ALL-WELD COMPANY LIMITED Laboratory test no. ---

Welding supervised by ANDREW LEWIS

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Code

Organization ALL-WELD COMPANY LIMITED Signature *R Bentley* Date JANUARY 26, 2006Issued under Ontario's Technical Standards and Safety Act  
Boilers and Pressure Vessels RegulationPER ASME  
Expiry Date: SECT. IX

FAN YANG

83

Welder

Symbol

Has passed the welding test required under Ontario's Technical Standards and Safety Act, Boilers and Pressure Vessels Regulation and is hereby authorized to weld for:

ALL-WELD COMPANY LIMITED

Subject to the limitations of this certificate

Director

Authorized Examiner

## Office Use Only

Test Requested By ROBERT BENTLEY  
(Print Person's Name)

ALL-WELD COMPANY LIMITED  
Tested At 49 PASSMORE AVE., SCARBOROUGH, ONT.  
(Print Address)

District # 13 Inspector # 20-037 Fee 105-

PV 05397 (09/04)

Welder's Last Name: **YANG** First Name: **FAN** Signature: *Fan Yang* Stamp No: **83**

Address: **76 LUCIENT ST., MARKHAM, ONT.** Postal Code: **L3R 5E1** Provincial Registration No: **WPR 3432.5**

Employer Name: **ALL-WELD COMPANY LIMITED** Company PQR No: **50**

Street Address: **49 PASSMORE AVENUE** Postal Code: **M1V 4T1** Company WPS No used: **50-1**

City: **SCARBOROUGH, ONTARIO** Type(s): **manual**  machine  semi-automatic  automatic

Welding Process(es) Used: **FCAW** Thickness(es): **3/8"**

Base Material(s): **SA 240-316 / SA 240-316**

Variables for All Processes	Actual Values	Range Qualified
Backing material (metal, weld metal, welded from both sides, flux, etc.)	<b>WITHOUT</b>	<b>WITH OR WITHOUT</b>
ASME P or S No. to ASME P or S No.	<b>P8</b> to <b>P8</b>	<b>P1 THRU P11 &amp; P4X PLATE &amp; ALL PIPES 2 7/8" O.D. &amp; UP</b>
( <input checked="" type="checkbox"/> ) Plate ( ) Pipe (enter diameter if pipe)	<b>3/8"</b>	
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)	<b>(5.22) E316LTO-1</b>	
Consumable Insert for GTAW or PAW (QW-404)		
Welding Position (1G, 5G, etc.) (QW-405)	<b>2G</b>	<b>2G</b>
Manual or Semi-automatic Variables (QW-350)	Actual Values	Range Qualified
Filler Metal F- No. (QW-404)	<b>F6</b>	<b>F6</b>
Filler Metal Product Form for GTAW, PAW (QW-404)		
Weld deposit thickness for each welding process (QW-404)	<b>3/8"</b>	<b>3/4" MAX</b>
Process 1 _____ 3 layers minimum Yes No		
Process 2 _____ 3 layers minimum Yes No		
Progression (uphill/downhill) (QW-405)		
GTAW, PAW or GMAW backing gas, or OFW fuel gas (QW-408)	<b>CO2</b>	<b>CO2</b>
GMAW transfer mode (spray/globular or pulse to short circuit) (QW-409)	<b>SPRAY</b>	<b>SPRAY, GLOBULAR &amp; PULSE</b>
GTAW welding current type & polarity (AC, DCEP, DCEN)(QW-409)		
Machine Welding Variables (QW-381-2)	Actual Values	Range Qualified
Direct or remote visual control		
Automatic arc voltage control (GTAW)		
Automatic joint tracking		
Multiple or single pass per side		
Automatic Welding Variables (QW-381-1)	Actual Values	Range Qualified
Filler metal (EBW or LBW)		
Laser type for LBW (CO2 to YAG etc.)		
Continuous drive or inertia welding (FW)		
Vacuum or out of vacuum (EBW)		

Note: Values in "Range Qualified" are valid only when used with a Qualified Welding Procedure.

**RESULTS**

Visual Examination of Completed Weld (QW-302.4) **ACCEPTED**

Bend test;  Transverse root and face (QW-462.3(a));  Longitudinal root and face (QW-462.3(b));  Side (QW-462.2);

Pipe bend specimen, corrosion-resistant overlay [QW-462.5(c)];  Plate bend specimen, corrosion-resistant overlay [QW-462.5(d)];

Macro test for fusion [QW-462.5(b)];  Macro test for fusion [QW-462.5(e)]

Type	Result	Type	Result	Type	Result
<b>QW462.3(a)</b>	<b>ACCEPTED</b>	<b>QW462.3(a)</b>	<b>ACCEPTED</b>		
<b>(ROOT)</b>		<b>(FACE)</b>			

Alternative radiographic examination results (QW-191) \_\_\_\_\_

Fillet weld — fracture test (QW-180) \_\_\_\_\_ Length and percent of defects \_\_\_\_\_

Macro examination (QW-184) \_\_\_\_\_ Fillet size (in.) \_\_\_\_\_ x \_\_\_\_\_ Concavity/convexity (in.) \_\_\_\_\_

Other tests \_\_\_\_\_

Film or specimens evaluated by \_\_\_\_\_ Company \_\_\_\_\_

Mechanical tests conducted by **ALL-WELD COMPANY LIMITED** Laboratory test no. \_\_\_\_\_

Welding supervised by **ANDREW LEWIS**

Test requested by (Print name) **ROBERT C. BENTLEY** Tested at (Print address) **49 PASSMORE AVE., SCARBOROUGH, ON**

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Boiler and Pressure Vessel Code.

Organization **ALL-WELD COMPANY LIMITED** Signature *Robert Bentley* Date **JAN. 14, 2008**  
(mm-dd-yyyy)

**FOR TSSA INSPECTOR USE ONLY**

The Welder named above has passed the welding test required under Ontario's *Technical Standards and Safety Act*, Boilers and Pressure Vessels Regulation and is hereby authorized, subject to the limitations of this certificate.

Check (✓) applicable box below:

To weld for the Employer named above only.  
 For seeking employment only.

This Certificate expires: **AS PER ASME**  
(mm-dd-yyyy)

Inspector Name and Number (Print) **FING WING WANG 0118** Inspector Signature *[Signature]*

Manufacturer's Safety Authority Toronto, Ontario M8X 2X4 Web site www.tssa.org

Welder's Last Name: HUYNH Initial: VAN LY First Name: LY Signature: [Signature] Stamp No: 87

Bus Address: 134 GOLDEN GATE CIR. WOODBRIDGE, ONTARIO Postal Code: L4H 1N6 Provincial Registration No: R2060.5 & R2363.5 D700.5

Company Name: ALL-WELD COMPANY LIMITED Company PQR No: 1 Street Address: 49 PASSMORE AVENUE Company WPS No used: 1-1

SCARBOROUGH, ONTARIO Postal Code: M1V 4T1

Welding Process(es) Used: SMAW Type(s):  manual  machine  semi-automatic  automatic

Base Material(s): SA 516-GR 70 / SA 516-GR 70 Thickness(es): 5/16"

Variables for All Processes	Actual Values	Range Qualified
Backing material (metal, weld metal, welded from both sides, flux, etc.)	WITHOUT	WITH OR WITHOUT
ASME P or S No. to ASME P or S No.	P1 to P1	P1 THRU P11 & P4X PLATE & ALL
( <input checked="" type="checkbox"/> ) Plate ( ) Pipe (enter diameter if pipe)	5/16"	PIPE 2 7/8" O.D. & UP
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)	(5.1) E7018	
Consumable Insert for GTAW or PAW (QW-404)	--	
Welding Position (1G, 5G, etc.) (QW-405)	2G	2G
<b>Manual or Semi-automatic Variables (QW-360)</b>		
Filler Metal F-No. (QW-404)	F4	F4
Filler Metal Product Form for GTAW, PAW (QW-404)	--	--
Weld deposit thickness for each welding process (QW-404)	5/16"	5/8" MAX
Progression (uphill/downhill) (QW-406)	--	PLATE GROOVE & PIPE 2 7/8" O.D. & UP & ALL FILLETS
GTAW, PAW or GMAW backing gas, or OFW fuel gas (QW-408)	--	--
GMAW transfer mode (QW-409)	--	--
GTAW welding current type & polarity (QW-409)	--	--
<b>Machine Welding Variables (QW-361-2)</b>		
Direct or remote visual control	--	--
Automatic voltage control (GTAW)	--	--
Automatic joint tracking	--	--
Multiple or single pass per side	--	--
<b>Automatic Welding Variables (QW-361-1)</b>		
Filler metal (EBW or LBW)	--	--
Laser type for LBW (CO <sub>2</sub> to YAG etc.)	--	--
Continuous drive or inertia welding (FW)	--	--
Vacuum or out of vacuum (EBW)	--	--

Note: Values in "Range Qualified" are valid only when used with a Qualified Welding Procedure.

RESULTS

Visual Examination of Completed Weld (QW-302.4) ACCEPTED

Bend test;  Transverse root and face [QW-462.3(a)];  Longitudinal root and face [QW-462.3(b)];  Side [QW-462.2];

Pipe bend specimen, corrosion-resistant overlay [QW-462.5(c)];  Plate bend specimen, corrosion-resistant overlay [QW-462.5(d)];

Macro test for fusion [QW-462.5(b)];  Macro test for fusion [QW-462.5(e)]

Type	Result	Type	Result	Type	Result
QW 462.3(a)	ACCEPTED	QW 462.3 (a)	ACCEPTED		
(ROOT)		(FACE)			

Alternative radiographic examination results (QW-191) --

Fillet weld — fracture test (QW-180) -- Length and percent of defects --

Macro examination (QW-184) -- Fillet size (in.) -- x -- Concavity/convexity (in.) --

Other tests --

Film or specimens evaluated by -- Company --

Mechanical tests conducted by ALL-WELD COMPANY LIMITED Laboratory test no. --

Welding supervised by ANDREW LEWIS

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Code

Organization ALL-WELD COMPANY LIMITED Signature [Signature] Date FEBRUARY 17, 2006



Issued under Ontario's Technical Standards and Safety Act Boilers and Pressure Vessels Regulation

PER ASME  
Expiry Date: SECT. IX

VAN LY HUYNH 87  
Welder Symbol

Has passed the welding test required under Ontario's Technical Standards and Safety Act, Boilers and Pressure Vessels Regulation and is hereby authorized to weld for:

ALL-WELD COMPANY LIMITED  
Subject to the limitations of this certificate

Authorized Examiner [Signature] Director [Signature]

Office Use Only

Test Requested By ROBERT BENTLEY  
(Print Person's Name)

ALL-WELD COMPANY LIMITED

Tested At 49 PASSMORE AVE., SCARBOROUGH, ONT.  
(Print Address)

District # 13 Inspector # ENT-037 Fee 1051-



Welder's Last Name: HUYNH Initial: VAN-LY First Name: LY Signature: [Signature] Stamp No: 87

Res. Address: 134 GOLDEN GATE CIR. WOODBRIDGE, ONTARIO, L4H 1N6 Postal Code: L4H 1N6 Provincial Registration No: OW2142.5R & R2180.5

Company Name: ALL-WELD COMPANY LIMITED Company PQR No: 3 Street Address: 49 PASSMORE AVENUE Company WPS No used: 3-1

SCARBOROUGH, ONTARIO Postal Code: M1V 4T1

Welding Process(es) Used: SMAW Type(s):  manual  machine  semi-automatic  automatic

Base Material(s): SA 240-304 / SA 240-304 Thickness(es): 3/8"

Variables for All Processes	Actual Values	Range Qualified
Backing material (metal, weld metal, welded from both sides, flux, etc.)	WITHOUT	WITH OR WITHOUT
ASME P or S No. to ASME P or S No.	P8 to P8	P1 THRU P11 & P4X PLATE & PIPE 2 7/8" O.D. & UP
( <input checked="" type="checkbox"/> ) Plate ( ) Pipe (enter diameter if pipe)	3/8"	
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)	(5.4) E308-16	
Consumable Insert for GTAW or PAW (QW-404)		
Welding Position (1G, 5G, etc.) (QW-406)	2G	2G
<b>Manual or Semi-automatic Variables (QW-350)</b>		
Filler Metal F. No. (QW-404)	F5	F5
Filler Metal Product Form for GTAW, PAW (QW-404)	--	--
Weld deposit thickness for each welding process (QW-404)	3/8"	3/4" MAX
Progression (uphill/downhill) (QW-405)	--	--
GTAW, PAW or GMAW backing gas; or OFW fuel gas (QW-408)	--	--
GMAW transfer mode (QW-409)	--	--
GTAW welding current type & polarity (QW-409)	--	--
<b>Machine Welding Variables (QW-361-2)</b>		
Direct or remote visual control	--	--
Automatic voltage control (GTAW)	--	--
Automatic joint tracking	--	--
Multiple or single pass per side	--	--
<b>Automatic Welding Variables (QW-361-1)</b>		
Filler metal (EBW or LBW)	--	--
Laser type for LBW (CO <sub>2</sub> to YAG etc.)	--	--
Continuous drive or inertia welding (FW)	--	--
Vacuum or out of vacuum (EBW)	--	--

Note: Values in "Range Qualified" are valid only when used with a Qualified Welding Procedure.

RESULTS

Visual Examination of Completed Weld (QW-302.4) ACCEPTED

Bend test;  Transverse root and face [QW-482.3(a)];  Longitudinal root and face [QW-482.3(b)];  Side [QW-482.2];

Pipe bend specimen, corrosion-resistant overlay [QW-482.5(c)];  Plate bend specimen, corrosion-resistant overlay [QW-482.5(d)];

Macro test for fusion [QW-482.5(b)];  Macro test for fusion [QW-482.5(e)]

Type	Result	Type	Result	Type	Result
QW462.3(a)	ACCEPTED	QW462.3(a)	ACCEPTED		
ROOT		FACE			

Alternative radiographic examination results (QW-191) --

Fillet weld — fracture test (QW-180) -- Length and percent of defects --

Macro examination (QW-184) -- Fillet size (in.) -- x -- Concavity/convexity (in.) --

Other tests --

Film or specimens evaluated by -- Company --

Mechanical tests conducted by ALL-WELD COMPANY LIMITED Laboratory test no. --

Welding supervised by ANDREW LEWIS

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Code

Organization ALL-WELD COMPANY LIMITED Signature [Signature] Date MAY 5/06



Issued under Ontario's Technical Standards and Safety Act Boilers and Pressure Vessels Regulation

PER ASME

Expiry Date: SECT. IX

Welder: VAN-LY HUYNH 87 Symbol

Has passed the welding test required under Ontario's Technical Standards and Safety Act, Boilers and Pressure Vessels Regulation and is hereby authorized to weld for:

ALL-WELD COMPANY LIMITED

Subject to the limitations of this certificate

Authorized Examiner [Signature] Director

**Office Use Only**

Test Requested By ROBERT BENTLEY (Print Person's Name)

ALL-WELD COMPANY LIMITED

Tested At 49 PASSMORE AVENUE, SCARBOROUGH, ONT. (Print Address)

District # 13 Inspector # ANT-057 Fee 105/-



Technical Standards and Safety Authority

14th Floor - Centre Tower  
3300 Bloor Street West  
Toronto, Ontario M8X 2X4  
Web site: www.tssa.org

# Welder/Welding Operator Certificate

Technical Standards and Safety Act  
Boilers and Pressure Vessels Regulation

No. 262466

Welder's Last Name <b>LIEW</b>	Initial <b>SL</b>	First Name <b>STEVE</b>	Signature 	Stamp No. <b>90</b>
Res. Address <b>11 INDIAN BOUND CRESCENT, ONTARIO</b>			Postal Code <b>M1H1W2</b>	Provincial Registration No. <b>WP-14628-S</b>
Employer Name <b>ALL - WELD COMPANY LIMITED</b>			Company PQR No. <b>3-3X</b>	
Street Address <b>49 PASSMORE AVE</b>			Company WPS No. used <b>3-38</b>	
SCARBOROUGH, ONT			Postal Code <b>M1V4T1</b>	
Welding Process(es) Used <b>SMAW</b>			Type(s) <input checked="" type="checkbox"/> manual <input type="checkbox"/> machine <input type="checkbox"/> semi-automatic <input type="checkbox"/> automatic	
Base Material(s) <b>SA-240-316 TO SA-240-316</b>			Thickness(es) <b>1 3/4"</b> <input checked="" type="checkbox"/> Test Coupon <input type="checkbox"/> Production Weld	
Variables for All Processes			Actual Values	
Backing material (with/without)			WITH	
Base Metal P-Number to P-Number			P1 THRU P15F, P34 & P4X PLATE AND PIPE 2 7/8" OD AND UP AND ALL FILLETS	
( X ) Plate ( ) Pipe (enter diameter if pipe)			1 3/4"	
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)			5.4 E316-16	
Consumable Insert for GTAW or PAW (QW-404)			NONE	
Welding Position (1G, 5G, etc.) (QW-405)			2G	
Manual or Semi-automatic Variables (QW-355)			Actual Values	
Filler Metal F-No. (QW-404)			F5	
Filler Metal Product Form for GTAW, PAW (QW-404)			NONE	
Weld deposit thickness for each welding process (QW-404)			1 3/4"	
Process 1: _____ 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No			---	
Process 2: _____ 3 layers minimum <input type="checkbox"/> Yes <input type="checkbox"/> No			NONE	
Vertical progression (uphill/downhill) (QW-405)			NONE	
GTAW, PAW or GMAW backing gas; or OPW fuel gas (QW-406)			NONE	
GMAW transfer mode (spray/globular or pulse to short circuit) (QW-409)			NONE	
GTAW welding current type & polarity (AC, DCEP, DCEN) (QW-409)			NONE	
Machine Welding Variables (QW-361.2)			Actual Values	
Direct or remote visual control			NONE	
Automatic arc voltage control (GTAW)			NONE	
Automatic joint tracking			NONE	
Multiple or single pass per side			NONE	
Automatic Welding Variables (QW-361.1)			Actual Values	
Filler Metal (EBW or LBW)			NONE	
Laser type for LBW (CO <sub>2</sub> to YAG etc.)			NONE	
Continuous drive or inertia welding (FW)			NONE	
Vacuum or out of vacuum (EBW)			NONE	

Note: Values in "Range Qualified" are valid only when used with a Qualified Welding Procedure.

## RESULTS

Visual Examination of Completed Weld (QW-302.4) ACCEPTED

- Transverse root and face [QW-462.3(a)];  Longitudinal root and face [QW-462.3(b)];  Side [QW-462.2];  
 Pipe bend specimen, corrosion-resistant overlay [QW-462.5(c)];  Plate bend specimen, corrosion-resistant overlay [QW-462.5(d)];  
 Pipe specimen, macro test for fusion [QW-462.5(b)];  Plate specimen, macro test for fusion [QW-462.5(e)]

Type	Result	Type	Result	Type	Result	Type	Result
QW-462.2	ACCEPTED	QW-462.2	ACCEPTED	QW-462.2	ACCEPTED	QW-462.2	ACCEPTED
(Side)		(Side)		(Side)		(Side)	

Alternative radiographic examination results (QW-191) NONE

Fillet weld - fracture test (QW-181.2) NONE Length and percent of defects \_\_\_\_\_

Fillet welds in plate [QW-462.4(b)]  Fillet welds in pipe [QW-462.4(c)]

Macro examination (QW-184) NONE Fillet size (in.) NONE x NONE Concavity/convexity (in.) NONE

Other tests NONE

Film or specimens evaluated by NONE Company NONE

Mechanical tests conducted by CAMBRIDGE MATERIAL TESTING LIMITED Laboratory test no. 634882-2013 & 634851-2013

Welding supervised by (Print name) ANDREW LEWIS

Test requested by (Print name) ROBERT BENTLEY Tested at (Print address) 49 PASSMORE AVE, SCARBOROUGH, ONT

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Boiler and Pressure Vessel Code.

Organization ALL - WELD COMPANY LIMITED Signature Robert Bentley Date 03-15-2013  
(mm-dd-yyyy)

### FOR TSSA INSPECTOR USE ONLY

The Welder named above has passed the welding test required under Ontario's Technical Standards and Safety Act, Boilers and Pressure Vessels Regulation and is hereby authorized, subject to the limitations of this certificate.

Check (✓) applicable box below:

- To weld for the Employer named above only.  
 For seeking employment only.

This Certificate expires: PER ASME SECTION IX  
(mm-dd-yyyy)

OUT 915  
Inspector Name and Number (Print)

MAR 15, 2013  
Inspector Signature and Date



Technical Standards and Safety Authority

14th Floor - Centre Tower  
3300 Bloor Street West  
Toronto, Ontario M8X 2X4  
Web site: www.tssa.org

Welder/Welding Operator Certificate  
Technical Standards and Safety Act  
Boilers and Pressure Vessels Regulation

No. 262464

Welder's Last Name: LIEW Initial: STEVE First Name: STEVE Signature: [Signature] Stamp No.: 99

Res Address: 11 INDIAN BOUND CRESCENT, ONTARIO Postal Code: M1H1W2 Provincial Registration No.: WP 74246.5

Employer Name: ALL - WELD COMPANY LIMITED Company PQR No.: 50-X

Street Address: 49 PASSMORE AVE Postal Code: M1V4T1 Company WPS No used: 50-2A

Welding Process(es) Used: FCAM Type(s):  manual  machine  semi-automatic  automatic

Base Material(s): SA-240-316 TO SA-240-316 Thickness(es): 3/8"  Test Coupons  Production Weld

Variables for All Processes	Actual Values	Range Qualified
Backing material (with/without)	WITH	WITH
Base Metal P-Number to P-Number	§ to §	P1 THRU P19F, P34 & P4X PLATE AND PIPE 2 7/8" OD AND UP
(X) Plate ( ) Pipe (enter diameter if pipe)	1 3/4"	• ALL FILLETS
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)	E316LTD-1	
Consumable Insert for GTAW or PAW (QW-404)	NONE	
Welding Position (1G, 5G, etc.) (QW-405)	3G	3G
Manual or Semi-automatic Variables (QW-398)	Actual Values	Range Qualified
Filler Metal F-No. (QW-404)	F8	F8
Filler Metal Product Form for GTAW, PAW (QW-404)	NONE	NONE
Weld deposit thickness for each welding process (QW-404)	1 3/4"	MAX TO BE WELDED
Process 1: _____ 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No		
Process 2: _____ 3 layers minimum <input type="checkbox"/> Yes <input type="checkbox"/> No	NONE	
Vertical progression (uphill/downhill) (QW-406)	NONE	
GTAW, PAW or GMAW heating gas; or OPW fuel gas (QW-408)	CO2	CO2
GMAW transfer mode (spray/globular or pulse to short circuit) (QW-409)	SPRAY	SPRAY, GLOBULAR & PULSE
GTAW welding current type & polarity (AC, DCEP, DCEN) (QW-409)	NONE	
Machine Welding Variables (QW-391.2)	Actual Values	Range Qualified
Direct or remote visual control	NONE	
Automatic arc voltage control (GTAW)	NONE	
Automatic joint tracking	NONE	
Multiple or single pass per side	NONE	
Automatic Welding Variables (QW-391.1)	Actual Values	Range Qualified
Filler Metal (EBW or LBW)	NONE	
Laser type for LBW (CO <sub>2</sub> to YAG etc.)	NONE	
Continuous drive or inertia welding (FW)	NONE	
Vacuum or out of vacuum (EBW)	NONE	

Note: Values in "Range Qualified" are valid only when used with a Qualified Welding Procedure.

RESULTS

Visual Examination of Completed Weld (QW-302.4) ACCEPTED

- Transverse root and face [QW-462.3(a)];  Longitudinal root and face [QW-462.3(b)];  Side [QW-462.2];
- Pipe bend specimen, corrosion-resistant overlay [QW-462.5(c)];  Plate bend specimen, corrosion-resistant overlay [QW-462.5(d)];
- Pipe specimen, macro test for fusion [QW-462.5(b)];  Plate specimen, macro test for fusion [QW-462.5(e)];

Type	Result	Type	Result	Type	Result	Type	Result
QW-462.2	ACCEPTED	QW-462.3	ACCEPTED	QW-462.3	ACCEPTED	QW-462.2	ACCEPTED
(SIDE)		(SIDE)		(SIDE)		(SIDE)	

Alternative radiographic examination results (QW-191) NONE

Fillet weld - fracture test (QW-181.2) NONE Length and percent of defects \_\_\_\_\_

Fillet welds in plate [QW-462.4(b)]  Fillet welds in pipe [QW-462.4(c)]

Macro examination (QW-184) NONE Fillet size (in.) NONE x NONE Concavity/convexity (in.) NONE

Other tests NONE

Film or specimens evaluated by NONE Company NONE

Mechanical tests conducted by CAMBRIDGE MATERIAL TESTING LIMITED Laboratory test no. 636448-2613 & 636458-2613

Welding supervised by (Print name) ANDREW LEWIS

Test requested by (Print name) ROBERT BENTLEY Tested at (Print address) 49 PASSMORE AVE, SCARBOROUGH, ONT

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Boiler and Pressure Vessel Code.

Organization ALL - WELD COMPANY LIMITED Signature [Signature] Date 03-27-2013 (mm-dd-yyyy)

FOR TSSA INSPECTOR USE ONLY

The Welder named above has passed the welding test required under Ontario's Technical Standards and Safety Act, Boilers and Pressure Vessels Regulation and is hereby authorized, subject to the limitations of this certificate.

Check (✓) applicable box below:

- To weld for the Employer named above only.
- For seeking employment only.

This Certificate expires: PER ASME SECTION IX (mm-dd-yyyy)

COXICA [Signature] ONT315  
Inspector Name and Number (Print)

[Signature] MAR 28, 2013  
Inspector Signature and Date



Technical Standards and Safety Authority

14th Floor - Centre Tower  
3300 Bloor Street West  
Toronto, Ontario M8X 2X4  
Web site: www.tssa.org

# Welder/Welding Operator Certificate

Technical Standards and Safety Act  
Boilers and Pressure Vessels Regulation

No. 258828

Welder's Last Name <b>ALROUBAYI</b>		Initial <b>A</b>	First Name <b>RAZZAK</b>	Signature 	Stamp No <b>109</b>
Res. Address <b>140 QUANTRELL TRIAL SCARBOROUGH, ONT</b>				Postal Code <b>M 1 B 1 L B</b>	Provincial Registration No. <b>R4428.5</b>
Employer Name <b>ALL - WELD COMPANY LIMITED</b>				Company PQR No. <b>SAW - 2A1</b>	
Street Address <b>49 PASSMORE AVE</b>				Company WPS No used <b>SAW - W - 2 - 1</b>	
SCARBOROUGH, ONT				Postal Code <b>M 1 V 4 T 1</b>	
Welding Process(es) Used <b>SAW</b>				Type(s) <input type="checkbox"/> manual <input type="checkbox"/> machine <input type="checkbox"/> semi-automatic <input checked="" type="checkbox"/> automatic	
Base Material(s) <b>SA - 240 - 304</b>			Thickness(es) <b>1"</b>		<input checked="" type="checkbox"/> Test Coupon <input type="checkbox"/> Production Weld
Variables for All Processes		Actual Values		Range Qualified	
Backing material (with/without)		<b>BASE &amp; WELD METAL</b>		<b>BASE &amp; WELD METAL</b>	
Base Metal P-Number to P-Number		P8 to P8		P1 THRU P15F, P34 & P4X PLATE AND PIPE 2 7/8" OD AND UP	
( <input checked="" type="checkbox"/> ) Plate ( ) Pipe (enter diameter if pipe)		<b>1"</b>			
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)		<b>5.9 ER308</b>			
Consumable Insert for GTAW or PAW (QW-404)		<b>NONE</b>			
Welding Position (1G, 5G, etc.) (QW-405)		<b>1G</b>		<b>1G</b>	
Manual or Semi-automatic Variables (QW-350)		Actual Values		Range Qualified	
Filler Metal F-No. (QW-404)		<b>6</b>		<b>6</b>	
Filler Metal Product Form for GTAW, PAW (QW-404)		<b>NONE</b>			
Weld deposit thickness for each welding process (QW-404)		<b>1"</b>		<b>MAX TO BE WELDED</b>	
Process 1: _____ 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No		<b>12</b>			
Process 2: _____ 3 layers minimum <input type="checkbox"/> Yes <input type="checkbox"/> No		<b>NONE</b>			
Vertical progression (uphill/downhill) (QW-405)		<b>NONE</b>			
GTAW, PAW or GMAW backing gas; or OFW fuel gas (QW-408)		<b>NONE</b>			
GMAW transfer mode (spray/globular or pulse to short circuit) (QW-409)		<b>NONE</b>			
GTAW welding current type & polarity (AC, DCEP, DCEN) (QW-409)		<b>NONE</b>			
Machine Welding Variables (QW-361.2)		Actual Values		Range Qualified	
Direct or remote visual control		<b>NONE</b>			
Automatic arc voltage control (GTAW)		<b>NONE</b>			
Automatic joint tracking		<b>NONE</b>			
Multiple or single pass per side		<b>NONE</b>			
Automatic Welding Variables (QW-361.1)		Actual Values		Range Qualified	
Filler Metal (EBW or LBW)		<b>NONE</b>			
Laser type for LBW (CO <sub>2</sub> to YAG etc.)		<b>NONE</b>			
Continuous drive or inertia welding (FW)		<b>NONE</b>			
Vacuum or out of vacuum (EBW)		<b>NONE</b>			

Note: Values in "Range Qualified" are valid only when used with a Qualified Welding Procedure.

### RESULTS

Visual Examination of Completed Weld (QW-302.4) **ACCEPTED**

- Transverse root and face [QW-462.3(a)];  Longitudinal root and face [QW-462.3(b)];  Side [QW-462.2];  
 Pipe bend specimen, corrosion-resistant overlay [QW-462.5(c)];  Plate bend specimen, corrosion-resistant overlay [QW-462.5(d)];  
 Pipe specimen, macro test for fusion [QW-462.5(b)];  Plate specimen, macro test for fusion [QW-462.5(e)]

Type	Result	Type	Result	Type	Result	Type	Result
QW-462.2	ACCEPTED	QW-462.2	ACCEPTED				

Alternative radiographic examination results (QW-191) **NONE**

Fillet weld -- fracture test (QW-181.2) **NONE** Length and percent of defects **NONE**

Fillet welds in plate [QW-462.4(b)]  Fillet welds in pipe [QW-462.4(c)]

Macro examination (QW-184) **NONE** Fillet size (in.) **NONE** x **NONE** Concavity/convexity (in.) **NONE**

Other tests **NONE**

Film or specimens evaluated by **NONE** Company **NONE**

Mechanical tests conducted by **ALL - WELD COMPANY LIMITED** Laboratory test no. **NONE**

Welding supervised by (Print name) **ANDREW LEWIS**

Test requested by (Print name) **ROBERT BENTLEY** Tested at (Print address) **49 PASSMORE AVE, SCARBOROUGH, ONT**

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Boiler and Pressure Vessel Code.

Organization **ALL - WELD COMPANY LIMITED** Signature Date **03 - 06 - 2012**  
(mm-dd-yyyy)

### FOR TSSA INSPECTOR USE ONLY

The Welder named above has passed the welding test required under Ontario's **Technical Standards and Safety Act**, Boilers and Pressure Vessels Regulation and is hereby authorized, subject to the limitations of this certificate.

Check (✓) applicable box below.

- To weld for the Employer named above only.  
 For seeking employment only.

This Certificate expires: **PER ASME SECTION IX**  
(mm-dd-yyyy)

**COSTICA ROSU**  
Inspector Name and Number (Print)

**ONT915**

**MAR 09, 2012**  
Inspector Signature and Date





Technical Standards and Safety Authority

1400 - Centre Tower  
3300 Bloor Street West  
Toronto, Ontario M8X 2X4  
Web site www.tssa.org

Welder/Welding Operator Certificate  
Technical Standards and Safety Act  
Boilers and Pressure Vessels Regulation

No. 257501

Welder's Last Name: INNIS Initial: ANDREW First Name: ANDREW Signature: *Andrew Innis* Stamp No: 110

Res Address: 21 BORNHOLM DRIVE TORONTO, ONTARIO Postal Code: M1C4P6 Provincial Registration No: QW2142.5R & R21#0.5 Company POR No: 3 & 3A Company WPS No used: 3-1

Employer Name: ALL - WELD COMPANY LIMITED Street Address: 49 PASSMORE AVE SCARBOROUGH, ONT Postal Code: M1V4T1

Welding Process(es) Used: SMAW Type(s):  manual  machine  semi-automatic  automatic

Base Material(s): SA-240-304 TO SA-240-304 Thickness(es): 3/8"  Test Coupon  Production Weld

Variables for All Processes	Actual Values	Range Qualified
Backing material (with/without)	WITHOUT	WITH OR WITHOUT
Base Metal P-Number to P-Number	8 to 8	P1 THRU P15F, P34 & P4X PLATE AND PIPE 2 7/8" OD AND UP
( X ) Plate ( ) Pipe (enter diameter if pipe)	0.375"	
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)	5.4 E308-16	
Consumable insert for GTAW or PAW (QW-404)	NONE	
Welding Position (1G, 5G, etc.) (QW-405)	2G	2G
Manual or Semi-automatic Variables (QW-350)	Actual Values	Range Qualified
Filler Metal F- No (QW-404)	F5	F5
Filler Metal Product Form for GTAW, PAW (QW-404)	NONE	
Weld deposit thickness for each welding process (QW-404)	3/8"	3/4" MAX
Process 1 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	4	PLATE GROOVE + PIPE 2 7/8" OD + UP + ALL FILLETS
Process 2 3 layers minimum <input type="checkbox"/> Yes <input type="checkbox"/> No	NONE	
Vertical progression (uphill/downhill) (QW-405)	NONE	
GTAW, PAW or GMAW backing gas, or OFW fuel gas (QW-408)	NONE	
GMAW transfer mode (spray/globular or pulse to short circuit) (QW-409)	NONE	
GTAW welding current type & polarity (AC, DCEP, DCEN) (QW-409)	NONE	
Machine Welding Variables (QW-361.2)	Actual Values	Range Qualified
Direct or remote visual control	NONE	
Automatic arc voltage control (GTAW)	NONE	
Automatic joint tracking	NONE	
Multiple or single pass per side	NONE	
Automatic Welding Variables (QW-361.1)	Actual Values	Range Qualified
Filler Metal (EBW or LBW)	NONE	
Laser type for LBW (CO2 to YAG etc.)	NONE	
Continuous drive or inertia welding (FW)	NONE	
Vacuum or out of vacuum (EBW)	NONE	

Note: Values in "Range Qualified" are valid only when used with a Qualified Welding Procedure.

RESULTS

Visual Examination of Completed Weld (QW-302.4) ACCEPTED

- Transverse root and face [QW-462.3(a)]  Longitudinal root and face [QW-462.3(b)]  Side [QW-462.2]  
 Pipe bend specimen, corrosion-resistant overlay [QW-462.5(c)]  Plate bend specimen, corrosion-resistant overlay [QW-462.5(d)]  
 Pipe specimen macro test for fusion [QW-462.5(b)]  Plate specimen, macro test for fusion [QW-462.5(e)]

Type	Result	Type	Result	Type	Result	Type	Result
QW-462.3 (a)	ACCEPTED	QW-462.3 (a)	ACCEPTED				
(Face)		(ROOT)					

Alternative radiographic examination results (QW-191) NONE

Fillet weld - fracture test (QW-181.2) NONE Length and percent of defects \_\_\_\_\_

- Fillet welds in plate [QW-462.4(b)]  Fillet welds in pipe [QW-462.4(c)]

Macro examination (QW-184) NONE Fillet size (in) NONE x NONE Concavity/convexity (in.) NONE

Other tests NONE

Film or specimens evaluated by NONE Company NONE

Mechanical tests conducted by ALL - WELD COMPANY LIMITED Laboratory test no NONE

Welding supervised by (Print name) ANDREW LEWIS

Test requested by (Print name) ROBERT BENTLEY Tested at (Print address) 49 PASSMORE AVE, SCARBOROUGH, ONT

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Boiler and Pressure Vessel Code

Organization ALL - WELD COMPANY LIMITED Signature: *Robert Bentley* Date 01-09-2012 (mm-dd-yyyy)

FOR TSSA INSPECTOR USE ONLY

The Welder named above has passed the welding test required under Ontario's Technical Standards and Safety Act, Boilers and Pressure Vessels Regulation and is hereby authorized, subject to the limitations of this certificate

Check (✓) applicable box below.

- To weld for the Employer named above only.  
 For seeking employment only.

This Certificate expires PER ASME SECTION IX (mm-dd-yyyy)

COSTICA ROSU ONTARIO  
Inspector Name and Number (Print)

Inspector Signature and Date



Technical Standards and Safety Authority

3300 Bloor Street West  
Toronto, Ontario M8X 2X4  
Web site: www.tssa.org

Technical Standards and Safety Act  
Boilers and Pressure Vessels Regulation

No. 262452

Welder's Last Name: KUMI Initial: TAE First Name: TAE Signature: [Signature] Stamp No: 121

Res. Address: 733 OSSINGTON AVE TORONTO, ONTARIO Postal Code: M 1 X 2 E 1 Provincial Registration No: QW2142 SR & R2180.5

Employer Name: ALL - WELD COMPANY LIMITED Company PQR No: 3 & 3A

Street Address: 48 PASSMORE AVE Company WPS No used: 3-1

City: SCARBOROUGH, ONT Postal Code: M 1 V 4 T 1

Welding Process(es) Used:  SMAW Type(s):  manual  machine  semi-automatic  automatic

Base Material(s):  SA-240-304 TO SA-240-304 Thickness(es):  3/8"  Test Coupon  Production Weld

Variables for All Processes		Actual Values	Range Qualified
Backing material (with/without)		<u> WITHOUT</u>	<u> WITH OR WITHOUT</u>
Base Metal P-Number to P-Number		<u> 0 to 0</u>	<u> P1 THRU P15F, P34 &amp; P4X PLATE AND PIPE 2 7/8" OD AND UP</u>
( <input checked="" type="checkbox"/> ) Plate ( ) Pipe (enter diameter if pipe)		<u> 0.375"</u>	
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)		<u> E308-16</u>	
Consumable insert for GTAW or PAW (QW-404)		<u> NONE</u>	
Welding Position (1G, 5G, etc.) (QW-405)		<u> 2G</u>	<u> 1G &amp; 2G</u>
Manual or Semi-automatic Variables (QW-350)		Actual Values	Range Qualified
Filler Metal F- No. (QW-404)		<u> F5</u>	<u> F5</u>
Filler Metal Product Form for GTAW, PAW (QW-404)		<u> NONE</u>	
Weld deposit thickness for each welding process (QW-404)		<u> 3/8"</u>	<u> 3/4" MAX</u>
Process 1 _____ 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No		<u> 4</u>	<u> PLATE GROOVE + PIPE 2 7/8" OD + UP + ALL FILLETS</u>
Process 2 _____ 3 layers minimum <input type="checkbox"/> Yes <input type="checkbox"/> No		<u> NONE</u>	
Vertical progression (uphill/downhill) (QW-405)		<u> NONE</u>	
GTAW, PAW or GMAW backing gas: or OFW fuel gas (QW-408)		<u> NONE</u>	
GMAW transfer mode (spray/globular or pulse to short circuit) (QW-409)		<u> NONE</u>	
GTAW welding current type & polarity (AC, DCEP, DCEN) (QW-409)		<u> NONE</u>	
Machine Welding Variables (QW-381.2)		Actual Values	Range Qualified
Direct or remote visual control		<u> NONE</u>	
Automatic arc voltage control (GTAW)		<u> NONE</u>	
Automatic joint tracking		<u> NONE</u>	
Multiple or single pass per side		<u> NONE</u>	
Automatic Welding Variables (QW-381.1)		Actual Values	Range Qualified
Filler Metal (EBW or LBW)		<u> NONE</u>	
Laser type for LBW (CO <sub>2</sub> to YAG etc.)		<u> NONE</u>	
Continuous drive or inertial welding (FW)		<u> NONE</u>	
Vacuum or out of vacuum (EBW)		<u> NONE</u>	

Note: Values in "Range Qualified" are valid only when used with a Qualified Welding Procedure.  
RESULTS

Visual Examination of Completed Weld (QW-302.4)  ACCEPTED

Transverse root and face [QW-462.3(a)];  Longitudinal root and face [QW-462.3(b)];  Side (QW-462.2).

Pipe bend specimen, corrosion-resistant overlay [QW-462.5(c)];  Plate bend specimen, corrosion-resistant overlay [QW-462.5(d)];

Pipe specimen, macro test for fusion [QW-462.5(b)];  Plate specimen, macro test for fusion [QW-462.5(e)]

Type	Result	Type	Result	Type	Result	Type	Result
QW-462.3(a) (Face)	ACCEPTED	QW-462.3(a) (ROOT)	ACCEPTED				

Alternative radiographic examination results (QW-191)  NONE

Fillet weld — fracture test (QW-181.2)  NONE Length and percent of defects \_\_\_\_\_

Fillet welds in plate [QW-462.4(b)]  Fillet welds in pipe [QW-462.4(c)]

Macro examination (QW-184)  NONE Fillet size (in.)  NONE x  NONE Concavity/convexity (in.)  NONE

Other tests  NONE

Film or specimens evaluated by  NONE Company  NONE

Mechanical tests conducted by  ALL - WELD COMPANY LIMITED Laboratory test no.  NONE

Welding supervised by (Print name)  ANDREW LEWIS

Test requested by (Print name)  ROBERT BENTLEY Tested at (Print address)  48 PASSMORE AVE, SCARBOROUGH, ONT

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Boiler and Pressure Vessel Code.

Organization  ALL - WELD COMPANY LIMITED Signature  [Signature] Date  06-12-2012  
(mm-dd-yyyy)

FOR TSSA INSPECTOR USE ONLY

The Welder named above has passed the welding test required under Ontario's Technical Standards and Safety Act, Boilers and Pressure Vessels Regulation and is hereby authorized, subject to the limitations of this certificate.

Check (✓) applicable box below

- To weld for the Employer named above only  
 For seeking employment only

This Certificate expires:  PER ASME SECTION IX  
(mm-dd-yyyy)

COSRICA 12080 OUTSIS  
Inspector Name and Number (Print)

[Signature]  DEC 10, 2012  
Inspector Signature and Date

QA COPY





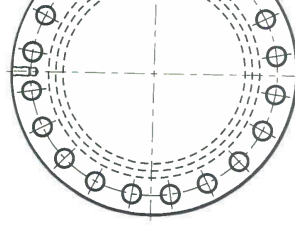
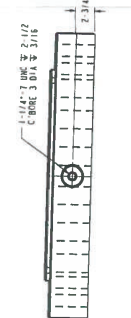




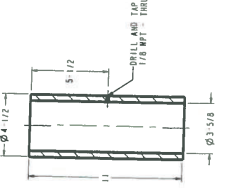
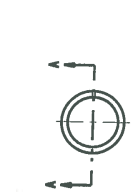
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23 1/4	1 1/4" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL
23 2/4	1 1/2" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL
23 3/4	1 3/4" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL
23 4/4	2" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL
24 1/4	1 1/4" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL
24 2/4	1 1/2" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL
24 3/4	1 3/4" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL
24 4/4	2" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL
25 1/4	1 1/4" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL
25 2/4	1 1/2" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL
25 3/4	1 3/4" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL
25 4/4	2" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL
26 1/4	1 1/4" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL
26 2/4	1 1/2" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL
26 3/4	1 3/4" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL
26 4/4	2" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL

**BILL OF MATERIAL**

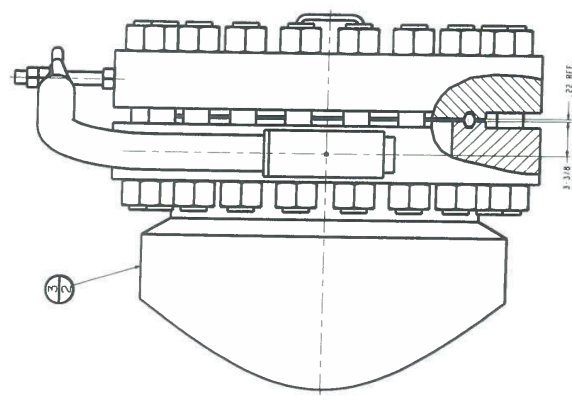
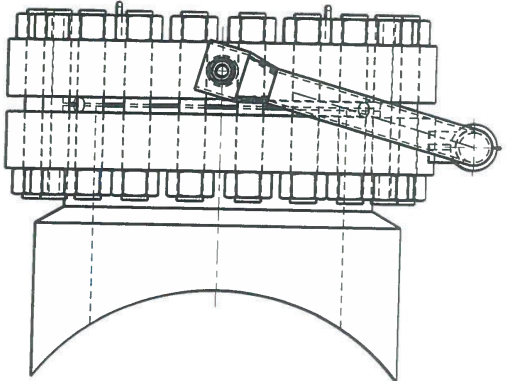
ITEM QTY.	DESCRIPTION	SPEC.
23 1/4	1 1/4" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL
23 2/4	1 1/2" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL
23 3/4	1 3/4" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL
23 4/4	2" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL
24 1/4	1 1/4" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL
24 2/4	1 1/2" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL
24 3/4	1 3/4" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL
24 4/4	2" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL
25 1/4	1 1/4" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL
25 2/4	1 1/2" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL
25 3/4	1 3/4" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL
25 4/4	2" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL
26 1/4	1 1/4" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL
26 2/4	1 1/2" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL
26 3/4	1 3/4" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL
26 4/4	2" DIA. 1/2" LONG	SAE 304 STAINLESS STEEL



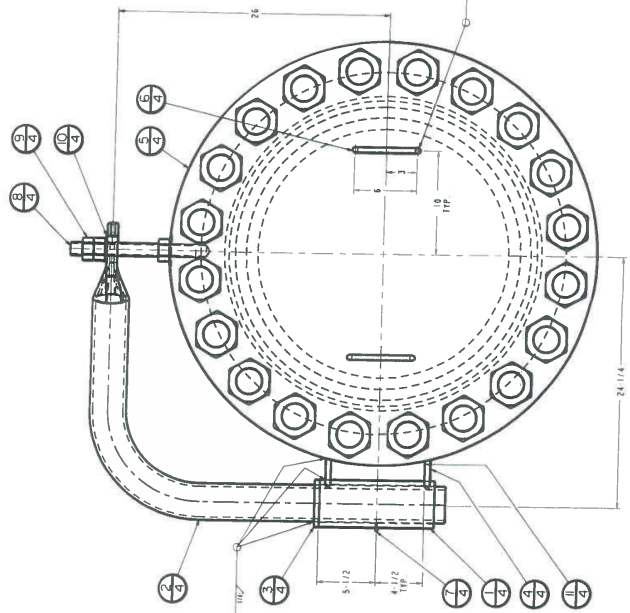
DETAIL ITEM 5/4



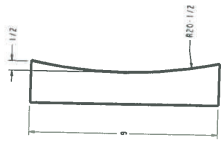
DETAIL ITEM 1/4



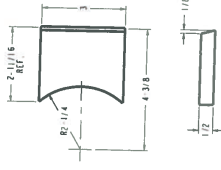
NOZZLE "NIB"



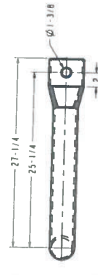
PURCHASE ORDER NUMBER: 1112



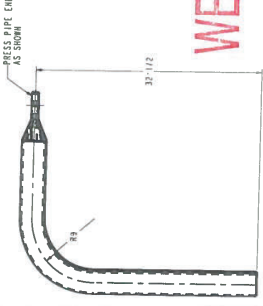
DETAIL ITEM 4/4



DETAIL ITEM 1/4



DETAIL ITEM 2/4



**WELD MAP**

(2) REQUIRED  
PLOTTED:

NOTE: DAVIT ARM ASSEMBLY IS DESIGNED TO SUPPORT TWICE THE BLIND FLANGE WEIGHT.

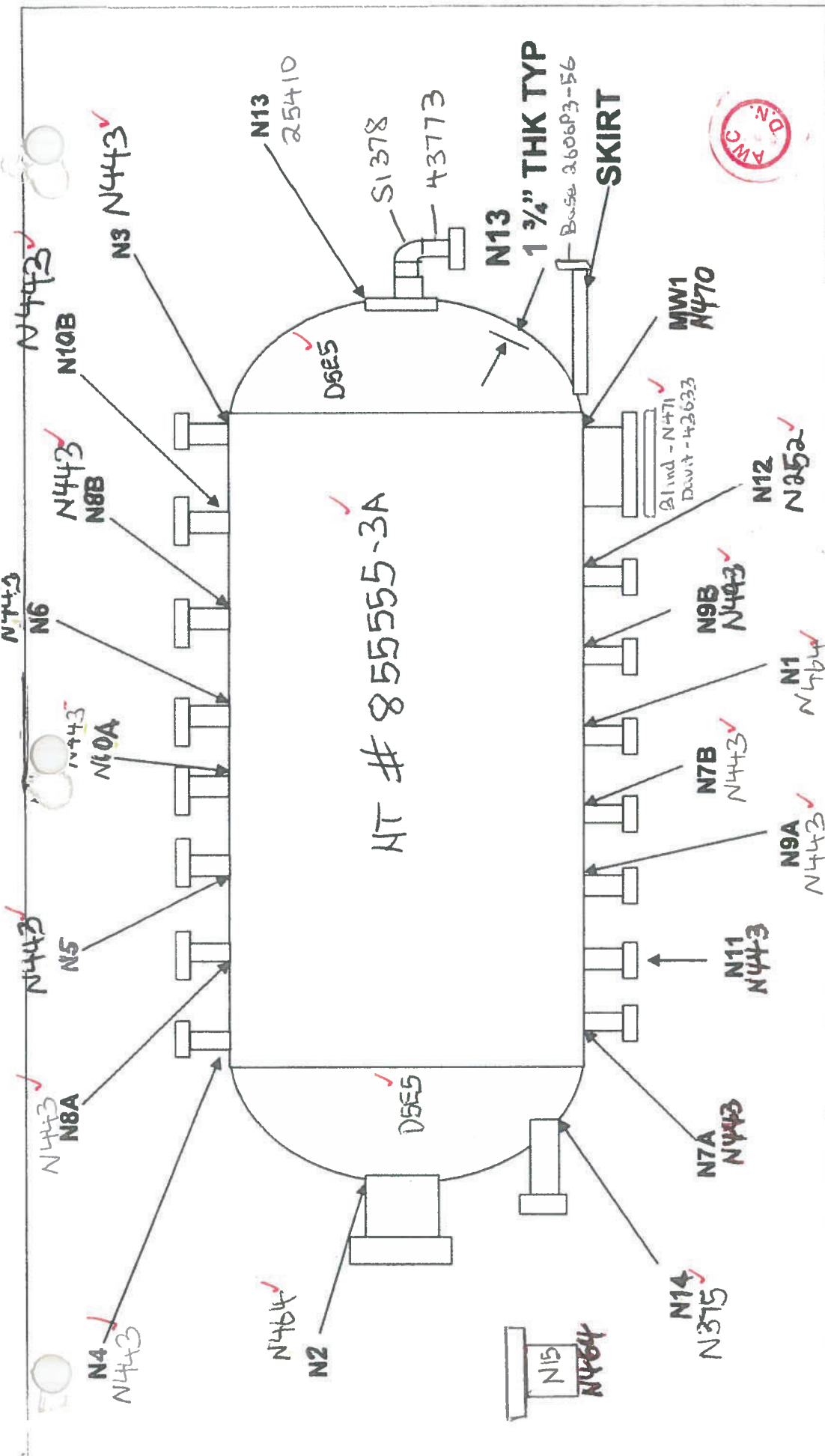
**ALL-WELD COMPANY LIMITED**  
Engineering Office Ltd.

ULTRAFAB INDUSTRIES LIMITED  
407 D.D. VERTICAL INLET SEPARATOR  
24" VERTICAL ASSEMBLY FOR DAVIT ASSEMBLY

THIS DRAWING IS THE PROPERTY OF ALL-WELD COMPANY LTD. and may not be reproduced or disclosed in any way without permission in writing.







<b>ALL-WELD CO. LTD. - HEAT NUMBER MAP</b>	
CLIENT: ULTRAFAB	
WORK ORDER #: 1173PQ	'SN 7473
JOB DESCRIPTION: 48" O.D. VERTICAL INLET	
DRAWING #: 1173-1-IN	
PREPARED BY: D.NESCI	
DATE: March 25, 2013	
HEAT NUMBER MAP - 1173PQ	
ASME SECTION VIII. DIV. 1	
MATERIAL SA-240 316/316L, SA-182 F316/316L	

N3, N4, N5, N6, N7A, N7B, N8A, N8B, N9A  
N9B, N10A, N10B, N11, N12, N13, N14

16/2 E9W8

17/2 E9W8

F9X7

15/2: E9C1

- 12/2- E9W8
- 23/2- ~~836433-1E~~
- 25/2- 2X469
- 26/2- 37463
- 21/2 YT22057
- 22/2- 89J9
- 24/2- 836433-1E

Item 2/3- 2606P3-56  
9/3- E9C1



DAVIT BRACKET-

91N3

6/7

E7H6

1/7

E5K2

NAME  
BRACKET  
E9W8

ALL-WELD COMPANY LTD. -  
HEAT NUMBER MAP PARTS

HEAT NUMBER MAP PARTS- 1173PQ

ASME SECTION VIII. DIV. 1

MATERIAL SA-240 316/316L

CLIENT: ULTRAFAB

WORK ORDER #: 1173PQ SN 7473

JOB DESCRIPTION: 48" O.D. VERTICAL INLET

DRAWING #: 1173-1-IN

PREPARED BY: D.NESCI

DATE: September 17, 2013



6870 HIGHWAY 42 EAST

# METALLURGICAL TEST REPORT

NORTH AMERICAN STAINLESS  
6870 HIGHWAY 42 EAST  
GHENT, KY 41045

Certificate: 789232 1 Mail To: JACQUET MID ATLANTIC  
CUSTOMER PICKUP  
Customer: 005417 005 12273 BROWN AVENUE  
RIVERSIDE, CA 92509

Ship To: JACQUET MID ATLANTIC  
CUSTOMER PICKUP  
12273 BROWN AVENUE  
RIVERSIDE, CA 92509

Date: 11/26/2012 Page: 1

Steel: 316/316L

Finish: HRAP

Your Order: 4436 NAS Order: IN 0157607 01 Corrosion: ASTM A262/02aE;180Bend-OK

## PRODUCT DESCRIPTION:

STAINLESS STEEL PLATE, HRAP; UNS 31600/31603  
ASTM A240/11b, A480/11b, A666/10; ASME SA240/11a, SA480/11a, SA666/11a  
CHEM ONLY ON FOLLOWING ASTM: A276/10, A479/11, A484/11, A312/11  
CHEM ONLY ON FOLLOWING ASME: SA312/11, SA479/11  
AMS 5707F/5524L X MRK;  
NACE MR0175/ISO 15156-3:2003 A, MR0103/07; QQS766D-A X MAG PERM  
MIN. SOLUTION ANNEAL TEMP 1900F, WATER QUENCHED

## REMARKS:

Mat'l is Free of Mercury Contamination. No weld repairs.  
EN 10204:2004 3.1; RoHS Compliant  
Material is Free of Radioactive Contamination  
NAS Steel Making Process: EAF, AOD, & Cont. Casting  
Product Mfg. by a Quality Mgt. Sys. in Conf. w/ISO 9001  
\*Melted & Manufactured in the USA; Mat'l is DFARS Compliant

Product Id	Plate#	Skid #	Thickness	Width	Weight	Length	Mark	Pieces	Commodity Code
03D5E5 CA	03D5E5 CA		1.7575	60.0000	7,500	PLATE	240.00	1	1

CHEMICAL ANALYSIS CM(Country of Melt) ES(Spain) US(United States) ZA(South Africa) JP(Japan) Chemical Analysis per ASTM A751/08

HEAT	CM	C %	CR %	CU %	MN %	MO %	N %	NI %	P %	S %
D5E5	US	.0226	16.5890	.4770	1.5150	2.0045	.0389	10.0350	.0345	.0010

W.O. # 11736  
 M.L. # SEE LT REPORT  
 TYPE # SEE LT REPORT  
 P.O. # 12-1612-1736  
 Certification of Material Per ASME  
 Qualifies to all requirements of SA 240-316/316L per Sect. II, Part B, Division 11, Appendix

## MECHANICAL PROPERTIES

Product Id#	Plate#	UTS KSI	.2% YS KSI	ELONG %-2"	Hard RB	R of A %
03D5E5 CA	03D5E5 CA	88.05	46.66	56.65	80.00	68.07

HT.# DDES  
MTR APPROVED  
DATE 12/14/12  
PSP  
QUALITY CONTROL DEPT

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: *Velocity America*  
CLARENDON SA 111

Q.C.I. N.D.  
Q.C.I. E.Y.

JACQUET NO. 27162

NAS hereby certifies that the analysis on this certification is correct. Based upon the results and the accuracy of the test methods used, the material meets the specifications stated. These results relate only to the items tested and this report cannot be reproduced, except in its entirety, without the written approval of NAS or LIC.

Eric Hess  
 Technical Dept. Mgr.  
 ERIC HESS  
 11/26/2012

# TRINITY HEADS, INC



FEBRUARY 15, 2013

ALL WELD CO LIMITED  
49 PASSMORE AVE  
TORONTO ON CANADA  
M1V 4T1

Attention:  
Reference: Customer: 12-1612-1173Q Tag # 1173-1  
Trinity SO # 112328

Gentlemen:

Attached are copies of mill test reports for the following material provided on your referenced purchase order.

8-SA240-316/316L ELLIP-2:1 HEAD 48.00 OD 1.750 NOM 1.6100 MIN WITH 2.0" SF.

CODE	QTY	THICKNESS	PRODUCER	MELT	SLAB	GRADE
SMYJ	4	1.750	NAS	D5E5		SA240-316/316L
SMYI	4	1.750	NAS	E2P3		SA240-316/316L

Trinity Heads, Inc. certifies that heads manufactured from material represented by this report were hot formed, annealed at 1950F(+/-25F) for 53 minutes and water quenched.

The items listed above were formed in strict accordance with all applicable requirements of the ASME Boiler and Pressure Vessel Code Section VIII, Div. 1. Heads comply with UG-79, UG-80 and UG-81.

Attached mill test reports are in compliance with ASME code Section II latest edition.

If you have further questions, please contact your customer service representative in Navasota, TX at 1-800-392-3594.

VERY TRULY YOURS

*Charles Draus*  
CHARLES DRAUS  
QUALITY MANAGER

ACCEPTED/REVIEWED/RELEASED 046  
for and on behalf of: SBM  
Print Name: GANTOSH SAHIL  
Signature: [Signature]  
Date: 2/26/13  
Applus® VELOSI  
Velosi America LLC



FEB 05 2013



# Certificate of Analysis and Tests

\*\*\*\*\*  
 \* RE-CERTIFICATION \*  
 \*\*\*\*\*

OUR ORDER 0282469 - 01

HEAT & PIECE 855555-3A 03/06/13

SOLD TO: ROLLED ALLOYS - CANADA  
 2283 ARGENTIA ROAD, UNIT 6

SHIP TO: ALL-WELD  
 CUSTOMER PICK UP  
 CONTACT ANDY@HTSINTL.COM  
 SCARBOROUGH ON 0000

00000

----- YOUR ORDER & DATE -----  
 0032037ME 11/16/12  
 ----- ITEM DESCRIPTION -----  
 HEAT & PIECE 855555 - 3A  
 WEIGHT 7564  
 FINISH 1  
 GRADE 316L / 316  
 DIMENSIONS 1.750 X 96.000 X 154.000 EXACT

----- SPECIFICATIONS -----  
 \*\*\* MFG IN NEW CASTLE, IN, USA FROM SLABS IMPORTED FROM BRITAIN  
 AMS 5507F WITH EXCEPTIONS AMS 5524L WITH EXCEPTIONS  
 ASTM A240-12A ASMESA240-11ED ASTM A480-12 ASMESA480 11ED  
 ROLLED ALLOYS SPECS 316L/316 NAFTA CTRY ORIGIN= SLAB CTRY  
 MEETS EU ELECTRICAL ROHS LIST HEAT/PCE/SIZE ON INVCE  
 NACE MRO175-2009/ISO 15156 NO GRIPPER MARKS  
 NO WELD REPAIRS  
 ASTM A262-02A PRACTICE A ASTM A262-02A PRACTICE E

PLATES & TEST PCS SOLUTION ANNEALED @ 1900 DEGREES FAHRENHEIT MINIMUM.  
 THEN WATER COOLED OR RAPIDLY COOLED BY AIR  
 FREE FROM MERCURY CONTAMINATION AT CURRENT DETECTION LIMITS  
 HOT ROLLED, ANNEALED & PICKLED (HRAP)

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBM  
 Print Name: GA MESH SAHA  
 Signature: [Signature]  
 Date: 11/16/13  
**Applus®**  
**VELOSI**  
 Velosi America LLC

----- MECHANICAL & OTHER TESTS -----  
 HARDNESS HRBW 81  
 GRAIN SIZE 6  
 YIELD STRENGTH (PSI) 46390  
 TENSILE STRENGTH (PSI) 80510  
 INTERGRANULAR CORROSION OK  
 ELONGATION % IN 2" 57.9  
 REDUCTION OF AREA % 59.3

W.O. # 1173Q  
 M.L. # 2  
 THK. # 1 3/4"  
 P.O. # 12-1613-1173Q

----- CHEMICAL COMPOSITION -----  
 CARBON (C) .015  
 MANGANESE (MN) 1.70  
 PHOSPHORUS (P) .031  
 SULFUR (S) .001  
 SILICON (SI) .29  
 CHROMIUM (CR) 16.33  
 NICKEL (NI) 10.06  
 COBALT (CO) .27  
 COPPER (CU) .35  
 MOLY (MO) 2.04  
 NITROGEN (N) .08  
 COLUMBIUM (CB) .015  
 TITANIUM (TI) .007  
 ALUMINIUM (AL) .006  
 TIN (SN) .007  
 TANTALUM (TA) .002

Certification of Material - Per ASME  
 HT# 855555-3A  
 Qualifies to all requirements of  
SA 240-316/316L per  
 Sect. II 10 Edition 11a Addenda



FEB 05 2013

WE HEREBY CERTIFY THAT THE MATERIAL HEREIN HAS BEEN MADE AND TESTED IN ACCORDANCE WITH THE LISTED SPECIFICATION(S) AND THAT THE RESULTS OF ALL TESTS ARE ACCEPTABLE.

JAMES DOUBMAN, QUALITY ASSURANCE MANAGER

CERTIFICATE IN CONFORMANCE WITH EN10204-95 3.1.B EN10204-2004 3.1

*James Douman*

1486 Wallace Road  
Oakville, Ontario L6L 2Y2  
Phone: 905-844-9448  
Fax: 905-844-6697

## Ultrasonic Examination Report UT

### General Data

Customer	All-Weld Company	Date	February 26, 2013		
Shop Order	1173 PQ Serial # 7473	Project			
Component		P.O. #	Worksheet #:	36451	
Drawing		Rev.	Technician	Frank Marunde	SNT-TC-1A Level III
NDT Specification	ASTM E 797	Appendix	NDT Procedure	KV-UT# 1 R.02	

### Technical Data - Ultrasonic Examination (UT)

Material Type	Stainless Steel	Technique	<input type="radio"/> Pulse Echo-Contact <input type="radio"/> Immersion <input type="radio"/> Dual
Material Thickness		Instrument Brand	<input checked="" type="radio"/> Olympus Epoch 1000i <input type="radio"/> Serial # 090054812
Weld Type	<input type="radio"/> Butt <input type="radio"/> T Joint <input type="radio"/> Fillet	Surface	<input checked="" type="radio"/> As Rolled <input type="radio"/> Ground <input type="radio"/> Machined <input type="radio"/> Shot Blasted
Weld Thickness	N/A	Couplant	<input checked="" type="radio"/> UT-X <input type="radio"/> Oil <input type="radio"/> Other <input type="radio"/> Temperature
Heat Treated	<input type="radio"/> YES <input type="radio"/> NO	Sensitivity (PRL)	75 dB
Heat Treatment		Surface Conditions	

### Transducers/Calibration Blocks

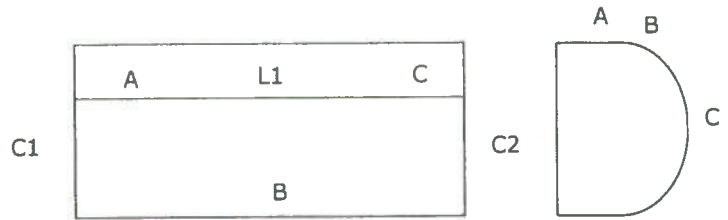
Diameter		Size	Beam Angle	Frequency	Manufacturer	Blocks
<input type="radio"/> 1/4"	<input type="radio"/> 3/4"	<input type="radio"/> 5/8" x 5/8"	<input type="radio"/> 45°	<input type="radio"/> 1.00 MHz	<input type="radio"/> Techsonic	<input type="radio"/> IIW A2
<input type="radio"/> 3/8"	<input type="radio"/> 1"	<input type="radio"/> 1/2" x 1"	<input type="radio"/> 60°	<input type="radio"/> 2.25 MHz	<input checked="" type="radio"/> Panametrics	<input type="radio"/> ASTM E164 MAB
<input checked="" type="radio"/> 1/2"	<input type="radio"/> 1 1/8"	<input type="radio"/> 1" x 1"	<input type="radio"/> 70°	<input checked="" type="radio"/> 5.00 MHz	<input type="radio"/> Krautkramer	<input type="radio"/> Back Reflection
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/> Normal	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/> Micrometer Shell

### Scope of Testing

#### Thickness Examinations

	Shell	Head to C1	Head to C2
A	1.756	1.778	1.797
B	1.774	1.736	1.737
C	1.770	1.751	1.754

All Dimensions are in inches



046

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SBM

Print Name: GANESH SAHA  
Signature: [Signature]  
Date: Feb 26 2013

Applus®  
VEE Scanning  
From: Velos America LLC

AWC  
ON  
FEB 28 2013

Test Area	Disposition	Length	Depth	Amplitude

### Evaluation - Acceptance

<input type="radio"/> Accepted	KV Inspection Services - Technician	<u>[Signature]</u>	Date	February 26, 2013
<input type="radio"/> Rejected	CGSB No. 48.9712-2000 Reg. No.	8885	Place	Scarborough, ON.



14527 Smith Rd.  
Humble, Texas 77396  
TEL: (281) 441-4088  
FAX: (281) 441-8899

REPORT NUMBER 72424

DATE 3/5/2013

FCI ORDER NUMBER 59176

Processed I.A.W. EN10204 3.1  
I.A.W. NACE MR0175

CUSTOMER ORDER NUMBER 13-0074  
SOLD/SHIPPED TO ALL-WELD CO., LTD.  
49 PASSMORE AVE.

SCARBOROUGH ONT MIV 4T1 CANADA

Item Quantity Description

1 3 24" X 900 X 26.50" LG RTJ I-2, 35" OD REINFORCEMENT ITEM 1173-4

HEAT NUMBER: N470

MATERIAL TYPE: SA182F316/L

Manufactured in USA

I.A.W. ASME 2010 ED 11AD.

CHEMICAL ANALYSIS

PHYSICAL PROPERTIES

C .018 ✓  
Mn 1.830 ✓  
P .0260 ✓  
S .0010 ✓  
Si .390 ✓  
Cr 16.600 ✓  
Mo 2.030 ✓

Yield PSI 49,300 ✓  
Tensile PSI 85,000 ✓  
Elongation 50 ✓  
Reduction of Area 75 ✓  
Hardness 170 HBW ✓

Ni 10.170 ✓  
.0800



Certification of Material - Per ASME  
HT# N470  
Qualifies to all requirements of  
SA182-F316L316L per  
Sect. II 10 Edition 11 Addenda

W.O. # 11730  
M.L. # 4(3/2)  
THK. #  
P.O. # 13-0074

MAR 18 2013

Heat Treatment SOLUTION ANNEALED  
Temperature 1925 °F  
Time at Temperature  
Cooling Media WATER



MAR 20 2013

Immediately following hot working, while at temperature above, parts were rapidly quenched.

We hereby certify that all test results and process information contained herein are correct and true as contained in the records of the company.

Prepared by

Name: Rene Ordorez

Title: QA Representative

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SBM  
Print Name: CHANDISH SAHU  
Signature: [Signature]  
Date: March 16/13  
Applus® VELOSI  
Velosi America LLC



14527 Smith Rd.  
Humble, Texas 77396  
TEL: (281) 441-4088  
FAX: (281) 441-8899

REPORT NUMBER 72426

DATE 3/5/2013

FCI ORDER NUMBER 59176

Processed I.A.W. EN10204 3.1  
I.A.W. NACE MR0175

CUSTOMER ORDER NUMBER 13-0074  
SOLD/SHIPPED TO ALL-WELD CO., LTD.  
49 PASSMORE AVE.

SCARBOROUGH ONT MIV 4T1 CANADA

Item Quantity Description

2	4	8" X 900 X 14" LG RTJ LWN
3	4	8" X 900 X 13.25" LG RTJ LWN

MTR REVISED 3/27/13  
ITEM 1173-5  
ITEM 1173-6

HEAT NUMBER:  
N464

MATERIAL TYPE:  
SA182F316/L

Manufactured in  
USA

I.A.W. ASME 2010 ED 11AD.

CHEMICAL ANALYSIS

PHYSICAL PROPERTIES

C	.028 ✓
Mn	1.740 ✓
P	.0450 ✓
S	.0090 ✓
Si	.380 ✓
Cr	16.610 ✓
Mo	2.030 ✓
Ni	10.040 ✓
N	.0757

Yield PSI	39,100 ✓
Tensile PSI	80,300 ✓
Elongation	60.2 ✓
Reduction of Area	76.5
Hardness	149, 163 HBW

Certification of Material - Per ASME  
HT# N464  
Qualifies to all requirements of  
SA182-F316/L per  
Sect. II 70 Edition 11 Addenda

W.O. # 11730  
M.L. # 5(4)6(5/2)  
THK. # 1.938  
P.O. # 13-0074

*Reviewed*  
*Phyllis*  
*Apr 5, 2013*  
Velocity America  
279

Q.C.I.  
N.D.

Q.C.I.  
E.Y.  
APR 05 2013

APR 03 2013

Heat Treatment SOLUTION ANNEALED  
Temperature 1925 °F  
Time at Temperature  
Cooling Media WATER

Immediately following hot working, while at temperature above, parts were rapidly quenched.  
We hereby certify that all test results and process information contained herein are correct and true as contained in the records of the company.

Prepared by *P. Holley*

Name: Phyllis Holley Title: QA Representative





14527 Smith Rd.  
Humble, Texas 77396  
TEL: (281) 441-4088  
FAX: (281) 441-8899

REPORT NUMBER 72430

DATE 3/5/2013

FCI ORDER NUMBER 59176

Processed I.A.W. EN10204 3.1  
I.A.W. NACE MR0175

CUSTOMER ORDER NUMBER 13-0074  
SOLD/SHIPPED TO ALL-WELD CO., LTD.  
49 PASSMORE AVE.

SCARBOROUGH ONT MIV 4T1 CANADA

Item Quantity Description

5 4 2' X 900 X 12.50" LG RTJ LWN

ITEM 1173-7

HEAT NUMBER:  
N375

MATERIAL TYPE:  
SA182F316/L

Manufactured in  
USA

I.A.W. ASME 2010 ED 11AD.

CHEMICAL ANALYSIS

PHYSICAL PROPERTIES

C .018 ✓  
Mn 1.720 ✓  
P .0290 ✓  
S .0280 ✓  
Si .360 ✓  
Cr 16.990 ✓  
Mo 2.030 ✓

Yield PSI 37,000 ✓  
Tensile PSI 83,000 ✓  
Elongation 62 ✓  
Reduction of Area 71 ✓  
Hardness 158 HBW ✓

Ni 10.000 ✓  
.0800

N14

Certification of Material - Per ASME  
HT# N375  
Qualifies to all requirements of  
SA182-F316/B16L per  
Sect. II 70 Edition 11 Addenda

W.O. # 11730  
M.L. # 70612  
THK. # 1.092  
P.O. # 13-0074



MAR 20 2013

MAR 18 2013

Heat Treatment SOLUTION ANNEALED  
Temperature 1925 °F  
Time at Temperature  
Cooling Media WATER

Immediately following hot working, while at temperature above, parts were rapidly quenched.

We hereby certify that all test results and process information contained herein are correct and true as contained in the records of the company.

Prepared by

Name: Rene Ordonez Title: QA Representative

ACCEPTED/REVIEWED/RELEASED 046  
for and on behalf of: SBM  
Print Name: GABRIEL SABA  
Signature: [Signature]  
Date: Mar 26/13  
Applus® VELOSI  
Velosi America LLC



14527 Smith Rd.  
Humble, Texas 77396  
TEL: (281) 441-4088  
FAX: (281) 441-8899

REPORT NUMBER 72775

DATE 3/14/2013

FCI ORDER NUMBER 59176

Processed I.A.W. EN10204 3.1  
I.A.W. NACE MR0175

CUSTOMER ORDER NUMBER 13-0074  
SOLD/SHIPPED TO ALL-WELD CO., LTD.  
49 PASSMORE AVE.

SCARBOROUGH ONT MIV 4T1 CANADA

Item Quantity Description

4 2 2' X 900 X 11" LG RTJ LWN

ITEM 1173-7

HEAT NUMBER:  
N252

MATERIAL TYPE:  
SA182F316/L

Manufactured in  
USA

I.A.W. ASME 2010 ED 11AD.

CHEMICAL ANALYSIS

PHYSICAL PROPERTIES

C .013 ✓  
Mn 1.630 ✓  
P .0220 ✓  
S .0160 ✓  
Si .520 ✓  
Cr 16.120 ✓  
Mo 2.050 ✓

Yield PSI 43,700 ✓  
Tensile PSI 82,800 ✓  
Elongation 56 ✓  
Reduction of Area 77 ✓  
Hardness 134 HBW ✓



Ni 11.580 ✓  
.0020

**N12**  
Certification of Material - Per ASME  
HT# N252  
Qualifies to all requirements of  
SA182F316/316L per  
Sect. II 10 Edition 11 Addenda

W.O. # 11730  
M.L. # 7(1/2)  
THK. # 1.081  
P.O. # 13-0074



MAR 26 2013

Heat Treatment SOLUTION ANNEALED  
Temperature 1900°F  
Time at Temperature  
Cooling Media WATER

We hereby certify that all test results and process information contained herein are correct and true as contained in the records of the company.

Prepared by

*P. Rios*

Name: Paul Rios Title: QA Representative

ACCEPTED/REVIEWED/RELEASED 046  
for and on behalf of: SAM OFFSHORE  
Print Name: GANESH SAHA  
Signature: *[Signature]*  
Date: 7/14/13  
Applus® VELOSI  
Velosi America LLC



14527 Smith Rd.  
Humble, Texas 77396  
TEL: (281) 441-4088  
FAX: (281) 441-8899

REPORT NUMBER 72783

DATE 3/14/2013

FCI ORDER NUMBER 59176

Processed I.A.W. EN10204 3.1  
I.A.W. NACE MR0175

CUSTOMER ORDER NUMBER 13-0074  
SOLD/SHIPPED TO ALL-WELD CO., LTD.  
49 PASSMORE AVE.

SCARBOROUGH ONT MIV 4T1 CANADA

Item Quantity Description

4 25 2" X 900 X 11" LG RTJ LWN

ITEM 1173-7

HEAT NUMBER:  
N443

MATERIAL TYPE:  
SA182F316/L

Material Origin: ITALY  
Manufactured in USA

I.A.W. ASME 2010 ED 11AD.

CHEMICAL ANALYSIS

PHYSICAL PROPERTIES

C .023 ✓  
Mn 1.830 ✓  
P .0290 ✓  
S .0260 ✓  
Si .350 ✓  
Cr 16.580 ✓  
Mo 2.030 ✓

Yield PSI 42,000 ✓  
Tensile PSI 85,000 ✓  
Elongation 58.9 ✓  
Reduction of Area 61.4 ✓  
Hardness 175 HBW ✓

Ni 10.150 ✓  
.0740

N3,4,5,6,11,7A,7B,8A,8B,9A,9B,10A,10B

Certification of Material - Per ASME  
HT# N443  
Qualifies to all requirements of  
SA182-316/316L per  
Sect. II 10 Edition 11 Addenda

W.O. # 11730  
M.L. # 7(6/2,7/2)  
THK. # 1.078  
P.O. # 13-0074



MAR 26 2013

Heat Treatment SOLUTION ANNEALED  
Temperature 1925 °F  
Time at Temperature  
Cooling Media WATER

Immediately following hot working, while at temperature above, parts were rapidly quenched.

We hereby certify that all test results and process information contained herein are correct and true as contained in the records of the company.

Prepared by *[Signature]*

Name: Rene Ordonez Title: QA Representative

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: *[Signature]*  
Print Name: GAABESH SAHA  
Signature: *[Signature]*  
Date: March 26/13  
Applus® VELOSI  
Velosi America LLC



14527 Smith Rd.  
Humble, Texas 77396  
TEL: (281) 441-4088  
FAX: (281) 441-8899

REPORT NUMBER 72485

DATE 3/7/2013

FCI ORDER NUMBER 59176

Processed I.A.W. EN10204 3.1

I.A.W. NACE MR0175

CUSTOMER ORDER NUMBER 13-0074  
SOLD/SHIPPED TO ALL-WELD CO., LTD.  
49 PASSMORE AVE.

SCARBOROUGH ONT MIV 4T1 CANADA

Item Quantity Description

1	1	24" X 900 X 26.50" LG RTJ I-2, 35" OD REINFORCEMENT	ITEM 1173-4
7	4	24" X 900 RTJ BLIND	ITEM 1173-9

HEAT NUMBER: N471

MATERIAL TYPE: SA182F316/L

Manufactured in USA

I.A.W. ASME 2010 ED 11AD.

CHEMICAL ANALYSIS

PHYSICAL PROPERTIES

C	.019	✓
Mn	1.410	✓
P	.0230	✓
S	.0003	✓
Si	.500	✓
Cr	16.430	✓
Mo	2.050	✓

Yield PSI	49,600	✓
Tensile PSI	90,100	✓
Elongation	52.8	✓
Reduction of Area	76.1	✓
Hardness	170/179 HBW	✓

Ni	10.100	✓
N	.0710	✓

Certification of Material - Per ASME  
HT# N471  
Qualifies to all requirements of  
SA182-F316/316L per  
Sect. II 10 Edition 11 Addenda

W.O. # 11730  
M.L. # 9(5/4)  
THK. # -  
P.O. # 13-0074

Q.C.I.  
E.Y.  
MAR 20 2013

Q.C.I.  
N.D.

MAR 18 2013

Heat Treatment SOLUTION ANNEALED  
Temperature 1925 °F  
Time at Temperature  
Cooling Media WATER

Immediately following hot working, while at temperature above, parts were rapidly quenched.

We hereby certify that all test results and process information contained herein are correct and true as contained in the records of the company.

Prepared by [Signature]

Name: Rene Ordonez Title: QA Representative

ACCEPTED/REVIEWED/RELEASED 046  
for and on behalf of: S.B.M  
Print Name: GARESH SAHA  
Signature: [Signature]  
Date: March 26/13  
Applus® VELOSI  
Velosi America LLC

# VIRAJ PROFILES LIMITED



Regi & Mkt off: G-33 & 34, MIDC, Industrial Area, Tarapur, Thane (Dist), Maharashtra, INDIA - 401506, E-Mail: sales@viraj.com  
 Works: SURVEY No- 114, 119 & 120, VILL. Mahagaon, Tal: Palgar, Dist: Thane-401501, MAHARASTRA, INDIA, vtelqc@viraj.com

## TEST CERTIFICATE

**CUSTOMER** \_\_\_\_\_ **ORDER NO** \_\_\_\_\_ **PACKING LIST NO** 51/935703/9 **INSPECTION NO** 100001546430 **DATE** 18.02.2012  
**GRADE** 316/316L **HEAT No** 25410

**BUNDLE NO :**  
 5182915 , 5182916 , 5182918 , 5182917 ,

**DESCRIPTION**  
 STAINLESS STEEL BRIGHT BARS

Certification of Material - Per ASME  
 HT# 25410  
 Qualifies to all requirements of  
 SA 182-F 316/316L per  
 Sect. II 10 Edition 11 Addenda

W.O. # 1173PQ.  
 M.L. # 12  
 THK. # 6"  
 P.O. # 13-0203

**ROUGH & PEELED**

SIZE	SHAPE	TOLERANCE	LENGTH	PIECES	WEIGHT
6"	ROUND	DIN 1013	12' - 15'	4	5,008.000 LB

### CHEMICAL ANALYSIS

%C	%Mn	%Si	%S	%P	%Cr	%Ni	%Cu	%Mo	%Co	%N2
0.0230	1.880	0.350	0.0210	0.0360	16.700	10.090	0.540	2.020	0.180	0.0730

Q.C.I.  
 N.D.

### TEST RESULTS

0.2% yield strength ksi	Tensile Strength ksi	Elongation %	Reduction Of Area %	Hardness BHN	Grain Size NOS
37.0	84.0	60.0	72.0	168.0	6.0

MAR 07 2013

Q.C.I.  
 E.Y.

MAR 07 2013

### SPECIFICATION:

MATERIAL CONFIRMS TO DIN EN 10088-3:2005; 1.4401/1.4404. EN 10222-5 AND EN 10272 COND-A & ASTM A182/A-182M-09, A276-10 COND A, A479/A479M-06a COND A, A193/A193M-10a B8M CL-1, A320/A320M-05a B8M CL-1, A484-10, A388/A388M-05, ASME SA 182-04, SA479-04, SA 193-04 B8M CL-1, SA320-04 B8M CL-1, ASTM A314-2002. IGC SATISFACTORY AS PER ASTM A 262-02a PRACTICE E. AMS 5648J / AMS 5653F (EXCEPT MARKING) , QQ-S-763F, NACE-MR0175-2002, SAE-AMS-S-7720A, MIL-S-862 B, AISI 316/316L & UNS#S31600/S31603. CERTIFICATION AS PER EN 10204-3.1.

### REMARKS

MATERIAL IS FREE FROM MERCURY CONTAMINATION, FREE FROM WELD OR WELD REPAIRS, MICRO: FREE FROM CONTINUOUS CARBIDE NETWORK ON GRAIN BOUNDARIES, MACRO: GOOD, MINIMUM SOLUTION ANNEALING TEMPERATURE 1050C, SOAKING TIME 02 HRS, WATER QUENCHED. MELT SOURCE: AOD. WE CONFIRM THAT THE MATERIAL HAS BEEN TESTED AND FOUND TO BE FREE FROM RADIOACTIVE CONTAMINATION. COUNTRY OF ORIGIN: INDIA.

We hereby certify that the material described above has been tested and certified in accordance with the terms of order/contract.

**VIJAYA BANK**  
 5043 / FUDBP / FDBPY  
 049 23124  
 Overseas Branch, Mumbai-21.

ACCEPTED / REVIEWED / RELEASED  
 for and on behalf of: Velosi America  
 Print Name: GANESH SAHA  
 Signature: [Signature]  
 Date: 14/12  
**Applus**  
 VELOSP  
 Velosi America LLC

[Signature]  
 WORKS INSPECTOR  
 K R K MURTHY

File POSa37

From: Alloy Piping Products, LLC  
Corporate Offices  
P O Box 7368  
Shreveport LA 71137-7368

To: PINACLE STAINLESS  
455 AMBASSADOR DR  
MISSISSAUGA ON L5T 2J3

Cust Ord#: 70696-1  
APP Inv#: 1253406

Heat Number Commodity Size 1 Schd 1 X Size 2 Schd 2

S1378 Alloy WP316/316L B/W LR 90° ELBOW 2.0000 160 Qty 4.0000  
Short PN 00005393

Ord Spec SA403 WP S SEAMLESS Mfg Dt 12/12  
Itm Spec ASTM Spec-A403 YR-2012 Made in USA  
Itm Spec ASME Spec-SA403 ED-2010

Raw Matl--Pipe Seamless

Chemical Composition:

Elem	Content	Elem	Content	Elem	Content	Elem	Content
C	.01800	MN	1.45000	P	.02800	S	.00100
SI	.50000	CR	16.80000	NI	11.10000	MO	2.10000

TEST RESULTS:

W/O#: 69333 LOAD: TEST SET: 1

Tensile Test 1

Specimen Type: .  
 Size 1 Before in After in  
 Size 2 Before in After in  
 Area Before .0000 sq in Red % .00 %  
 Gauge Lnth .00 in Elng % 52.60 %  
 Tensile Load 0 Tensile Strength 81,700 lb/sq in  
 Yield Load 0 Yield Strength 61,800 lb/sq in

Hardness Test

Hardness 183.00 Expressed as BHN unless stated otherwise

Heat Treat Statement 1

SOLUTION ANNEALED AT 1950°F +/- 25°F FOR 1 HOUR  
PER INCH OF THICKNESS, BUT NOT LESS THAN 15 MIN.  
AND WATER QUENCHED.

Certification of Material - Per ASME  
HT# S1378  
Qualifies to all requirements of  
SA403-316/316L per  
Sect. II 10 Edition 11 Addend

TED/RE:   
 for on behalf of SBM OFFSHORE  
 name: GARETH SAH  
 signature: [Signature]  
 Date: APR 15 2013  
 046  
 Applus® VELOSI  
 Velosi America LLC

Q.C.I. N.D.

HARDNESS IS ACCEPTABLE  
I.A.W. NACE MRO-175/ISO 15156

W.O. # 11730  
 M.L. # 13 (10/2)  
 THK. # 414  
 P.O. # 13-

Q.C.I. E.Y.

APR 08 2013

Material, when shipped, is free from contamination by mercury, radium, alpha source and low melting elements. Welds 100% Radiographed and acceptable to (ASME Section VIII - Para UW-51) when applicable. We Hereby Certify that the materials listed above have been manufactured in accordance with, and meet the above applicable specifications and grades.

[Signature]  
QA/QC/MTR Specialist

4/05/13  
Date



TUBACEX

**INSPECTION CERTIFICATE**  
**EN 10204 3.1**

Number: 519285 Rev: 00  
Page: 1 / 3

Created on: Modified on:  
Date: 09.05.2011

**TTI - TUBACEX TUBOS INOXIDABLES**

Registro Mercantil de Alava, Tomo 587, Folio 189, Hoja VI 2885 - N.I.F. A-01140227

Tres cruces, 8

01400 Llodio (Alava)

SPAIN

TL: +34 946719300

FAX: +34 946725062

E-MAIL: qualitytti@tubacex.es

**CUSTOMER DESCRIPTION**

**CLIENT SOLD TO**

PINACLE STAINLESS STEEL INC.  
455 AMBASSADOR DRIVE  
MISSISSAUGA, ONTARIO ON L5T 2J3  
CANADA

**CLIENT SHIP TO**

PINACLE STAINLESS STEEL INC.  
455 AMBASSADOR DRIVE  
MISSISSAUGA, ONTARIO ON L5T 2J3  
CANADA

CLIENT ORDER: 57733  
SALES ORDER: 101551

W.O. # 11736  
M.L. # 14 (11/2)  
THK. # .347  
P.O. # 13-0243REV1

MATERIAL: SEAML. STAINL. STEEL TUBES/PIPES,  
PICKLED-PASSIVATED

GRADE: TP316/316L,

STANDARD: ASTM A312M-09 / ASME SA312M ED.10

TOLERANCES: ASTM A999/A312

PLAIN ENDS,

DIMENSIONS: 2" SCH 160

COLD FINISHED

NACE MRO103-10 / NACE MR0175 / ISO 15156-3 : 2009

Certification of Material - Per ASME  
HT# 43773  
Qualifies to all requirements of  
SA312-316/316L per  
Sect. II 10 Edition 11 Addenda

Sales Item	Client Item	Delivery Nr	Prod. Order	Insp. Lot	Heat Nr	Pieces	Weight	Tot Lgth	Un Lgth
170		8110007615	100323631	200040492	37015	1	82 KG	7.31 M	5791-7315 MM
170		8110007615	100323631	200040493	43773	15	1.050 KG	94.32 M	5791-7315 MM

**RAW MATERIAL**

Heat Nr:	Supplier	Method
37015	ACERALAVA	Electric furnace+AOD
43773	ACERALAVA	Electric furnace+AOD

MAR 26 2013

**CHEMICAL COMPOSITION (%)**

*	Heat	Seq	*Ladle C:Products									
			C	Mn	Si	P	S	Ni	Cr	Mo		
L	37015	1	0.025	1.53	0.480	0.028	0.0010	11.60	16.90	2.10		
L	43773	1	0.015	1.55	0.500	0.028	0.0010	11.20	16.90	2.20		

**HEAT TREATMENT**

SOLUT.ANNEALED 1100 °C HOLDING TIME >= 1.5 MIN / MM WATER COOLING

renewed  
279  
Velos America  
April 1, 2013

Q.C.I.  
N.D.



TUBACEX TUBOS INOXIDABLES  
INGENIERIA DE CALIDAD

*[Signature]*



TUBACEX

INSPECTION CERTIFICATE  
EN 10204 3.1

Number: 519285  
Page: 2 / 3

Rev: 00

Created on:  
Date: 09.05.2011

Modified on:

TENSILE TEST

Prod. Order	Ins. Lot	Sample	T	Rp0.2	Rp1.0	Rm	A2"	A5
			°C	N/mm2	N/mm2	N/mm2	%	%
100323631	200040492	1	20	291	347	566	53	50
	200040493	1	20	296	354	578	54	51
		2	20					

HARDNESS TEST

Prod. Order	Ins. Lot	Sample	HRB1	HRB2
100323631	200040492	1	78	79
	200040493	1	77	78

METALURGICAL TESTS

INTERGRANULAR CORROSION TEST ACC. TO ASTM A262 PRACT."E": SATISFACTORY

NON-DESTRUCTIVE TESTS

100 % EDDY CURRENT TEST AT E.426, GOOD.

POSITIVE MATERIAL IDENTIFICATION TEST ON EACH TUBE/PIPE BY  
"X-RAY-FLUORESCENCE-ANALYZER": SATISFACTORY

VISUAL INSPECTION ON EACH TUBE: SATISFACTORY

DIMENSIONAL CHECKING ON EACH TUBE: SATISFACTORY

TECHNOLOGICAL TESTS

FLATTENING TEST: SATISFACTORY

*Reviewed*  
*Rit*  
*April 1, 2013*



MAR 26 2013



MARKING

TUBACEX 2" SCH 160 ASME SA312 ASTM A312 TP316 TP316L CD SMLS NH ET  
HEAT/ PMI LOT NO/ SPAIN TX2 TX1

REMARKS

NO MERCURY, MERCURY COMPOUNDS OR MERCURY BEARING INSTRUMENTS AND/OR EQUIPMENT HAVE BEEN USED ALONG MANUFACTURING AND INSPECTION PROCESS.

NO WELD REPAIR WAS PERFORMED

MATERIAL MANUFACTURER APPROVED WITH CERTIFICATE NR. 07/2001/MUC BY TUV SUDDEUTSCHLAND (NOTIFIED BODY 0036) TO ISSUE CERTIFICATES OF SPECIFIC PRODUCT CONTROL IN ACCORDING TO PRESSURE EQUIPMENT DIRECTIVE 97/23/EC ANNEX I POINT 4.3.

MATERIAL CHARACTERISTICS COMPLY WITH POINT 7.5 OF ANNEX I TO PED BY HAVING AN ELONGATION AFTER RUPTURE AT



TUBACEX TUBOS  
INOXIDABLES  
INGENIERIA DE CALIDAD

*[Signature]*





**INSPECTION CERTIFICATE  
EN 10204 3.1**

Number: 519285	Rev: 00
Page: 3 / 3	

Created on: Date: 09.05.2011	Modified on:
---------------------------------	--------------

**REMARKS**

TENSILE TEST NO LESS THAN 14% AND A BENDING RUPTURE ENERGY AT IMPACT TEST NO LESS THAN 27J AT 20°C.

MATERIAL IS FREE OF RADIATION CONTAMINATION



**TUBACEX TUBOS  
INOXIDABLES**  
INGENIERIA DE CALIDAD



# METALLURGICAL TEST REPORT

NORTH AMERICAN STAINLESS  
6870 HIGHWAY 42 EAST  
GHENT, KY 41045

153070

6870 HIGHWAY 42 EAST

Mail To:

C.F.F. STAINLESS STEEL, INC.  
1840 BURLINGTON STREET E.  
HAMILTON, ON L8H3L4

Ship To:

C.F.F. STAINLESS STEEL, INC.  
1840 BURLINGTON STREET E.  
HAMILTON, ON L8H3L4

Date: 1/29/2013 Page: 1

Steel: 316/316L

Finish: BRAP

Corrosion: ASTM A262/02aK, 180Bend-OK

Your Order: C87097

NAS Order: IN 0161382 01

## PRODUCT DESCRIPTION

STAINLESS STEEL COIL, BRAP; UNS 31600/31603  
ASTM A240/11b, A480/11b, A666/10; ASME SA240/11a, SA480/11a, SA666/11a  
CHEM ONLY ON FOLLOWING ASTM: A276/10, A679/11, A484/11, A312/11  
CHEM ONLY ON FOLLOWING ASME: SA312/11, SA479/11  
AMS 5507F/5524L I MLK;  
NACE MR0175/ISO 15156-3:2003 A, MR0103/07; Q08766D-A I MAG PEEK  
HIS. SOLUTION ANNEAL TEMP 1900F, WATER QUENCHED

## REMARKS:

Mat'l is Free of Mercury Contamination. No weld repairs.  
EN 10204:2004 3.1; HOME 1 & 2 Compliant  
Material is Free of Radioactive Contamination  
NAS Steel Making Process: EAF, AOD, & Cont. Casting  
Product Mfg. by a Quality Mgt. Sys. in Conf. w/ISO 9001  
Melted & Manufactured in the USA, Mat'l is DPARS Compliant

Product Id	Coil #	Skid #	Thickness	Width	Weight	Length	Mark	Pieces	Commodity Code
04E9W8 A	04E9W8 A		.2460	60.0000	14,610	COIL		1	1

CHEMICAL ANALYSIS CM(Country of Mkt) ES(Spain) US(United States) ZA(South Africa) JP(Japan) Chemical Analysis per ASTM A751/08

HEAT	CM	C %	CR %	CU %	NI %	MO %	SI %	P %	S %
E9W8	US	.0139	16.6330	.4580	1.5125	2.0060	.0489	10.0750	.0365
									.0010

Q.C.I. N.D.

W.O. # 11730  
M.L. # 16(21314161758) (13)  
TRK. # - 249  
P.O. # 13-0165

## MECHANICAL PROPERTIES

Product Id#	Coil #	UTS	Y8	ELONG	Hard	Tail
04E9W8 A	04E9W8 A	88.77	47.88	49.59	84.00	87.50

Q.C.I. E.Y.

Certification of Material - Per ASME  
HT# E928  
Qualifies to all requirements of SA240-316 per Sect. II 10 Edition Addenda

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SRM OFFSHORE  
Print Name: GANESHSAN  
Signature: [Signature]  
Applus VELOSI  
Veloc America LLC

MAR 12 2013

NAS hereby certifies that the analysis on this certification is correct. Based upon the results and the accuracy of the test methods used, the material meets the specifications stated. These results relate only to the items analyzed. This report cannot be reproduced, except in its entirety, without the written approval of NAS.

Technical Dept. Mgr. ERIC HESS

1/31/2013



NORTH AMERICAN STAINLESS  
6870 HIGHWAY 42 EAST  
GHENT, KY 41045

# METALLURGICAL TEST REPORT

6870 HIGHWAY 42 EAST

Certificate: 809250 2 Mail To: Ship To: Date: 2/11/2013 Page: 1  
 ROLARK STAINLESS STEEL, INC. ROLARK STAINLESS STEEL, INC.  
 71 CONAIR PARKWAY 71 CONAIR PARKWAY  
 WOODBRIDGE, ON L4H0S4 WOODBRIDGE, ON L4H0S4  
 Customer: 007050 001

Your Order: 54026 NAS Order: DS 0002818 01 Corrosion: ASTM A262/02aE;180Bend-OK

## PRODUCT DESCRIPTION:

STAINLESS STEEL PLATE, HRAP; UNS 31600/31603  
 ASTM A240/11b, A480/11a, A666/10; ASME SA240/11a, SA480/11a, SA666/11a  
 CHEM ONLY ON FOLLOWING ASTM: A276/10, A479/11, A484/11, A312/11  
 CHEM ONLY ON FOLLOWING ASME: SA312/11, SA479/11  
 AMS 5507F/552AL X MRK;  
 NACE MR0175/ISO 15156-3:2003 A, MR0103/07; QQS766D-A X MAG PERM  
 MIN. SOLUTION ANNEAL TEMP 1900F, WATER QUENCHED

## REMARKS:

Mat'l is Free of Mercury Contamination. No weld repairs.  
 EN 10204:2004 3.1; RoHS 1 & 2 Compliant  
 Material is Free of Radioactive Contamination  
 NAS Steel Making Process: EAF, AOD, & Cont. Casting  
 Product Mfg. by a Quality Mgt. Sys. in Conf. w/ISO 9001  
 \*Melted & Manufactured in the USA; Mat'l is DFARS Compliant  
 EN 10204 3.1.B

ACC: 11730  
 for and on behalf of: *Shyvelo America*  
 Signature: *Mark July*  
 Date: *2/11/2013*  
**ACPLUS®**  
**VELOSI**  
 Velosi America LLC

Product Id	Plate#	Skid #	Thickness	Width	Weight	Length	Mark
05F2M9 AA	05F2M9 AA	PC3186	.4940	48.0000	1,670	240.00	1

## CHEMICAL ANALYSIS

US (United States) ES (Spain) CM (Country of Melt) ZA (South Africa) JP (Japan)

HEAT	CM	C %	CR %	CU %	MN %	MO %	N %	NI %	P %	S %
F2M9	US	.0182	16.7745	.4700	1.4880	2.0480	.0297	10.0300	.0400	.0015

SI %  
 .3000

W.O. # 11730  
 M.L.S. # 17(13)  
 THK. # .502  
 P.O. # 13-0203

Q.C.I.  
 N.D.

## MECHANICAL PROPERTIES

Product Id#	Plate#	1 d	UTS	.2% YS	ELONG	Hard	R of A
		KSI	KSI	%-2"	RB	%	
05F2M9 AA	05F2M9 AA	FT	85.73	39.06	56.10	72.00	75.52

MAR 12 2013

Q.C.I.  
 E.Y.

Certification of Material - Per ASME  
 HT# *Fam9*  
 Qualifies to all requirements of *SA 480-316/316L* per  
 Sect. II *10* Edition *II* Addenda

NAS hereby certifies that the analysis on this certification is correct. Based upon the results and the accuracy of the test methods used, the material meets the specifications stated. These results relate only to the items tested and this report cannot be reproduced, except in its entirety, without the written approval of NAS.

Technical  
 Dept. Mgr.

*Eric Hess*  
 ERIC HESS

2/11/2013

**ESSAR STEEL**

ESSAR STEEL ALGOMA INC., 105 West Street, Sault Ste. Marie, Ontario, Canada P6A 7B4

0005981

SO No., Item & Date: 8006515 000020 2013/01/05

Shipment No. & Date: 1000023647 2013/01/06

Customer PO No./Item: P007755 / 2

Customer Name and Address: QUALITY PLATES & PROFILES LTD  
 NICHOLAS BEAVER ROAD RR#3 20  
 ABERFOYLE, Ontario, Canada  
 N1H 6H9

Customer Specification: HR STEEL PLATE Carbon Multi Cert ASTM A516 GR 70 (10) / ASME SA516 GR 70 (11A) Meets NACE MR 0175 latest Ed. BHN < 200. D.O.CEQ. 43 max. Inclusion Shape Control Calcium Treated Normalized Temp 1670 - 1734 min. C.M.L. Flan. 15 / 12 FT LBF. at 0 - 50.0 F. Std Thickness Toll PVQ Top and Bottom Standard Surface Finishness 1/2 A20 Latest Ed + Addenda of ASME Code section II part A applies Fine Grain Fully Killed No Weld Repair

Customer PO No./Item: ESA 38932 2013/01/07 10 15 07

Customer Name and Address: P007755 / 2  
 1000023647  
 ROBINSON TRANSPORT LTD - 205(661)

Customer Use: PVQ

Supplementary Instructions: Test Cert 1519-937-2227

Inspection Report As Per Spec

ESSAR STEEL ALGOMA INC. HEREBY CERTIFIES THAT THE MATERIAL HEREIN DESCRIBED WAS MADE AND TESTED IN ACCORDANCE WITH THE RULES OF THE SPECIFICATION SHOWN. ALL RESULTS ARE RETAINED IN ACCORDANCE WITH THE COMPANY'S STANDARD RECORD KEEPING PRACTICES. THIS MILL TEST REPORT MAY NOT BE REPRODUCED EXCEPT IN FULL WITHOUT WRITTEN APPROVAL OF ESSAR STEEL ALGOMA INC. IF YOU RECEIVE THIS DOCUMENT AND ARE NOT THE INTENDED RECEIVER PLEASE CALL 1705 945-4026 FOR INSTRUCTIONS ON METHOD OF DISPOSAL OF DOCUMENT.

MEETS EN 10004 2004 TYPE J1

ISO 9001 AND ENVIRONMENTAL CERTIFICATE AVAILABLE AT WWW.ESSARSTEELALGOMA.COM

ALL HEATS FULLY KILLED  
 HEATS INDICATED WITH (\*) FINE GRAINED  
 HEATS INDICATED WITH (-) MADE IN CANADA WITH DOMESTIC AND NORTH AMERICAN MATERIALS

Dimensions (T x W x L)	Heat No.-MS	Quantity	No. of Pcs
1 0000" x 120 000" x 384 00"	AB8769	13 068 LB	1
1 0000" x 120 000" x 384 00"	AB8771	13 068 LB	1

Heat No. (wt%)	C	Mn	P	S	Si	Cr	Ni	Cu	Mo	Al	Nb	V	B	Ti	DO
2606P3*	0.20	1.06	0.012	0.004	0.340	0.02	0.15	0.02	0.01	0.027	0.000	0.014	0.0003	0.002	0.4000
2797P3*	0.19	1.00	0.009	0.005	0.310	0.02	0.15	0.03	0.00	0.024	0.000	0.015	0.0002	0.003	0.3900

MECHANICAL PROPERTIES

Heat No.	SRCE	LAB	GAUGE	COND	LOC	MTHO	HARDNESS
2606P3	166"	ALG	1 0000	NORM B	HBW	HBW	153
2606P3	166"	ALG	1 0000	NORM B	HBW	HBW	153
2797P3	166"	ALG	1 0000	NORM B	HBW	HBW	153

**LIMITS OF UNSPECIFIED ELEMENTS PER ASME SECTION II (SA-20)**

CU + Ni + CR + MO = 0.23  
 CR + MO = 0.03

W.O. # 11739  
 M.L. # 19 (7/3)  
 TRK. #  
 P.O. # 13-0220

Q.C.I. E.Y.  
 K. UGHADPAGA  
 MANAGER METALLURGICAL SERVICES

Q.C.I. N.D.

MILL TEST REPORTS APPROVED BY Q.C. P.O.

Certification of Material - Per ASME HT# 2606P3-56  
 Quantities to all requirements of SA 516 GR 70 per Sect. II 10 Edition Addenda

WARNING: THE TEST REPORTS AND WELLS REPORTED HEREIN INDICATE ONLY THAT THE PARTICULAR STEEL FOR WHICH THIS CERTIFICATE IS ISSUED MEETS THE MINIMUM SPECIFIED YIELD STRENGTH AND (2) THE ANALYSIS AND PHYSICAL PROPERTIES OF SUCH STEEL ARE IN CONFORMANCE WITH THE REQUIREMENTS OF THE SPECIFICATION INDICATED. THE ANALYSIS AND PHYSICAL PROPERTIES REPORTED HEREIN CAN NOT BE USED TO QUALIFY THE STEEL FOR ANY SPECIFICATION OTHER THAN THE ONE INDICATED AND CAN NOT BE RELIED UPON FOR ANY PURPOSE (INCLUDING DESIGN OR CALCULATION) EXCEPT AS SPECIFIED IN THE ACTUAL SPECIFICATION OF SUCH STEEL.

APR 19 2013

DATE 2013/01/07 Time 12 25 32 Page no 1 of 2

MAR 27 2013

Contact: HELENE/BRIAN  
 Inv: 1055184  
 Date: 03/19/2013  
 Heat: 2606P3



ESSAR STEEL ALGOMA INC., 105 West Street, Sault Ste. Marie, Ontario, Canada P6A 7B4

SO No., Item & Date:	8006515 000020 2013/01/05	Shipment No. & Date:	1000023647 2013/01/06	TC No., Date & Time:	ESA-38932 2013/01/07 - 10:15:07
Sold to Customer Name and Address:	QUALITY PLATES & PROFILES LTD NICHOLAS BEAVER ROAD RR#3 20 ABERFOYLE, Ontario, Canada N1H 6H9	Ship to Customer Name and Address:	QUALITY PLATES & PROFILES LTD NICHOLAS BEAVER ROAD RR#3 20 ABERFOYLE, Ontario, Canada N1H 6H9	Customer PO NO./Rem:	P007755 / 2
Customer Specification:	HR STEEL PLATE Carbon Multi Cert ASTM A516 GR 70 (10) / ASME SA516 GR 70 (11A) Meets NACE MR0175 latest Ed. BHN < 200, D Q CEQ .43 max. inclusion Shape Control Calcium Treated Normalized Temp 1670 °F 34 min CVN Req. 15' 12 FT-LBF at 0.50.0 F Std Thickness Tol PVQ Top and Bottom Standard Surface Flatness 1/2 A20 Latest Ed + Addenda of ASME Code section II part A applies Fine Grain Fully Killed No Weld Repair	Carrier:	ROBINSON TRANSPORT LTD - 205(661)	BOL NO:	1000023647
Supplementary Instructions:	Test Cert 1-519-837-2227	Cust. Part No.:			
Temp T/R:	Test Report As Per Spec	Curt Use:	PVQ		

ESSAR STEEL ALGOMA INC HEREBY CERTIFIES THAT THE MATERIAL HEREIN DESCRIBED WAS MADE AND TESTED IN ACCORDANCE WITH THE RULES OF THE SPECIFICATION SHOWN. ALL RESULTS ARE RETAINED IN ACCORDANCE WITH THE COMPANY'S STANDARD RECORD KEEPING PRACTICES. THIS MILL TEST REPORT MAY NOT BE REPRODUCED EXCEPT IN FULL WITHOUT WRITTEN APPROVAL OF ESSAR STEEL ALGOMA INC. IF YOU RECEIVE THIS DOCUMENT AND ARE NOT THE INTENDED RECEIVER, PLEASE CALL (705) 945-4009 FOR INSTRUCTIONS ON METHOD OF DISPOSAL OF DOCUMENT.

METS EN 10204 2004 TYPE 3.1  
 ISO QUALITY AND ENVIRONMENTAL CERTIFICATES AVAILABLE AT WWW.ESSARSTEELALGOMA.COM

MECHANICAL PROPERTIES												
Head No.	Batch No.	SRCE	LAB	GAUGE	COND	METH	DIR	LOC	SIZE	TEMP(°F)	ENERGY (ft-lbf)	
2606P3	A88769	166"	ALG	1.0000	NORM	CVN	L	B	FULL	-50	71 69 77	
2606P3	A88770	166"	ALG	1.0000	NORM	CVN	L	B	FULL	-50	59 61 73	
2797P3	A88771	166"	ALG	1.0000	NORM	CVN	L	B	FULL	-50	84 86 65	
Tensile Tests												
Head No.	Batch No.	SRCE	LAB	GAUGE	COND	METH	DIR	LOC	YIELD(KSI)	TENSILE(KSI)	EL SCALE	ELONG(%)
2606P3	A88769	166"	ALG	1.0000	NORM	2	T	B	49.5	78.2	2"	33
2606P3	A88770	166"	ALG	1.0000	NORM	2	T	B	49.0	77.1	2"	32
2797P3	A88771	166"	ALG	1.0000	NORM	2	T	B	50.7	77.2	2"	31

*Handwritten:* Velocity America 279  
 April 1, 2013

MAR 27 2013



APR 03 2013

K. UGHADEPAGA  
 MANAGER METALLURGICAL SERVICES

\*\*\*WARNING\*\*\* THE TEST RESULTS AND VALUES REPORTED HEREIN INDICATE ONLY THAT (1) THE PARTICULAR STEEL FOR WHICH THIS CERTIFICATE IS ISSUED MEETS THE MINIMUM SPECIFIED YIELD STRENGTH AND (2) THE MECHANICAL AND PHYSICAL PROPERTIES OF SUCH STEEL ARE IN CONFORMANCE WITH THE REQUIREMENTS OF THE SPECIFICATION INDICATED. THE RESULTS OR VALUES REPORTED HEREIN CAN NOT BE USED TO QUALIFY THE STEEL FOR ANY SPECIFICATION OTHER THAN THE ONE INDICATED AND CAN NOT BE RELIED UPON FOR ANY PURPOSE (INCLUDING DESIGN OR CALCULATIONS) AS REPRESENTING THE ACTUAL STRENGTH OF SUCH STEEL.



# METALLURGICAL TEST REPORT

NORTH AMERICAN STAINLESS  
6870 HIGHWAY 42 EAST  
GHENT, KY 41045

03855751

6870 HIGHWAY 42 EAST

Certificate: 809666 16  
Customer: 007050 001

Ship To:  
ROLARK STAINLESS STEEL, INC.  
71 CONAIR PARKWAY  
WOODBIDGE, ON L4H0S4

Date: 2/12/2013 Page: 1

Steel: 316/316L  
Finish: HRAP

Corrosion: ASTM A262/02aE; 180Bend-OK

NAS Order: DS 0002765 03

Your Order: 53951

## REMARKS:

Mat'l is Free of Mercury Contamination. No weld repairs.  
EN 10204:2004 3.1; RoHS 1 & 2 Compliant  
Material is Free of Radioactive Contamination  
NAS Steel Making Process: EAF, AOD, & Cont. Casting  
Product Mfg. by a Quality Mgt. Sys. in Conf. w/ISO 9001  
\*Melted & Manufactured in the USA; Mat'l is DFARS Compliant  
EN 10204 3.1.B

## PRODUCT DESCRIPTION:

STAINLESS STEEL CONT. MILL PLATE, HRAP; UNS 31600/31603  
ASTM A240/11b, A480/11b, A666/10; ASME SA240/11a, SA480/11a, SA666/11a  
CHEM ONLY ON FOLLOWING ASTM: A276/10, A479/11, A484/11, A312/11  
CHEM ONLY ON FOLLOWING ASME: SA312/11, SA479/11  
AMS 5507F/5524L X MRK;  
NACE MR0175/ISO 15156-3:2003 A, MR0103/07; QQS766D-A X MAG PERM  
MIN. SOLUTION ANNEAL TEMP 1900F, WATER QUENCHED

Product Id	Coil #	Skid #	Thickness	Width	Weight	Length	Mark	Pieces	Commodity Code
DE0841	05F3K0 B		.3748	48.0000	2,545 SHEETS	240.00	3	2	

CHEMICAL ANALYSIS CM(Country of Melt) ES(Spain) US(United States) ZA(South Africa) JP(Japan) Chemical Analysis Per ASTM A751/08

HEAT	CM	C %	CR %	CU %	MN %	MO %	N %	NI %	P %	S %
F3K0 ✓	US	.0157	16.5870	.3955	1.5420	2.0170	.0409	10.0100	.0340	.0010

SI %  
.3435

## MECHANICAL PROPERTIES

Product Id#	Coil #	UTS	.2% YS	ELONG	Hard	Tail
DE0841	05F3K0	F T 85.55	KSI 52.63	%-2" 49.68	RB 83.50	Hard 83.50

Q.C.I. N.D.

Q.C.I. E.Y.

W.O. # 11730  
M.L. # 20 (3/3, 4/3)  
I.H.K. # .382  
P.O. # 13-0221

MAR 14 2013

Certification of Material - Per ASME  
HT# F3K0  
Qualifies to all requirements of  
SA240-316/316L per  
Sect. II 10 Edition II Addenda

NAS hereby certifies that the analysis on this certification is correct. Based upon the results and the accuracy of the test methods used, the material meets the specifications stated. These results relate only to the items tested and this report cannot be reproduced, except in its entirety, without the written approval of NAS.

Technical  
Dept. Mgr.

Signature



**INSPECTION CERTIFICATE**  
**EN 10204 3.1**

Number: 516293 Page: 1 / 2	Rev: 00
Created on: Date: 01.04.2011	Modified on:

**TTI - TUBACEX TUBOS INOXIDABLES**

Registro Mercantil de Alava, Tomo 587, Folio 189, Hoja VI 2885 - N.I.F. A-01140227

Tres cruces, 8

01400 I. Iodio (Alava)

SPAIN

TL: +34 946719300

FAX: +34 946725062

E-MAIL: qualitytti@tubacex.es

**CUSTOMER DESCRIPTION**

<b>CLIENT SOLD TO</b> PINACLE STAINLESS STEEL INC. 455 AMBASSADOR DRIVE MISSISSAUGA, ONTARIO ON L5T 2J3 CANADA	<b>CLIENT SHIP TO</b> PINACLE STAINLESS STEEL INC. 455 AMBASSADOR DRIVE MISSISSAUGA, ONTARIO ON L5T 2J3 CANADA
--	--

CLIENT ORDER: 57733

SALES ORDER: 101551

MATERIAL: SEAML. STAINL. STEEL TUBES/PIPES,  
PICKLED-PASSIVATED

GRADE: TP316/316L,

STANDARD: ASTM A312M-09 / ASME SA312M ED.10

TOLERANCES: ASTM A999/A312

PLAIN ENDS,

DIMENSIONS: 4" SCH 40

HOT FINISHED

NACE MR0103-10 / MR0175 / ISO 15156-3 : 2009

W.O. # 1173  
M.L. # 21 (5/3)  
THK. # 244  
P.O. # 13-0243-REV1

Certification of Material - Per ASME  
HT# 43633  
Qualifies to all requirements of  
SA312-316/316L per  
Sect. II 10 Edition 11 Addenda

Sales Item	Client Item	Delivery Nr	Prod. Order	Insp. Lot	Heat Nr	Pieces	Weight	Tot Lgth	Un Lgth
130		8110006752	100323274	200038013	43633	15	1.718 KG	100,01 M	5791-7315 MM

RAW MATERIAL		Supplier	Method
Heat Nr:	43633	ACERALAVA	Electric furnace+AOD

CHEMICAL COMPOSITION (%)				*L: Ladle C:Products							
*	Heat	Seq	C	Mn	Si	P	S	Ni	Cr	Mo	
L	43633	1	0.013	1.43	0.510	0.021	0.0090	11.20	16.70	2.12	

**HEAT TREATMENT**  
SOLUT. ANNEALED 1040 °C RAPIDLY COOLED

TENSILE TEST		Sample T	Rp0.2	Rp1.0	Rm	A2"	A5	
Prod. Order	Insp. Lot	°C	N/mm2	N/mm2	N/mm2	%	%	
100323274	200038013	1	20	385	418	598	52	48

Q.C.I.  
E.Y.

Q.C.I.  
N.D.

MAR 26 2013

Reviewed  
V  
279  
RIS  
M/TI, 2013



**TUBACEX TUBOS INOXIDABLES**  
INGENIERIA DE CALIDAD  
*[Signature]*



**TUBACEX**

**INSPECTION CERTIFICATE  
EN 10204 3.1**

Number: 516293  
Page: 2 / 2

Rev: 00

Created on:  
Date: 01.04.2011

Modified on:

**HARDNESS TEST**

Prod. Order Ins. Lot ✓ Sample HRB1 HRB2  
100323274 200038013 1 88 89

**METALURGICAL TESTS**

INTERGRANULAR CORROSION TEST ACC. TO ASTM A262 PRACT."E": SATISFACTORY

**NON-DESTRUCTIVE TESTS**

100 % HYDROSTATIC PRESSURE TESTED AT 1400 PSI, DURING 5 SEC, GOOD.

POSITIVE MATERIAL IDENTIFICATION TEST ON EACH TUBE/PIPE BY  
"X-RAY-FLUORESCENCE-ANALYZER": SATISFACTORY

VISUAL INSPECTION ON EACH TUBE: SATISFACTORY

DIMENSIONAL CHECKING ON EACH TUBE: SATISFACTORY

**TECHNOLOGICAL TESTS**

FLATTENING TEST: SATISFACTORY

**MARKING**

TUBACEX 4" SCH 40 ASME SA312 ASTM A312 TP316 TP316L HF SMLS HEAT/  
PMI LOT NO/ SPAIN TX3 TX1

**REMARKS**

NO MERCURY, MERCURY COMPOUNDS OR MERCURY BEARING INSTRUMENTS AND/OR EQUIPMENT HAVE BEEN USED ALONG  
MANUFACTURING AND INSPECTION PROCESS.

NO WELD REPAIR WAS PERFORMED

MATERIAL MANUFACTURER APPROVED WITH CERTIFICATE NR. 07/2001/MUC BY TUV SÜDDEUTSCHLAND (NOTIFIED BODY 0036) TO  
ISSUE CERTIFICATES OF SPECIFIC PRODUCT CONTROL IN ACCORDING TO PRESSURE EQUIPMENT DIRECTIVE 97/23/EC ANNEX 1  
POINT 4.3.

MATERIAL CHARACTERISTICS COMPLY WITH POINT 7.5 OF ANNEX 1 TO PED BY HAVING AN ELONGATION AFTER RUPTURE AT  
TENSILE TEST NO LESS THAN 14% AND A BENDING RUPTURE ENERGY AT IMPACT TEST NO LESS THAN 27J AT 20°C.

MATERIAL IS FREE OF RADIATION CONTAMINATION



MAR 26 2013

*Renewal*  
*Amil 1, 2013*



**TUBACEX TUBOS  
INOXIDABLES**  
INGENIERIA DE CALIDAD





No/Nr/N° (A03)

24546300937484

Salzgitter Mannesmann Stainless Tubes France SAS (A01)

B.P.10 - F 21501 Montbard Cedex - FRANCE

www.smst-tubes.com

**INSPECTION CERTIFICATE**  
Abnahmeprüfzeugnis  
Certificat de réception

EN 10204: 2004 TYPE 3.1

(A02)

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Salzgitter Mannesmann Stainless Tubes France SAS - B.P.10 - F 21501 Montbard Cedex - FRANCE  
**SHAW ALLOY PIPING PRODUCTS**  
740 MARKET  
71107 SHREVEPORT  
Etats-Unis

Purchaser/Besteller/Acheteur

Customer order no./Kunde Auftragsnr./N° Commande client (A07)

PO#51684

SMST-Tubes order no./Auftragsnr./N° Commande (A08)

0000246463

SMST-Tubes Item

0000246463-000009

Product Description/Produkt Beschreibung/Description du produit (B01) (B02) (B04)

Seamless stainless hot finished pipe pickled and passivated / Tubes finis à chaud sans soudure, décapés et passivés

Specifications/Spezifikationen/Spécifications

ASME SA 312 11 a / ASME SA 376 11 a / ASTM A 312 11 / ASTM A 376 08 / NACE MR0103 2007 / NACE MR0175/ISO 15168-3 2009

Grade/Werkstoff/Nuance TP 316 / TP 316L

Tolerances/Toleranzen/Tolérances A 312

Marking of the product/Kennzeichnung des Produktes/Marquage du produit (B08-D01)

WO : 324546300901 - DMV-F - ASTM A 376 / ASTM A 312 / ASME SA 376 / ASME SA 312 - TP 316 / TP 316L - NPS 4 X SCH 120 - 23.43 FT - SML - 449090 - QL30037484 - FRANCE

Quantity/Menge/Quantité						Dimensions		Abmessungen	
Heat no Schmelze Nr. N° de Coulée	Quality lot Qualitätslos Lot qualité	SMST Item	Pieces Stück Pièces (B08)	Total weight Gesamtwicht Masse totale (B13)	Total length Gesamtlänge Longueur totale	OD (B09)	WT (B10)	Tube length Rohrlänge Longueur tube min (B11) max	
449090	QL30037484	000009	7	1454.00 Kg 3206 Lbs	49.370 m 161.98 Ft	114.30 mm NPS 4	11.19 mm SCH 120	8098 mm 20.00 Ft	7316 mm 24.00 Ft

Chemical Analysis / Chemische Zusammensetzung / Analyse chimique (C71 - C92)

Heat no./Schmelzen Nr./N° de coulée 449090

Melting Process/Erschmelzungsart/Élaboration (C70) VOD

Heat Origin/Urspr. der Schmelze/Origine de la Coule Germany

Heat Analysis / Analyse de coulées

	C	Si	Mn	P	S	Cr	Ni	Mo
Min	0.00	0.00	0.00	0.00	0.00	18.00	11.00	2.00
Max	0.030	0.75	2.00	0.045	0.0300	18.00	14.00	3.00
	0.018	0.37	1.81	0.025	0.008	18.75	11.44	2.14

Certification of Material - Per ASME

HT# 449090

Qualifies to all requirements of

SAB 12-316/316L per  
Sect. II 10 Edition II Addenda

APR 24 2013



W.O. # 1173  
M.L. # 23 (1/4, 3/4)  
THK. # 443  
P.O. # 13-0243-REV

This certificate is issued by a computerized system and is valid without signature. In case the owner of the original would release a copy of it he must attest its conformity and will be responsible for any unauthorized or illegal use. Any alterations or falsification will be subject to law.  
Dieses Zeugnis bzw. diese Beschreibung wurde mit Hilfe der EDV erstellt und ist ohne Unterschrift gültig. Veränderungen sowie Verweigerung der andern Erzeugnisse werden als Urkundenfälschung und Betrug strafrechtlich verfolgt.  
Ce certificat est rédigé à l'aide d'un traitement électronique de données et est applicable sans signature. Tout changement ou application pour d'autres produits seront considérés comme falsification de documents et fraude et seront sujet à la juridiction pénale.

Salzgitter Mannesmann Stainless Tubes France SAS ISO9001 - LROA N°928418

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SDM Offshore  
Print Name: DANESH SAH  
Signature: [Signature]  
Date: 13/04/13  
Applus<sup>®</sup> VELOSI  
Velosi America LLC

046



Salzgitter Mannesmann Stainless Tubes France SAS (A01)  
B.P.10 - F 21501 Monibard Cedex - FRANCE  
www.emsl-tubes.com

Page/Selle  
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No/Nr/N° (A03)  
24548300937484

**INSPECTION CERTIFICATE**  
Abnahmeprüfzeugnis  
Certificat de réception  
EN 10204: 2004 TYPE 3.1 (A02)

**Mechanical testing**

Quality Lot : QL30037484

Tensile test at room temperature/Zugversuch bei Raumtemperatur/Essai de traction à température ambiante (C10)

ASTM A 370

Test no Proben Nr. N° d'échantillon (C00)	Direction Probenricht- ung Direction (C02)	Yield strength/Dehngrenze/Limite d'élasticité (C11)			Tensile strength / Zugfestigkeit / Résistance à la traction (C12)	Elongation/Bruchdehnung/Allongement (C13)					Reduction of area Z%		
		0.2 %	0.5 %	1 %		2"	50 mm	5D	6,85 √So	4D			
		ksi	/	/		ksi	%	/	/	/		/	/
		Mln	30	/	/	75	35	/	/	/	/	/	/
		Max	/	/	/	/	/	/	/	/	/	/	/
30128250	LONGITUDINAL	47.67	/	/	87.20	49.75	/	/	/	/	/	/	/

Hardness test/Härteprüfung/Essai de dureté (C30)

NACE MR0175/ISO 15166-3 NACE MR0103

Test no Proben Nr. N° d'échantillon	Load /																					
	HB			HRC			HV			HRB			HR 15-T			HR 30-T						
	Mln	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	
	Max	/	/	/	22	22	22	/	/	/	/	/	/	/	/	/	/	/	/	/	/	
		mfn	max	avg	mfn	max	avg	mfn	max	avg	mfn	max	avg	mfn	max	avg	mfn	max	avg	mfn	max	avg
30128250		/	/	/	< 18	< 18	< 18	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/

Flattening test/Faltversuch/Essai d'aplatissement (C60)

ASTM A 999

Test Number	Result
30128249	OK
30128250	OK

APR 24 2013

**Other testing**



Quality Lot : QL30037484

This certificate is issued by a computerized system and is valid without signature. In case the owner of the original would release a copy of it he must attest its conformity and will be responsible for any unlawful or not allowed use. Any alterations or falsification will be subject to law.

Dieses Zeugnis bzw. diese Bescheinigung wurde mit Hilfe der EDV erstellt und ist ohne Unterschrift gültig. Veränderungen sowie Verwendung für andere Erzeugnisse werden als Urkundenfälschung und Betrug strafrechtlich verfolgt.

Ce certificat est rédigé à l'aide d'un traitement électronique de données et est applicable sans signature. Tout changement ou application pour d'autres produits seront considérés comme falsification de documents et fraude et seront sujet à la juridiction pénale.

Salzgitter Mannesmann Stainless Tubes France SAS ISO9001 - LRQA N° 825478

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: S.B.M. OFFSHORE  
Print Name: GAMESHA SAITH  
Signature: [Signature]  
Date: July 14/13  
046  
Applus®  
VELOSI  
Velosi America LLC



No/Nr/N° (A03)

24546300937484

Salzgitter Mannesmann Stainless Tubes France SAS (A01)

B.P.10 - F 21501 Montbard Cedex - FRANCE

www.smt-tubes.com

INSPECTION CERTIFICATE

Abnahmeprüfzeugnis

Certificat de réception

EN 10204: 2004 TYPE 3.1

(A02)

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Intergranular corrosion test/Prüfung Interkristalliner Korrosion/Essai de corrosion Intergranulaire

MIL-P-24691/3 Feb, 1991 Ad 1 ASTM A 282 PRACTICE E

Test Number	Result
30128249	Satisfactory
30128250	Satisfactory

This certificate is issued by a computerized system and is valid without signature. In case the owner of the original would release a copy of it he must attest its conformity and will be responsible for any unauthorised or not allowed use. Any alteration or falsification will be subject to law.

Dieses Zeugnis bzw. diese Bescheinigung wurde mit Hilfe der EDV erstellt und ist ohne Unterschrift gültig. Veränderungen sowie Verwendung für andere Erzeugnisse werden als Urkundenfälschung und Betrug strafrechtlich verfolgt.

Ce certificat est rédigé à l'aide d'un traitement électronique et est valide sans signature. Tout changement ou application pour d'autres produits seront considérés comme falsification de documents et fraude et seront sujets à la juridiction pénale.



No/Nr/N° (A03)

24546300937484

Salzgitter Mannesmann Stainless Tubes France SAS (A01)

B.P. 10 - F 21501 Montbard Cedex - FRANCE

www.smst-tubes.com

**INSPECTION CERTIFICATE**  
Abnahmeprüfzeugnis  
Certificat de réception

EN 10204; 2004 TYPE 3.1

(A02)

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Other Tests and Declarations / Andere Prüfungen und Prüferstellungen / Autres tests et déclarations

QL30037484

Visual and dimensional inspection (VT) / Beschichtigung und Masskontrolle / Examen visuel et dimensionnel : Satisfactory/Bestanden/Satisfaisant

Heat Treatment / Wärmebehandlung / Traitement Thermique / Annealed : Temperature : > 1040°C 1804°F Rapid cooling

Hydrostatic Test / Wasserdichtdruckversuch / Essai Hydraulique : 190 BARS / 5 sec

Analysis check (PMI) of all tubes by spectrographic analysis / Verwechslungsprüfung an allen Rohren mittels Spektroskopie / Contrôle anti-mélange par PMI 100% : Satisfactory/Bestanden/Satisfaisant

No Weld repair / Keine Reparaturerschweißung / Aucune réparation par soudure

The material is conforming to directive 2000/53/EC, 2002/95/EC and CD 2005/618/EC. / Das Material entspricht den Anforderungen der Richtlinien 2000/53/EC, 2002/95/EC und CD 2005/618/EC. / Le matériau est conforme aux directives 2000/53/EC, 2002/95/EC et CD 2005/618/EC.

Tubes are free from mercury contamination and from radioactive contamination / Die Rohre sind frei von Quecksilberverunreinigungen und frei von radioaktiver Verunreinigung / Les tubes sont exempts de contamination par le mercure et de contamination radioactive

Confirmation with reference to Pressure Equipment Directive 97/23/EC:

The works operates a quality management system that has undergone a specific assessment for materials for pressure equipment and is certified by a competent body (TÜV-SÜD CERT.No:05/2011/MAN)

Bestätigung in Bezug auf Druckgeräterichtlinie 97/23/EC:

Das Werk wendet ein Qualitätsmanagementsystem an, das in Bezug auf Werkstoffe für Druckgeräte einer spezifischen Bewertung unterzogen wurde und von einer zuständigen Stelle (TÜV-SÜD CERT.No:05/2011/MAN) zertifiziert ist.

Confirmation concernant la Directive Equipements sous Pression 97/23/EC : L'usine applique un système de management de la qualité qui a fait l'objet d'une évaluation spécifique pour les matériaux pour équipements sous pression et qui est certifié par un organisme compétent (TÜV-SÜD CERT.No:05/2011/MAN)

SMST certify that the delivered products comply with the requirements stipulated in the order. / Die Erzeugnisse wurden bestellungsgemäß geprüft und für die Ordnung befunden. / SMST-Tubes atteste que les produits livrés sont conformes aux stipulations de la commande.

Validation by manufacturer's representative / Validierung durch Vertreter des Herstellers

Main Inspector  
Werksachverständiger T POMMERY  
Le contrôleur usine

Date of edition  
Ausgabedatum 11/10/2012  
Date d'édition

This certificate is issued by a computerized system and the valid without signature. In case the owner of the original would release a copy of it, he must attest its conformity and will be responsible for any untruthful or not altered use. Any alterations or falsification will be subject to law.

Dieses Zeugnis bzw. diese Bescheinigung wurde mit Hilfe der EDV erstellt und ist ohne Unterschrift gültig. Verwendungen sowie Veränderungen für andere Erzeugnisse werden als Unwahrheitsbehauptung und Betrug strafrechtlich verfolgt.

Ce certificat est rédigé à l'aide d'un traitement électronique de données et est applicable sans signature. Tout changement ou application pour d'autres produits seront considérés comme falsification de documents et fraude et seront sujet à la justice pénale.



**INSPECTION CERTIFICATE**  
EN 10204 3.1

Number: 516297 Rev: 00  
Page: 1 / 2

Created on: Modified on:  
Date: 01.04.2011

**TTI - TUBACEX TUBOS INOXIDABLES**

Registro Mercantil de Alava, Tomo 587, Folio 189, Hoja VI 2885 - N.I.F. A-01140227  
Tres cruces, 8  
01400 Llodio (Alava)  
SPAIN

TL: +34 946719300  
FAX: +34 946725062  
E-MAIL: qualitytti@tubacex.es

**CUSTOMER DESCRIPTION**

<b>CLIENT SOLD TO</b> PINACLE STAINLESS STEEL INC. 455 AMBASSADOR DRIVE MISSISSAUGA, ONTARIO ON L5T 2J3 CANADA	<b>CLIENT SHIP TO</b> PINACLE STAINLESS STEEL INC. 455 AMBASSADOR DRIVE MISSISSAUGA, ONTARIO ON L5T 2J3 CANADA
--	--

**CLIENT ORDER:** 57733  
**SALES ORDER:** 101551

MATERIAL: SEAML. STAINL. STEEL TUBES/PIPES,  
PICKLED-PASSIVATED  
GRADE: TP316/316L,  
STANDARD: ASTM A312M-09 / ASME SA312M ED.10  
TOLERANCES: ASTM A999/A312  
PLAIN ENDS,  
DIMENSIONS: 3" SCH 160  
HOT FINISHED  
NACE MR0103-10 / MR0175 / ISO 15156-3 : 2009

W.O. # 11730  
M.L. # 24 (274)  
THK. # 436  
P.O. # 13-0243-REV1

Q.C.I.  
E.Y.

Q.C.I.  
N.D.

MAR 26 2013

Certification of Material - Per ASME  
HT# 43633  
Qualifies to all requirements of  
SA312-316/316L per  
Sect. II 10 Edition II Addenda

Sales Item	Client Item	Delivery Nr	Prod. Order	Insp. Lot	Heat Nr	Pieces	Weight	Tot Lgth	Un Lgth
180		8110006752	100323250	200037778	43633	8	1.091 KG	47,95 M	5791-7315 MM

<b>RAW MATERIAL</b>		
Heat Nr:	Supplier	Method
43633	ACERALAVA	Electric furnace+AOD

CHEMICAL COMPOSITION (%)											
*	Heat	Seq	C	Mn	Si	P	S	Ni	Cr	Mo	
L	43633	1	0,013	1,43	0,510	0,021	0,0090	11,20	16,70	2,12	

**HEAT TREATMENT**  
SOLUT.ANNEALED 1040 °C RAPIDLY COOLED

TENSILE TEST									
Prod. Order	Insp. Lot	Sample	T	Rp0.2	Rp1.0	Rm	A2"	A5	
			°C	N/mm2	N/mm2	N/mm2	%	%	
100323250	200037778	1	20	432	472	625	54	48	

Q.C.I.  
N.D.

Review  
RD  
Apr 11 2013  
Velosi America  
V  
279



TUBACEX TUBOS  
INOXIDABLES  
INGENIERIA DE CALIDAD  
*[Signature]*



**INSPECTION CERTIFICATE  
EN 10204 3.1**

Number: 516297	Rev: 00
Page: 2 / 2	

Created on: Date: 01.04.2011	Modified on:
---------------------------------	--------------

**HARDNESS TEST**

Prod. Order	Ins. Lot	Sample	HRB1	HRB2
100323250	200037778	1	88	89

**METALURGICAL TESTS**

INTERGRANULAR CORROSION TEST ACC. TO ASTM A262 PRACT."E": SATISFACTORY

**NON-DESTRUCTIVE TESTS**

100 % HYDROSTATIC PRESSURE TESTED AT 2500 PSI, DURING 5 SEC, GOOD.

POSITIVE MATERIAL IDENTIFICATION TEST ON EACH TUBE/PIPE BY  
"X-RAY-FLUORESCENCE-ANALYZER": SATISFACTORY

VISUAL INSPECTION ON EACH TUBE: SATISFACTORY

DIMENSIONAL CHECKING ON EACH TUBE: SATISFACTORY

**TECHNOLOGICAL TESTS**

FLATTENING TEST: SATISFACTORY



*Revised*  
*April 1, 2013*

**MARKING**

TUBACEX 3" SCH 160 ASME SA312 ASTM A312 TP316 TP316L HF SMLS HEAT/  
PMI LOT NO/ SPAIN TX3 TX1

**REMARKS**

NO MERCURY, MERCURY COMPOUNDS OR MERCURY BEARING INSTRUMENTS AND/OR EQUIPMENT HAVE BEEN USED ALONG  
MANUFACTURING AND INSPECTION PROCESS.

NO WELD REPAIR WAS PERFORMED

MATERIAL MANUFACTURER APPROVED WITH CERTIFICATE NR. 07/2001/MUC BY TÜV SÜDDEUTSCHLAND (NOTIFIED BODY 0036) TO  
ISSUE CERTIFICATES OF SPECIFIC PRODUCT CONTROL. IN ACCORDING TO PRESSURE EQUIPMENT DIRECTIVE 97/23/EC ANNEX 1  
POINT 4.3.

MATERIAL CHARACTERISTICS COMPLY WITH POINT 7.5 OF ANNEX 1 TO PED BY HAVING AN ELONGATION AFTER RUPTURE AT  
TENSILE TEST NO LESS THAN 14% AND A BENDING RUPTURE ENERGY AT IMPACT TEST NO LESS THAN 27J AT 20°C.

MATERIAL IS FREE OF RADIATION CONTAMINATION



**TUBACEX TUBOS  
INOXIDABLES**  
INGENIERIA DE CALIDAD

*[Signature]*



# METALLURGICAL TEST REPORT

NORTH AMERICAN STAINLESS  
801 TWIN RAIL DRIVE  
MINOOKA, IL 60447

## NORTH AMERICAN STAINLESS

Ship To:  
ROLLED ALLOYS  
125 W. STEERS RD.  
TEMPERANCE, MI 48182

Date: 3/21/2006 Page: 1

Steel: 316/316L

Finish: ENAF

Corrosion: ASTM A262/02aE; 1808-end-OK

Customer: 002830 001

Temp: 48182

REMARKS:

Material free from mercury contamination. No weld repairs.  
EN 10204 3.1 FED 97/23/EC Annex1, Para. 4.3 QQS7637 Cond A  
Material is NiORS-Compliant  
EN 10204 3.1.B  
ENACE NBO 175 EN 10204 3.1.B  
Melted & Manufactured in the USA

Product Order: IN 0006185 01

## PRODUCT DESCRIPTION:

STAINLESS STEEL PLATE, HOT ROLLED, ANNEALED AND PICKLED.  
ASTM A240/05a, 480/05, 666/03, ASME SA240/04-A05, 480/04-A05, SA666/04  
ASTM A240/05a, 480/05, 666/03, ASME SA240/04-A05, 480/04-A05, SA666/04  
(X GRAIN), QQS766D-A X MG PERM, AMS55077/AMS5526K X MKK  
Chem only for following: ASTM A276/A312/M79, ASME SA312/SA479

## Product Id

Product Id	Coil #	Thickness	Width	Weight	Length	Mark	Pieces	Commodity Code
0991N3 HC	0991N3 HC	.4960	48.0000	1,005 PLATE	144.00	4	1	

ACCEPTED/REVIEWED/RELEASED

for and on behalf of: SPM OFFSHORE  
Print Name: JAMESH SAHAI  
Signature: [Signature]  
Date: 4/10/13

046  
Applus®  
VELOSI  
Velosi America LLC

## CHEMICAL ANALYSIS

Heat	CM	C	CR	CU	MN	MO	N	NI	P	S	SI
91N3	US	.017	16.952	.712	1.527	2.096	.046	10.232	.033	.002	.130

JUN 12 2006

## MECHANICAL PROPERTIES

Product Id#	Coil #	UTS KSI	2% YS KSI	ELONG %-2"	Hard RB
0991N3 HC F T	0991N3 HC F T	80.82	37.73	58.95	76.50

Certification of Material - Per ASME

HT# 91N3  
Qualifies to all requirements of SA240-316/316L per Section II Edition II Addenda

Q.C.I. N.D.

TRACER# 129838

APR 24 2013

ROLLED ALLOYS QUALITY ASSURANCE  
APPROVED [Signature]  
DATE 3-27-06

Q.C.I. E.V.

QC ENGINEER

[Signature]

ERIC HESS

3/21/2006

OCT 12 2006

**VIRAJ IMPOEXPO LIMITED**

10, IMPERIAL CHAMBERS, 1ST FLOOR  
WILSON ROAD, BALLARD ESTATE  
MUMBAI - 400 038 INDIA

**TEST CERTIFICATE**

**CUSTOMER :**

FIDELITY STAINLESS LTD.  
2213 NORTH SHERIDAN WAY  
MISSISSAUGA, ON L5K 1A3  
CANADA

**ORDER NO .**  
P-573

**BUNDLE NO .**  
130997

**PACKING LIST NO.**  
IMP/13802

**INSPECTION NO**  
IMP/13802/8

**DATE**  
10/12/2004

**GRADE**  
316/316L

**DESCRIPTION :**

STAINLESS STEEL BRIGHT BARS

**SMOOTH TURNED**

SIZE (INC)	SHAPE	TOLERANCE	LENGTH (FT)	PIECES	WEIGHT (LBS)
1/2	ROUND	ASTM A484	12' - 14'	226	1850

**CHEMICAL ANALYSIS**

HEAT NO.

67624

C	Mn	Si	S	P	Ni	Cr	Mo	Cu	N	Co
0.024	1.58	0.44	0.020	0.037	10.16	16.21	2.05	0.50	0.078	0.18

**TEST RESULT**

.2% YIELD STRENGTH KSI	TENSILE STRENGTH KSI	ELONGATION %	REDUCTION OF AREA %	HARDNESS BHN	GRAIN SIZE
71	91	47	75	187	6

**Specification :**

MATERIAL CONFIRMS TO ASTM A276-00/A 479-01/A484-00/A282-00 PRACTICE E, RMS 80, ASTM A168-01b BSM CL1, A308-01ED, A182-01a AMS 8848/5053E, ASME SA-182-00ED, SA479-00ED, SA-182-00 BSM C L1, QQ-S-783F, MILL-S-7720A AM2, NACE-MR-01-75-99, UNS S316 00/S31603, ASTM E 112-06 (GRAIN SIZE), CERTIFICATION AS PER EN 10204-3.1B

**Remarks :**

MATERIAL IS FREE MERCURY CONTAMINATION, FREE FROM WELD OR WELD REPAIRS, MICRO-FREE FROM CONTINUOUS CARBIDE NETWORK ON GRAIN BOUNDARIES, MACRO-GOOD, MINIMUM SOLUTION ANNEALING TEMPERATURE 1060C, WATER QUENCHED.

We hereby certified that the material described above has been tested and complies with the terms of order/contract.

Certification of Material - Per ASME  
HT# 67624  
Qualifies to all requirements of  
SA479-316/316L per  
Sect. II 10 Edition II Addenda

W.O. # 11730  
M.L. # 270614  
THK. # 499  
P.O. # B604-110411

*K.R.K. Murthy*  
**WORKS INSPECTOR**  
( K. R. K. MURTHY )

Q.C.I.  
N.D.

APR 24 2013

Q.C.I.  
E.Y.

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SAM OFFSHORE  
Print Name: GANESH SAHAI  
Signature: [Signature]  
Date: JULY 10 2013  
**Applus<sup>®</sup> VELOSI**  
Velosi America LLC





14527 Smith Rd.  
Humble, Texas 77396  
TEL: (281) 441-4088  
FAX: (281) 441-8899

REPORT NUMBER 74244

DATE 4/23/2013

FCI ORDER NUMBER 60030

Processed I.A.W. EN10204 3.1  
I.A.W. NACE MR0175

CUSTOMER ORDER NUMBER 13-0266  
SOLD/SHIPPED TO ALL-WELD CO., LTD.  
49 PASSMORE AVE.

SCARBOROUGH ONT MIV 4T1 CANADA

Item Quantity Description

1	4	8" X 900 X 13.25" LG RTJ LWN	ITEM# 1173-40
2	4	8" X 900 X RTJ BLIND	ITEM# 1173-41

HEAT NUMBER:  
N434

MATERIAL TYPE:  
SA182F316/L

Manufactured in  
USA

I.A.W. ASME 2010 ED 11AD.

CHEMICAL ANALYSIS

PHYSICAL PROPERTIES

C .027 ✓  
Mn 1.160 ✓  
P .0290 ✓  
S .0250 ✓  
Si .350 ✓  
Cr 17.450 ✓  
Mo 2.030 ✓

Yield PSI 47,000 ✓  
Tensile PSI 86,000 ✓  
Elongation 77.1 ✓  
Reduction of Area 79.6  
Hardness 176 HBW

Q.C.I.  
N.D.

10.310 ✓  
N .0980

Certification of Material - Per ASME  
HT# N434  
Qualifies to all requirements of  
SA182-F316/316L per  
Sect. II 10 Edition 11 Addenda

W.O. # 11730  
M.L. # 40(5/12)41C(8/11)  
THK. # 1.962  
P.O. # 13-0266

Heat Treatment SOLUTION ANNEALED  
Temperature 1900 °F  
Time at Temperature  
Cooling Media WATER

ACCEPTED/REVIEWED/RELEASED 046  
for and on behalf of: SBM Offshore  
Print Name: G.A. Velosi MAY 27 2013  
Signature: [Signature]  
Date: July 19 13  
Applus® VELOSI  
Velosi America LLC

Immediately following hot working, while at temperature above, parts were rapidly quenched.

We hereby certify that all test results and process information contained herein are correct and true as contained in the records of the company.

Prepared by [Signature]

Name: Helen Fielder Title: QA Representative



14527 Smith Rd.  
Humble, Texas 77396  
TEL: (281) 441-4088  
FAX: (281) 441-8899

REPORT NUMBER 74420

DATE 4/26/2013

FCI ORDER NUMBER 60028

Processed I.A.W. EN10204 3.1  
I.A.W. NACE MR0175

CUSTOMER ORDER NUMBER 13-0279  
SOLD/SHIPPED TO ALL-WELD CO., LTD.  
49 PASSMORE AVE.

SCARBOROUGH ONT MIV 4T1 CANADA

Item Quantity Description

1 4 2" X 900 RTJ WN S/160

ITEM# 1173-46

HEAT NUMBER:  
N432

MATERIAL TYPE:  
SA182F316/L

Manufactured in  
USA

I.A.W. ASME 2010 ED 11AD.

CHEMICAL ANALYSIS

PHYSICAL PROPERTIES

C .017 ✓  
Mn 1.730 ✓  
P .0280 ✓  
S .0220 ✓  
Si .450 ✓  
Cr 16.300 ✓  
Mo 2.090 ✓

Yield PSI 47,100 ✓  
Tensile PSI 87,500 ✓  
Elongation 60.2 ✓  
Reduction of Area 78.1  
Hardness 156 HBW

Ni 10.120 ✓  
.0720

W.O. # 11730  
M.L. # 46 (8/2)  
THK. # 24 160 407  
P.O. # 13-0279

N13  
Certification of Material - Per ASME  
HT# N432  
Qualifies to all requirements of  
SA182-F316/316L per  
Sect. II TC Edition 11 Addenda



MAY 27 2013

Heat Treatment SOLUTION ANNEALED  
Temperature 1925 °F  
Time at Temperature  
Cooling Media WATER

Immediately following hot working, while at temperature above, parts were rapidly quenched.

We hereby certify that all test results and process information contained herein are correct and true as contained in the records of the company.

Prepared by

Name: Helen Fielder

Title: QA Representative

ACCEPTED/REVIEWED/RELEASED 046  
for and on behalf of: SIMON OFF SHOOTER  
Print Name: GANESH SAHA  
Signature: [Signature]  
Date: July 17 103  
Applus® VELOSI  
Velosi America LLC

# L PALACE PIPE CO., LTD

## TEST CERTIFICATE

W.O. # 11739  
 M.L. # 42(1/2, 2, 1/2, 1/2)  
 THK. # 0.150  
 P.O. # 13-0707

CRYS

CERTIFICATE (No.: QAC0021058/A)

DATE OF ISSUE: 2013/7/16

CUSTOMER	ACCEPTED/REVIEWED/RELEASED for and on behalf of SHANGHAI CRYSTAL PALACE PIPE CO., LTD									
P.O. NO.	CERTIFICATE NO.: 2013-05-021-I-17									
COMMODITY: STAINLESS STEEL SEAMLESS PIPE.	ORDER NO.: 2013-05-021-I									
CONDITION: COLD FINISH / SOLUTION TREATED / PICKLED / PLAIN END	GRADE: ASTM A312-12 TP316/316L									
CHEMICAL CONTENTS (WT%)	HEAT NO.: YT22057									
ELEMENTS	C	Mn	P	S	Si	Ni	Cr	Mo		
SPECIFICATION	≤ 0.035	≤ 2.00	≤ 0.045	≤ 0.030	≤ 1.00	11.0~14.0	16.0~18.0	2.00~3.00		
RESULTS (LADLE)	0.024	1.06	0.039	0.004	0.34	11.07	16.71	2.07		

### PHYSICAL PROPERTIES

NPS	Dimensions		Bundle No.	Pieces	Weight (kg)	0.2%YS (Mpa)	TS (Mpa)	EL (%)	FLATTENING TEST	HARDNESS HRB	EDDY CURRENT TEST (100%)
	W.T (SCH)	Length (feet)									
2"	40S	20	Z13-5-295	250	8428	≥ 205	≥ 515	≥ 35	OK	---	OK

REMARKS:  
 AS PER A312-12/SA312-10  
 IN COMPLIANCE TO NACE MR0175-2003, MR0175/ISO 15156  
 SOLUTION HEAT TREATMENT: 1050°C X 1.5m/min  
 NO WELD REPAIR WAS PERFORMED  
 FREE FROM MERCURY CONTAMINATION  
 FREE FROM RADIATION CONTAMINATION  
 IC TESTING ACCORDANCE TO ASTM A262 E - SATISFACTORY  
 COUNTRY OF ORIGIN: CHINA  
 PMI TESTING DONE.  
 MATERIAL TEST CERTIFICATE TO EN 10204/3.1  
 IN COMPLIANCE TO NACE MR0103-2003

1. WE HEREBY CERTIFY THAT THE MATERIAL DESCRIBED HEREIN HAS BEEN TESTED AND THE TEST RESULTS ARE IN COMPLIANCE WITH THE TERMS OF THE PURCHASE ORDER OR CONTRACT  
 2. THE CERTIFICATE SHALL NOT BE REPRODUCED, EXCEPT IN FULL, WITHOUT THE WRITTEN APPROVAL OF THE COMPANY.

SHANGHAI CRYSTAL PALACE PIPE CO., LTD  
 Dingwei Guo  
 MANAGER OF QUALITY ASSURANCE DEPARTMENT / DING WEI-GUO

APPROVED  
 VERIFIED  
 STAINLESS  
 PINGSHI  
 WELDS  
 Vitol America LLC  
 Signature: [Signature]  
 Date: 2013/7/16



Outokumpu Stainless Plate, Inc.



Certificate of Analysis and Tests

OUR ORDER 0252379 - 13

HEAT & PIECE 836433-1E 06/23/06

SOLD TO: INTEGRIS METALS LTD. - Etobicoke SHIP TO: INTEGRIS METALS LTD. - Etobicoke  
 161 THE WEST MALL 161 THE WEST MALL  
 ETOBICOKE, ON M9C 4V8 ETOBICOKE, ON M9C 4V8

YOUR ORDER & DATE  
 539197 4/12/06 TAG# 7581-2043

HEAT & PIECE 836433 - 1E  
 WEIGHT 2782  
 FINISH 1  
 GRADE 316L / 316  
 DIMENSIONS .375 X 96.000 X UNS-S31603 / UNS-S31600  
 253.000 EXACT COUNTRY OF ORIGIN BRT

SPECIFICATIONS  
 FROM SLABS IMPORTED FROM BRITAIN  
 ASTM A240-06  
 ASTM A262-02A PRACTICE A  
 NO CRIPPER MARKS

PLATES & TEST PCS SOLUTION ANNEALED @ 1950 DEGREES FAHRENHEIT MINIMUM.  
 THEN WATER COOLED OR RAPIDLY COOLED BY AIR  
 FREE FROM MERCURY CONTAMINATION AT CURRENT DETECTION LIMITS  
 HOT ROLLED, ANNEALED & PICKLED (HRAP)

MECHANICAL & OTHER TESTS  
 HARDNESS RB 81  
 GRAIN SIZE 6  
 YIELD STRENGTH (PSI) 48161  
 TENSILE STRENGTH (PSI) 85640  
 BEND OK  
 INTERGRANULAR CORROSION OK  
 ELONGATION % IN 2" 52.8  
 REDUCTION OF AREA % 65.8

Certification of Material - Per ASME  
 HT# 836433-1E  
 Qualifies to all requirements of  
 SA 240-316L per  
 Sect. II 10 Edition II Addenda

CHEMICAL COMPOSITION  
 CARBON (C) .018 ✓  
 MANGANESE (MN) 1.69 ✓  
 PHOSPHORUS (P) .027 ✓  
 SULFUR (S) .001 ✓  
 SILICON (SI) .38 ✓  
 CHROMIUM (CR) 16.27 ✓  
 NICKEL (NI) 10.11 ✓  
 COBALT (CO) .38 ✓  
 COPPER (CU) .36 ✓  
 MOLY (MO) 2.05 ✓  
 NITROGEN (N) .04 ✓  
 COLUMBIUM (CB) .022 ✓  
 TITANIUM (TI) .003 ✓  
 ALUMINUM (AL) .006 ✓  
 TIN (SN) .007 ✓

W.O. # 11730  
 M.L. # 51 (23/2) (25)  
 THK. # 0.386  
 P.O. # D545-110411

Q.C.I.  
 E.Y.

AUG 16 2013

446  
 ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: BSM OFF SHORE  
 Print Name: GAURESH SATHI  
 Signature: [Signature]  
 Date: Sept 3/13  
 Applus®  
 VELOSI  
 Velosi America LLC

WE HEREBY CERTIFY THAT THE MATERIAL HEREIN HAS BEEN MADE AND TESTED IN ACCORDANCE WITH THE LISTED SPECIFICATION(S) AND THAT THE RESULTS OF ALL TESTS ARE ACCEPTABLE.

JAMES DOUBMAN, QUALITY ASSURANCE MANAGER

CERTIFICATE IN CONFORMANCE WITH EN10204-95 3.1.B/EN10204-2004 3.1

*James Douman*



# MATERIAL TEST & INSPECTION CERTIFICATE

CUSTOMER: SOUTHWEST STAINLESS, INC. According to  
 PROJECT NAME: N/A DIN 50049 3.1 / EN 10204 3.1 / ISO 10474 3.1

PURCHASE ORDER NO.	75061	SPEC. FOR MATERIAL	ASTM/AASME A/SA-403 WP316 316L W 0707ED	CERTIFICATE NO.	GCLJ2012011134
PJT NO.	N/A	SPEC. FOR INSPECTION	ASME B16.9	DATE OF ISSUE	2011 12 26
STARTING MATERIAL	STEEL PLATE	SKB NO.	2011053012	VISUAL & DIMENSION	SATISFACTORY
NO.	SEQ/LINE/ITEM NO	DESCRIPTION	QTY	HEAT NO.	MFG ID NO.
841		90D ELBOW(S) S80S B.W WELD SUS	3	035085	035085
842		90D ELBOW(S) S80S B.W WELD SUS	4	035085	035085
849		90D ELBOW(S) S80S B.W WELD SUS	2	035085	035085
925		STRAIGHT TEE S80S B.W WELD SUS	2	035085	035085

STD.	SPEC.	CHEMICAL COMPOSITION(%) (L : LADLE, P : PRODUCT)														TENSILE TEST							
		C	Si	Mn	P	S	Ni	Cr	Mo	Cu	V	Nb	Al	B	Zr	Fe	TI	C.E	SPEC.	Y.S 0.2% offset	T.S	EL	R <sub>A</sub>
HEAT NO.	MIN	0.030	1.00	2.00	0.045	0.030	10.00	16.00	2.00										MIN	30.0	75.0	%	28.0
	MAX	0.025	0.32	1.28	0.037	0.002	10.11	16.74	2.03										MAX	45.2	81.5	%	57.0
035085	L																						
	P																						
	L																						
	P																						

IMPACT TEST	HEAT NO.	TEST TEMP.	SIZE OF SPECIMEN(mm)	ABSORBED ENERGY		LATERAL EXPANSION		PERCENT SHEAR		HARDNESS		HEAT TREATMENT		SOLUTION TREATED
				STD./	AVE.	STD./	AVE.	STD./	VALUE	MIN	MAX	PMI	N.D.E	
035085			BIM											N/A
			H.A.Z											N/A
			WIM											N/A
			BIM											N/A
			H.A.Z											N/A
			WIM											N/A

MATERIAL MEETS THE REQUIREMENTS OF NACE MR0175 ✓

WE CERTIFY THIS MATERIAL HAS BEEN MANUFACTURED AND EXAMINED IN ACCORDANCE WITH ALL REQUIREMENTS OF THE SPECIFICATION AND THE RESULTS OF ALL EXAMINATION ARE ACCEPTABLE

REVIEWED BY :  
 WITNESSED BY :

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBM OFFSHORE

Print Name: GANESH SAHA  
 Signature: [Signature]  
 Date: Sept 3/13

036  
 P.O. # 11738  
 M.L. # 54069-1  
 THK # 530  
 P.O. # 13-0707

Q.M. DIV. SENIOR MANAGING DIRECTOR

# MATERIAL TEST & INSPECTION CERTIFICATE

**SUNGKWANG BEND CO., LTD.(S'KB)**  
 1720, Songjeong-Dong, Gangseo-Ku, Busan, Korea  
 TEL : 82-051-3300-450  
 FAX : 82-051-3300-335  
 http://www.skbend.com

According to  
 DIN 50049 3.1 / EN 10204 3.1 / ISO 10474 3.1

CUSTOMER: SOUTHWEST STAINLESS, INC  
 PROJECT NAME: N/A

PURCHASE ORDER NO.	170554	SPEC. FOR MATERIAL	ASTM/A316 A.S.A.403WP316316-W 2424ED	CERTIFICATE NO.	QCL2007060315
PJT JOB NO.	N/A	SPEC. FOR INSPECTION	ASME B16.9	DATE OF ISSUE	2007.07.21
STARTING MATERIAL	STEEL PLATE	SKB JOB NO.	2006121107	VISUAL & DIMENSION	SATISFACTORY
NO.	SEQUENCE ITEM NO	DESCRIPTION	90° ELBOW SHORT	MILL MAKER	PORICODE/TAG NO
914		1" B.W WELDED SUS	1	HEAT NO. SC08099	DAEKYUNG CORP.

STD.	SPEC.	CHEMICAL COMPOSITION(S) (LADLE P. PRODUCT)										TENSILE TEST												
		C	Si	Mn	P	S	N	Cr	Mo	Cu	V	Nb	H	Ai	B	W	Sn	Ti	C.E	SPEC.	Y.S	T.S	EL	RA
HEAT NO.	MIN	1.00	0.05	2.00	0.045	0.008	0.002	10.16	16.73	2.04										MIN	30.0	75.0	26.0	N
	MAX	0.018	0.55	1.12	0.029	0.002	10.16	16.73	2.04										MAX	45.8	84.9	30.0		
SC08099	P																		L					
	L																		P					
	P																		P					

IMPACT TEST	TEST TEMP.	SIZE OF SPECIMEN(mm)	ABSORBED ENERGY		LATERAL EXPANSION		PERCENT SHEAR		HARDNESS		HEAT TREATMENT		SOLUTION TREATED: 100°C, 40Min, "Water"	
			STD./	VALUE	STD./	AVE	VALUE	AVE	MIN	MAX	N.D.E	FLATTENING TEST	R.T.GOOD	PMT
HEAT NO.		B/W												
SC08099		H/AZ												
		T/W												
		B/W												
		H/AZ												
		H/W												

WE CERTIFY THIS MATERIAL HAS BEEN MANUFACTURED AND EXAMINED IN ACCORDANCE WITH ALL REQUIREMENTS OF THE SPECIFICATION AND THE RESULTS OF ALL EXAMINATION ARE ACCEPTABLE.

Q REVIEWED BY :  
 Q WITNESSED BY :  
 SKC-8903

Q.C.I. N.D.  
 Q.C.I. E.Y.  
 QM DIV. SENIOR MANAGING DIRECTOR

*Chul Suk*

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: *SKB OFF-SITE*  
 Print Name: *CHUL SUK*  
 Signature: *[Signature]*  
 Date: *2007.07.21*  
 Applus  
 VETOSI  
 VETOSI America LLC

W.O. # 11730  
 M.M. # 5403-316-1  
 THK. # 523/2-0  
 P.O. # 13-0707

Certification of Material Per ASMB  
 HT# - SC08099  
 Qualifies to all requirements of  
 SA403-316/316L per  
 Sect. II, Edition II Addenda

AUG 16 2007





Ship TO: FRANKIE HUGHES  
161 THE WEST MALL  
LAVAL QC CANADA

Specialty Products  
500 Green Street  
Washington, PA 15301

CERTIFIED MATERIAL  
TEST REPORT

INTERIUS METALS  
161 THE WEST MALL  
ETHBURCOKE ON CANADA

YOUR ORDER NO. 04230  
MEMO NO. 433098  
DATE 05/20/2003  
SALESMAN NO. 1584

*P.M. Dabito*  
P.M. Dabito - Product Quality Engineer

H71 545000

ALC 316/316L STAINLESS HPAP  
ASTM A240/040 ASME SA 240-04

Heat: 820113  
FROM 5110 1728J PART A  
920237 70822 A  
FROM SLIP 19218 PART A

Heat: 820113  
820237

Lot No 153406  
154596

Size	Qty	Weight	Part No	Part Name	Part Desc	Part Loc
7500 x 250.0000	1	5302	7500 x 250.0000	7500 x 250.0000	7500 x 250.0000	7500 x 250.0000
7500 x 246.0000	1	5266	7500 x 246.0000	7500 x 246.0000	7500 x 246.0000	7500 x 246.0000

MATERIAL WAS NOT WELD REPAIRED  
MATERIAL WAS PRODUCED WITHOUT KNOWN CONTACT WITH MERCURY  
MATERIAL IS OF USA MELT AND MANUFACTURE  
MATERIAL WAS SOLUTION ANNEALED (HEAT TREATED) ABOVE 1900F AND WATER WELDED  
UN 50047 3.1.8 AND EN 10204 3.1.8 CERTIFICATE

Certification of Material - Per ASME  
HTS 820113  
Qualifies to all sections of  
SA 240-04/040 per  
Part II of ASME Section II, Addenda

PAGE 1 FINAL PAGE

046  
ACCEPTED BY VELIUS...  
for and on behalf of: W. AMESIA SAHA  
Print Name: W. AMESIA SAHA  
Signature: [Signature]  
Date: 08/13/13  
Appplus  
Velosi America LLC

Q.C.I.  
N.D.

W.O. # 1173  
M.L. # 55  
THK. # 771  
P.O. # D545-110411

AUG 16 2013

Outokumpu Stainless Plate, Inc.

**OUTOKUMPU**

**Certificate of Analysis and Tests**

OUR ORDER 0246237 - 01

HEAT & PIECE 831846-2B 05/27/05

SOLD TO: METAUX INTEGRIS LTEE  
3399 FRANCIS HUGHES  
LAVAL, QC H7L5A5

SHIP TO: METAUX INTEGRIS LTEE  
3399 FRANCIS HUGHES  
LAVAL, QC H7L5A5

YOUR ORDER & DATE

453513

5/23/05

TAG# 7581-2543

HEAT & PIECE 831846 - 2B  
WEIGHT 5654  
FINISH 1  
GRADE 316L / 316  
DIMENSIONS .750 X 96.000 X 264.000 EXACT  
ITEM DESCRIPTION UNS-S31603 / UNS-S31600  
COUNTRY OF ORIGIN BRT

\*\*\* MFG IN NEW CASTLE, IN, USA  
ASME SA240 04 EDITION  
ASTM A480/A480M-03C  
ASTM A262-02A PRACTICE E  
NO WELD REPAIRS  
SPECIFICATIONS FROM SLABS IMPORTED FROM BRITAIN  
ASTM A240-05  
ASTM A262-02A PRACTICE A  
NO CRIPPER MARKS

PLATES & TEST PCS SOLUTION ANNEALED @ 1950 DEGREES FAHRENHEIT MINIMUM.  
THEN WATER COOLED OR RAPIDLY COOLED BY AIR  
FREE FROM MERCURY CONTAMINATION AT CURRENT DETECTION LIMITS  
HOT ROLLED, ANNEALED & PICKLED (HRAP)

Q.C.I.  
N.D.

MECHANICAL & OTHER TESTS

HARDNESS RE 85  
GRAIN SIZE 5  
YIELD STRENGTH (PSI) 52552 ✓  
TENSILE STRENGTH (PSI) 85940 ✓  
BEND OK  
INTERGRANULAR CORROSION OK  
ELONGATION % IN 2" 45.8 ✓  
REDUCTION OF AREA % 68.5 ✓

Certification of Material - Per ASME  
HT# 831846-2B  
Qualifies to all requirements of  
SA240-316/316L per  
Sect. II, Edition II, Addenda

CHEMICAL COMPOSITION

CARBON	(C)	.015	✓
MANGANESE	(MN)	1.80	✓
PHOSPHORUS	(P)	.029	✓
SULFUR	(S)	.001	✓
SILICON	(SI)	.31	✓
CHROMIUM	(CR)	16.31	✓
NICKEL	(NI)	10.17	✓
COBALT	(CO)	.26	✓
COPPER	(CU)	.40	✓
MOLY	(MO)	2.09	✓
NITROGEN	(N)	.03	✓
COLUMBIUM	(CB)	.014	✓
TITANIUM	(TI)	.003	✓
ALUMINUM	(AL)	.007	✓
TIN	(SN)	.015	✓

W.O. # 1173Q  
M.L. # 55  
THK. # 768  
P.O. # D545-110411

1 pc

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SAM OFFSHORE  
Print Name: LAVESH SAHA  
Signature: [Signature]  
Date: Sep 3/13  
Applus<sup>®</sup> VELOSI  
Velosi America LLC

WE HEREBY CERTIFY THAT THE MATERIAL HEREIN HAS BEEN MADE AND TESTED IN ACCORDANCE WITH THE LISTED SPECIFICATION(S) AND THAT THE RESULTS OF ALL TESTS ARE ACCEPTABLE.

JAMES DOUBMAN, QUALITY ASSURANCE MANAGER

CERTIFICATE IN CONFORMANCE WITH DIN50049 3.1.B/EN10204 3.1.B





**Kanzen Tetsu Sdn Bhd**

Company No 166887-W  
10, Box 727 2, Lot 4, Persiaran Perusahaan  
Kawasan 23, 40708 Shah Alam, Selangor Darul Ehsan, Malaysia  
Tel: (603) 5533 0200 Fax: (603) 5531 9775  
http://www.kanzen-tetsu.com e-mail: info@kanzen-tetsu.com

**MILL TEST REPORT**  
IN ACCORDANCE TO EN 10204 3.1

CERTIFICATE NO: 9135511 (1) DATE: 16/12/2011

CONTRACT NO: KANZEN TETSU SDN BHD

ORDER NO: PINACLE STAINLESS STEEL INC.

PRODUCT: STAINLESS STEEL BUTT WELDING  
SPECIFICATION: FITT HBS ASTM A403/ASME SA403A-07a

SIZE	QTY PCS	TOTAL LENGTH M	WEIGHT KGS	HEAT NO	TENSILE TEST				YIELD TENSILE TEST	LONGITUDINAL TEST	CORROSION TEST IN ACCORDANCE TO	CHEMICAL COMPOSITION (%)							
					TS MPa	YS MPa	EL %	AP %				C	Mn	P	S	Ni	Cr	Mo	
NP316/316L W X B* X SCH10S X 45 LR ELBOW	20	-	100	63V9605	292	598	59	81	-	-	-	2.2	43	83	30	1	1002	1653	201
NP316/316L W X 2* X SCH40S X 45 LR ELBOW	20	-	7	63U8605	292	598	59	81	-	-	-	2.2	43	83	30	1	1002	1653	201
NP304/304L W X B* X 4* X SCH10S X ECC REDUCER	20	-	51	43X7401	312	685	52	86	-	-	-	3.0	52	96	36	6	804	1812	-

Certification of Material - Per ASME  
HT# 63U8605  
Qualifies to all requirements of  
SA403-316/316L per  
Sect. II, Edition II, Addenda

W.O. # 11730  
M.L. # 59 (24/2/28/12)  
THK. # -147  
P.O. # 13-0707

Q.C.I. N.D.  
Q.C.I. E.Y.

AUG 12 2013

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SAM O FIF S HOME  
Print Name: SAM O FIF S HOME  
Signature: [Signature]  
Date: 13 Sept 2013  
Appius VELOSI  
Velosi America LLC

HEAT TREATMENT: 1050 DEGREE CELSIUS QUENCHED IN WATER

NOTE: THIS CERTIFICATE IS VALID ONLY IF THE ORGANIZATION'S SYSTEM IS REGISTERED WITH THE RELEVANT AUTHORITY

QUALITY CONTROL  
LIM KEE HENG  
QA MANAGER

Hardness are in accordance to NACE MR 0175 / ISO 15156-3 and NACE MR 0103 (Latest Edition)



**ESSAR STEEL ALGOMA INC., 105 West Street, Sault Ste. Marie, Ontario, Canada P6A 7B4**

SO No., Item & Date:	8004571 000010 2012/10/27	Shipment No. & Date:	1000012968 2012/10/29	TC No., Date & Time:	ESA-22183 2012/10/30 - 20:30:57
Sold to Customer Name and Address:	CANADIAN PLATE AND PROFILES IN KAMATO ROAD 920 MISSISSAUGA, Ontario, Canada L4W 2R6	Ship to Customer Name and Address:	CANADIAN PLATE AND PROFILES IN KAMATO ROAD 920 MISSISSAUGA, Ontario, Canada L4W 2R6	Customer PO NO./Item:	18651-STK / 1
BOL NO.:	1000012968	Cust.Part No.:		Carrier:	TRIPLE K TRANSPORT LTD - 35099 (250)
Customer Specification:	HR STEEL PLATE Carbon Multi Cert ASTM A516 GR 70 (11A) Meets NACE MR 0103 latest Ed., NACE MR 0175 latest Ed., BHN < 200, Calcium Treated for Sulphide Shape Control Normalized Temp 1670 F 34 min CVNL Req. 15 1/2 FT-LBF at -50.0 F Sid Thickness Tol PVQ Top and Bottom Standard Surface Flatness 1/2 A20 Latest Ed. +Addenda of ASME Code section II part A applies Fine Grain Fully Killed No Weld Repair				

Supplementary instructions : Test Cert 1: drafting@canadianplate.com Test Cert 2: 905-206-1370

Insp T/R : Test Report As Per Spec  
Cust Use : PVQ

ESSAR STEEL ALGOMA INC. HEREBY CERTIFIES THAT THE MATERIAL HEREIN DESCRIBED WAS MADE AND TESTED IN ACCORDANCE WITH THE RULES OF THE SPECIFICATION SHOWN. ALL RESULTS ARE RETAINED IN ACCORDANCE WITH THE COMPANY'S STANDARD RECORD KEEPING PRACTICES  
THIS MILL TEST REPORT MAY NOT BE REPRODUCED EXCEPT IN FULL WITHOUT WRITTEN APPROVAL OF ESSAR STEEL ALGOMA INC. IF YOU RECEIVE THIS DOCUMENT AND ARE NOT THE INTENDED RECEIVER, PLEASE CALL (705)945-4095 FOR INSTRUCTIONS ON METHOD OF DISPOSAL OF DOCUMENT

MEETS EN 10204:2004 TYPE 3.1  
ISO QUALITY AND ENVIRONMENTAL CERTIFICATES AVAILABLE AT WWW.ESSARSTEELALGOMA.COM

ALL HEATS FULLY KILLED.  
HEATS INDICATED WITH (\*) FINE GRAINED.  
HEATS INDICATED WITH (+) MADE IN CANADA WITH DOMESTIC AND NORTH AMERICAN MATERIALS.

Dimensions (T x W x L)	Batch No.	Heat No-MS	Quantity	No. of Pcs	Dimensions (T x W x L)	Batch No.	Heat No-MS	Quantity	No. of Pcs
1,000 " x 120,000 " x 480.00 "	AB0907	0811P3-02	16,335 LB	1	1,0000 " x 120,000 " x 480.00 "	AB0908	0811P3-54	16,335 LB	1

Heat No. (wt%)	CHEMICAL PROPERTIES										Ti	DO			
	C	Mn	P	S	Si	Cr	Ni	Cu	Mo	Al			Nb	V	B
0811P3*	0.19	1.08	0.009	0.004	0.330	0.05	0.16	0.04	0.01	0.030	0.000	0.015	0.0002	0.003	0.4000

Hardness Tests				MECHANICAL PROPERTIES			
Heat No.	Batch No.	SRCE LAB	GAUGE	COND	LOC	MTHD	HARDNESS
0811P3	AB0907	166"	ALG 1.0000	N	B	HBW	153
0811P3	AB0908	166"	ALG 1.0000	N	B	HBW	150

**LIMITS OF UNSPECIFIED ELEMENTS PER ASME SECTION II (SA-20)**  
 CU + Ni + CR + MO = .26  
 CR + MO = .06

Certification of Material - Per ASME  
 HT# 0811P3-02  
 Qualifies to all requirements of SA516-GR70 per Sect. II Edition II Addenda

W.O. # 11739  
 M.L. # 60 (713)  
 THK. # 1"  
 P.O. # 13-0720

Q.C.I. N.D.  
 Q.C.I. E.Y.

046  
 ACCEPTED FOR REVIEW BY THE BASED  
 for and on behalf of: SAHM GROUP SAHM  
 Print Name: U.A. SAHM  
 Signature: [Signature]  
 Date: 08/13/13  
 Velocity America LLC

K. UGHADPAGA  
 AUG 20 2013  
 MANAGER METALLURGICAL SERVICES

**\*\*WARNING\*\*** THE TEST RESULTS AND VALUES REPORTED HEREIN INDICATE ONLY THAT (1) THE PARTICULAR STEEL FOR WHICH THIS CERTIFICATE IS ISSUED MEETS THE MINIMUM SPECIFIED YIELD STRENGTH AND (2) THE ANALYSIS AND PHYSICAL PROPERTIES OF SUCH STEEL ARE IN CONFORMANCE WITH THE REQUIREMENTS OF THE SPECIFICATION INDICATED. THE RESULTS OR VALUES REPORTED HEREIN CAN NOT BE USED TO QUALIFY THE STEEL FOR ANY SPECIFICATION OTHER THAN THE ONE INDICATED AND CAN NOT BE RELIED UPON FOR ANY PURPOSE (INCLUDING DESIGN OR CALCULATIONS) AS REPRESENTING THE ACTUAL STRENGTH OF SUCH STEEL.



**ESSAR STEEL ALGOMA INC., 105 West Street, Sault Ste. Marie, Ontario, Canada P6A 7B4**

SO No., Item & Date.: 8004571 000010 2012/10/27	Shipment No. & Date.: 1000012968 2012/10/29	TC No., Date & Time : ESA-22183 2012/10/30 - 20:30:57
Sold to Customer Name and Address : CANADIAN PLATE AND PROFILES IN KAMATO ROAD 920 MISSISSAUGA, Ontario, Canada L4W 2R6	Ship to Customer Name and Address: CANADIAN PLATE AND PROFILES IN KAMATO ROAD 920 MISSISSAUGA, Ontario, Canada L4W 2R6	Customer PO NO./Item: 18651-STK / 1 BOL NO.: 1000012968 Cust. Part No.: Carrier : TRIPLE K TRANSPORT LTD - 35099 (250)
Customer Specification : HR STEEL PLATE Carbon Multi Cert ASTM A516 GR 70 (10) / ASME SA516 GR 70 (11A) Meets NACE MR 0103 latest Ed., NACE MR 0175 latest Ed., BHN < 200, Calcium Treated for Sulphide Shape Control Normalized Temp 1670 °F 34 min CVNL Req. 15 1/2 FT-LBF at -50.0 F Std Thickness Tol PVQ Top and Bottom Standard Surface Flatness 1/2 A20 Latest Ed., Addenda of ASME Code section II part A applies Fine Grain Fully Killed No Weld Repair		
Supplementary instructions : Test Cert 1: drafting@canadianplate.com Test Cert 2: 905-206-1370		
Insp T/R : Test Report As Per Spec		Cust Use : PVQ
ESSAR STEEL ALGOMA INC. HEREBY CERTIFIES THAT THE MATERIAL HEREIN DESCRIBED WAS MADE AND TESTED IN ACCORDANCE WITH THE RULES OF THE SPECIFICATION SHOWN. ALL RESULTS ARE RETAINED IN ACCORDANCE WITH THE COMPANY'S STANDARD RECORD KEEPING PRACTICES. THIS MILL TEST REPORT MAY NOT BE REPRODUCED EXCEPT IN FULL WITHOUT WRITTEN APPROVAL OF ESSAR STEEL ALGOMA INC. IF YOU RECEIVE THIS DOCUMENT AND ARE NOT THE INTENDED RECEIVER, PLEASE CALL (705)945-4095 FOR INSTRUCTIONS ON METHOD OF DISPOSAL OF DOCUMENT. MEETS EN 10204:2004 TYPE 3.1 ISO QUALITY AND ENVIRONMENTAL CERTIFICATES AVAILABLE AT WWW.ESSARSTEELALGOMA.COM		
***** MECHANICAL PROPERTIES *****		
Impact Tests	SRCE LAB GAUGE COND METH DIR LOC SIZE	TEMP(°F) FULLENERGY(fr- FULL AVG(fr-lbf)
Heat No. Batch No.		
0811P3 AB0907	166" ALG 1.0000 N CVN L B FULL -50	101 74 89 88
0811P3 AB0908	166" ALG 1.0000 N CVN L B FULL -50	89 108 107 101
Tensile Tests	SRCE LAB GAUGE COND METH DIR LOC YIELD(KSI) TENSILE(KSI) ELSCALE	ELONG(%)
Heat No. Batch No.		
0811P3 AB0907	166" ALG 1.0000 N .2 T B 50.5	75.5 2" 36
0811P3 AB0908	166" ALG 1.0000 N .2 T B 50.0	77.0 2" 37

046

**ACCEPTED/REVIEWED/RELEASED**

for and on behalf of: SOM OFF SHORE

Print Name: GARRETT SAHA **Applus®**

Signature: [Signature] **VELOSI**

Date: Sept 3/13 **Velosi America LLC**



AUG 20 2013

K. UGHADPAGA  
MANAGER METALLURGICAL SERVICES

**\*\*WARNING\*\*** THE TEST RESULTS AND VALUES REPORTED HEREIN INDICATE ONLY THAT (1) THE PARTICULAR STEEL FOR WHICH THIS CERTIFICATE IS ISSUED MEETS THE MINIMUM SPECIFIED YIELD STRENGTH AND (2) THE ANALYSIS AND PHYSICAL PROPERTIES OF SUCH STEEL ARE IN CONFORMANCE WITH THE REQUIREMENTS OF THE SPECIFICATION INDICATED. THE RESULTS OR VALUES REPORTED HEREIN CAN NOT BE USED TO QUALIFY THE STEEL FOR ANY SPECIFICATION OTHER THAN THE ONE INDICATED AND CAN NOT BE RELIED UPON FOR ANY PURPOSE (INCLUDING DESIGN OR CALCULATIONS) AS REPRESENTING THE ACTUAL STRENGTH OF SUCH STEEL.



**ESSAR STEEL ALGOMA INC., 105 West Street, Sault Ste. Marie, Ontario, Canada P6A 7B4**

SO No., Item & Date.: 8004571 000010 2012/10/27	Shipment No. & Date.: 1000012968 2012/10/29	TC No., Date & Time : ESA-22183 2012/10/30 - 20:30:57
Sold to Customer Name and Address : CANADIAN PLATE AND PROFILES IN KAMATO ROAD 920 MISSISSAUGA, Ontario, Canada L4W 2R6	Ship to Customer Name and Address: CANADIAN PLATE AND PROFILES IN KAMATO ROAD 920 MISSISSAUGA, Ontario, Canada L4W 2R6	Customer PO NO./Item: 18651-STK / 1 BOL NO.: 1000012968 Cust.Part No.: Carrier: TRIPLE K TRANSPORT LTD - 35099 (250)
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<b>Supplementary Instructions :</b> Test Cert 1: drafting@canadianplate.com Test Cert 2: 905-206-1370		
<b>Insp T/R :</b> Test Report As Per Spec		Cust Use : PVQ
<small>ESSAR STEEL ALGOMA INC. HEREBY CERTIFIES THAT THE MATERIAL HEREIN DESCRIBED WAS MADE AND TESTED IN ACCORDANCE WITH THE RULES OF THE SPECIFICATION SHOWN. ALL RESULTS ARE RETAINED IN ACCORDANCE WITH THE COMPANY'S STANDARD RECORD KEEPING PRACTICES. THIS MILL TEST REPORT MAY NOT BE REPRODUCED EXCEPT IN FULL WITHOUT WRITTEN APPROVAL OF ESSAR STEEL ALGOMA INC. IF YOU RECEIVE THIS DOCUMENT AND ARE NOT THE INTENDED RECEIVER, PLEASE CALL (705)945-4095 FOR INSTRUCTIONS ON METHOD OF DISPOSAL OF DOCUMENT.</small>		
<small>MEETS EN 10204:2004 TYPE 3.1 ISO QUALITY AND ENVIRONMENTAL CERTIFICATES AVAILABLE AT WWW.ESSARSTEELALGOMA.COM</small>		
<b>MECHANICAL PROPERTIES</b>		
<b>Impact Tests</b>		
Heat No.	Batch No.	SRCE LAB GAUGE COND METH DIR LOC SIZE TEMP(°F) FULLENERGY(ft-lbf) FULL AVG(ft-lbf)
0811P3	AB0907	166" ALG 1.0000 N CVN L B FULL -50 101 74 89 88
0811P3	AB0908	166" ALG 1.0000 N CVN L B FULL -50 89 108 107 101
<b>Tensile Tests</b>		
Heat No.	Batch No.	SRCE LAB GAUGE COND METH DIR LOC YIELD(KSI) TENSILE(KSI) EL SCALE ELONG(%)
0811P3	AB0907	166" ALG 1.0000 N .2 T B 50.5 75.5 2" 36
0811P3	AB0908	166" ALG 1.0000 N .2 T B 50.0 77.0 2" 37

**ACCEPTED/REVIEWED/RELEASED**  
 for and on behalf of: SJM OFF SHORE  
 Print Name: GARY SAHAI  
 Signature: [Signature]  
 Date: Sept 3/13

046  
**Appius®**  
**VELOSI**  
 Velosi America LLC



AUG 20 2013

K. UGHADPAGA  
 MANAGER METALLURGICAL SERVICES

**\*\*WARNING\*\*** THE TEST RESULTS AND VALUES REPORTED HEREIN INDICATE ONLY THAT (1) THE PARTICULAR STEEL FOR WHICH THIS CERTIFICATE IS ISSUED MEETS THE MINIMUM SPECIFIED YIELD STRENGTH AND (2) THE ANALYSIS AND PHYSICAL PROPERTIES OF SUCH STEEL ARE IN CONFORMANCE WITH THE REQUIREMENTS OF THE SPECIFICATION INDICATED. THE RESULTS OR VALUES REPORTED HEREIN CAN NOT BE USED TO QUALIFY THE STEEL FOR ANY SPECIFICATION OTHER THAN THE ONE INDICATED AND CAN NOT BE RELIED UPON FOR ANY PURPOSE (INCLUDING DESIGN OR CALCULATIONS) AS REPRESENTING THE ACTUAL STRENGTH OF SUCH STEEL.



# METALLURGICAL TEST REPORT

NORTH AMERICAN STAINLESS  
6870 HIGHWAY 42 EAST  
GHENT, KY 41045

107055430  
L

6870 HIGHWAY 42 EAST

Mail To: ROLARK STAINLESS STEEL, INC. 71 CONAIR PARKWAY WOODBRIDGE, ON L4H0S4  
 Ship To: ROLARK STAINLESS STEEL, INC. 71 CONAIR PARKWAY WOODBRIDGE, ON L4H0S4  
 Certificate: 806076 1 Date: 1/30/2013 Page: 1  
 Customer: 007050 001 Steel: 316/316L  
 Finish: HRAP

Your Order: 53930 NAS Order: IN 0161281 01 Corrosion: ASTM A262/02aE;180Bend-OK

## PRODUCT DESCRIPTION:

STAINLESS STEEL PLATE, HRAP; UNS 31600/31603  
 ASTM A240/11b, A480/11b, A666/10; ASME SA240/11a, SA480/11a, SA666/11a  
 CHEM ONLY ON FOLLOWING ASTM: A276/10, A479/11, A484/11, A312/11  
 CHEM ONLY ON FOLLOWING ASME: SA312/11, SA479/11  
 AMS 5507F/5524L X MRK;  
 NACE MR0175/ISO 15156-3:2003 A, MR0103/07; QOS766D-A X MAG PERM  
 MIN. SOLUTION ANNEAL TEMP 1900F, WATER QUENCHED

## REMARKS:

Mat'l is Free of Mercury Contamination. No weld repairs.  
 EN 10204:2004 3.1; RoHS 1 & 2 Compliant  
 Material is Free of Radioactive Contamination  
 NAS Steel Making Process: EAF, AOD, & Cont. Casting  
 Product Mfg. by a Quality Mgt. Sys. in Conf. w/ISO 9001  
 \*Melted & Manufactured in the USA; Mat'l is DFARS Compliant

Product Id	Plate#	Skid #	Thickness	Width	Weight	Length	Mark	Pieces	Commodity Code
05E9C1 AA	05E9C1 AA	1.5075	60.0000	6,275	PLATE	240.00	1	1	

## CHEMICAL ANALYSIS

CM(Country of Melt) ES(Spain) US(United States) ZA(South Africa) JP(Japan) Chemical Analysis per ASTM A751/08

HEAT	CM	C %	CR %	CU %	MN %	MO %	N %	NI %	P %	S %
E9C1	US	0.0193	16.5860	0.4350	1.5900	2.1020	0.0498	10.0400	0.0340	0.0010

ACCEPTED FOR RELEASE  
 for and on behalf of: 5 PM OFFSHORE  
 Print Name: GAMBESH SAHAR  
 Signature: [Signature]  
 Title: SAHAR B113  
 Applus®  
 Velost America LLC

W.O. # 11739  
 M.L. # 62(9/13)  
 P.O. # 13-5713  
 MCH 6501/2

## MECHANICAL PROPERTIES

Product Id#	Plate#	UTS KSI	ELONG %-2"	HARD RB	R of A
05E9C1 AA	05E9C1 AA	90.42	46.74	58.88	78.00
		F T			73.14

O.C.I.  
 E.Y.

Certification of Material - Per ASME  
 HT# E9C1  
 Qualifies to all requirements of SA240-316/316L per Sect. II 10 Edition 11 Addenda

AUG 16 2013

NAS hereby certifies that the analysis on this certification is correct. Based upon the results and the accuracy of the test methods used, the material meets the specifications stated. These results relate only to the items tested and this report cannot be reproduced, except in its entirety, without the written approval of NAS.

Technical Dept. Mgr. [Signature]  
 ERIC HESS 1/30/2013





# METALLURGICAL TEST REPORT

NORTH AMERICAN STAINLESS  
6870 HIGHWAY 42 EAST  
GHENT, KY 41045

VNORT P5-3-23

6870 HIGHWAY 42 EAST

Certificate: 791192 7 Mail To:  
ROLARK STAINLESS STEEL, INC.  
71 CONAIR PARKWAY  
WOODBIDGE, ON L4H0S4

Ship To:  
ROLARK STAINLESS STEEL, INC.  
71 CONAIR PARKWAY  
WOODBIDGE, ON L4H0S4

Date: 12/03/2012 Page: 1

Customer: 007050 001

Steel: 316/316L

Finish: HRAP

Your Order: 53232

NAS Order: DS 0002154 07

Corrosion: ASTM A262/02aE;180Bend-OK

## PRODUCT DESCRIPTION:

STAINLESS STEEL CONT. MILL FLARE, HRAP; UNS 31600/31603  
ASTM A240/11b, A480/11b, A666/10; ASME SA240/11a, SA480/11a, SA666/11a  
CHEM ONLY ON FOLLOWING ASTM: A276/10, A479/11, A484/11, A312/11  
CHEM ONLY ON FOLLOWING ASME: SA312/11, SA479/11  
AMS 5507F/5524L X MRK;  
NACE MR0175/ISO 15156-3:2003 A, MR0103/07; QCS766D-A X MAG PERM  
MIN. SOLUTION ANNEAL TEMP 1900F, WATER QUENCHED

## REMARKS:

Mat'1 is Free of Mercury Contamination. No weld repairs.  
EN 10204:2004 3.1; ROHS Compliant  
Material is Free of Radioactive Contamination  
NAS Steel Making Process: EAF, AOD, & Cont. Casting  
Product Mfg. by a Quality Mgt. Sys. in Conf. w/ISO 9001  
\*Melted & Manufactured in the USA; Mat'1 is DFARS Compliant  
EN 10204 3.1.B

Product Id	Coil #	Skid #	Thickness	Width	Weight	Length	Mark	Pieces	Commodity Code
DD2371	06E5K2 B		.3748	48.0000	2,545 SHEETS	240.00	16	2	

## CHEMICAL ANALYSIS

CM(Country of Melt) ES(Spain) US(United States) ZA(South Africa) JP(Japan) Chemical Analysis per ASTM A751/08

HEAT	CM	C %	CR %	CU %	MN %	MO %	N %	NI %	P %	S %
E5K2	US	.0154	16.5720	.4135	1.4470	2.0650	.0461	10.0450	.0310	.0192

SI % .3760

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SAM SAFSAH  
Print Name: GABRIELA SAHA **Arplus®**  
Signature: [Signature] **VELOSI**  
Date: Sept 13/13 **Velosi America LLC**

V.O. # 11730  
M.S. # 63 (17R 10/17)  
P.O. # 13-0713

## MECHANICAL PROPERTIES

Product Id#	Coil #	l d	UTS	.2% YS	ELONG	Hard	Tail
		C E	KSI	KSI	%-2"	RB	HARD
DD2371	06E5K2	F T	85.68	48.52	51.53	87.00	89.00

Q.C.I. N.D.

AUG 16 2013

Certification of Material - Per ASME  
HT# ESK2  
Qualifies to all requirements of  
SA340-316 B1CL per  
Sect. II, Edition 11 Addenda

NAS hereby certifies that the analysis on this certification is correct. Based upon the results and the accuracy of the test methods used, the material meets the specifications stated. These results relate only to the items tested and this report cannot be reproduced, except in its entirety, without the written approval of NAS.

Technical  
Dept. Mgr. [Signature]  
ERIC HESS

12/03/2012

Certificate: 794815 1  
Customer: 007050 001

Mail To:  
ROLARK STAINLESS STEEL, INC.  
71 CONAIR PARKWAY  
WOODBIDGE, OH 44084

Ship To:  
ROLARK STAINLESS STEEL, INC.  
71 CONAIR PARKWAY  
WOODBIDGE, OH 44084

Date: 12/14/2012 Page: 1  
Steel: 316/316L  
Finish: HRAP

Our Order: 53315

NAS Order: DS 0002247 05

Corrosion: ASTM A262/02aE,180Bend-OK

PRODUCT DESCRIPTION:

STAINLESS STEEL CONT. MILL PLATE, HRAP, UNS 31600/31603  
ASTM A240/11b, A480/11b, A666/10; ASME SA240/11a, SA480/11a, SA566/11a  
CHEM ONLY ON FOLLOWING ASTM: A276/10, A479/11, A484/11, A312/11  
CHEM ONLY ON FOLLOWING ASME: SA312/11, SA479/11  
AMS 5507F/5524L X HRK;  
NACE MR0175/ISO 15156-3; 2003 A, MR0103/07; Q9766D-A X MAG PERM  
MIN. SOLUTION ANNEAL TEMP 1900F, WATER QUENCHED

REMARKS:

Mat'l is Free of Mercury Contamination. No weld repairs.  
EN 10204:2004 3.1; RoHS Compliant  
Material is Free of Radioactive Contamination  
NAS Steel Making Process: EAF, AOD, & Cont. Casting  
Product Mfg. by a Quality Mgt. Sys. in Conf. w/ISO 9001  
\*Melted & Manufactured in the USA; Mat'l is DFARS Compliant  
EN 10204 3.1.B

Product Id	Coil #	Skid #	Thickness	Width	Weight	Length	Mark	Pieces	Commodity Code
DD4383	02E7K6 A		.3748	60.0000	4,750	SHEETS	240.00	9	3

CHEMICAL ANALYSIS CM(Country of Melt) ES(Spain) US(United States) ZA(South Africa) JP(Japan) Chemical Analysis per ASTM A751/08

HEAT	CM	C %	CR %	CU %	FE %	MO %	N %	NI %	P %	S %	
E776	US	.0205	16.6005	.4100	1.5245	2.0550	.0394	10.0400	.0330	.0010	
		SI %									
		.5115									

MECHANICAL PROPERTIES

Product Id#	Coil #	UTS	2% YS	ELONG	Hard	Tail
		KSI	KSI	%-2"	RD	Hard
DD4383	02E7K6	88.88	55.61	50.97	87.00	89.00



NAS hereby certifies that the analysis on this certification is correct. Based upon the results and the accuracy of the test methods used, the material meets the specifications stated. These results relate only to the items tested and this report cannot be reproduced, except in its entirety, without the written approval of NAS.

Technical Dept. Mgr. ERTC HESS 12/14/2012

Certification of Material - Per ASME  
HT# E7K6  
Qualifies to all requirements of  
SA240-316/316L per  
Sect. II IC Edition 11 Addenda

W.O. # 11730  
M.L. # 63 (1/16/10)  
THK. # 376  
P.O. # 13-0713



AUG 16 2012

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SIBM OFFSHORE  
Print Name: L. ANDREW SAHA  
Signature: [Signature]  
Date: 12/14/12  
Applus<sup>®</sup> VELOSI  
Velosi America LLC



# METALLURGICAL TEST REPORT

NORTH AMERICAN STAINLESS  
6870 HIGHWAY 42 EAST  
GHENT, KY 41045

6870 HIGHWAY 42 EAST

Certificate: 798933 1 MAIL TO: ROLARK STAINLESS STEEL, INC.

SHIP TO: ROLARK STAINLESS STEEL, INC.

Date: 1/04/2013 Page: 1

Customer: 007050 012

Steel: 316/316L

Finish: BRAP

Corrosion: ASTM A262/02aE; 180Bead-OK

NAS Order: DS 000233 01

Your Order: 53412

## PRODUCT DESCRIPTION

STAINLESS STEEL COIL, BRAP; UNS 31600/31603  
ASTM A240/11b, A480/11b, A666/10; ASME SA240/11a, SA480/11a, SA666/11a  
CHECK ONLY ON FOLLOWING ASTM: A276/10, A479/11, A484/11, A312/11  
CHECK ONLY ON FOLLOWING ASME: SA312/11, SA479/11  
AMS 5507P/5526L X MRK;  
NACE MR0175/ISO 15156-3:2003 A, MR0103/07; Q35766D-A X NAG PERM  
MIN. SOLUTION ANNEAL TEMP 1900F, WATER QUENCHED

## REMARKS:

Mat'l in Free of Mercury Contamination. No weld repairs.  
EN 10204:2004 3.1; ROHS 1 & 2 Compliant  
Material is Free of Radioactive Contamination  
NAS Steel Making Process: EAF, AOD, & Cont. Casting  
Product Mfg. by a Quality Mgt. Sys. in Conf. w/ISO 9001  
\*Melted & Manufactured in the USA; Mat'l is DPARS Compliant

Product Id	Coil #	Skid #	Thickness	Width	Weight	Length	Mark	Pieces	Commodity Code
05E9B3 C	05E9B3 C		.3748	60.0000	22.730	COIL		1	1

## CHEMICAL ANALYSIS

CM(Country of Melt) ES(Spain) US(United States) ZA(South Africa) JP(Japan)  
Chemical Analysis per ASTM A751/08

Element	C %	CR %	CU %	MN %	MO %	N %	NI %	P %	S %
US	.0207	16.8085	.4240	1.4520	2.0375	.0412	10.0055	.0330	.0010

SI %  
.3575

W.O. # 11730  
M.L. # 63(17 to 10/17)  
TIK # 378  
P.O. # 13-0713

## MECHANICAL PROPERTIES

Product Id #	Coil #	T	F	T	Y	TS	YS	ELONG	Hard	RB	Hard	RB	Hard	RB
05E9B3 C	05E9B3 C	37.43	54.04	49.86	87.00	87.00	87.00	87.00	87.00	87.00	87.00	87.00	87.00	87.00

Certification of Material - Per ASME

HT# E903  
Qualifies to all requirements of  
SA-340-316/316L  
Sect. II Edition II Addenda

Q.C.I.  
E.Y.

AUG 16 2013

NAS hereby certifies that the analysis on this certification is correct. Based upon the results and the accuracy of the test methods used, the material meets the specifications stated. These results relate only to the items stated in its entirety. Without the written approval of NAS.

Technical  
Dept. Mgr. ERIC HESS

1/06/2013

APPLIUS  
VELOSI  
Date: 8/16/13  
Signature: [Signature]  
Print Name: ERIC HESS  
for and on behalf of: [Signature]  
ACCEPTED REVIEW RELEASED  
046

**PHOENIX TUBE COMPANY, INC.**  
 Manufacturer of Stainless Ornamental and Structural Tubing  
**CERTIFICATION OF TEST**

Sold To: RYERSON CANADA  
 161 THE WEST MALL  
 PAUL MASSE@416-620-3865 FOR APPT  
 ETOBICOKE ON M9C  
 CAN

Shlp To: RYERSON CANADA  
 161 THE WEST MALL  
 PAUL MASSE@416-620-3865 FOR APPT  
 ETOBICOKE ON M9C  
 CAN

CUSTOMER ORDER#: 739299  
 CUST REF NBR: 71366671  
 DATE SHIPPED: 07/10/13

Phone# 6223100 Ext:  
 ORDER#: 311820  
 QTY SHIPPED: 555.0

SIZE: 2" X 3/8" HRAP  
 SOURCE: USA D  
 VENDOR: NAS

W.O. # 11730  
 M.L. # 66 (47 to 9)  
 THK. # -375  
 P.O. # 13-0889

GRADE: 316L NO WELD: BAR  
 HEAT#: D5F9  
 TEST REPORT#: TR010548  
 Report Date: 08/27/12

Specification:

CHEMISTRY THIS COLUMN:  
 ASTM A276-13  
 ASME SA276-08 COND. A  
 ASTM A479-13  
 ASME SA479-13, S2.1  
 QQ-S-766D, COND. A

ASTM A262, PRACTICE E  
 CORROSION OK, HRAP  
 ASTM A484-13  
 ASME SA484-13  
 NO WELD REPAIR  
 EN 10204 2.2

ASTM A240-13  
 ASME SA240-13  
 MILS 5059D AMEND 3  
 AMS 5648L & AMS 5653G  
 ASTM A480-13  
 ASME SA480-13

TYPE 316L/316 DUAL CERTIFIED  
 UNS# 31600 / 31603  
 ASTM A666-10  
 NACE MR0175/01 / MR0103



SEP 19 2013



Certification of Material - Per ASME  
 HT# D5F9  
 Qualifies to all requirements of  
SA 479-316/316L per  
 Sect. II 10 Edition II Addenda

MERCURY IS NOT USED BY US AS AN ALLOYING MATERIAL NOR IS METALLIC MERCURY HANDLED IN THE VICINITY OF OUR PROCESSING LINES. WE ARE NOT PRESENTLY AWARE OF ANY MERCURY CONTAMINATION. MATERIAL HAS BEEN HEATED TO A MINIMUM OF 1900 DEG. F AND IS SUBSEQUENTLY COOLED RAPIDLY TO PREVENT CARBIDE PRECIPITATION

Chemical Analysis

C ✓	MN ✓	P ✓	S ✓	SI ✓	CR ✓	NI ✓	MO ✓	CU	CO	N2	TI
.023	1.57	.037	.001	.38	16.58	10.08	2.11	.56	0	.04	0

Physical Analysis

Hardness	YIELD		TENSILE		OTHER	
	PSI	MPA	PSI	MPA	Percent EL	Percent RA
RB 87	53510	0	88630	0	52	69

THE CHEMICAL ANALYSES ARE CORRECT AS CONTAINED IN OUR CORPORATE RECORDS.  
 PHYSICAL PROPERTIES ARE DETERMINED WHILE MATERIAL IS IN STRIP FORM.

Melted & Manufactured in the USA FAR BAA complies, DFARS BAA complies, FAR TAA complies

CERTIFIED BY Quality Control Dept.

*Devin Uguiza*

1185 WIN DR, BETHLEHEM, PA., 18017 - (610) 665-5557  
 FAX NUMBER: 610-865-4073

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SIM OFFSHORE  
 Print Name: CAMPBELL SAHA  
 Signature: [Signature]  
 Date: 8/27/13  
 046  
**Applus®**  
 VELOSI  
 Velosi America LLC

# ALL-WELD COMPANY LIMITED

49 Passmore Avenue,

Toronto, Ontario,

Canada M1V 4T1

[www.allweld.ca](http://www.allweld.ca)



## COMPRESS Pressure Vessel Design Calculations

**Item:** 48" OD Vertical Stainless Steel Inlet Separator  
**Vessel No:** 772-VESE-101/201  
**Customer:** Ultrafab Industries Limited  
**Designer:** Todd Clark, P. Eng.  
**Date:** Tuesday, July 16, 2013



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42. [Skirt Base Ring](#)
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## Nozzle Schedule

Nozzle mark	Service	Size	Materials		Impact Tested	Normalized	Fine Grain	Flange	Blind
<a href="#">MW1</a>	Manway c/w Blind Flange	35 OD x 5.5	Nozzle	SA-182 F316 > 5	No	No	No	NPS 24 Class 900 V2 A182 F316	NPS 24 Class 900 A182 F316
<a href="#">N1</a>	Inlet	11.75 OD x 1.875	Nozzle	SA-182 F316 <= 5	No	No	No	NPS 8 Class 900 LWN A182 F316	No
<a href="#">N10A</a>	Level Gauge High	4.12 OD x 1.06	Nozzle	SA-182 F316 <= 5	No	No	No	NPS 2 Class 900 LWN A182 F316	No
<a href="#">N10B</a>	Level Gauge Low	4.12 OD x 1.06	Nozzle	SA-182 F316 <= 5	No	No	No	NPS 2 Class 900 LWN A182 F316	No
<a href="#">N11</a>	Spare	4.12 OD x 1.06	Nozzle	SA-182 F316 <= 5	No	No	No	NPS 2 Class 900 LWN A182 F316	No
<a href="#">N12</a>	Purge	4.12 OD x 1.06	Nozzle	SA-182 F316 <= 5	No	No	No	NPS 2 Class 900 LWN A182 F316	No
<a href="#">N13</a>	Bottom Drain	NPS 2 Sch 160	Nozzle	SA-312 TP316L Smls pipe (low stress)	No	No	No	NPS 2 Class 900 WN A182 F316	No
<a href="#">N14</a>	Vent	4.12 OD x 1.06	Nozzle	SA-182 F316 <= 5	No	No	No	NPS 2 Class 900 LWN A182 F316	No
<a href="#">N15</a>	Inspection c/w Blind Flange	11.75 OD x 1.875	Nozzle	SA-182 F316 <= 5	No	No	No	NPS 8 Class 900 LWN A182 F316	No
<a href="#">N2</a>	Gas Outlet	11.75 OD x 1.875	Nozzle	SA-182 F316 <= 5	No	No	No	NPS 8 Class 900 LWN A182 F316	No
<a href="#">N3</a>	Liquid Outlet	4.12 OD x 1.06	Nozzle	SA-182 F316 <= 5	No	No	No	NPS 2 Class 900 LWN A182 F316	No
<a href="#">N4</a>	PSV	4.12 OD x 1.06	Nozzle	SA-182 F316 <= 5	No	No	No	NPS 2 Class 900 LWN A182 F316	No
<a href="#">N5</a>	Pressure Indicator	4.12 OD x 1.06	Nozzle	SA-182 F316 <= 5	No	No	No	NPS 2 Class 900 LWN A182 F316	No
<a href="#">N6</a>	Temperature Indicator	4.12 OD x 1.06	Nozzle	SA-182 F316 <= 5	No	No	No	NPS 2 Class 900 LWN A182 F316	No
<a href="#">N7A</a>	PDI High	4.12 OD x 1.06	Nozzle	SA-182 F316 <= 5	No	No	No	NPS 2 Class 900 LWN A182 F316	No
<a href="#">N7B</a>	PDI Low	4.12 OD x 1.06	Nozzle	SA-182 F316 <= 5	No	No	No	NPS 2 Class 900 LWN A182 F316	No

<a href="#">N8A</a>	Level Bridle - (Process) High	4.12 OD x 1.06	Nozzle	SA-182 F316 <= 5	No	No	No	NPS 2 Class 900 LWN A182 F316	No
<a href="#">N8B</a>	Level Bridle - (Process) Low	4.12 OD x 1.06	Nozzle	SA-182 F316 <= 5	No	No	No	NPS 2 Class 900 LWN A182 F316	No
<a href="#">N9A</a>	Level Bridle - (Safety) High	4.12 OD x 1.06	Nozzle	SA-182 F316 <= 5	No	No	No	NPS 2 Class 900 LWN A182 F316	No
<a href="#">N9B</a>	Level Bridle - (Safety) Low	4.12 OD x 1.06	Nozzle	SA-182 F316 <= 5	No	No	No	NPS 2 Class 900 LWN A182 F316	No



## Nozzle Summary

Nozzle mark	OD (in)	t <sub>n</sub> (in)	Req t <sub>n</sub> (in)	A <sub>1</sub> ?	A <sub>2</sub> ?	Shell			Reinforcement Pad		Corr (in)	A <sub>a</sub> / A <sub>r</sub> (%)
						Nom t (in)	Design t (in)	User t (in)	Width (in)	t <sub>pad</sub> (in)		
<a href="#">MW1</a>	35	5.5	1.1622	Yes	Yes	1.75	1.6094		N/A	N/A	0	111.5
<a href="#">N1</a>	11.75	1.875	0.3983	Yes	Yes	1.75	1.6093		N/A	N/A	0	141.4
<a href="#">N10A</a>	4.12	1.06	0.2074	Yes	Yes	1.75	N/A		N/A	N/A	0	Exempt
<a href="#">N10B</a>	4.12	1.06	0.2074	Yes	Yes	1.75	N/A		N/A	N/A	0	Exempt
<a href="#">N11</a>	4.12	1.06	0.2074	Yes	Yes	1.75	N/A		N/A	N/A	0	Exempt
<a href="#">N12</a>	4.12	1.06	0.2074	Yes	Yes	1.75	N/A		N/A	N/A	0	Exempt
<a href="#">N13</a>	2.375	0.344	0.154	Yes	Yes	1.73*	N/A		N/A	N/A	0	Exempt
<a href="#">N14</a>	4.12	1.06	0.2074	Yes	Yes	1.73*	N/A		N/A	N/A	0	Exempt
<a href="#">N15</a>	11.75	1.875	0.3983	Yes	Yes	1.75	1.6093		N/A	N/A	0	141.4
<a href="#">N2</a>	11.75	1.875	0.3634	Yes	Yes	1.73*	1.4483		N/A	N/A	0	139.2
<a href="#">N3</a>	4.12	1.06	0.2074	Yes	Yes	1.75	N/A		N/A	N/A	0	Exempt
<a href="#">N4</a>	4.12	1.06	0.2074	Yes	Yes	1.75	N/A		N/A	N/A	0	Exempt
<a href="#">N5</a>	4.12	1.06	0.2074	Yes	Yes	1.75	N/A		N/A	N/A	0	Exempt
<a href="#">N6</a>	4.12	1.06	0.2074	Yes	Yes	1.75	N/A		N/A	N/A	0	Exempt
<a href="#">N7A</a>	4.12	1.06	0.2074	Yes	Yes	1.75	N/A		N/A	N/A	0	Exempt
<a href="#">N7B</a>	4.12	1.06	0.2074	Yes	Yes	1.75	N/A		N/A	N/A	0	Exempt
<a href="#">N8A</a>	4.12	1.06	0.2074	Yes	Yes	1.75	N/A		N/A	N/A	0	Exempt
<a href="#">N8B</a>	4.12	1.06	0.2074	Yes	Yes	1.75	N/A		N/A	N/A	0	Exempt
<a href="#">N9A</a>	4.12	1.06	0.2074	Yes	Yes	1.75	N/A		N/A	N/A	0	Exempt
<a href="#">N9B</a>	4.12	1.06	0.2074	Yes	Yes	1.75	N/A		N/A	N/A	0	Exempt

t<sub>n</sub>: Nozzle thickness

Req t<sub>n</sub>: Nozzle thickness required per UG-45/UG-16

Nom t: Vessel wall thickness

Design t: Required vessel wall thickness due to pressure + corrosion allowance per UG-37

User t: Local vessel wall thickness (near opening)

A<sub>a</sub>: Area available per UG-37, governing condition

A<sub>r</sub>: Area required per UG-37, governing condition

Corr: Corrosion allowance on nozzle wall

\* Head minimum thickness after forming

## Pressure Summary

### Pressure Summary for Chamber bounded by 48 OD BOTTOM SE HEAD and 48 OD TOP SE HEAD

Identifier	P Design (psi)	T Design (°F)	MAWP (psi)	MAEP (psi)	T <sub>e</sub> external (°F)	MDMT (°F)	MDMT Exemption	Impact Tested
<a href="#">48 OD TOP SE HEAD</a>	1,378	140	1,541.68	566.01	140	-320	Note 1	No
<a href="#">Straight Flange on 48 OD TOP SE HEAD</a>	1,378	140	1,519.84	630.75	140	-320	Note 2	No
<a href="#">48 OD SHELL</a>	1,378	140	1,501.51	622.51	140	-320	Note 2	No
<a href="#">Straight Flange on 48 OD BOTTOM SE HEAD</a>	1,378	140	1,519.12	630.75	140	-320	Note 2	No
<a href="#">48 OD BOTTOM SE HEAD</a>	1,378	140	1,540.53	566.01	140	-320	Note 3	No
<a href="#">Manway c/w Blind Flange (MW1)</a>	1,378	140	1,378	622.51	140	-55	Note 4	No
<a href="#">Inlet (N1)</a>	1,378	140	1,378	622.51	140	-55	Note 4	No
<a href="#">Level Gauge High (N10A)</a>	1,378	140	1,378	622.51	140	-55	Note 4	No
<a href="#">Level Gauge Low (N10B)</a>	1,378	140	1,378	622.51	140	-55	Note 4	No
<a href="#">Spare (N11)</a>	1,378	140	1,378	622.51	140	-55	Note 4	No
<a href="#">Purge (N12)</a>	1,378	140	1,378	622.51	140	-55	Note 4	No
<a href="#">Bottom Drain (N13)</a>	1,378	140	1,378	566.01	140	-55	Note 4	No
<a href="#">Vent (N14)</a>	1,378	140	1,378	566.01	140	-55	Note 4	No
<a href="#">Inspection c/w Blind Flange (N15)</a>	1,378	140	1,378	622.51	140	-55	Note 4	No
<a href="#">Gas Outlet (N2)</a>	1,378	140	1,378	566.01	140	-55	Note 4	No
<a href="#">Liquid Outlet (N3)</a>	1,378	140	1,378	622.51	140	-55	Note 4	No
<a href="#">PSV (N4)</a>	1,378	140	1,378	622.51	140	-55	Note 4	No
<a href="#">Pressure Indicator (N5)</a>	1,378	140	1,378	622.51	140	-55	Note 4	No
<a href="#">Temperature Indicator (N6)</a>	1,378	140	1,378	622.51	140	-55	Note 4	No
<a href="#">PDI High (N7A)</a>	1,378	140	1,378	622.51	140	-55	Note 4	No
<a href="#">PDI Low (N7B)</a>	1,378	140	1,378	622.51	140	-55	Note 4	No
<a href="#">Level Bridle - (Process) High (N8A)</a>	1,378	140	1,378	622.51	140	-55	Note 4	No
<a href="#">Level Bridle - (Process) Low (N8B)</a>	1,378	140	1,378	622.51	140	-55	Note 4	No
<a href="#">Level Bridle - (Safety) High (N9A)</a>	1,378	140	1,378	622.51	140	-55	Note 4	No
<a href="#">Level Bridle - (Safety) Low (N9B)</a>	1,378	140	1,378	622.51	140	-55	Note 4	No

Chamber design MDMT is -20 °F

Chamber rated MDMT is -55 °F @ 1,378 psi

Chamber MAWP was used in the MDMT determination

Chamber MAWP hot & corroded is 1,378 psi @ 140 °F

This is due to the MAWP limit set in the Calculations tab of the Set Mode dialog.

Chamber MAEP is 566.01 psi @ 140 °F

Vacuum rings did not govern the external pressure rating.

#### Notes for Maximum Pressure Rating:

Note #	Details
1.	Option to calculate MAP was not selected. See the Calculation->General tab of the Set Mode dialog.

### Notes for MDMT Rating:

Note #	Exemption	Details
1.	<a href="#">Straight Flange</a> governs MDMT	
2.	Rated MDMT per UHA-51(d)(1)(a) = -320 °F	
3.	<a href="#">Straight Flange</a> governs MDMT	
4.	Flange rating governs: Flange rated MDMT = -320 °F Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F	Per UHA-51(d)(1)(a)

Design notes are available on the [Settings Summary](#) page.

## Settings Summary

COMPRESS 2013 Build 7320

**Units: U.S. Customary**

**Datum Line Location: 0.00" from top seam**

### Design

ASME Section VIII Division 1, 2010 Edition, A11 Addenda

Design or Rating:	Get Thickness from Pressure
Minimum thickness:	0.0625" per UG-16(b)
Design for cold shut down only:	No
Design for lethal service (full radiography required):	Yes
User has limited MAWP to:	1,378 psi
Design nozzles for:	Vessel MAWP
Corrosion weight loss:	100% of theoretical loss
UG-23 Stress Increase:	1.20
Skirt/legs stress increase:	1.3
Minimum nozzle projection:	4"
Juncture calculations for $\alpha > 30$ only:	Yes
Preheat P-No 1 Materials $> 1.25"$ and $\leq 1.50"$ thick:	No
UG-37(a) shell tr calculation considers longitudinal stress:	No

Butt welds are tapered per Figure UCS-66.3(a).

### 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:	RT1
UG-116(f) Postweld heat treatment:	None

### Code Cases/Interpretations

Use Code Case 2547:	No
Apply interpretation VIII-1-83-66:	Yes
Apply interpretation VIII-1-86-175:	Yes
Apply interpretation VIII-1-01-37:	Yes
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:	No
Note: UG-22(b),(c) and (f) loads only considered when supports are present.	

### Thickness Summary

Component Identifier	Material	Diameter (in)	Length (in)	Nominal t (in)	Design t (in)	Total Corrosion (in)	Joint E	Load
<a href="#">48 OD TOP SE HEAD</a>	SA-240 316	48 OD	12.865	1.73*	1.5571	0	1.00	Internal
<a href="#">Straight Flange on 48 OD TOP SE HEAD</a>	SA-240 316	48 OD	2	1.77	1.6093	0	1.00	Internal
<a href="#">48 OD SHELL</a>	SA-240 316	48 OD	96	1.75	1.61	0	1.00	Internal
<a href="#">Straight Flange on 48 OD BOTTOM SE HEAD</a>	SA-240 316	48 OD	2	1.77	1.6101	0	1.00	Internal
<a href="#">48 OD BOTTOM SE HEAD</a>	SA-240 316	48 OD	12.865	1.73*	1.5583	0	1.00	Internal
<a href="#">46-3/4" OD Skirt</a>	SA-240 316	46.75 OD	20	0.5	0.0579	0	0.55	Seismic

Nominal t: Vessel wall nominal thickness

Design t: Required vessel thickness due to governing loading + corrosion

Joint E: Longitudinal seam joint efficiency

\* Head minimum thickness after forming

Load

internal: Circumferential stress due to internal pressure governs

external: External pressure governs

Wind: Combined longitudinal stress of pressure + weight + wind governs

Seismic: Combined longitudinal stress of pressure + weight + seismic governs

## Weight Summary

Component	Weight ( lb) Contributed by Vessel Elements										Surface Area ft <sup>2</sup>
	Metal New*	Metal Corroded*	Insulation	Insulation Supports	Lining	Piping + Liquid	Operating Liquid		Test Liquid		
							New	Corroded	New	Corroded	
<a href="#">48 OD TOP SE HEAD</a>	1,349.3	1,349.3	0	0	0	0	0	0	542.8	542.8	21
<a href="#">48 OD SHELL</a>	6,385.9	6,385.9	0	0	0	0	1,019.6	1,019.6	5,518.3	5,518.3	91
<a href="#">48 OD BOTTOM SE HEAD</a>	1,408.1	1,408.1	0	0	0	0	582.9	582.9	529.9	529.9	21
<a href="#">46-3/4" OD Skirt</a>	400.3	400.3	0	0	0	0	0	0	0	0	41
<a href="#">Skirt Base Ring</a>	318	318	0	0	0	0	0	0	0	0	20
<b>TOTAL:</b>	<b>9,861.6</b>	<b>9,861.6</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1,602.5</b>	<b>1,602.5</b>	<b>6,590.9</b>	<b>6,590.9</b>	<b>194</b>

\* Shells with attached nozzles have weight reduced by material cut out for opening.

Component	Weight ( lb) Contributed by Attachments										Surface Area ft <sup>2</sup>
	Body Flanges		Nozzles & Flanges		Packed Beds	Ladders & Platforms	Trays	Tray Supports	Rings & Clips	Vertical Loads	
	New	Corroded	New	Corroded							
<a href="#">48 OD TOP SE HEAD</a>	0	0	378.5	378.5	0	0	0	0	31.9	0	6
<a href="#">48 OD SHELL</a>	0	0	7,893.4	7,893.4	0	0	0	0	0	0	57
<a href="#">48 OD BOTTOM SE HEAD</a>	0	0	28.7	28.7	0	0	0	0	0	0	1
<a href="#">46-3/4" OD Skirt</a>	0	0	60	60	0	0	0	0	16.2	0	1
<b>TOTAL:</b>	<b>0</b>	<b>0</b>	<b>8,360.7</b>	<b>8,360.7</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>48.1</b>	<b>0</b>	<b>65</b>

Vessel operating weight, Corroded: 19,873 lb  
Vessel operating weight, New: 19,873 lb  
Vessel empty weight, Corroded: 18,270 lb  
Vessel empty weight, New: 18,270 lb  
Vessel test weight, New: 24,861 lb  
Vessel test weight, Corroded: 24,861 lb  
Vessel surface area: 259 ft<sup>2</sup>

### Vessel center of gravity location - from datum - lift condition

Vessel Lift Weight, New: 18,270 lb  
Center of Gravity: 56.4867"

### Vessel Capacity

Vessel Capacity\*\* (New): 773 US gal  
Vessel Capacity\*\* (Corroded): 773 US gal

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

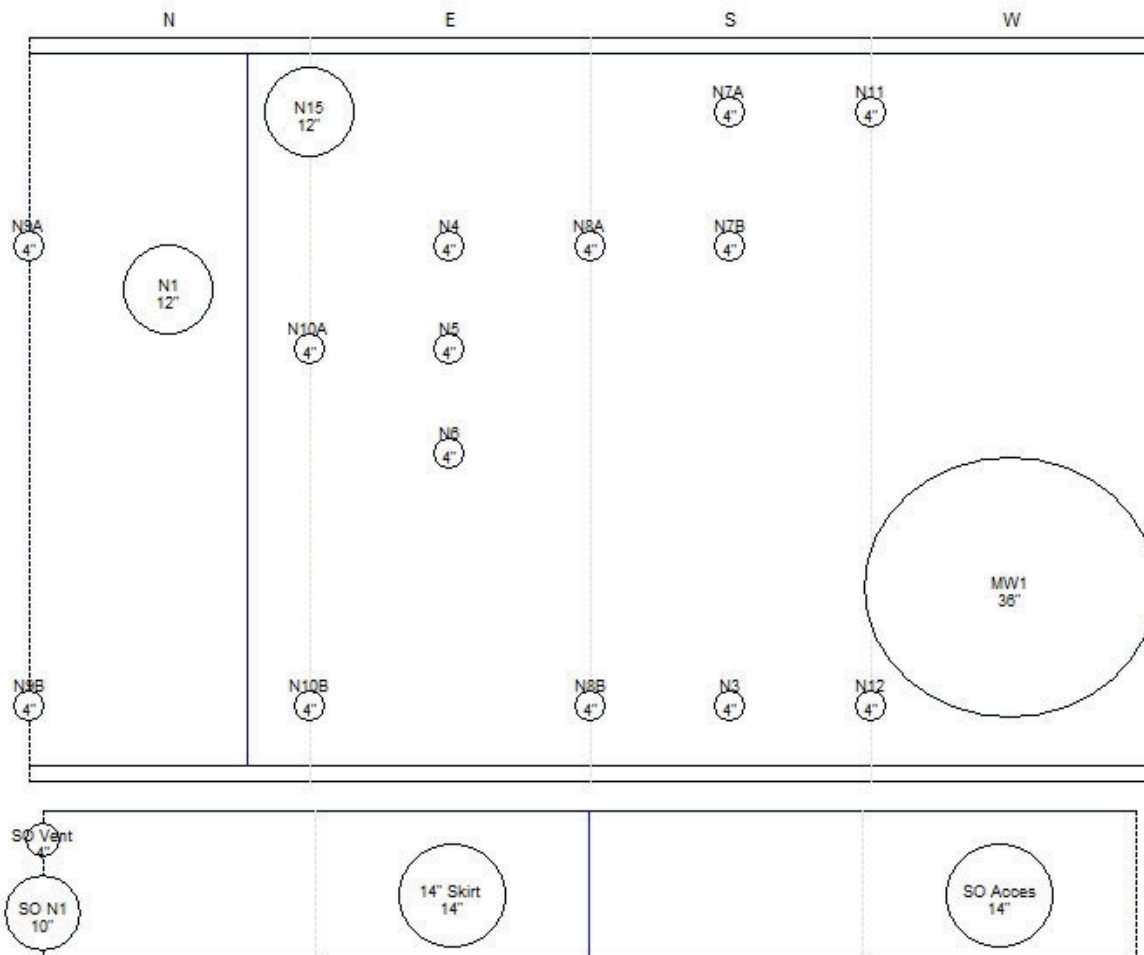
## Long Seam Summary

Shell Long Seam Angles	
Component	Seam 1
<a href="#">48 OD SHELL</a>	25°
<a href="#">46-3/4" OD Skirt</a>	135°

Shell Plate Lengths		
Component	Starting Angle	Plate 1
<a href="#">48 OD SHELL</a>	25°	145.2987"
<a href="#">46-3/4" OD Skirt</a>	135°	145.2987"

\*North is located at 0°

\*Plate Lengths use the circumference of the vessel based on the mid diameter of the components





## Shell Rollout

## Hydrostatic Test

### Shop test pressure determination for Chamber bounded by 48 OD BOTTOM SE HEAD and 48 OD TOP SE HEAD based on MAWP per UG-99(b)

Shop hydrostatic test gauge pressure is 1,791.4 psi at 50 °F (the chamber MAWP = 1,378 psi)

The shop test is performed with the vessel in the horizontal position.

Identifier	Local test pressure psi	Test liquid static head psi	UG-99(b) stress ratio	UG-99(b) pressure factor
48 OD TOP SE HEAD (1)	1,793.431	2.031	1	1.30
Straight Flange on 48 OD TOP SE HEAD	1,793.43	2.03	1	1.30
48 OD SHELL	1,793.431	2.031	1	1.30
Straight Flange on 48 OD BOTTOM SE HEAD	1,793.43	2.03	1	1.30
48 OD BOTTOM SE HEAD	1,793.431	2.031	1	1.30
Bottom Drain (N13)	1,792.658	1.258	1.0637	1.30
Gas Outlet (N2)	1,792.772	1.372	1	1.30
Inlet (N1)	1,791.761	0.361	1	1.30
Inspection c/w Blind Flange (N15)	1,792.117	0.717	1	1.30
Level Bridle - (Process) High (N8A)	1,793.47	2.07	1	1.30
Level Bridle - (Process) Low (N8B)	1,793.47	2.07	1	1.30
Level Bridle - (Safety) High (N9A)	1,792.04	0.64	1	1.30
Level Bridle - (Safety) Low (N9B)	1,792.04	0.64	1	1.30
Level Gauge High (N10A)	1,792.04	0.64	1	1.30
Level Gauge Low (N10B)	1,792.04	0.64	1	1.30
Liquid Outlet (N3)	1,793.782	2.382	1	1.30
Manway c/w Blind Flange (MW1)	1,793.061	1.661	1	1.30
PDI High (N7A)	1,793.782	2.382	1	1.30
PDI Low (N7B)	1,793.782	2.382	1	1.30
PSV (N4)	1,792.663	1.263	1	1.30
Pressure Indicator (N5)	1,792.663	1.263	1	1.30
Purge (N12)	1,793.47	2.07	1	1.30
Spare (N11)	1,793.47	2.07	1	1.30
Temperature Indicator (N6)	1,792.663	1.263	1	1.30
Vent (N14)	1,792.255	0.855	1	1.30

**Notes:**

- (1) 48 OD TOP SE HEAD limits the UG-99(b) stress ratio.
- (2) The zero degree angular position is assumed to be up, and the test liquid height is assumed to the top-most flange.

The field test condition has not been investigated for the Chamber bounded by 48 OD BOTTOM SE HEAD and 48 OD TOP SE HEAD.

## Vacuum Summary

Component	Line of Support	Elevation above Datum (in)	Length Le (in)
<a href="#">48 OD TOP SE HEAD</a>	-	-14.865	N/A
-	<a href="#">1/3 depth of 48 OD TOP SE HEAD</a>	-5.7117	N/A
<a href="#">Straight Flange on 48 OD TOP SE HEAD Top</a>	-	-2	107.4233
<a href="#">Straight Flange on 48 OD TOP SE HEAD Bottom</a>	-	0	107.4233
<a href="#">48 OD SHELL Top</a>	-	0	107.4233
<a href="#">48 OD SHELL Bottom</a>	-	96	107.4233
<a href="#">Straight Flange on 48 OD BOTTOM SE HEAD Top</a>	-	96	107.4233
<a href="#">Straight Flange on 48 OD BOTTOM SE HEAD Bottom</a>	-	98	107.4233
-	<a href="#">1/3 depth of 48 OD BOTTOM SE HEAD</a>	101.7117	N/A
<a href="#">48 OD BOTTOM SE HEAD</a>	-	110.865	N/A

Note
For main components, the listed value of 'Le' is the largest unsupported length for the component.

## Engineering Notes

1. External loads have not been considered in the flange pressure rating.
2. The minimum thickness of the top and bottom heads are from the readings taken by KV Inspection Services. Reports dated February 26, 2013.
3. The style of lifting lug analysed here is only analysed for vertical lifting only. The software will not complete a "rigging analyses" on this style of lifting lug.
4. The Compress software does not analyse the seismic and wind loads simultaneously so this information is not contained within this report. The magnitude of the wind loading in comparison to the motion "seismic" loads is miniscule when compared to the motion loads. The total wind load on this vessel equates to a force of 660 pounds acting on one side of the vessel.

## Seismic Code

<b>Method of seismic analysis:</b>	<b>User-defined</b>
Base Shear Multiplier	0.5000
Portion at Top	0.0700
Vertical Accelerations Considered:	Yes
Force Multiplier:	= 1.4738
Minimum Weight Multiplier:	= 1.0000

### Vessel Characteristics

Vessel height: 11.3954 ft

Vessel Weight:

Operating, Corroded: 19,873 lb

Empty, Corroded: 18,270 lb

Vacuum, Corroded: 19,873 lb

### Period of Vibration Calculation

Fundamental Period, T:

Operating, Corroded: 0.019 sec (f = 52.0 Hz)

Empty, Corroded: 0.019 sec (f = 52.5 Hz)

Vacuum, Corroded: 0.019 sec (f = 52.0 Hz)

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

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

$W_i$  is the weight of the  $i^{\text{th}}$  lumped mass, and  
 $y_i$  is its deflection when the system is treated as a cantilever beam.

### Seismic Shear Reports:

[Operating, Corroded](#)

[Empty, Corroded](#)

[Vacuum, Corroded](#)

[Base Shear Calculations](#)

**Seismic Shear Report: Operating, Corroded**

Component	Elevation of bottom above base (in)	Elastic modulus E (10 <sup>6</sup> psi)	Inertia I (ft <sup>4</sup> )	Seismic shear at Bottom (lbf)	Bending Moment at Bottom (lbf-ft)
48 OD TOP SE HEAD	121.88	27.9	*	2,376	2,187
48 OD SHELL	25.88	27.9	3.2834	9,365	69,180
48 OD BOTTOM SE HEAD (top)	20	27.9	*	9,518	73,808
46-3/4" OD Skirt	0	27.9	0.9369	9,936	90,304
*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 <sup>6</sup> psi)	Inertia I (ft <sup>4</sup> )	Seismic shear at Bottom (lbf)	Bending Moment at Bottom (lbf-ft)
48 OD TOP SE HEAD	121.88	28.3	*	2,245	2,062
48 OD SHELL	25.88	28.3	3.2834	8,682	66,612
48 OD BOTTOM SE HEAD (top)	20	28.3	*	8,772	70,889
46-3/4" OD Skirt	0	28.3	0.9369	9,135	86,062
*Moment of Inertia I varies over the length of the component					

**Seismic Shear Report: Vacuum, Corroded**

Component	Elevation of bottom above base (in)	Elastic modulus E (10 <sup>6</sup> psi)	Inertia I (ft <sup>4</sup> )	Seismic shear at Bottom (lbf)	Bending Moment at Bottom (lbf-ft)
48 OD TOP SE HEAD	121.88	27.9	*	2,376	2,187
48 OD SHELL	25.88	27.9	3.2834	9,365	69,180
48 OD BOTTOM SE HEAD (top)	20	27.9	*	9,518	73,808
46-3/4" OD Skirt	0	27.9	0.9369	9,936	90,304
*Moment of Inertia I varies over the length of the component					

**Vertical Acceleration Term,  $V_{Accel}$**

Factor is applied to dead load.

Compressive Side: = 1.0 +  $V_{Accel}$

<b><math>V_{Accel}</math> Term is: greater of (Force Mult * Base Shear / Weight) or (Min. Weight Mult.)</b>				
Force multiplier = 1.4738		Minimum Weight Multiplier = 1.0000		
Condition	Base Shear ( lbf)	Weight ( lb)	<b>Force Mult * Shear Weight</b>	$V_{Accel}$
Operating, Corroded	9,936	19,872.9	0.7369	1
Operating, New	9,936	19,872.9	0.7369	1
Empty, Corroded	9,135	18,270.4	0.7369	1
Empty, New	9,135	18,270.4	0.7369	1
Vacuum, Corroded	9,936	19,872.9	0.7369	1

**Base Shear Calculations**

- [Operating, Corroded](#)
- [Empty, Corroded](#)
- [Vacuum, Corroded](#)

**Base Shear Calculations: Operating, Corroded**

$$\begin{aligned} V &= \text{Base Shear Multiplier} * W \\ &= 0.5000 * 19,872.8789 \\ &= 9,936.44 \text{ lb} \end{aligned}$$

**Base Shear Calculations: Empty, Corroded**

$$\begin{aligned} V &= \text{Base Shear Multiplier} * W \\ &= 0.5000 * 18,270.3887 \\ &= 9,135.19 \text{ lb} \end{aligned}$$

**Base Shear Calculations: Vacuum, Corroded**

$$\begin{aligned} V &= \text{Base Shear Multiplier} * W \\ &= 0.5000 * 19,872.8789 \\ &= 9,936.44 \text{ lb} \end{aligned}$$

## Wind Code

**Building Code:** **User Defined**  
 Elevation of base above grade: 0.0000 ft  
 Increase effective outer diameter by: 0.0000 ft  
 Wind Force Coefficient Cf: 0.8000

### Vessel Characteristics

Vessel height, h: 11.3954 ft  
 Vessel Minimum Diameter  
     Operating, Corroded: 4.0000 ft  
     Empty, Corroded: 4.0000 ft  
 Fundamental Frequency,  $n_1$   
     Operating, Corroded: 52.0264 Hz  
     Empty, Corroded: 52.5492 Hz  
 Damping coefficient,  $\beta$   
     Operating, Corroded: 0.0248  
     Empty, Corroded: 0.0200

### Wind Deflection Reports:

[Operating, Corroded](#)  
[Empty, Corroded](#)  
[Vacuum, Corroded](#)  
[Wind Pressure Table](#)

### Wind Deflection Report: Operating, Corroded

Component	Elevation of bottom above base (in)	Effective OD (ft)	Elastic modulus E (10 <sup>6</sup> psi)	Inertia I (ft <sup>4</sup> )	Platform wind shear at Bottom (lbf)	Total wind shear at Bottom (lbf)	bending moment at Bottom (lbf-ft)	Deflection at top (in)
48 OD TOP SE HEAD	121.88	4.00	27.9	*	0	50	95	0.0018
48 OD SHELL	25.88	4.00	27.9	3.283	0	447	22,569	0.0015
48 OD BOTTOM SE HEAD (top)	20	4.00	27.9	*	0	471	22,794	0.0002
46-3/4" OD Skirt	0	3.90	27.9	0.9369	0	551	23,646	0.0001
*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 <sup>6</sup> psi)	Inertia I (ft <sup>4</sup> )	Platform wind shear at Bottom (lbf)	Total wind shear at Bottom (lbf)	bending moment at Bottom (lbf-ft)	Deflection at top (in)
48 OD TOP SE HEAD	121.88	4.00	28.3	*	0	50	95	0.0017
48 OD SHELL	25.88	4.00	28.3	3.283	0	447	22,569	0.0015
48 OD BOTTOM SE HEAD (top)	20	4.00	28.3	*	0	471	22,794	0.0002
46-3/4" OD Skirt	0	3.90	28.3	0.9369	0	551	23,646	0.0001
*Moment of Inertia I varies over the length of the component								

**Wind Deflection Report: Vacuum, Corroded**

Component	Elevation of bottom above base (in)	Effective OD (ft)	Elastic modulus E (10 <sup>6</sup> psi)	Inertia I (ft <sup>4</sup> )	Platform wind shear at Bottom (lbf)	Total wind shear at Bottom (lbf)	bending moment at Bottom (lbf-ft)	Deflection at top (in)
48 OD TOP SE HEAD	121.88	4.00	27.9	*	0	50	95	0.0018
48 OD SHELL	25.88	4.00	27.9	3.283	0	447	22,569	0.0015
48 OD BOTTOM SE HEAD (top)	20	4.00	27.9	*	0	471	22,794	0.0002
46-3/4" OD Skirt	0	3.90	27.9	0.9369	0	551	23,646	0.0001
*Moment of Inertia I varies over the length of the component								

**Wind Pressure (WP) table**

Wind Force Coefficient Cf: 0.8000

**Design Wind Pressures**

To Height Z (')	Wind Pressure (psf)	Adjusted by Cf (psf)
15.00	15.5000	12.4000

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

## 48 OD TOP SE HEAD

### ASME Section VIII, Division 1, 2010 Edition, A11 Addenda

Component: Ellipsoidal Head  
Material Specification: SA-240 316 (II-D p.70, In. 26)  
Straight Flange governs MDMT

Internal design pressure:  $P = 1,378$  psi @ 140 °F

External design pressure:  $P_e = 15$  psi @ 140 °F

#### Static liquid head:

$P_s = 0$  psi (SG=1.1,  $H_s=0$ " Operating head)

$P_{th} = 2.03$  psi (SG=1,  $H_s=56.27$ " Horizontal test head)

Corrosion allowance: Inner C = 0" Outer C = 0"

Design MDMT = -20°F

Rated MDMT = -320°F

No impact test performed

Material is not normalized

Material is not produced to fine grain practice

PWHT is not performed

Do not Optimize MDMT / Find MAWP

Radiography: Category A joints - Seamless No RT  
Head to shell seam - Full UW-11(a) Type 1

Estimated weight\*: new = 1,349.3 lb corr = 1,349.3 lb  
Capacity\*: new = 63.5 US gal corr = 63.5 US gal  
\* includes straight flange

Outer diameter = 48"  
Minimum head thickness = 1.73"  
Head ratio D/2h = 2 (new)  
Head ratio D/2h = 2 (corroded)  
Straight flange length  $L_{sf}$  = 2"  
Nominal straight flange thickness  $t_{sf}$  = 1.77"

#### Results Summary

The governing condition is internal pressure.

Minimum thickness per UG-16 =  $0.0625" + 0" = 0.0625"$

Design thickness due to internal pressure (t) = 1.5571"

Design thickness due to external pressure ( $t_e$ ) = 0.1193"

Maximum allowable working pressure (MAWP) = 1,541.68 psi

Maximum allowable external pressure (MAEP) = 566.01 psi

#### K (Corroded)

$$K = (1/6) * [2 + (D / (2 * h))^2] = (1/6) * [2 + (44.54 / (2 * 11.135))^2] = 1$$

#### K (New)

$$K = (1/6) * [2 + (D / (2 * h))^2] = (1/6) * [2 + (44.54 / (2 * 11.135))^2] = 1$$

**Design thickness for internal pressure, (Corroded at 140 °F) Appendix 1-4(c)**

$$\begin{aligned}
 t &= P \cdot D_o \cdot K / (2 \cdot S \cdot E + 2 \cdot P \cdot (K - 0.1)) + \text{Corrosion} \\
 &= 1,378 \cdot 48 \cdot 1 / (2 \cdot 20,000 \cdot 1 + 2 \cdot 1,378 \cdot (1 - 0.1)) + 0 \\
 &= 1.557"
 \end{aligned}$$

The head internal pressure design thickness is [1.5571](#)".

**Maximum allowable working pressure, (Corroded at 140 °F) Appendix 1-4(c)**

$$\begin{aligned}
 P &= 2 \cdot S \cdot E \cdot t / (K \cdot D_o - 2 \cdot t \cdot (K - 0.1)) - P_s \\
 &= 2 \cdot 20,000 \cdot 1 \cdot 1.73 / (1 \cdot 48 - 2 \cdot 1.73 \cdot (1 - 0.1)) - 0 \\
 &= 1,541.68 \text{ psi}
 \end{aligned}$$

The maximum allowable working pressure (MAWP) is [1,541.68](#) psi.

**Design thickness for external pressure, (Corroded at 140 °F) UG-33(d)**

Equivalent outside spherical radius ( $R_o$ )

$$\begin{aligned}
 R_o &= K_o \cdot D_o \\
 &= 0.8395 \cdot 48 \\
 &= 40.2954 \text{ in}
 \end{aligned}$$

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (40.2954 / 0.119274) \\
 &= 0.00037
 \end{aligned}$$

From Table HA-2:  $B = 5,067.5892$  psi

$$\begin{aligned}
 P_a &= B / (R_o / t) \\
 &= 5,067.5892 / (40.2954 / 0.1193) \\
 &= 15 \text{ psi}
 \end{aligned}$$

$$t = 0.1193" + \text{Corrosion} = 0.1193" + 0" = 0.1193"$$

Check the external pressure per UG-33(a)(1) Appendix 1-4(c)

$$\begin{aligned}
 t &= 1.67 \cdot P_e \cdot D_o \cdot K / (2 \cdot S \cdot E + 2 \cdot 1.67 \cdot P_e \cdot (K - 0.1)) + \text{Corrosion} \\
 &= 1.67 \cdot 15 \cdot 48 \cdot 1 / (2 \cdot 20,000 \cdot 1 + 2 \cdot 1.67 \cdot 15 \cdot (1 - 0.1)) + 0 \\
 &= 0.03"
 \end{aligned}$$

The head external pressure design thickness ( $t_e$ ) is [0.1193](#)".

**Maximum Allowable External Pressure, (Corroded at 140 °F) UG-33(d)**

Equivalent outside spherical radius ( $R_o$ )

$$\begin{aligned}
 R_o &= K_o \cdot D_o \\
 &= 0.8395 \cdot 48 \\
 &= 40.2954 \text{ in}
 \end{aligned}$$

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (40.2954 / 1.73) \\
 &= 0.005367
 \end{aligned}$$

From Table HA-2:  $B = 13,183.56$  psi

$$\begin{aligned}
 P_a &= B / (R_o / t) \\
 &= 13,183.56 / (40.2954 / 1.73) \\
 &= 566.0093 \text{ psi}
 \end{aligned}$$

**Check the Maximum External Pressure, UG-33(a)(1) Appendix 1-4(c)**

$$\begin{aligned}
 P &= 2 * S * E * t / ((K * D_o - 2 * t * (K - 0.1)) * 1.67) - P_{s2} \\
 &= 2 * 20,000 * 1 * 1.73 / ((1 * 48 - 2 * 1.73 * (1 - 0.1)) * 1.67) - 0 \\
 &= 923.16 \text{ psi}
 \end{aligned}$$

The maximum allowable external pressure (MAEP) is [566.01](#) psi.

**% Forming strain - UHA-44(a)(2)(b)**

$$\begin{aligned}
 EFE &= (75 * t / R_f) * (1 - R_f / R_o) \\
 &= (75 * 1.77 / 8.4568) * (1 - 8.4568 / \infty) \\
 &= 15.6974\%
 \end{aligned}$$

## Straight Flange on 48 OD TOP SE HEAD

### ASME Section VIII Division 1, 2010 Edition, A11 Addenda

Component: Straight Flange  
Material specification: SA-240 316 (II-D p. 70, ln. 26)  
Rated MDMT per UHA-51(d)(1)(a) = -320 °F

Internal design pressure:  $P = 1,378 \text{ psi @ } 140 \text{ °F}$

External design pressure:  $P_e = 15 \text{ psi @ } 140 \text{ °F}$

#### Static liquid head:

$P_s = 0 \text{ psi}$  (SG = 1.1,  $H_s = 0''$ , Operating head)  
 $P_{th} = 2.03 \text{ psi}$  (SG = 1,  $H_s = 56.23''$ , Horizontal test head)

Corrosion allowance Inner C = 0" Outer C = 0"

Design MDMT = -20 °F No impact test performed  
Rated MDMT = -320 °F Material is not normalized  
Material is not produced to Fine Grain Practice  
PWHT is not performed

Radiography: Longitudinal joint - Seamless No RT  
Circumferential joint - Full UW-11(a) Type 1

Estimated weight New = 149.1 lb corr = 149.1 lb  
Capacity New = 13.44 US gal corr = 13.44 US gal

OD = 48"  
Length = 2"  
 $L_c$   
t = 1.77"

#### Design thickness, (at 140 °F) Appendix 1-1

t =  $P \cdot R_o / (S \cdot E + 0.40 \cdot P) + \text{Corrosion}$   
=  $1,378 \cdot 24 / (20,000 \cdot 1.00 + 0.40 \cdot 1,378) + 0$   
= 1.6093"

#### Maximum allowable working pressure, (at 140 °F) Appendix 1-1

P =  $S \cdot E \cdot t / (R_o - 0.40 \cdot t) - P_s$   
=  $20,000 \cdot 1.00 \cdot 1.77 / (24 - 0.40 \cdot 1.77) - 0$   
= 1,519.84 psi

#### External Pressure, (Corroded & at 140 °F) UG-28(c)

$L / D_o = 107.4233 / 48 = 2.2380$   
 $D_o / t = 48 / 0.2194 = 218.7532$   
From table G: A = 0.000180  
From table HA-2: B = 2,460.9773 psi

$P_a = 4 \cdot B / (3 \cdot (D_o / t))$   
=  $4 \cdot 2,460.98 / (3 \cdot (48 / 0.2194))$

$$= 15 \text{ psi}$$

**Design thickness for external pressure  $P_a = 15 \text{ psi}$**

$$t_a = t + \text{Corrosion} = 0.2194 + 0 = 0.2194''$$

**Maximum Allowable External Pressure, (Corroded & at 140 °F) UG-28(c)**

$$L / D_o = 107.4233 / 48 = 2.2380$$

$$D_o / t = 48 / 1.77 = 27.1186$$

From table G:  $A = 0.004031$

From table  
HA-2:  $B = 12,828.9038 \text{ psi}$

$$\begin{aligned} P_a &= 4*B / (3*(D_o / t)) \\ &= 4*12,828.9 / (3*(48 / 1.77)) \\ &= 630.75 \text{ psi} \end{aligned}$$

**% Forming strain - UHA-44(a)(2)(a)**

$$\begin{aligned} EFE &= (50*t / R_f)^*(1 - R_f / R_o) \\ &= (50*1.77 / 23.115)^*(1 - 23.115 / \infty) \\ &= 3.8287\% \end{aligned}$$

**Design thickness = 1.6093"**

The governing condition is due to internal pressure.

The cylinder thickness of 1.77" is adequate.

## 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 <sub>t</sub>	S <sub>c</sub>					
<a href="#">Operating, Hot &amp; Corroded</a>	1,378	20,000	<a href="#">13.729</a>	140	0	Wind	<a href="#">0.6305</a>	<a href="#">0.6304</a>
						Seismic	<a href="#">0.6311</a>	<a href="#">0.6293</a>
<a href="#">Operating, Hot &amp; New</a>	1,378	20,000	<a href="#">13.729</a>	140	0	Wind	<a href="#">0.6305</a>	<a href="#">0.6304</a>
						Seismic	<a href="#">0.6311</a>	<a href="#">0.6293</a>
<a href="#">Hot Shut Down, Corroded</a>	0	20,000	<a href="#">13.729</a>	140	0	Wind	<a href="#">0.0007</a>	<a href="#">0.0008</a>
						Seismic	<a href="#">0.0001</a>	<a href="#">0.0024</a>
<a href="#">Hot Shut Down, New</a>	0	20,000	<a href="#">13.729</a>	140	0	Wind	<a href="#">0.0007</a>	<a href="#">0.0008</a>
						Seismic	<a href="#">0.0001</a>	<a href="#">0.0024</a>
<a href="#">Empty, Corroded</a>	0	20,000	<a href="#">13.908</a>	70	0	Wind	<a href="#">0.0007</a>	<a href="#">0.0008</a>
						Seismic	<a href="#">0.0001</a>	<a href="#">0.0023</a>
<a href="#">Empty, New</a>	0	20,000	<a href="#">13.908</a>	70	0	Wind	<a href="#">0.0007</a>	<a href="#">0.0008</a>
						Seismic	<a href="#">0.0001</a>	<a href="#">0.0023</a>
<a href="#">Vacuum</a>	-15	20,000	<a href="#">13.729</a>	140	0	Wind	<a href="#">0.0108</a>	<a href="#">0.0109</a>
						Seismic	<a href="#">0.0099</a>	<a href="#">0.0125</a>
<a href="#">Hot Shut Down, Corroded, Weight &amp; Eccentric Moments Only</a>	0	20,000	<a href="#">13.729</a>	140	0	Weight	<a href="#">0.0008</a>	<a href="#">0.0009</a>

### Allowable Compressive Stress, Hot and Corroded- S<sub>cHC</sub>, (table HA-2)

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (24 / 1.77) \\
 &= 0.009219 \\
 B &= 13,729 \text{ psi} \\
 S &= 20,000 / 1.00 = 20,000 \text{ psi} \\
 S_{cHC} &= \min(B, S) = \underline{13.729 \text{ psi}}
 \end{aligned}$$

### Allowable Compressive Stress, Hot and New- S<sub>cHN</sub>

$$\begin{aligned}
 S_{cHN} &= S_{cHC} \\
 &= \underline{13.729 \text{ psi}}
 \end{aligned}$$

### Allowable Compressive Stress, Cold and New- S<sub>cCN</sub>, (table HA-2)

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (24 / 1.77) \\
 &= 0.009219 \\
 B &= 13,908 \text{ psi} \\
 S &= 20,000 / 1.00 = 20,000 \text{ psi} \\
 S_{cCN} &= \min(B, S) = \underline{13.908 \text{ psi}}
 \end{aligned}$$

### Allowable Compressive Stress, Cold and Corroded- S<sub>cCC</sub>

$$\begin{aligned}
 S_{cCC} &= S_{cCN} \\
 &= \underline{13.908 \text{ psi}}
 \end{aligned}$$

**Allowable Compressive Stress, Vacuum and Corroded-  $S_{cVC}$ , (table HA-2)**

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (24 / 1.77) \\
 &= 0.009219 \\
 B &= 13,729 \text{ psi} \\
 S &= 20,000 / 1.00 = 20,000 \text{ psi} \\
 S_{cVC} &= \min(B, S) = \underline{13.729 \text{ psi}}
 \end{aligned}$$

**Operating, Hot & Corroded, Wind, Bottom Seam**

$$\begin{aligned}
 t_p &= P \cdot R / (2 \cdot S_t \cdot K_s \cdot E_c + 0.40 \cdot |P|) && \text{(Pressure)} \\
 &= 1,378 \cdot 22.23 / (2 \cdot 20,000 \cdot 1.20 \cdot 1.00 + 0.40 \cdot |1,378|) \\
 &= 0.6309" \\
 t_m &= M / (\pi \cdot R_m^2 \cdot S_t \cdot K_s \cdot E_c) && \text{(bending)} \\
 &= 1,145 / (\pi \cdot 23.115^2 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\
 &= 0" \\
 t_w &= W / (2 \cdot \pi \cdot R_m \cdot S_t \cdot K_s \cdot E_c) && \text{(Weight)} \\
 &= 1,759.7 / (2 \cdot \pi \cdot 23.115 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\
 &= 0.0005" \\
 t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\
 &= 0.6309 + 0 - (0.0005) \\
 &= \underline{0.6305"} \\
 t_c &= |t_{mc} + t_{wc} - t_{pc}| && \text{(total, net tensile)} \\
 &= |0 + (0.0005) - (0.6309)| \\
 &= \underline{0.6304"}
 \end{aligned}$$

**Maximum allowable working pressure, Longitudinal Stress**

$$\begin{aligned}
 P &= 2 \cdot S_t \cdot K_s \cdot E_c \cdot (t - t_m + t_w) / (R - 0.40 \cdot (t - t_m + t_w)) \\
 &= 2 \cdot 20,000 \cdot 1.20 \cdot 1.00 \cdot (1.77 - 0 + (0.0005)) / (22.23 - 0.40 \cdot (1.77 - 0 + (0.0005))) \\
 &= 3,948.69 \text{ psi}
 \end{aligned}$$

**Operating, Hot & New, Wind, Bottom Seam**

$$\begin{aligned}
 t_p &= P \cdot R / (2 \cdot S_t \cdot K_s \cdot E_c + 0.40 \cdot |P|) && \text{(Pressure)} \\
 &= 1,378 \cdot 22.23 / (2 \cdot 20,000 \cdot 1.20 \cdot 1.00 + 0.40 \cdot |1,378|) \\
 &= 0.6309" \\
 t_m &= M / (\pi \cdot R_m^2 \cdot S_t \cdot K_s \cdot E_c) && \text{(bending)} \\
 &= 1,145 / (\pi \cdot 23.115^2 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\
 &= 0" \\
 t_w &= W / (2 \cdot \pi \cdot R_m \cdot S_t \cdot K_s \cdot E_c) && \text{(Weight)} \\
 &= 1,759.7 / (2 \cdot \pi \cdot 23.115 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\
 &= 0.0005" \\
 t_t &= t_p + t_m - t_w && \text{(total required, tensile)}
 \end{aligned}$$



$$= 0.6309 + 0 - (0.0005)$$

$$= \underline{0.6305''}$$

$$t_c = |t_{mc} + t_{wc} - t_{pc}| \quad \text{(total, net tensile)}$$

$$= |0 + (0.0005) - (0.6309)|$$

$$= \underline{0.6304''}$$

### Maximum allowable working pressure, Longitudinal Stress

$$P = 2 * S_t * K_s * E_c * (t - t_m + t_w) / (R - 0.40 * (t - t_m + t_w))$$

$$= 2 * 20,000 * 1.20 * 1.00 * (1.77 - 0 + (0.0005)) / (22.23 - 0.40 * (1.77 - 0 + (0.0005)))$$

$$= 3,948.69 \text{ psi}$$

### Hot Shut Down, Corroded, Wind, Bottom Seam

$$t_p = 0'' \quad \text{(Pressure)}$$

$$t_m = M / (\pi * R_m^2 * S_c * K_s) \quad \text{(bending)}$$

$$= 1,145 / (\pi * 23.115^2 * 13,728.59 * 1.20)$$

$$= 0''$$

$$t_w = W / (2 * \pi * R_m * S_c * K_s) \quad \text{(Weight)}$$

$$= 1,759.7 / (2 * \pi * 23.115 * 13,728.59 * 1.20)$$

$$= 0.0007''$$

$$t_t = |t_p + t_m - t_w| \quad \text{(total, net compressive)}$$

$$= |0 + 0 - (0.0007)|$$

$$= \underline{0.0007''}$$

$$t_c = t_{mc} + t_{wc} - t_{pc} \quad \text{(total required, compressive)}$$

$$= 0 + (0.0007) - (0)$$

$$= \underline{0.0008''}$$

### Hot Shut Down, New, Wind, Bottom Seam

$$t_p = 0'' \quad \text{(Pressure)}$$

$$t_m = M / (\pi * R_m^2 * S_c * K_s) \quad \text{(bending)}$$

$$= 1,145 / (\pi * 23.115^2 * 13,728.59 * 1.20)$$

$$= 0''$$

$$t_w = W / (2 * \pi * R_m * S_c * K_s) \quad \text{(Weight)}$$

$$= 1,759.7 / (2 * \pi * 23.115 * 13,728.59 * 1.20)$$

$$= 0.0007''$$

$$t_t = |t_p + t_m - t_w| \quad \text{(total, net compressive)}$$

$$= |0 + 0 - (0.0007)|$$

$$= \underline{0.0007''}$$

$$t_c = t_{mc} + t_{wc} - t_{pc} \quad \text{(total required, compressive)}$$

$$= 0 + (0.0007) - (0)$$

$$= \underline{0.0008''}$$

### Empty, Corroded, Wind, Bottom Seam

$$t_p = 0'' \quad \text{(Pressure)}$$

$$t_m = M / (\pi R_m^2 S_c K_s) \quad (\text{bending})$$

$$= 1,145 / (\pi * 23.115^2 * 13,907.75 * 1.20)$$

$$= 0"$$

$$t_w = W / (2 \pi R_m S_c K_s) \quad (\text{Weight})$$

$$= 1,759.7 / (2 \pi * 23.115 * 13,907.75 * 1.20)$$

$$= 0.0007"$$

$$t_t = |t_p + t_m - t_w| \quad (\text{total, net compressive})$$

$$= |0 + 0 - (0.0007)|$$

$$= \underline{0.0007}"$$

$$t_c = t_{mc} + t_{wc} - t_{pc} \quad (\text{total required, compressive})$$

$$= 0 + (0.0007) - (0)$$

$$= \underline{0.0008}"$$

### Empty, New, Wind, Bottom Seam

$$t_p = 0" \quad (\text{Pressure})$$

$$t_m = M / (\pi R_m^2 S_c K_s) \quad (\text{bending})$$

$$= 1,145 / (\pi * 23.115^2 * 13,907.75 * 1.20)$$

$$= 0"$$

$$t_w = W / (2 \pi R_m S_c K_s) \quad (\text{Weight})$$

$$= 1,759.7 / (2 \pi * 23.115 * 13,907.75 * 1.20)$$

$$= 0.0007"$$

$$t_t = |t_p + t_m - t_w| \quad (\text{total, net compressive})$$

$$= |0 + 0 - (0.0007)|$$

$$= \underline{0.0007}"$$

$$t_c = t_{mc} + t_{wc} - t_{pc} \quad (\text{total required, compressive})$$

$$= 0 + (0.0007) - (0)$$

$$= \underline{0.0008}"$$

### Vacuum, Wind, Bottom Seam

$$t_p = P R / (2 S_c K_s + 0.40 |P|) \quad (\text{Pressure})$$

$$= -15 * 22.23 / (2 * 13,728.59 * 1.20 + 0.40 * |15|)$$

$$= -0.0101"$$

$$t_m = M / (\pi R_m^2 S_c K_s) \quad (\text{bending})$$

$$= 1,145 / (\pi * 23.115^2 * 13,728.59 * 1.20)$$

$$= 0"$$

$$t_w = W / (2 \pi R_m S_c K_s) \quad (\text{Weight})$$

$$= 1,759.7 / (2 \pi * 23.115 * 13,728.59 * 1.20)$$

$$= 0.0007"$$

$$t_t = |t_p + t_m - t_w| \quad (\text{total, net compressive})$$

$$= |-0.0101 + 0 - (0.0007)|$$

$$= \underline{0.0108}"$$

$$t_c = t_{mc} + t_{wc} - t_{pc} \quad (\text{total required, compressive})$$

$$= 0 + (0.0007) - (-0.0101)$$

$$= \underline{0.0109}"$$

### Maximum Allowable External Pressure, Longitudinal Stress

$$\begin{aligned} P &= 2 \cdot S_c \cdot K_s \cdot (t - t_{mc} - t_{wc}) / (R - 0.40 \cdot (t - t_{mc} - t_{wc})) \\ &= 2 \cdot 13,728.59 \cdot 1.20 \cdot (1.77 - 0 - 0.0007) / (22.23 - 0.40 \cdot (1.77 - 0 - 0.0007)) \\ &= 2,708.51 \text{ psi} \end{aligned}$$

### Hot Shut Down, Corroded, Weight & Eccentric Moments Only, Bottom Seam

$$\begin{aligned} t_p &= 0'' && \text{(Pressure)} \\ t_m &= M / (\pi \cdot R_m^2 \cdot S_c \cdot K_s) && \text{(bending)} \\ &= 826 / (\pi \cdot 23.115^2 \cdot 13,728.59 \cdot 1.00) \\ &= 0'' \\ t_w &= W / (2 \cdot \pi \cdot R_m \cdot S_c \cdot K_s) && \text{(Weight)} \\ &= 1,759.7 / (2 \cdot \pi \cdot 23.115 \cdot 13,728.59 \cdot 1.00) \\ &= 0.0009'' \\ t_t &= |t_p + t_m - t_w| && \text{(total, net compressive)} \\ &= |0 + 0 - (0.0009)| \\ &= \underline{0.0008''} \\ t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\ &= 0 + (0.0009) - (0) \\ &= \underline{0.0009''} \end{aligned}$$

### Operating, Hot & Corroded, Seismic, Bottom Seam

$$\begin{aligned} t_p &= P \cdot R / (2 \cdot S_t \cdot K_s \cdot E_c + 0.40 \cdot |P|) && \text{(Pressure)} \\ &= 1,378 \cdot 22.23 / (2 \cdot 20,000 \cdot 1.20 \cdot 1.00 + 0.40 \cdot |1,378|) \\ &= 0.6309'' \\ t_m &= M / (\pi \cdot R_m^2 \cdot S_t \cdot K_s \cdot E_c) && \text{(bending)} \\ &= 26,243 / (\pi \cdot 23.115^2 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\ &= 0.0007'' \\ t_w &= W / (2 \cdot \pi \cdot R_m \cdot S_t \cdot K_s \cdot E_c) && \text{(Weight)} \\ &= 1,759.7 / (2 \cdot \pi \cdot 23.115 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\ &= 0.0005'' \\ t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\ &= 0.6309 + 0.0007 - (0.0005) \\ &= \underline{0.6311''} \\ t_{wc} &= (1 + V_{Accel}) \cdot W / (2 \cdot \pi \cdot R_m \cdot S_t \cdot K_s \cdot E_c) && \text{(Weight)} \\ &= 2.00 \cdot 1,759.7 / (2 \cdot \pi \cdot 23.115 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\ &= 0.001'' \\ t_c &= |t_{mc} + t_{wc} - t_{pc}| && \text{(total, net tensile)} \\ &= |0.0007 + (0.001) - (0.6309)| \\ &= \underline{0.6293''} \end{aligned}$$

### Maximum allowable working pressure, Longitudinal Stress

$$\begin{aligned} P &= 2 \cdot S_t \cdot K_s \cdot E_c \cdot (t - t_m + t_w) / (R - 0.40 \cdot (t - t_m + t_w)) \\ &= 2 \cdot 20,000 \cdot 1.20 \cdot 1.00 \cdot (1.77 - 0.0007 + (0.0005)) / (22.23 - 0.40 \cdot (1.77 - 0.0007 + (0.0005))) \\ &= 3,947.25 \text{ psi} \end{aligned}$$

### Operating, Hot & New, Seismic, Bottom Seam

$$\begin{aligned}t_p &= P \cdot R / (2 \cdot S_t \cdot K_s \cdot E_c + 0.40 \cdot |P|) && \text{(Pressure)} \\&= 1,378 \cdot 22.23 / (2 \cdot 20,000 \cdot 1.20 \cdot 1.00 + 0.40 \cdot |1,378|) \\&= 0.6309'' \\t_m &= M / (\pi \cdot R_m^2 \cdot S_t \cdot K_s \cdot E_c) && \text{(bending)} \\&= 26,243 / (\pi \cdot 23.115^2 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\&= 0.0007'' \\t_w &= W / (2 \cdot \pi \cdot R_m \cdot S_t \cdot K_s \cdot E_c) && \text{(Weight)} \\&= 1,759.7 / (2 \cdot \pi \cdot 23.115 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\&= 0.0005'' \\t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\&= 0.6309 + 0.0007 - (0.0005) \\&= \underline{0.6311''} \\t_{wc} &= (1 + V_{\text{Accel}}) \cdot W / (2 \cdot \pi \cdot R_m \cdot S_t \cdot K_s \cdot E_c) && \text{(Weight)} \\&= 2.00 \cdot 1,759.7 / (2 \cdot \pi \cdot 23.115 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\&= 0.001'' \\t_c &= |t_{mc} + t_{wc} - t_{pc}| && \text{(total, net tensile)} \\&= |0.0007 + (0.001) - (0.6309)| \\&= \underline{0.6293''}\end{aligned}$$

### **Maximum allowable working pressure, Longitudinal Stress**

$$\begin{aligned}P &= 2 \cdot S_t \cdot K_s \cdot E_c \cdot (t - t_m + t_w) / (R - 0.40 \cdot (t - t_m + t_w)) \\&= 2 \cdot 20,000 \cdot 1.20 \cdot 1.00 \cdot (1.77 - 0.0007 + (0.0005)) / (22.23 - 0.40 \cdot (1.77 - 0.0007 + (0.0005))) \\&= 3,947.25 \text{ psi}\end{aligned}$$

### Hot Shut Down, Corroded, Seismic, Bottom Seam

$$\begin{aligned}t_p &= 0'' && \text{(Pressure)} \\t_m &= M / (\pi \cdot R_m^2 \cdot S_t \cdot K_s \cdot E_c) && \text{(bending)} \\&= 26,243 / (\pi \cdot 23.115^2 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\&= 0.0007'' \\t_w &= W / (2 \cdot \pi \cdot R_m \cdot S_t \cdot K_s \cdot E_c) && \text{(Weight)} \\&= 1,759.7 / (2 \cdot \pi \cdot 23.115 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\&= 0.0005'' \\t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\&= 0 + 0.0007 - (0.0005) \\&= \underline{0.0001''} \\t_{mc} &= M / (\pi \cdot R_m^2 \cdot S_c \cdot K_s) && \text{(bending)} \\&= 26,243 / (\pi \cdot 23.115^2 \cdot 13,728.59 \cdot 1.20) \\&= 0.0009'' \\t_{wc} &= (1 + V_{\text{Accel}}) \cdot W / (2 \cdot \pi \cdot R_m \cdot S_c \cdot K_s) && \text{(Weight)} \\&= 2.00 \cdot 1,759.7 / (2 \cdot \pi \cdot 23.115 \cdot 13,728.59 \cdot 1.20) \\&= 0.0015'' \\t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\&= 0.0009 + (0.0015) - (0)\end{aligned}$$

$$= 0.0024''$$

### Hot Shut Down, New, Seismic, Bottom Seam

$$\begin{aligned}
 t_p &= 0'' && \text{(Pressure)} \\
 t_m &= M / (\pi R_m^2 S_t K_s E_c) && \text{(bending)} \\
 &= 26,243 / (\pi 23.115^2 20,000 * 1.20 * 1.00) \\
 &= 0.0007'' \\
 t_w &= W / (2 \pi R_m S_t K_s E_c) && \text{(Weight)} \\
 &= 1,759.7 / (2 \pi 23.115 * 20,000 * 1.20 * 1.00) \\
 &= 0.0005'' \\
 t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\
 &= 0 + 0.0007 - (0.0005) \\
 &= 0.0001'' \\
 t_{mc} &= M / (\pi R_m^2 S_c K_s) && \text{(bending)} \\
 &= 26,243 / (\pi 23.115^2 13,728.59 * 1.20) \\
 &= 0.0009'' \\
 t_{wc} &= (1 + VAccel) * W / (2 \pi R_m S_c K_s) && \text{(Weight)} \\
 &= 2.00 * 1,759.7 / (2 \pi 23.115 * 13,728.59 * 1.20) \\
 &= 0.0015'' \\
 t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\
 &= 0.0009 + (0.0015) - (0) \\
 &= 0.0024''
 \end{aligned}$$

### Empty, Corroded, Seismic, Bottom Seam

$$\begin{aligned}
 t_p &= 0'' && \text{(Pressure)} \\
 t_m &= M / (\pi R_m^2 S_t K_s E_c) && \text{(bending)} \\
 &= 24,740 / (\pi 23.115^2 20,000 * 1.20 * 1.00) \\
 &= 0.0006'' \\
 t_w &= W / (2 \pi R_m S_t K_s E_c) && \text{(Weight)} \\
 &= 1,759.7 / (2 \pi 23.115 * 20,000 * 1.20 * 1.00) \\
 &= 0.0005'' \\
 t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\
 &= 0 + 0.0006 - (0.0005) \\
 &= 0.0001'' \\
 t_{mc} &= M / (\pi R_m^2 S_c K_s) && \text{(bending)} \\
 &= 24,740 / (\pi 23.115^2 13,907.75 * 1.20) \\
 &= 0.0009'' \\
 t_{wc} &= (1 + VAccel) * W / (2 \pi R_m S_c K_s) && \text{(Weight)} \\
 &= 2.00 * 1,759.7 / (2 \pi 23.115 * 13,907.75 * 1.20) \\
 &= 0.0015'' \\
 t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\
 &= 0.0009 + (0.0015) - (0) \\
 &= 0.0023''
 \end{aligned}$$

### Empty, New, Seismic, Bottom Seam

$$\begin{aligned}t_p &= 0'' && \text{(Pressure)} \\t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\&= 24,740 / (\pi * 23.115^2 * 20,000 * 1.20 * 1.00) \\&= 0.0006'' \\t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\&= 1,759.7 / (2 * \pi * 23.115 * 20,000 * 1.20 * 1.00) \\&= 0.0005'' \\t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\&= 0 + 0.0006 - (0.0005) \\&= \underline{0.0001''} \\t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\&= 24,740 / (\pi * 23.115^2 * 13,907.75 * 1.20) \\&= 0.0009'' \\t_{wc} &= (1 + VAccel) * W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\&= 2.00 * 1,759.7 / (2 * \pi * 23.115 * 13,907.75 * 1.20) \\&= 0.0015'' \\t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\&= 0.0009 + (0.0015) - (0) \\&= \underline{0.0023''}\end{aligned}$$

### Vacuum, Seismic, Bottom Seam

$$\begin{aligned}t_p &= P * R / (2 * S_c * K_s + 0.40 * |P|) && \text{(Pressure)} \\&= -15 * 22.23 / (2 * 13,728.59 * 1.20 + 0.40 * |15|) \\&= -0.0101'' \\t_m &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\&= 26,243 / (\pi * 23.115^2 * 13,728.59 * 1.20) \\&= 0.0009'' \\t_w &= W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\&= 1,759.7 / (2 * \pi * 23.115 * 13,728.59 * 1.20) \\&= 0.0007'' \\t_t &= |t_p + t_m - t_w| && \text{(total, net compressive)} \\&= |-0.0101 + 0.0009 - (0.0007)| \\&= \underline{0.0099''} \\t_{wc} &= (1 + VAccel) * W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\&= 2.00 * 1,759.7 / (2 * \pi * 23.115 * 13,728.59 * 1.20) \\&= 0.0015'' \\t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\&= 0.0009 + (0.0015) - (-0.0101) \\&= \underline{0.0125''}\end{aligned}$$

### **Maximum Allowable External Pressure, Longitudinal Stress**

$$\begin{aligned}P &= 2 * S_c * K_s * (t - t_{mc} - t_{wc}) / (R - 0.40 * (t - t_{mc} - t_{wc})) \\&= 2 * 13,728.59 * 1.20 * (1.77 - 0.0009 - 0.0015) / (22.23 - 0.40 * (1.77 - 0.0009 - 0.0015))\end{aligned}$$

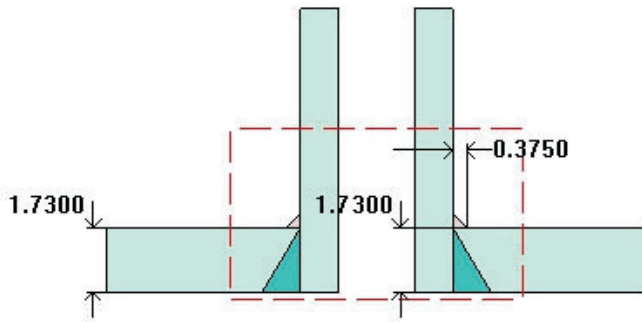
= 2,705.92 psi

## Vent (N14)

### ASME Section VIII Division 1, 2010 Edition, A11 Addenda

$$t_{w(\text{lower})} = 1.73 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

#### Location and Orientation

Located on:	48 OD TOP SE HEAD
Orientation:	315°
End of nozzle to datum line:	-19.5 in
Calculated as hillside:	Yes
Distance to head center, R:	16 in
Passes through a Category A joint:	No

#### Nozzle

Access opening:	No
Material specification:	SA-182 F316 <= 5 (II-D p. 70, In. 22)
Inside diameter, new:	2 in
Nominal wall thickness:	1.06 in
Corrosion allowance:	0 in
Opening chord length:	2.2234 in
Projection available outside vessel, L <sub>pr</sub> :	5.2776 in
Projection available outside vessel to flange face, L <sub>f</sub> :	7.0276 in
Local vessel minimum thickness:	1.73 in
Liquid static head included:	0 psi
Longitudinal joint efficiency:	1

#### ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 LWN A182 F316
Bolt Material:	SA-193 B7 Bolt <= 2 1/2 (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55 °F
(Per UHA-51(d)(1)(a))	
(Flange rated MDMT = -320 °F)	
Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F)	
Liquid static head:	0 psi



MAWP rating:	2,040 psi @ 140°F
MAP rating:	2,160 psi @ 50°F
Hydrotest rating:	3,250 psi @ 50°F
PWHT performed:	No

**Reinforcement Calculations for Chamber MAWP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For P = 1,378 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

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

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for internal pressure 1,378 psi @ 140 °F**

Nozzle Impact test exempt per UHA-51(g)(coincident ratio = 0.0678).

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.2234, 1.1117 + (1.06 - 0) + (1.73 - 0)) \\
 &= 3.9017 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.73 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

**Required thickness t<sub>r</sub> from UG-37(a)**

$$\begin{aligned}
 t_r &= P \cdot D_o \cdot K / (2 \cdot S \cdot E + 2 \cdot P \cdot (K - 0.1)) \\
 &= 1,378 \cdot 48 \cdot 1 / (2 \cdot 20,000 \cdot 1 + 2 \cdot 1,378 \cdot (1 - 0.1)) \\
 &= 1.557 \text{ in}
 \end{aligned}$$

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

### UW-16(c) Weld Check

Fillet weld:  $t_{\min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$

$t_{c(\min)} = \text{lesser of } 0.25 \text{ or } 0.7*t_{\min} = 0.25 \text{ in}$

$t_{c(\text{actual})} = 0.7*\text{Leg} = 0.7*0.375 = 0.2625 \text{ in}$

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

Interpretation VIII-1-83-66 has been applied.

$$\begin{aligned}t_{a \text{ UG-27}} &= P*R / (S*E - 0.6*P) + \text{Corrosion} \\ &= 1,378*1 / (20,000*1 - 0.6*1,378) + 0 \\ &= 0.0719 \text{ in}\end{aligned}$$

$$\begin{aligned}t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0719, 0 ] \\ &= 0.0719 \text{ in}\end{aligned}$$

$$t_{b1} = 1.557 \text{ in}$$

$$\begin{aligned}t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.557, 0.0625 ] \\ &= 1.557 \text{ in}\end{aligned}$$

$$\begin{aligned}t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.2074, 1.557 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0719, 0.2074 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

**Reinforcement Calculations for MAEP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For Pe = 566.01 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for external pressure 566.01 psi @ 140 °F**

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.2205, 1.1103 + (1.06 - 0) + (1.73 - 0)) \\
 &= 3.9003 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.73 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-28 t<sub>m</sub> = 0.1383 in**

**From UG-37(d)(1) required thickness t<sub>r</sub> = 1.73 in**

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

**UW-16(c) Weld Check**

Fillet weld: t<sub>min</sub> = lesser of 0.75 or t<sub>n</sub> or t = 0.75 in  
 t<sub>c(min)</sub> = lesser of 0.25 or 0.7\*t<sub>min</sub> = [0.25](#) in  
 t<sub>c(actual)</sub> = 0.7\*Leg = 0.7\*0.375 = 0.2625 in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

Interpretation VIII-1-83-66 has been applied.

$$t_{a \text{ UG-28}} = 0.1383 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.1383, 0 ] \\ &= 0.1383 \text{ in} \end{aligned}$$

$$t_{b2} = 0.6623 \text{ in}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2}, t_{b \text{ UG16}} ] \\ &= \max[ 0.6623, 0.0625 ] \\ &= 0.6623 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b2} ] \\ &= \min[ 0.2074, 0.6623 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.1383, 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

### External Pressure, (Corroded & at 140 °F) UG-28(c)

$$L / D_o = 9.0272 / 4.12 = 2.1911$$

$$D_o / t = 4.12 / 0.1383 = 29.7856$$

From table G:  $A = 0.003548$

From table  
HA-2:  $B = 12,644.1965 \text{ psi}$

$$\begin{aligned} P_a &= 4*B / (3*(D_o / t)) \\ &= 4*12,644.2 / (3*(4.12 / 0.1383)) \\ &= 566.01 \text{ psi} \end{aligned}$$

### Design thickness for external pressure $P_a = 566.01 \text{ psi}$

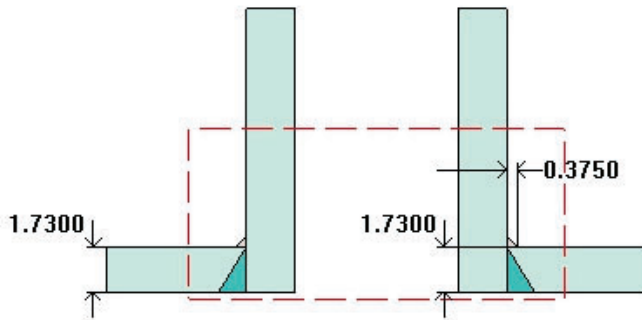
$$t_a = t + \text{Corrosion} = 0.1383 + 0 = 0.1383''$$

## Gas Outlet (N2)

### ASME Section VIII Division 1, 2010 Edition, A11 Addenda

$$t_{w(\text{lower})} = 1.73 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

#### Location and Orientation

Located on:	48 OD TOP SE HEAD
Orientation:	0°
End of nozzle to datum line:	-24.5 in
Calculated as hillside:	No
Distance to head center, R:	0 in
Passes through a Category A joint:	No

#### Nozzle

Access opening:	No
Material specification:	SA-182 F316 <= 5 (II-D p. 70, In. 22)
Inside diameter, new:	8 in
Nominal wall thickness:	1.875 in
Corrosion allowance:	0 in
Projection available outside vessel, Lpr:	7.2764 in
Projection available outside vessel to flange face, Lf:	10.0264 in
Local vessel minimum thickness:	1.73 in
Liquid static head included:	0 psi
Longitudinal joint efficiency:	1

#### ASME B16.5-2009 Flange

Description:	NPS 8 Class 900 LWN A182 F316
Bolt Material:	SA-193 B7 Bolt <= 2 1/2 (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55 °F
(Per UHA-51(d)(1)(a))	
(Flange rated MDMT = -320 °F	
Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F)	
Liquid static head:	0 psi
MAWP rating:	2,040 psi @ 140 °F

MAP rating:	2,160 psi @ 50°F
Hydrotest rating:	3,250 psi @ 50°F
PWHT performed:	No

**Reinforcement Calculations for Chamber MAWP**

<b>UG-37 Area Calculation Summary (in<sup>2</sup>)</b> For P = 1,378 psi @ 140 °F The opening is adequately reinforced							<b>UG-45 Nozzle Wall Thickness Summary (in)</b> The nozzle passes UG-45	
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
<a href="#">11.5866</a>	<a href="#">16.1259</a>	<a href="#">2.2534</a>	<a href="#">13.7319</a>	--	--	<a href="#">0.1406</a>	<a href="#">0.3281</a>	1.875

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

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for internal pressure 1,378 psi @ 140 °F**

Nozzle rated MDMT per UHA-51(d)(1)(a) = -320 °F.

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(8, 4 + (1.875 - 0) + (1.73 - 0)) \\
 &= 8 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.73 - 0), 2.5*(1.875 - 0) + 0) \\
 &= 4.325 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 4 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.2875 \text{ in}
 \end{aligned}$$

**Required thickness t<sub>r</sub> from UG-37(a)(c)**

$$\begin{aligned}
 t_r &= P \cdot K_1 \cdot D_o / (2 \cdot S \cdot E + 0.8 \cdot P) \\
 &= 1,378 \cdot 0.9 \cdot 48 / (2 \cdot 20,000 \cdot 1 + 0.8 \cdot 1,378) \\
 &= 1.4483 \text{ in}
 \end{aligned}$$



### Area required per UG-37(c)

Allowable stresses:  $S_n = 20,000$ ,  $S_v = 20,000$  psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$\begin{aligned} A &= d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1}) \\ &= 8 \cdot 1.4483 \cdot 1 + 2 \cdot 1.875 \cdot 1.4483 \cdot 1 \cdot (1 - 1) \\ &= \underline{11.5866} \text{ in}^2 \end{aligned}$$

### Area available from FIG. UG-37.1

$A_1 =$  larger of the following = 2.2534 in<sup>2</sup>

$$\begin{aligned} &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 8 \cdot (1 \cdot 1.73 - 1 \cdot 1.4483) - 2 \cdot 1.875 \cdot (1 \cdot 1.73 - 1 \cdot 1.4483) \cdot (1 - 1) \\ &= 2.2534 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2 \cdot (1.73 + 1.875) \cdot (1 \cdot 1.73 - 1 \cdot 1.4483) - 2 \cdot 1.875 \cdot (1 \cdot 1.73 - 1 \cdot 1.4483) \cdot (1 - 1) \\ &= 2.0309 \text{ in}^2 \end{aligned}$$

$A_2 =$  smaller of the following = 13.7319 in<sup>2</sup>

$$\begin{aligned} &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t \\ &= 5 \cdot (1.875 - 0.2875) \cdot 1 \cdot 1.73 \\ &= 13.7319 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (1.875 - 0.2875) \cdot 1 \cdot 1.875 \\ &= 14.8828 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} A_{41} &= \text{Leg}^2 \cdot f_{r2} \\ &= 0.375^2 \cdot 1 \\ &= \underline{0.1406} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_{41} \\ &= 2.2534 + 13.7319 + 0.1406 \\ &= \underline{16.1259} \text{ in}^2 \end{aligned}$$

As Area  $\geq$  A the reinforcement is adequate.

### UW-16(c) Weld Check

Fillet weld:  $t_{\min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$

$t_{c(\min)} = \text{lesser of } 0.25 \text{ or } 0.7 * t_{\min} = 0.25 \text{ in}$

$t_{c(\text{actual})} = 0.7 * \text{Leg} = 0.7 * 0.375 = 0.2625 \text{ in}$

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

Interpretation VIII-1-83-66 has been applied.

$$\begin{aligned} t_{a \text{ UG-27}} &= P * R / (S * E - 0.6 * P) + \text{Corrosion} \\ &= 1,378 * 4 / (20,000 * 1 - 0.6 * 1,378) + 0 \\ &= 0.2875 \text{ in} \end{aligned}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.2875, 0 ] \\ &= 0.2875 \text{ in} \end{aligned}$$

$$t_{b1} = 1.557 \text{ in}$$

$$\begin{aligned} t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.557, 0.0625 ] \\ &= 1.557 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.3281, 1.557 ] \\ &= 0.3281 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.2875, 0.3281 ] \\ &= 0.3281 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.875 \text{ in}$

The nozzle neck thickness is adequate.

**Reinforcement Calculations for MAEP**

<p align="center"><b>UG-37 Area Calculation Summary (in<sup>2</sup>)</b>                  For Pe = 566.01 psi @ 140 °F                  The opening is adequately reinforced</p>							<p align="center"><b>UG-45 Nozzle Wall Thickness Summary (in)</b>                  The nozzle passes UG-45</p>	
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
6.92	13.2159	--	13.0753	--	--	0.1406	0.3634	1.875

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	0.25	0.2625	weld size is adequate

**Calculations for external pressure 566.01 psi @ 140 °F**

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(8, 4 + (1.875 - 0) + (1.73 - 0)) \\
 &= 8 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.73 - 0), 2.5*(1.875 - 0) + 0) \\
 &= 4.325 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-28 t<sub>m</sub> = 0.3634 in**

**From UG-37(d)(1) required thickness t<sub>r</sub> = 1.73 in**

**Area required per UG-37(d)(1)**

Allowable stresses: S<sub>n</sub> = 20,000, S<sub>v</sub> = 20,000 psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$\begin{aligned}
 A &= 0.5*(d*t_r*F + 2*t_n*t_r*F*(1 - f_{r1})) \\
 &= 0.5*(8*1.73*1 + 2*1.875*1.73*1*(1 - 1))
 \end{aligned}$$

$$= 6.92 \text{ in}^2$$

### Area available from FIG. UG-37.1

$$A_1 = \text{larger of the following} = 0 \text{ in}^2$$

$$\begin{aligned} &= d(E_1 t - F t_r) - 2 t_n (E_1 t - F t_r) (1 - f_{r1}) \\ &= 8(1 \cdot 1.73 - 1 \cdot 1.73) - 2 \cdot 1.875(1 \cdot 1.73 - 1 \cdot 1.73)(1 - 1) \\ &= 0 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 2(t + t_n)(E_1 t - F t_r) - 2 t_n (E_1 t - F t_r) (1 - f_{r1}) \\ &= 2(1.73 + 1.875)(1 \cdot 1.73 - 1 \cdot 1.73) - 2 \cdot 1.875(1 \cdot 1.73 - 1 \cdot 1.73)(1 - 1) \\ &= 0 \text{ in}^2 \end{aligned}$$

$$A_2 = \text{smaller of the following} = 13.0753 \text{ in}^2$$

$$\begin{aligned} &= 5(t_n - t_{rn}) f_{r2} t \\ &= 5(1.875 - 0.3634) \cdot 1 \cdot 1.73 \\ &= 13.0753 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 5(t_n - t_{rn}) f_{r2} t_n \\ &= 5(1.875 - 0.3634) \cdot 1 \cdot 1.875 \\ &= 14.1712 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} A_{41} &= \text{Leg}^2 f_{r2} \\ &= 0.375^2 \cdot 1 \\ &= 0.1406 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_{41} \\ &= 0 + 13.0753 + 0.1406 \\ &= 13.2159 \text{ in}^2 \end{aligned}$$

As Area  $\geq$  A the reinforcement is adequate.

### UW-16(c) Weld Check

Fillet weld:  $t_{\min}$  = lesser of 0.75 or  $t_n$  or  $t = 0.75$  in

$t_{c(\min)}$  = lesser of 0.25 or  $0.7 \cdot t_{\min} = 0.25$  in

$t_{c(\text{actual})} = 0.7 \cdot \text{Leg} = 0.7 \cdot 0.375 = 0.2625$  in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

## UG-45 Nozzle Neck Thickness Check

Interpretation VIII-1-83-66 has been applied.

$$t_{a \text{ UG-28}} = 0.3634 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.3634, 0 ] \\ &= 0.3634 \text{ in} \end{aligned}$$

$$t_{b2} = 0.6623 \text{ in}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2}, t_{b \text{ UG16}} ] \\ &= \max[ 0.6623, 0.0625 ] \\ &= 0.6623 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b2} ] \\ &= \min[ 0.3281, 0.6623 ] \\ &= 0.3281 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.3634, 0.3281 ] \\ &= 0.3634 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.875 \text{ in}$

The nozzle neck thickness is adequate.

### External Pressure, (Corroded & at 140 °F) UG-28(c)

$$L / D_o = 10.0264 / 11.75 = 0.8533$$

$$D_o / t = 11.75 / 0.3634 = 32.3334$$

From table G: A = 0.009195

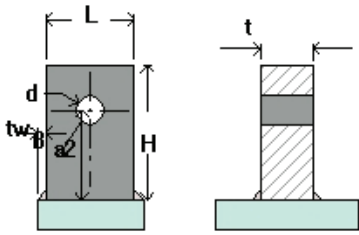
From table  
HA-2: B = 13,725.7301 psi

$$\begin{aligned} P_a &= 4*B / (3*(D_o / t)) \\ &= 4*13,725.73 / (3*(11.75 / 0.3634)) \\ &= 566.01 \text{ psi} \end{aligned}$$

### Design thickness for external pressure $P_a = 566.01 \text{ psi}$

$$t_a = t + \text{Corrosion} = 0.3634 + 0 = 0.3634''$$

## Lifting Lug



### Geometry Inputs

Attached To	48 OD TOP SE HEAD
Material	SA-240 316
Orientation	Longitudinal
Distance of Lift Point From Datum	-14.0001"
Angular Position	0.00°
Length of Lug, L	5"
Height of Lug, H	7.5"
Thickness of Lug, t	1.5"
Hole Diameter, d	1.5625"
Pin Diameter, D <sub>p</sub>	1.5"
Load Eccentricity, a <sub>1</sub>	0"
Distance from Load to Shell or Pad, a <sub>2</sub>	5"
Weld Size, t <sub>w</sub>	0.5"
Load Angle Normal to Vessel, β	145.3411 °
Load Angle from Vertical, φ	110.7073 °

### Intermediate Values

Load Factor	1.5000
Vessel Weight (new, incl. Load Factor), W	27406 lb
Lug Weight (new), $W_{lug}$	16 lb
Distance from Center of Gravity to Top Lug, $l_1$	70.4868"
Distance from Center of Gravity to Tail Lug, $l_2$	61.8933"
Distance from Vessel Center Line to Tail Lug, $l_3$	28.375"
Allowable Stress, Tensile, $\sigma_t$	19980 psi
Allowable Stress, Shear, $\sigma_s$	13320 psi
Allowable Stress, Bearing, $\sigma_p$	29970 psi
Allowable Stress, Bending, $\sigma_b$	22201 psi
Allowable Stress, Weld Shear, $\tau_{allowable}$	13320 psi
Allowable Stress set to 1/3 Sy per ASME B30.20	No

### Summary Values

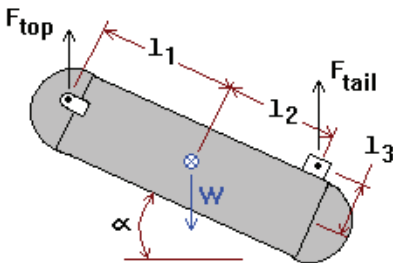
Required Lift Pin Diameter, $d_{reqd}$	<a href="#">0.8093"</a>
Required Lug Thickness, $t_{reqd}$	<a href="#">0.3048"</a>
Lug Stress Ratio, $\sigma_{ratio}$	<a href="#">0.21</a>
Weld Shear Stress Ratio, $\tau_{ratio}$	<a href="#">0.36</a>
Lug Design	Acceptable
Local Stresses	Acceptable

### Lift Forces

Lift force on lugs during rotational lift ( $0^\circ \leq \alpha \leq 90^\circ$ ):

$$2 * F_{top} = W * (l_2 * \cos(\alpha) + l_3 * \sin(\alpha)) / (l_1 * \cos(\alpha) + l_2 * \cos(\alpha) + l_3 * \sin(\alpha))$$

$$F_{tail} = W - (2 * F)$$



$\alpha$ [°]	$F_{top}$ [lbf]	$F_{tail}$ [lbf]
0	6,407	14,592
15	6,803	13,800
30	7,210	12,985
45	7,694	12,017
60	8,382	10,642
75	9,649	8,107
90	13,703	0
90 <sup>1</sup>	13,703	0
90 <sup>2</sup>	13,703	0
<sup>1</sup> Lift angle at maximum lug stress.		
<sup>2</sup> Lift angle at maximum weld stress.		
Shell angle at lift lug	235.37°	

### Lug Pin Diameter - Shear stress

$$d_{reqd} = (2 \cdot F_r / (\pi \cdot \sigma_s))^{0.5}$$

$$= (2 \cdot 13,703 / (\pi \cdot 13,320))^{0.5} = \underline{0.8093"}$$

$$d_{reqd} / D_p = 0.8093 / 1.5 = 0.54 \quad \text{Acceptable}$$

$$\sigma = F_r / A$$

$$= F_r / (2 \cdot (0.25 \cdot \pi \cdot D_p^2))$$

$$= 13,703 / (2 \cdot (0.25 \cdot \pi \cdot 1.5^2)) = 3,877 \text{ psi}$$

$$\sigma / \sigma_s = 3,877 / 13,320 = 0.29 \quad \text{Acceptable}$$

### Lug Thickness - Tensile stress

$$t_{reqd} = F_r / ((L - d) \cdot \sigma_t)$$

$$= 13,703 / ((5 - 1.5625) \cdot 19,980) = 0.1995"$$

$$t_{reqd} / t = 0.1995 / 1.5 = 0.13 \quad \text{Acceptable}$$

$$\sigma = F_r / A$$

$$= F_r / ((L - d) \cdot t)$$

$$= 13,703 / ((5 - 1.5625) \cdot 1.5) = 2,658 \text{ psi}$$

$$\sigma / \sigma_t = 2,658 / 19,980 = 0.13 \quad \text{Acceptable}$$

### Lug Thickness - Bearing stress

$$t_{reqd} = F_v / (D_p \cdot \sigma_p)$$

$$= 13,703 / (1.5 \cdot 29,970) = \underline{0.3048"}$$



$$t_{\text{reqd}} / t = 0.3048 / 1.5 = 0.20 \quad \text{Acceptable}$$

$$\begin{aligned} \sigma &= F_v / A_{\text{bearing}} \\ &= F_v / (D_p * t) \\ &= 13,703 / (1.5 * (1.5)) = 6,090 \text{ psi} \end{aligned}$$

$$\sigma / \sigma_p = 6,090 / 29,970 = 0.2 \quad \text{Acceptable}$$

### Lug Thickness - Shear stress

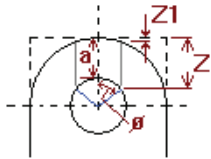
$$\begin{aligned} t_{\text{reqd}} &= [F_v / \sigma_s] / (2 * L_{\text{shear}}) \\ &= (13,703 / 13,320) / (2 * 2.0153) = \underline{0.2552"} \end{aligned}$$

$$t_{\text{reqd}} / t = 0.2552 / 1.5 = 0.17 \quad \text{Acceptable}$$

$$\begin{aligned} \tau &= F_v / A_{\text{shear}} \\ &= F_v / (2 * t * L_{\text{shear}}) \\ &= 13,703 / (2 * 1.5 * 2.0153) = 2,266 \text{ psi} \end{aligned}$$

$$\tau / \sigma_s = 2,266 / 13,320 = 0.17 \quad \text{Acceptable}$$

Shear stress length (per Pressure Vessel and Stacks, A. Keith Escoe)



$$\begin{aligned} \phi &= 55 * D_p / d \\ &= 55 * 1.5 / 1.5625 \\ &= 52.8^\circ \end{aligned}$$

$$\begin{aligned} L_{\text{shear}} &= (H - a - 0.5 * d) + 0.5 * D_p * (1 - \cos(\phi)) \\ &= (7.5 - 5 - 0.5 * 1.5625) + 0.5 * 1.5 * (1 - \cos(52.8)) \\ &= 2.0153" \end{aligned}$$

### Lug Plate Stress

Lug stress tensile + bending during lift:

$$\begin{aligned} \sigma_{\text{ratio}} &= [F_{\text{ten}} / (A_{\text{ten}} * \sigma_t)] + [M_{\text{bend}} / (Z_{\text{bend}} * \sigma_b)] \leq 1 \\ &= [(F_r * \cos(\alpha)) / (t * L * \sigma_t)] + [(6 * \text{abs}(F_r * \sin(\alpha) * \text{Hght} - F_r * \cos(\alpha) * a_1)) / (t * L^2 * \sigma_b)] \leq 1 \\ &= (13,703 * \cos(145.4)) / (1.5 * 5 * 19,980) + (6 * \text{abs}(13,703 * \sin(145.4) * 5 - 13,703 * \cos(145.4) * 0)) / (1.5 * 5^2 * 22,201) \\ &= \underline{0.21} \quad \text{Acceptable} \end{aligned}$$

## Weld Stress

Weld stress, tensile, bending and shear during lift:

Direct shear:

Shear stress at lift angle 145.34°; lift force = 13,703 lbf

$$A_{\text{weld}} = 2 \cdot (0.707) \cdot t_w \cdot (L + t)$$

$$= 2 \cdot (0.707) \cdot 0.5 \cdot (5 + 1.5) = 4.5955 \text{ in}^2$$

$$\tau_t = F_r \cdot \cos(\alpha) / A_{\text{weld}}$$

$$= 13,703 \cdot \cos(145.3) / 4.5955 = -2,453 \text{ psi}$$

$$\tau_s = F_r \cdot \sin(\alpha) / A_{\text{weld}}$$

$$= 13,703 \cdot \sin(145.3) / 4.5955 = 1,696 \text{ psi}$$

$$\tau_b = \frac{M \cdot c}{I}$$

$$= \frac{3 \cdot (F_r \cdot \sin(\alpha) \cdot \text{Hght} - F_r \cdot \cos(\alpha) \cdot a_1)}{(0.707 \cdot h \cdot L \cdot (3 \cdot t + L))}$$

$$= \frac{3 \cdot \text{abs}(13,703 \cdot \sin(145.3) \cdot 5 - 13,703 \cdot \cos(145.3) \cdot (0))}{(16.7912)}$$

$$= 6,961 \text{ psi}$$

$$\tau_{\text{ratio}} = \frac{\text{sqr}(\tau_t + \tau_b)^2 + \tau_s^2}{\tau_{\text{allowable}}} \leq 1$$

$$= \frac{\text{sqr}((-2,453 + 6,961)^2 + (1,696)^2)}{13,320}$$

$$= \underline{0.36} \quad \text{Acceptable}$$

## EN 13445 Lift Lug Procedure

### Geometry Inputs - EN13445

Nominal Vessel Thickness, $e_n$	1.73"
Pad Thickness, $e_2$	0"
Length of Lug, $b_1$	5"
Width of Pad, $b_2$	0"
Length of Pad, $b_3$	0"

### Intermediate Values - EN13445

Equivalent Diameter of Vessel at Lug, $ID_{\text{eq}}$	<u>30.0889"</u>
Shell Allowable Stress, $f$	20000 psi
Pad Allowable Stress, $f_2$	N/A
Design Factor, $K_2$	1.2500

## Summary Values - EN13445

Force on Vessel, $F_r$	<a href="#">13.703 lbf</a>
Maximum Allowable Load, $F_{Rmax}$	<a href="#">68.941 lbf</a>
Load Acceptance Ratio, $F_R / F_{Rmax}$	<b>0.1988</b>
Lug Design	Acceptable

### Equivalent Inner Diameter

$$ID_{eq} = D_i \cdot \sqrt{1 - 3 \cdot (x / D_i)^2}$$

$$ID_{eq} = 44.54 \cdot \sqrt{1 - 3 \cdot (18.9602 / 44.54)^2}$$

$$ID_{eq} = 30.0889''$$

where 'x' is the distance between the axis of semi-ellipsoidal head and the center of the lug

### Applied Force

$$F_r = \text{force on vessel at lug}$$

$$F_r = [W / \cos(\phi_1)] \cdot (1 - x_1 / (x_1 + x_2))$$

$$= (27,405.6) / \cos(110.7073) \cdot (1 - 0 / (0 + 0))$$

$$= \a href="#">13.703 lbf$$

where 'x<sub>1</sub>' is the distance between this lug and the center of gravity

'x<sub>2</sub>' is the distance between the second lift lug and the center of gravity

### Lug factors

$$\lambda = \text{line load factor}$$

$$\lambda = b / \sqrt{ID_{eq} \cdot e_n}$$

$$= 5 / \sqrt{30.0889 \cdot 1.73}$$

$$= 0.693$$

$$v_1 = \text{ratio between local membrane stress and local bending stress}$$

$$v_1 = \min(0.08 \cdot \lambda, 0.2)$$

$$= 0.055$$

$$\sigma_m = \text{global membrane stress}$$

$$\sigma_m = P \cdot ID_{eq} / (2 \cdot e_n)$$

$$= 0 \cdot 30.0889 / (2 \cdot 1.73)$$

$$= 0.0000 \text{ psi}$$

$$v_2 = \text{ratio between global membrane stress and allowable stress}$$

$$v_2 = \sigma_m / (K_2 \cdot f)$$

$$= 0 / (1.25 \cdot 20,000)$$

$$= 0$$

$$K_{13} = 1 / (1.2 \cdot \sqrt{1 + 0.06 \cdot \lambda^2})$$

$$= 1 / (1.2 \cdot \sqrt{1 + 0.06 \cdot 0.693^2})$$

$$= 0.8216$$

$$\begin{aligned} K_{14} &= 1 / (0.6 * \text{sqr}(1 + 0.03 * \lambda^2)) \\ &= 1 / (0.6 * \text{sqr}(1 + 0.03 * 0.693^2)) \\ &= 1.6548 \end{aligned}$$

### Bending Limit Stress

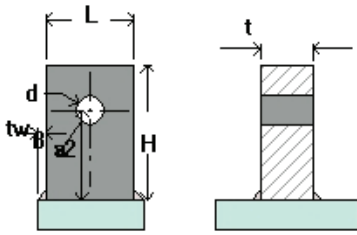
$$\begin{aligned} K_1 &= (1 - v_2^2) / ( (1/3 + v_1 * v_2) + \text{sqr}( (1/3 + v_1 * v_2)^2 + (1 - v_2^2) * v_1^2 ) ) \\ &= (1 - 0^2) / ( (1/3 + 0.0554 * 0) + \text{sqr}( (1/3 + 0.0554 * 0)^2 + (1 - 0^2) * 0.0554^2 ) ) \\ &= 1.4898 \end{aligned}$$

$$\begin{aligned} \sigma_b &= K_1 * K_2 * f \\ &= 1.4898 * 1.25 * 20,000 \\ &= 37,244 \text{ psi} \end{aligned}$$

### Maximum Allowable Load

$$\begin{aligned} F_{Rmax} &= \sigma_b * e_n^2 / (K_{13} * |\cos(\beta)| + K_{14} * |a_2 * \sin(\beta) - a_1 * \cos(\beta)| / b_1) \\ &= 37,244 * (1.73)^2 / (0.8216 * |\cos(145.3411)| + 1.6548 * |5 * \sin(145.3411) - 0 * \cos(145.3411)| / 5) \\ &= [68.941 \text{ lbf}](#) \end{aligned}$$

## Lifting Lug 2



### Geometry Inputs

Attached To	48 OD TOP SE HEAD
Material	SA-240 316
Orientation	Longitudinal
Distance of Lift Point From Datum	-13.5003"
Angular Position	180.00 °
Length of Lug, L	5"
Height of Lug, H	7.5"
Thickness of Lug, t	1.5"
Hole Diameter, d	1.5625"
Pin Diameter, D <sub>p</sub>	1.5"
Load Eccentricity, a <sub>1</sub>	0"
Distance from Load to Shell or Pad, a <sub>2</sub>	5"
Weld Size, t <sub>w</sub>	0.5"
Load Angle Normal to Vessel, β	143.1925 °
Load Angle from Vertical, φ	106.4106 °

### Intermediate Values

Load Factor	1.5000
Vessel Weight (new, incl. Load Factor), W	27406 lb
Lug Weight (new), $W_{lug}$	16 lb
Distance from Center of Gravity to Top Lug, $l_1$	70.4868"
Distance from Center of Gravity to Tail Lug, $l_2$	61.8933"
Distance from Vessel Center Line to Tail Lug, $l_3$	28.375"
Allowable Stress, Tensile, $\sigma_t$	19980 psi
Allowable Stress, Shear, $\sigma_s$	13320 psi
Allowable Stress, Bearing, $\sigma_p$	29970 psi
Allowable Stress, Bending, $\sigma_b$	22201 psi
Allowable Stress, Weld Shear, $\tau_{allowable}$	13320 psi
Allowable Stress set to 1/3 Sy per ASME B30.20	No

### Summary Values

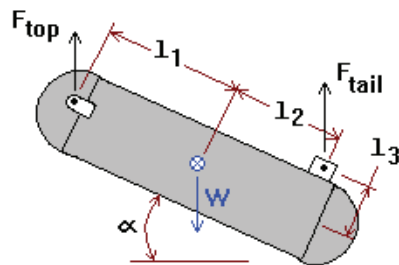
Required Lift Pin Diameter, $d_{reqd}$	<a href="#">0.8093"</a>
Required Lug Thickness, $t_{reqd}$	<a href="#">0.3048"</a>
Lug Stress Ratio, $\sigma_{ratio}$	<a href="#">0.22</a>
Weld Shear Stress Ratio, $\tau_{ratio}$	<a href="#">0.39</a>
Lug Design	Acceptable
Local Stresses	Acceptable

### Lift Forces

Lift force on lugs during rotational lift ( $0^\circ \leq \alpha \leq 90^\circ$ ):

$$2 * F_{top} = W * (l_2 * \cos(\alpha) + l_3 * \sin(\alpha)) / (l_1 * \cos(\alpha) + l_2 * \cos(\alpha) + l_3 * \sin(\alpha))$$

$$F_{tail} = W - (2 * F)$$



$\alpha$ [°]	$F_{top}$ [lbf]	$F_{tail}$ [lbf]
0	6,407	14,592
15	6,803	13,800
30	7,210	12,985
45	7,694	12,017
60	8,382	10,642
75	9,649	8,107
90	13,703	0
90 <sup>1</sup>	13,703	0
90 <sup>2</sup>	13,703	0
<sup>1</sup> Lift angle at maximum lug stress.		
<sup>2</sup> Lift angle at maximum weld stress.		
Shell angle at lift lug	233.22°	

### Lug Pin Diameter - Shear stress

$$d_{reqd} = (2 \cdot F_r / (\pi \cdot \sigma_s))^{0.5}$$

$$= (2 \cdot 13,703 / (\pi \cdot 13,320))^{0.5} = \underline{0.8093"}$$

$$d_{reqd} / D_p = 0.8093 / 1.5 = 0.54 \quad \text{Acceptable}$$

$$\sigma = F_r / A$$

$$= F_r / (2 \cdot (0.25 \cdot \pi \cdot D_p^2))$$

$$= 13,703 / (2 \cdot (0.25 \cdot \pi \cdot 1.5^2)) = 3,877 \text{ psi}$$

$$\sigma / \sigma_s = 3,877 / 13,320 = 0.29 \quad \text{Acceptable}$$

### Lug Thickness - Tensile stress

$$t_{reqd} = F_r / ((L - d) \cdot \sigma_t)$$

$$= 13,703 / ((5 - 1.5625) \cdot 19,980) = 0.1995"$$

$$t_{reqd} / t = 0.1995 / 1.5 = 0.13 \quad \text{Acceptable}$$

$$\sigma = F_r / A$$

$$= F_r / ((L - d) \cdot t)$$

$$= 13,703 / ((5 - 1.5625) \cdot 1.5) = 2,658 \text{ psi}$$

$$\sigma / \sigma_t = 2,658 / 19,980 = 0.13 \quad \text{Acceptable}$$

### Lug Thickness - Bearing stress

$$t_{reqd} = F_v / (D_p \cdot \sigma_p)$$

$$= 13,703 / (1.5 \cdot 29,970) = \underline{0.3048"}$$

$$t_{\text{reqd}} / t = 0.3048 / 1.5 = 0.20 \quad \text{Acceptable}$$

$$\begin{aligned} \sigma &= F_v / A_{\text{bearing}} \\ &= F_v / (D_p * t) \\ &= 13,703 / (1.5 * (1.5)) = 6,090 \text{ psi} \end{aligned}$$

$$\sigma / \sigma_p = 6,090 / 29,970 = 0.2 \quad \text{Acceptable}$$

### Lug Thickness - Shear stress

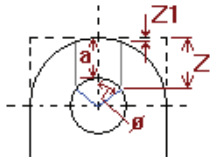
$$\begin{aligned} t_{\text{reqd}} &= [F_v / \sigma_s] / (2 * L_{\text{shear}}) \\ &= (13,703 / 13,320) / (2 * 2.0153) = \underline{0.2552"} \end{aligned}$$

$$t_{\text{reqd}} / t = 0.2552 / 1.5 = 0.17 \quad \text{Acceptable}$$

$$\begin{aligned} \tau &= F_v / A_{\text{shear}} \\ &= F_v / (2 * t * L_{\text{shear}}) \\ &= 13,703 / (2 * 1.5 * 2.0153) = 2,266 \text{ psi} \end{aligned}$$

$$\tau / \sigma_s = 2,266 / 13,320 = 0.17 \quad \text{Acceptable}$$

Shear stress length (per Pressure Vessel and Stacks, A. Keith Escoe)



$$\begin{aligned} \phi &= 55 * D_p / d \\ &= 55 * 1.5 / 1.5625 \\ &= 52.8^\circ \end{aligned}$$

$$\begin{aligned} L_{\text{shear}} &= (H - a - 0.5 * d) + 0.5 * D_p * (1 - \cos(\phi)) \\ &= (7.5 - 5 - 0.5 * 1.5625) + 0.5 * 1.5 * (1 - \cos(52.8)) \\ &= 2.0153" \end{aligned}$$

### Lug Plate Stress

Lug stress tensile + bending during lift:

$$\begin{aligned} \sigma_{\text{ratio}} &= [F_{\text{ten}} / (A_{\text{ten}} * \sigma_t)] + [M_{\text{bend}} / (Z_{\text{bend}} * \sigma_b)] \leq 1 \\ &= [(F_r * \cos(\alpha)) / (t * L * \sigma_t)] + [(6 * \text{abs}(F_r * \sin(\alpha) * \text{Hght} - F_r * \cos(\alpha) * a_1)) / (t * L^2 * \sigma_b)] \leq 1 \\ &= (13,703 * \cos(143.2)) / (1.5 * 5 * 19,980) + (6 * \text{abs}(13,703 * \sin(143.2) * 5 - 13,703 * \cos(143.2) * 0)) / (1.5 * 5^2 * 22,201) \\ &= \underline{0.22} \quad \text{Acceptable} \end{aligned}$$



## Weld Stress

Weld stress, tensile, bending and shear during lift:

Direct shear:

Shear stress at lift angle 143.19°; lift force = 13,703 lbf

$$A_{\text{weld}} = 2 \cdot (0.707) \cdot t_w \cdot (L + t)$$

$$= 2 \cdot (0.707) \cdot 0.5 \cdot (5 + 1.5) = 4.5955 \text{ in}^2$$

$$\tau_t = F_r \cdot \cos(\alpha) / A_{\text{weld}}$$

$$= 13,703 \cdot \cos(143.2) / 4.5955 = -2,387 \text{ psi}$$

$$\tau_s = F_r \cdot \sin(\alpha) / A_{\text{weld}}$$

$$= 13,703 \cdot \sin(143.2) / 4.5955 = 1,786 \text{ psi}$$

$$\tau_b = \frac{M \cdot c}{I}$$

$$= \frac{3 \cdot (F_r \cdot \sin(\alpha) \cdot \text{Hght} - F_r \cdot \cos(\alpha) \cdot a_1)}{(0.707 \cdot h \cdot L \cdot (3 \cdot t + L))}$$

$$= \frac{3 \cdot \text{abs}(13,703 \cdot \sin(143.2) \cdot 5 - 13,703 \cdot \cos(143.2) \cdot (0))}{(16.7912)}$$

$$= 7,334 \text{ psi}$$

$$\tau_{\text{ratio}} = \frac{\text{sqr}(\tau_t + \tau_b)^2 + \tau_s^2}{\tau_{\text{allowable}}} \leq 1$$

$$= \frac{\text{sqr}((-2,387 + 7,334)^2 + (1,786)^2)}{13,320}$$

$$= \underline{0.39} \quad \text{Acceptable}$$

## EN 13445 Lift Lug Procedure

### Geometry Inputs - EN13445

Nominal Vessel Thickness, $e_n$	1.73"
Pad Thickness, $e_2$	0"
Length of Lug, $b_1$	5"
Width of Pad, $b_2$	0"
Length of Pad, $b_3$	0"

### Intermediate Values - EN13445

Equivalent Diameter of Vessel at Lug, $ID_{\text{eq}}$	<u>29.0267"</u>
Shell Allowable Stress, $f$	20000 psi
Pad Allowable Stress, $f_2$	N/A
Design Factor, $K_2$	1.2500

## Summary Values - EN13445

Force on Vessel, $F_r$	<a href="#">13.703 lbf</a>
Maximum Allowable Load, $F_{Rmax}$	<a href="#">67.596 lbf</a>
Load Acceptance Ratio, $F_R / F_{Rmax}$	<b>0.2027</b>
Lug Design	Acceptable

### Equivalent Inner Diameter

$$ID_{eq} = D_i \cdot \sqrt{1 - 3 \cdot (x / D_i)^2}$$

$$ID_{eq} = 44.54 \cdot \sqrt{1 - 3 \cdot (19.5044 / 44.54)^2}$$

$$ID_{eq} = 29.0267''$$

where 'x' is the distance between the axis of semi-ellipsoidal head and the center of the lug

### Applied Force

$$F_r = \text{force on vessel at lug}$$

$$F_r = [W / \cos(\phi_1)] \cdot (1 - x_1 / (x_1 + x_2))$$

$$= (27,405.6) / \cos(106.4106) \cdot (1 - 0 / (0 + 0))$$

$$= \a href="#">13.703 lbf$$

where 'x<sub>1</sub>' is the distance between this lug and the center of gravity

'x<sub>2</sub>' is the distance between the second lift lug and the center of gravity

### Lug factors

$$\lambda = \text{line load factor}$$

$$\lambda = b / \sqrt{ID_{eq} \cdot e_n}$$

$$= 5 / \sqrt{29.0267 \cdot 1.73}$$

$$= 0.706$$

$$v_1 = \text{ratio between local membrane stress and local bending stress}$$

$$v_1 = \min(0.08 \cdot \lambda, 0.2)$$

$$= 0.056$$

$$\sigma_m = \text{global membrane stress}$$

$$\sigma_m = P \cdot ID_{eq} / (2 \cdot e_n)$$

$$= 0 \cdot 29.0267 / (2 \cdot 1.73)$$

$$= 0.0000 \text{ psi}$$

$$v_2 = \text{ratio between global membrane stress and allowable stress}$$

$$v_2 = \sigma_m / (K_2 \cdot f)$$

$$= 0 / (1.25 \cdot 20,000)$$

$$= 0$$

$$K_{13} = 1 / (1.2 \cdot \sqrt{1 + 0.06 \cdot \lambda^2})$$

$$= 1 / (1.2 \cdot \sqrt{1 + 0.06 \cdot 0.7056^2})$$

$$= 0.8212$$

$$\begin{aligned} K_{14} &= 1 / (0.6 * \text{sqr}(1 + 0.03 * \lambda^2)) \\ &= 1 / (0.6 * \text{sqr}(1 + 0.03 * 0.7056^2)) \\ &= 1.6544 \end{aligned}$$

### Bending Limit Stress

$$\begin{aligned} K_1 &= (1 - \nu_2^2) / ( (1/3 + \nu_1 * \nu_2) + \text{sqr}( (1/3 + \nu_1 * \nu_2)^2 + (1 - \nu_2^2) * \nu_1^2 ) ) \\ &= (1 - 0^2) / ( (1/3 + 0.0564 * 0) + \text{sqr}( (1/3 + 0.0564 * 0)^2 + (1 - 0^2) * 0.0564^2 ) ) \\ &= 1.4894 \end{aligned}$$

$$\begin{aligned} \sigma_b &= K_1 * K_2 * f \\ &= 1.4894 * 1.25 * 20,000 \\ &= 37,235 \text{ psi} \end{aligned}$$

### Maximum Allowable Load

$$\begin{aligned} F_{Rmax} &= \sigma_b * e_n^2 / (K_{13} * |\cos(\beta)| + K_{14} * |a_2 * \sin(\beta) - a_1 * \cos(\beta)| / b_1) \\ &= 37,235 * (1.73)^2 / (0.8212 * |\cos(143.1925)| + 1.6544 * |5 * \sin(143.1925) - 0 * \cos(143.1925)| / 5) \\ &= [67,596 lbf](#) \end{aligned}$$



$$= 4 * 2,460.98 / (3 * (48 / 0.2194))$$

$$= 15 \text{ psi}$$

**Design thickness for external pressure  $P_a = 15 \text{ psi}$**

$$t_a = t + \text{Corrosion} = 0.2194 + 0 = 0.2194''$$

**Maximum Allowable External Pressure, (Corroded & at 140 °F) UG-28(c)**

$$L / D_o = 107.4233 / 48 = 2.2380$$

$$D_o / t = 48 / 1.75 = 27.4286$$

From table G: A = 0.003965

From table HA-2: B = 12,805.8347 psi

$$P_a = 4 * B / (3 * (D_o / t))$$

$$= 4 * 12,805.83 / (3 * (48 / 1.75))$$

$$= 622.51 \text{ psi}$$

**% Forming strain - UHA-44(a)(2)(a)**

$$\text{EFE} = (50 * t / R_i) * (1 - R_i / R_o)$$

$$= (50 * 1.75 / 23.125) * (1 - 23.125 / \infty)$$

$$= 3.7838\%$$

**External Pressure + Weight + Wind Loading Check (Bergman, ASME paper 54-A-104)**

$$P_v = W / (2 * \pi * R_m) + M / (\pi * R_m^2)$$

$$= 16,039 / (2 * \pi * 23.125) + 270,826 / (\pi * 23.125^2)$$

$$= 271.5912 \text{ lb/in}$$

$$\alpha = P_v / (P_e * D_o)$$

$$= 271.5912 / (15 * 48)$$

$$= 0.3772$$

$$n = 3$$

$$m = 1.23 / (L / D_o)^2$$

$$= 1.23 / (107.4233 / 48)^2$$

$$= 0.2456$$

$$\text{Ratio } P_e = (n^2 - 1 + m + m * \alpha) / (n^2 - 1 + m)$$

$$= (3^2 - 1 + 0.2456 + 0.2456 * 0.3772) / (3^2 - 1 + 0.2456)$$

$$= 1.0112$$

Ratio  $P_e * P_e \leq \text{MAEP}$  design cylinder thickness is satisfactory.

**External Pressure + Weight + Seismic Loading Check (Bergman, ASME paper 54-A-104)**

$$P_v = (1 + V_{\text{Accel}}) * W / (2 * \pi * R_m) + M / (\pi * R_m^2)$$

$$= 2.00 * 16,039 / (2 * \pi * 23.125) + 830,156 / (\pi * 23.125^2)$$

$$= 714.9091 \text{ lb/in}$$

$$\alpha = P_v / (P_e * D_o)$$

$$= 714.9091 / (15 * 48)$$

$$\begin{aligned}
 &= 0.9929 \\
 n &= 3 \\
 m &= 1.23 / (L / D_o)^2 \\
 &= 1.23 / (107.4233 / 48)^2 \\
 &= 0.2456 \\
 \text{Ratio } P_e &= (n^2 - 1 + m + m \cdot \alpha) / (n^2 - 1 + m) \\
 &= (3^2 - 1 + 0.2456 + 0.2456 \cdot 0.9929) / (3^2 - 1 + 0.2456) \\
 &= 1.0296
 \end{aligned}$$

Ratio  $P_e \cdot P_e \leq$  MAEP design cylinder thickness is satisfactory.

**Design thickness = 1.61"**

The governing condition is due to internal pressure.

The cylinder thickness of 1.75" is adequate.

### 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 <sub>t</sub>	S <sub>c</sub>					
<a href="#">Operating, Hot &amp; Corroded</a>	1,378	20,000	<a href="#">13.716</a>	140	0	Wind	<a href="#">0.6336</a>	<a href="#">0.6202</a>
						Seismic	<a href="#">0.6475</a>	<a href="#">0.6017</a>
<a href="#">Operating, Hot &amp; New</a>	1,378	20,000	<a href="#">13.716</a>	140	0	Wind	<a href="#">0.6336</a>	<a href="#">0.6202</a>
						Seismic	<a href="#">0.6475</a>	<a href="#">0.6017</a>
<a href="#">Hot Shut Down, Corroded</a>	0	20,000	<a href="#">13.716</a>	140	0	Wind	<a href="#">0.0021</a>	<a href="#">0.0165</a>
						Seismic	<a href="#">0.016</a>	<a href="#">0.0434</a>
<a href="#">Hot Shut Down, New</a>	0	20,000	<a href="#">13.716</a>	140	0	Wind	<a href="#">0.0021</a>	<a href="#">0.0165</a>
						Seismic	<a href="#">0.016</a>	<a href="#">0.0434</a>
<a href="#">Empty, Corroded</a>	0	20,000	<a href="#">13.895</a>	70	0	Wind	<a href="#">0.0021</a>	<a href="#">0.0163</a>
						Seismic	<a href="#">0.0152</a>	<a href="#">0.0418</a>
<a href="#">Empty, New</a>	0	20,000	<a href="#">13.895</a>	70	0	Wind	<a href="#">0.0021</a>	<a href="#">0.0163</a>
						Seismic	<a href="#">0.0152</a>	<a href="#">0.0418</a>
<a href="#">Vacuum</a>	-15	20,000	<a href="#">13.716</a>	140	0	Wind	<a href="#">0.007</a>	<a href="#">0.0266</a>
						Seismic	<a href="#">0.009</a>	<a href="#">0.0536</a>
<a href="#">Hot Shut Down, Corroded, Weight &amp; Eccentric Moments Only</a>	0	20,000	<a href="#">13.716</a>	140	0	Weight	<a href="#">0.0018</a>	<a href="#">0.0188</a>

#### Allowable Compressive Stress, Hot and Corroded- S<sub>cHC</sub>, (table HA-2)

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (24 / 1.75) \\
 &= 0.009115 \\
 B &= 13,716 \text{ psi} \\
 S &= 20,000 / 1.00 = 20,000 \text{ psi} \\
 S_{cHC} &= \min(B, S) = \underline{13.716 \text{ psi}}
 \end{aligned}$$

#### Allowable Compressive Stress, Hot and New- S<sub>cHN</sub>

$$\begin{aligned}
 S_{cHN} &= S_{cHC} \\
 &= \underline{13.716 \text{ psi}}
 \end{aligned}$$

#### Allowable Compressive Stress, Cold and New- S<sub>cCN</sub>, (table HA-2)

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (24 / 1.75) \\
 &= 0.009115 \\
 B &= 13,895 \text{ psi} \\
 S &= 20,000 / 1.00 = 20,000 \text{ psi} \\
 S_{cCN} &= \min(B, S) = \underline{13.895 \text{ psi}}
 \end{aligned}$$

#### Allowable Compressive Stress, Cold and Corroded- S<sub>cCC</sub>

$$\begin{aligned}
 S_{cCC} &= S_{cCN} \\
 &= \underline{13.895 \text{ psi}}
 \end{aligned}$$

**Allowable Compressive Stress, Vacuum and Corroded-  $S_{cVC}$ , (table HA-2)**

$$\begin{aligned} A &= 0.125 / (R_o / t) \\ &= 0.125 / (24 / 1.75) \\ &= 0.009115 \\ B &= 13,716 \text{ psi} \\ S &= 20,000 / 1.00 = 20,000 \text{ psi} \\ S_{cVC} &= \min(B, S) = \underline{13.716 \text{ psi}} \end{aligned}$$

**Operating, Hot & Corroded, Wind, Bottom Seam**

$$\begin{aligned} t_p &= P \cdot R / (2 \cdot S_t \cdot K_s \cdot E_c + 0.40 \cdot |P|) && \text{(Pressure)} \\ &= 1,378 \cdot 22.25 / (2 \cdot 20,000 \cdot 1.20 \cdot 1.00 + 0.40 \cdot |1,378|) \\ &= 0.6315" \\ t_m &= M / (\pi \cdot R_m^2 \cdot S_t \cdot K_s \cdot E_c) && \text{(bending)} \\ &= 270,826 / (\pi \cdot 23.125^2 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\ &= 0.0067" \\ t_w &= W / (2 \cdot \pi \cdot R_m \cdot S_t \cdot K_s \cdot E_c) && \text{(Weight)} \\ &= 16,039 / (2 \cdot \pi \cdot 23.125 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\ &= 0.0046" \\ t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\ &= 0.6315 + 0.0067 - (0.0046) \\ &= \underline{0.6336"} \\ t_c &= |t_{mc} + t_{wc} - t_{pc}| && \text{(total, net tensile)} \\ &= |0.0067 + (0.0046) - (0.6315)| \\ &= \underline{0.6202"} \end{aligned}$$

**Maximum allowable working pressure, Longitudinal Stress**

$$\begin{aligned} P &= 2 \cdot S_t \cdot K_s \cdot E_c \cdot (t - t_m + t_w) / (R - 0.40 \cdot (t - t_m + t_w)) \\ &= 2 \cdot 20,000 \cdot 1.20 \cdot 1.00 \cdot (1.75 - 0.0067 + (0.0046)) / (22.25 - 0.40 \cdot (1.75 - 0.0067 + (0.0046))) \\ &= 3,893.04 \text{ psi} \end{aligned}$$

**Operating, Hot & New, Wind, Bottom Seam**

$$\begin{aligned} t_p &= P \cdot R / (2 \cdot S_t \cdot K_s \cdot E_c + 0.40 \cdot |P|) && \text{(Pressure)} \\ &= 1,378 \cdot 22.25 / (2 \cdot 20,000 \cdot 1.20 \cdot 1.00 + 0.40 \cdot |1,378|) \\ &= 0.6315" \\ t_m &= M / (\pi \cdot R_m^2 \cdot S_t \cdot K_s \cdot E_c) && \text{(bending)} \\ &= 270,826 / (\pi \cdot 23.125^2 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\ &= 0.0067" \\ t_w &= W / (2 \cdot \pi \cdot R_m \cdot S_t \cdot K_s \cdot E_c) && \text{(Weight)} \\ &= 16,039 / (2 \cdot \pi \cdot 23.125 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\ &= 0.0046" \\ t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \end{aligned}$$



$$= 0.6315 + 0.0067 - (0.0046)$$

$$= \underline{0.6336''}$$

$$t_c = |t_{mc} + t_{wc} - t_{pc}| \quad \text{(total, net tensile)}$$

$$= |0.0067 + (0.0046) - (0.6315)|$$

$$= \underline{0.6202''}$$

### Maximum allowable working pressure, Longitudinal Stress

$$P = 2 * S_t * K_s * E_c * (t - t_m + t_w) / (R - 0.40 * (t - t_m + t_w))$$

$$= 2 * 20,000 * 1.20 * 1.00 * (1.75 - 0.0067 + (0.0046)) / (22.25 - 0.40 * (1.75 - 0.0067 + (0.0046)))$$

$$= 3,893.04 \text{ psi}$$

### Hot Shut Down, Corroded, Wind, Bottom Seam

$$t_p = 0'' \quad \text{(Pressure)}$$

$$t_m = M / (\pi * R_m^2 * S_t * K_s * E_c) \quad \text{(bending)}$$

$$= 270,826 / (\pi * 23.125^2 * 20,000 * 1.20 * 1.00)$$

$$= 0.0067''$$

$$t_w = W / (2 * \pi * R_m * S_t * K_s * E_c) \quad \text{(Weight)}$$

$$= 16,039 / (2 * \pi * 23.125 * 20,000 * 1.20 * 1.00)$$

$$= 0.0046''$$

$$t_t = t_p + t_m - t_w \quad \text{(total required, tensile)}$$

$$= 0 + 0.0067 - (0.0046)$$

$$= \underline{0.0021''}$$

$$t_{mc} = M / (\pi * R_m^2 * S_c * K_s) \quad \text{(bending)}$$

$$= 270,826 / (\pi * 23.125^2 * 13,715.98 * 1.20)$$

$$= 0.0098''$$

$$t_{wc} = W / (2 * \pi * R_m * S_c * K_s) \quad \text{(Weight)}$$

$$= 16,039 / (2 * \pi * 23.125 * 13,715.98 * 1.20)$$

$$= 0.0067''$$

$$t_c = t_{mc} + t_{wc} - t_{pc} \quad \text{(total required, compressive)}$$

$$= 0.0098 + (0.0067) - (0)$$

$$= \underline{0.0165''}$$

### Hot Shut Down, New, Wind, Bottom Seam

$$t_p = 0'' \quad \text{(Pressure)}$$

$$t_m = M / (\pi * R_m^2 * S_t * K_s * E_c) \quad \text{(bending)}$$

$$= 270,826 / (\pi * 23.125^2 * 20,000 * 1.20 * 1.00)$$

$$= 0.0067''$$

$$t_w = W / (2 * \pi * R_m * S_t * K_s * E_c) \quad \text{(Weight)}$$

$$= 16,039 / (2 * \pi * 23.125 * 20,000 * 1.20 * 1.00)$$

$$= 0.0046''$$

$$t_t = t_p + t_m - t_w \quad \text{(total required, tensile)}$$

$$= 0 + 0.0067 - (0.0046)$$

$$= \underline{0.0021''}$$

$$\begin{aligned}
t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\
&= 270,826 / (\pi * 23.125^2 * 13,715.98 * 1.20) \\
&= 0.0098" \\
t_{wc} &= W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\
&= 16,039 / (2 * \pi * 23.125 * 13,715.98 * 1.20) \\
&= 0.0067" \\
t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\
&= 0.0098 + (0.0067) - (0) \\
&= \underline{0.0165"}
\end{aligned}$$

### Empty, Corroded, Wind, Bottom Seam

$$\begin{aligned}
t_p &= 0" && \text{(Pressure)} \\
t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\
&= 270,826 / (\pi * 23.125^2 * 20,000 * 1.20 * 1.00) \\
&= 0.0067" \\
t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\
&= 16,039 / (2 * \pi * 23.125 * 20,000 * 1.20 * 1.00) \\
&= 0.0046" \\
t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\
&= 0 + 0.0067 - (0.0046) \\
&= \underline{0.0021"} \\
t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\
&= 270,826 / (\pi * 23.125^2 * 13,894.91 * 1.20) \\
&= 0.0097" \\
t_{wc} &= W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\
&= 16,039 / (2 * \pi * 23.125 * 13,894.91 * 1.20) \\
&= 0.0066" \\
t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\
&= 0.0097 + (0.0066) - (0) \\
&= \underline{0.0163"}
\end{aligned}$$

### Empty, New, Wind, Bottom Seam

$$\begin{aligned}
t_p &= 0" && \text{(Pressure)} \\
t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\
&= 270,826 / (\pi * 23.125^2 * 20,000 * 1.20 * 1.00) \\
&= 0.0067" \\
t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\
&= 16,039 / (2 * \pi * 23.125 * 20,000 * 1.20 * 1.00) \\
&= 0.0046" \\
t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\
&= 0 + 0.0067 - (0.0046) \\
&= \underline{0.0021"} \\
t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\
&= 270,826 / (\pi * 23.125^2 * 13,894.91 * 1.20)
\end{aligned}$$

$$= 0.0097''$$

$$\begin{aligned} t_{wc} &= W / (2\pi R_m S_c K_s) && \text{(Weight)} \\ &= 16,039 / (2\pi * 23.125 * 13,894.91 * 1.20) \\ &= 0.0066'' \end{aligned}$$

$$\begin{aligned} t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\ &= 0.0097 + (0.0066) - (0) \\ &= \underline{0.0163''} \end{aligned}$$

### Vacuum, Wind, Bottom Seam

$$\begin{aligned} t_p &= P * R / (2 * S_c * K_s + 0.40 * |P|) && \text{(Pressure)} \\ &= -15 * 22.25 / (2 * 13,715.98 * 1.20 + 0.40 * |15|) \\ &= -0.0101'' \end{aligned}$$

$$\begin{aligned} t_m &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\ &= 270,826 / (\pi * 23.125^2 * 13,715.98 * 1.20) \\ &= 0.0098'' \end{aligned}$$

$$\begin{aligned} t_w &= W / (2\pi R_m S_c K_s) && \text{(Weight)} \\ &= 16,039 / (2\pi * 23.125 * 13,715.98 * 1.20) \\ &= 0.0067'' \end{aligned}$$

$$\begin{aligned} t_t &= |t_p + t_m - t_w| && \text{(total, net compressive)} \\ &= |-0.0101 + 0.0098 - (0.0067)| \\ &= \underline{0.007''} \end{aligned}$$

$$\begin{aligned} t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\ &= 0.0098 + (0.0067) - (-0.0101) \\ &= \underline{0.0266''} \end{aligned}$$

### **Maximum Allowable External Pressure, Longitudinal Stress**

$$\begin{aligned} P &= 2 * S_c * K_s * (t - t_{mc} - t_{wc}) / (R - 0.40 * (t - t_{mc} - t_{wc})) \\ &= 2 * 13,715.98 * 1.20 * (1.75 - 0.0098 - 0.0067) / (22.25 - 0.40 * (1.75 - 0.0098 - 0.0067)) \\ &= 2,647.17 \text{ psi} \end{aligned}$$

### Hot Shut Down, Corroded, Weight & Eccentric Moments Only, Bottom Seam

$$\begin{aligned} t_p &= 0'' && \text{(Pressure)} \\ t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\ &= 246,659 / (\pi * 23.125^2 * 20,000 * 1.00 * 1.00) \\ &= 0.0073'' \end{aligned}$$

$$\begin{aligned} t_w &= W / (2\pi R_m S_t K_s E_c) && \text{(Weight)} \\ &= 16,039 / (2\pi * 23.125 * 20,000 * 1.00 * 1.00) \\ &= 0.0055'' \end{aligned}$$

$$\begin{aligned} t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\ &= 0 + 0.0073 - (0.0055) \\ &= \underline{0.0018''} \end{aligned}$$

$$\begin{aligned} t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\ &= 246,659 / (\pi * 23.125^2 * 13,715.98 * 1.00) \\ &= 0.0107'' \end{aligned}$$

$$t_{wc} = W / (2\pi R_m S_c K_s) \quad (\text{Weight})$$

$$= 16,039 / (2\pi * 23.125 * 13,715.98 * 1.00)$$

$$= 0.008"$$

$$t_c = t_{mc} + t_{wc} - t_{pc} \quad (\text{total required, compressive})$$

$$= 0.0107 + (0.008) - (0)$$

$$= \underline{0.0188}"$$

### Operating, Hot & Corroded, Seismic, Bottom Seam

$$t_p = P * R / (2 * S_t * K_s * E_c + 0.40 * |P|) \quad (\text{Pressure})$$

$$= 1,378 * 22.25 / (2 * 20,000 * 1.20 * 1.00 + 0.40 * |1,378|)$$

$$= 0.6315"$$

$$t_m = M / (\pi * R_m^2 * S_t * K_s * E_c) \quad (\text{bending})$$

$$= 830,156 / (\pi * 23.125^2 * 20,000 * 1.20 * 1.00)$$

$$= 0.0206"$$

$$t_w = W / (2\pi R_m S_t K_s E_c) \quad (\text{Weight})$$

$$= 16,039 / (2\pi * 23.125 * 20,000 * 1.20 * 1.00)$$

$$= 0.0046"$$

$$t_t = t_p + t_m - t_w \quad (\text{total required, tensile})$$

$$= 0.6315 + 0.0206 - (0.0046)$$

$$= \underline{0.6475}"$$

$$t_{wc} = (1 + V_{\text{Accel}}) * W / (2\pi R_m S_t K_s E_c) \quad (\text{Weight})$$

$$= 2.00 * 16,039 / (2\pi * 23.125 * 20,000 * 1.20 * 1.00)$$

$$= 0.0092"$$

$$t_c = |t_{mc} + t_{wc} - t_{pc}| \quad (\text{total, net tensile})$$

$$= |0.0206 + (0.0092) - (0.6315)|$$

$$= \underline{0.6017}"$$

### **Maximum allowable working pressure, Longitudinal Stress**

$$P = 2 * S_t * K_s * E_c * (t - t_m + t_w) / (R - 0.40 * (t - t_m + t_w))$$

$$= 2 * 20,000 * 1.20 * 1.00 * (1.75 - 0.0206 + (0.0046)) / (22.25 - 0.40 * (1.75 - 0.0206 + (0.0046)))$$

$$= 3,861.15 \text{ psi}$$

### Operating, Hot & New, Seismic, Bottom Seam

$$t_p = P * R / (2 * S_t * K_s * E_c + 0.40 * |P|) \quad (\text{Pressure})$$

$$= 1,378 * 22.25 / (2 * 20,000 * 1.20 * 1.00 + 0.40 * |1,378|)$$

$$= 0.6315"$$

$$t_m = M / (\pi * R_m^2 * S_t * K_s * E_c) \quad (\text{bending})$$

$$= 830,156 / (\pi * 23.125^2 * 20,000 * 1.20 * 1.00)$$

$$= 0.0206"$$

$$t_w = W / (2\pi R_m S_t K_s E_c) \quad (\text{Weight})$$

$$= 16,039 / (2\pi * 23.125 * 20,000 * 1.20 * 1.00)$$

$$= 0.0046"$$

$$t_t = t_p + t_m - t_w \quad (\text{total required, tensile})$$

$$= 0.6315 + 0.0206 - (0.0046)$$

$$= 0.6475''$$

$$\begin{aligned} t_{wc} &= (1 + V_{\text{Accel}}) * W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\ &= 2.00 * 16,039 / (2 * \pi * 23.125 * 20,000 * 1.20 * 1.00) \\ &= 0.0092'' \end{aligned}$$

$$\begin{aligned} t_c &= |t_{mc} + t_{wc} - t_{pc}| && \text{(total, net tensile)} \\ &= |0.0206 + (0.0092) - (0.6315)| \\ &= 0.6017'' \end{aligned}$$

### Maximum allowable working pressure, Longitudinal Stress

$$\begin{aligned} P &= 2 * S_t * K_s * E_c * (t - t_m + t_w) / (R - 0.40 * (t - t_m + t_w)) \\ &= 2 * 20,000 * 1.20 * 1.00 * (1.75 - 0.0206 + (0.0046)) / (22.25 - 0.40 * (1.75 - 0.0206 + (0.0046))) \\ &= 3,861.15 \text{ psi} \end{aligned}$$

### Hot Shut Down, Corroded, Seismic, Bottom Seam

$$t_p = 0'' \quad \text{(Pressure)}$$

$$\begin{aligned} t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\ &= 830,156 / (\pi * 23.125^2 * 20,000 * 1.20 * 1.00) \\ &= 0.0206'' \end{aligned}$$

$$\begin{aligned} t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\ &= 16,039 / (2 * \pi * 23.125 * 20,000 * 1.20 * 1.00) \\ &= 0.0046'' \end{aligned}$$

$$\begin{aligned} t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\ &= 0 + 0.0206 - (0.0046) \\ &= 0.016'' \end{aligned}$$

$$\begin{aligned} t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\ &= 830,156 / (\pi * 23.125^2 * 13,715.98 * 1.20) \\ &= 0.03'' \end{aligned}$$

$$\begin{aligned} t_{wc} &= (1 + V_{\text{Accel}}) * W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\ &= 2.00 * 16,039 / (2 * \pi * 23.125 * 13,715.98 * 1.20) \\ &= 0.0134'' \end{aligned}$$

$$\begin{aligned} t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\ &= 0.03 + (0.0134) - (0) \\ &= 0.0434'' \end{aligned}$$

### Hot Shut Down, New, Seismic, Bottom Seam

$$t_p = 0'' \quad \text{(Pressure)}$$

$$\begin{aligned} t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\ &= 830,156 / (\pi * 23.125^2 * 20,000 * 1.20 * 1.00) \\ &= 0.0206'' \end{aligned}$$

$$\begin{aligned} t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\ &= 16,039 / (2 * \pi * 23.125 * 20,000 * 1.20 * 1.00) \\ &= 0.0046'' \end{aligned}$$

$$\begin{aligned} t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\ &= 0 + 0.0206 - (0.0046) \end{aligned}$$

$$= 0.016"$$

$$\begin{aligned} t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\ &= 830,156 / (\pi * 23.125^2 * 13,715.98 * 1.20) \\ &= 0.03" \end{aligned}$$

$$\begin{aligned} t_{wc} &= (1 + V_{Accel}) * W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\ &= 2.00 * 16,039 / (2 * \pi * 23.125 * 13,715.98 * 1.20) \\ &= 0.0134" \end{aligned}$$

$$\begin{aligned} t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\ &= 0.03 + (0.0134) - (0) \\ &= 0.0434" \end{aligned}$$

### Empty, Corroded, Seismic, Bottom Seam

$$t_p = 0" \quad \text{(Pressure)}$$

$$\begin{aligned} t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\ &= 799,344 / (\pi * 23.125^2 * 20,000 * 1.20 * 1.00) \\ &= 0.0198" \end{aligned}$$

$$\begin{aligned} t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\ &= 16,039 / (2 * \pi * 23.125 * 20,000 * 1.20 * 1.00) \\ &= 0.0046" \end{aligned}$$

$$\begin{aligned} t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\ &= 0 + 0.0198 - (0.0046) \\ &= 0.0152" \end{aligned}$$

$$\begin{aligned} t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\ &= 799,344 / (\pi * 23.125^2 * 13,894.91 * 1.20) \\ &= 0.0285" \end{aligned}$$

$$\begin{aligned} t_{wc} &= (1 + V_{Accel}) * W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\ &= 2.00 * 16,039 / (2 * \pi * 23.125 * 13,894.91 * 1.20) \\ &= 0.0132" \end{aligned}$$

$$\begin{aligned} t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\ &= 0.0285 + (0.0132) - (0) \\ &= 0.0418" \end{aligned}$$

### Empty, New, Seismic, Bottom Seam

$$t_p = 0" \quad \text{(Pressure)}$$

$$\begin{aligned} t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\ &= 799,344 / (\pi * 23.125^2 * 20,000 * 1.20 * 1.00) \\ &= 0.0198" \end{aligned}$$

$$\begin{aligned} t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\ &= 16,039 / (2 * \pi * 23.125 * 20,000 * 1.20 * 1.00) \\ &= 0.0046" \end{aligned}$$

$$\begin{aligned} t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\ &= 0 + 0.0198 - (0.0046) \\ &= 0.0152" \end{aligned}$$

$$t_{mc} = M / (\pi * R_m^2 * S_c * K_s) \quad \text{(bending)}$$

$$= 799,344 / (\pi * 23.125^2 * 13,894.91 * 1.20)$$

$$= 0.0285"$$

$$t_{wc} = (1 + V_{Accel}) * W / (2 * \pi * R_m * S_c * K_s) \quad (\text{Weight})$$

$$= 2.00 * 16,039 / (2 * \pi * 23.125 * 13,894.91 * 1.20)$$

$$= 0.0132"$$

$$t_c = t_{mc} + t_{wc} - t_{pc} \quad (\text{total required, compressive})$$

$$= 0.0285 + (0.0132) - (0)$$

$$= \underline{0.0418}"$$

### Vacuum, Seismic, Bottom Seam

$$t_p = P * R / (2 * S_t * K_s * E_c + 0.40 * |P|) \quad (\text{Pressure})$$

$$= -15 * 22.25 / (2 * 20,000 * 1.20 * 1.00 + 0.40 * |15|)$$

$$= -0.007"$$

$$t_m = M / (\pi * R_m^2 * S_t * K_s * E_c) \quad (\text{bending})$$

$$= 830,156 / (\pi * 23.125^2 * 20,000 * 1.20 * 1.00)$$

$$= 0.0206"$$

$$t_w = W / (2 * \pi * R_m * S_t * K_s * E_c) \quad (\text{Weight})$$

$$= 16,039 / (2 * \pi * 23.125 * 20,000 * 1.20 * 1.00)$$

$$= 0.0046"$$

$$t_t = t_p + t_m - t_w \quad (\text{total required, tensile})$$

$$= -0.007 + 0.0206 - (0.0046)$$

$$= \underline{0.009}"$$

$$t_{pc} = P * R / (2 * S_c * K_s + 0.40 * |P|) \quad (\text{Pressure})$$

$$= -15 * 22.25 / (2 * 13,715.98 * 1.20 + 0.40 * |15|)$$

$$= -0.0101"$$

$$t_{mc} = M / (\pi * R_m^2 * S_c * K_s) \quad (\text{bending})$$

$$= 830,156 / (\pi * 23.125^2 * 13,715.98 * 1.20)$$

$$= 0.03"$$

$$t_{wc} = (1 + V_{Accel}) * W / (2 * \pi * R_m * S_c * K_s) \quad (\text{Weight})$$

$$= 2.00 * 16,039 / (2 * \pi * 23.125 * 13,715.98 * 1.20)$$

$$= 0.0134"$$

$$t_c = t_{mc} + t_{wc} - t_{pc} \quad (\text{total required, compressive})$$

$$= 0.03 + (0.0134) - (-0.0101)$$

$$= \underline{0.0536}"$$

### **Maximum Allowable External Pressure, Longitudinal Stress**

$$P = 2 * S_c * K_s * (t - t_{mc} - t_{wc}) / (R - 0.40 * (t - t_{mc} - t_{wc}))$$

$$= 2 * 13,715.98 * 1.20 * (1.75 - 0.03 - 0.0134) / (22.25 - 0.40 * (1.75 - 0.03 - 0.0134))$$

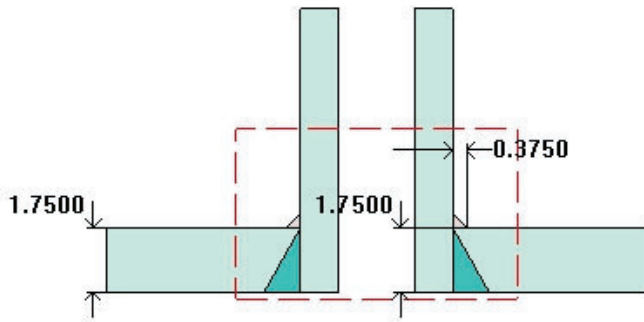
$$= 2,604.73 \text{ psi}$$

## Level Gauge High (N10A)

### ASME Section VIII Division 1, 2010 Edition, A11 Addenda

$$t_{w(\text{lower})} = 1.75 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

#### Location and Orientation

Located on:	48 OD SHELL
Orientation:	45°
Nozzle center line offset to datum line:	40 in
End of nozzle to shell center:	32 in
Passes through a Category A joint:	No

#### Nozzle

Access opening:	No
Material specification:	SA-182 F316 ≤ 5 (II-D p. 70, In. 22)
Inside diameter, new:	2 in
Nominal wall thickness:	1.06 in
Corrosion allowance:	0 in
Projection available outside vessel, L <sub>pr</sub> :	6.25 in
Projection available outside vessel to flange face, L <sub>f</sub> :	8 in
Local vessel minimum thickness:	1.75 in
Liquid static head included:	0 psi
Longitudinal joint efficiency:	1

#### ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 LWN A182 F316
Bolt Material:	SA-193 B7 Bolt ≤ 2 1/2 (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55°F
(Per UHA-51(d)(1)(a))	
(Flange rated MDMT = -320 °F)	
Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F)	
Liquid static head:	0 psi
MAWP rating:	2,040 psi @ 140°F
MAP rating:	2,160 psi @ 50°F



Hydrotest rating:  
PWHT performed:

3,250 psi @ 50°F  
No

**Reinforcement Calculations for Chamber MAWP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For P = 1,378 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

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

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for internal pressure 1,378 psi @ 140 °F**

Nozzle Impact test exempt per UHA-51(g)(coincident ratio = 0.0788).

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

**Required thickness t<sub>r</sub> from UG-37(a)**

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378) \\
 &= 1.6092 \text{ in}
 \end{aligned}$$

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

### UW-16(c) Weld Check

Fillet weld:  $t_{\min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$

$t_{c(\min)} = \text{lesser of } 0.25 \text{ or } 0.7*t_{\min} = 0.25 \text{ in}$

$t_{c(\text{actual})} = 0.7*\text{Leg} = 0.7*0.375 = 0.2625 \text{ in}$

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$\begin{aligned} t_{a \text{ UG-27}} &= P*R / (S*E - 0.6*P) + \text{Corrosion} \\ &= 1,378*1 / (20,000*1 - 0.6*1,378) + 0 \\ &= 0.0719 \text{ in} \end{aligned}$$

$$t_{a \text{ UG-22}} = 0.0835 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0719, 0.0835 ] \\ &= 0.0835 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= P*R_o / (S*E + 0.4*P) + \text{Corrosion} \\ &= 1,378*24 / (20,000*1 + 0.4*1,378) + 0 \\ &= 1.6092 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6092, 0.0625 ] \\ &= 1.6092 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.2074, 1.6092 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0835, 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

## Applied Loads

Radial load:	$P_r = 334$	$lb_f$
Circumferential moment:	$M_c = 2,965$	$lb_f\text{-in}$
Circumferential shear:	$V_c = 409$	$lb_f$
Longitudinal moment:	$M_L = 2,965$	$lb_f\text{-in}$
Longitudinal shear:	$V_L = 409$	$lb_f$
Torsion moment:	$M_t = 4,160$	$lb_f\text{-in}$
Internal pressure:	$P = 1,378$	$psi$
Mean shell radius:	$R_m = 23.125$	$in$
Local shell thickness:	$t = 1.75$	$in$
Shell yield stress:	$S_y = 27,900$	$psi$

### Maximum stresses due to the applied loads at the nozzle OD (includes pressure)

$$R_m / t = 23.125 / 1.75 = 13.2143$$

Pressure stress intensity factor,  $I = 1.05703$  (derived from PVP-Vol. 399, pages 77-82)

$$\text{Local circumferential pressure stress} = I * P * R_i / t = 18,519 \text{ psi}$$

$$\text{Local longitudinal pressure stress} = I * P * R_i / (2 * t) = 9,260 \text{ psi}$$

$$\text{Maximum combined stress } (P_L + P_b + Q) = 18,780 \text{ psi}$$

$$\text{Allowable combined stress } (P_L + P_b + Q) = +-3 * S = +-60,000 \text{ psi}$$

Note: The allowable combined stress  $(P_L + P_b + Q)$  is based on the strain hardening characteristics of this material.

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

$$\text{Maximum local primary membrane stress } (P_L) = 18,524 \text{ psi}$$

$$\text{Allowable local primary membrane stress } (P_L) = +-1.5 * S = +-30,000 \text{ psi}$$

The maximum local primary membrane stress  $(P_L)$  is within allowable limits.

Stresses at the nozzle OD per WRC Bulletin 107										
Figure	value	$\beta$	$A_u$	$A_l$	$B_u$	$B_l$	$C_u$	$C_l$	$D_u$	$D_l$
3C*	2.5705	0.0779	0	0	0	0	-21	-21	-21	-21
4C*	2.6145	0.0779	-22	-22	-22	-22	0	0	0	0
1C	0.2014	0.0779	0	0	0	0	-132	132	-132	132
2C-1	0.1661	0.0779	-109	109	-109	109	0	0	0	0
3A*	0.1676	0.0779	0	0	0	0	-7	-7	7	7
1A	0.1061	0.0779	0	0	0	0	-342	342	342	-342
3B*	0.6597	0.0779	-27	-27	27	27	0	0	0	0
1B-1	0.0616	0.0779	-199	199	199	-199	0	0	0	0
<b>Pressure stress*</b>			18,519	18,519	18,519	18,519	17,520	17,520	17,520	17,520
<b>Total circumferential stress</b>			18,162	18,778	18,614	18,434	17,018	17,966	17,716	17,296
<b>Primary membrane circumferential stress*</b>			18,470	18,470	18,524	18,524	17,492	17,492	17,506	17,506
3C*	2.5705	0.0779	-21	-21	-21	-21	0	0	0	0
4C*	2.6145	0.0779	0	0	0	0	-22	-22	-22	-22
1C-1	0.2031	0.0779	-133	133	-133	133	0	0	0	0
2C	0.1599	0.0779	0	0	0	0	-105	105	-105	105
4A*	0.2212	0.0779	0	0	0	0	-9	-9	9	9
2A	0.063	0.0779	0	0	0	0	-203	203	203	-203
4B*	0.1671	0.0779	-7	-7	7	7	0	0	0	0
2B-1	0.098	0.0779	-316	316	316	-316	0	0	0	0
<b>Pressure stress*</b>			8,760	8,760	8,760	8,760	9,260	9,260	9,260	9,260
<b>Total longitudinal stress</b>			8,283	9,181	8,929	8,563	8,921	9,537	9,345	9,149
<b>Primary membrane longitudinal stress*</b>			8,732	8,732	8,746	8,746	9,229	9,229	9,247	9,247
<b>Shear from <math>M_t</math></b>			89	89	89	89	89	89	89	89
<b>Circ shear from <math>V_c</math></b>			36	36	-36	-36	0	0	0	0
<b>Long shear from <math>V_L</math></b>			0	0	0	0	-36	-36	36	36
<b>Total Shear stress</b>			125	125	53	53	53	53	125	125
<b>Combined stress (<math>P_L+P_B+Q</math>)</b>			18,164	18,780	18,614	18,434	17,018	17,966	17,718	17,298

Note: \* denotes primary stress.

### Longitudinal stress in the nozzle wall due to internal pressure + external loads

$$\begin{aligned} \sigma_{n(P_m)} &= P \cdot R_i / (2 \cdot t_n) - P_r / (\pi \cdot (R_o^2 - R_i^2)) + M \cdot R_o / I \\ &= 1,378 \cdot 1 / (2 \cdot 1.06) - 334 / (\pi \cdot (2.06^2 - 1^2)) + 4,193.1 \cdot 2.06 / 13.3582 \\ &= 1,264 \text{ psi} \end{aligned}$$

The average primary stress  $P_m$  (see Division 2 5.6.a.1) across the nozzle wall due to internal pressure + external loads is acceptable ( $\leq S = 20,000$  psi)

### Shear stress in the nozzle wall due to external loads

$$\begin{aligned} \sigma_{\text{shear}} &= (V_L^2 + V_c^2)^{0.5} / (\pi \cdot R_i \cdot t_n) \\ &= (409^2 + 409^2)^{0.5} / (\pi \cdot 1 \cdot 1.06) \\ &= 174 \text{ psi} \end{aligned}$$

$$\begin{aligned} \sigma_{\text{torsion}} &= M_t / (2 \cdot \pi \cdot R_i^2 \cdot t_n) \\ &= 4,160 / (2 \cdot \pi \cdot 1^2 \cdot 1.06) \end{aligned}$$

= 625 psi

$$\begin{aligned}\sigma_{\text{total}} &= \sigma_{\text{shear}} + \sigma_{\text{torsion}} \\ &= 174 + 625 \\ &= 798 \text{ psi}\end{aligned}$$

UG-45: The total combined shear stress (798 psi) is below than the allowable ( $0.7 \cdot S_n = 0.7 \cdot 20,000 = 14,000$  psi)

**Reinforcement Calculations for MAEP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For Pe = 622.51 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for external pressure 622.51 psi @ 140 °F**

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-28 t<sub>m</sub> = 0.1482 in**

**From UG-37(d)(1) required thickness t<sub>r</sub> = 1.75 in**

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

**UW-16(c) Weld Check**

Fillet weld: t<sub>min</sub> = lesser of 0.75 or t<sub>n</sub> or t = 0.75 in  
 t<sub>c(min)</sub> = lesser of 0.25 or 0.7\*t<sub>min</sub> = [0.25](#) in  
 t<sub>c(actual)</sub> = 0.7\*Leg = 0.7\*0.375 = 0.2625 in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$t_{a \text{ UG-28}} = 0.1482 \text{ in}$$

$$t_{a \text{ UG-22}} = 0.0489 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}} , t_{a \text{ UG-22}} ] \\ &= \max[ 0.1482 , 0.0489 ] \\ &= 0.1482 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 622.5059 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 622.5059) + 0 \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2} , t_{b \text{ UG16}} ] \\ &= \max[ 0.7378 , 0.0625 ] \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3} , t_{b2} ] \\ &= \min[ 0.2074 , 0.7378 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a , t_b ] \\ &= \max[ 0.1482 , 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

### External Pressure, (Corroded & at 140 °F) UG-28(c)

$$L / D_o = 8.0886 / 4.12 = 1.9632$$

$$D_o / t = 4.12 / 0.1482 = 27.7945$$

From table G:  $A = 0.004502$

From table  
HA-2:  $B = 12,976.6933 \text{ psi}$

$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 12,976.69 / (3 \cdot (4.12 / 0.1482)) \\ &= 622.51 \text{ psi} \end{aligned}$$

**Design thickness for external pressure  $P_a = 622.51 \text{ psi}$**

$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482 \text{ in}$$

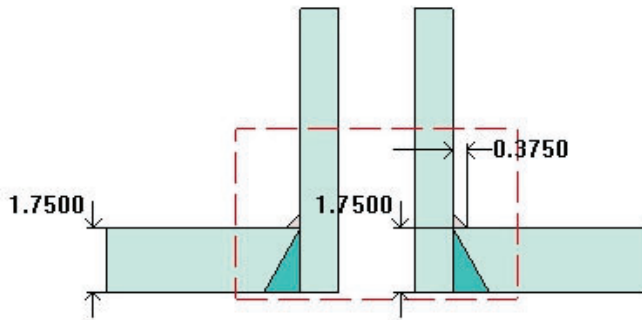


## Liquid Outlet (N3)

### ASME Section VIII Division 1, 2010 Edition, A11 Addenda

$$t_{w(\text{lower})} = 1.75 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

#### Location and Orientation

Located on:	48 OD SHELL
Orientation:	180°
Nozzle center line offset to datum line:	88 in
End of nozzle to shell center:	32 in
Passes through a Category A joint:	No

#### Nozzle

Access opening:	No
Material specification:	SA-182 F316 ≤ 5 (II-D p. 70, In. 22)
Inside diameter, new:	2 in
Nominal wall thickness:	1.06 in
Corrosion allowance:	0 in
Projection available outside vessel, L <sub>pr</sub> :	6.25 in
Projection available outside vessel to flange face, L <sub>f</sub> :	8 in
Local vessel minimum thickness:	1.75 in
Liquid static head included:	0.3574 psi
Longitudinal joint efficiency:	1

#### ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 LWN A182 F316
Bolt Material:	SA-193 B7 Bolt ≤ 2 1/2 (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55°F
(Per UHA-51(d)(1)(a))	
(Flange rated MDMT = -320 °F)	
Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F)	
Liquid static head:	0.3177 psi
MAWP rating:	2,040 psi @ 140°F
MAP rating:	2,160 psi @ 50°F

Hydrotest rating:  
PWHT performed:

3,250 psi @ 50°F  
No

**Reinforcement Calculations for Chamber MAWP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For P = 1,378.36 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

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

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for internal pressure 1,378.36 psi @ 140 °F**

Nozzle Impact test exempt per UHA-51(g)(coincident ratio = 0.0678).

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378.3574 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378.3574) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

**Required thickness t<sub>r</sub> from UG-37(a)**

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 1,378.3574 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378.3574) \\
 &= 1.6097 \text{ in}
 \end{aligned}$$

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

### UW-16(c) Weld Check

Fillet weld:  $t_{\min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$

$t_{c(\min)} = \text{lesser of } 0.25 \text{ or } 0.7 \cdot t_{\min} = 0.25 \text{ in}$

$t_{c(\text{actual})} = 0.7 \cdot \text{Leg} = 0.7 \cdot 0.375 = 0.2625 \text{ in}$

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$\begin{aligned}t_{a \text{ UG-27}} &= P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion} \\ &= 1,378.3574 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378.3574) + 0 \\ &= 0.0719 \text{ in}\end{aligned}$$

$$\begin{aligned}t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0719, 0 ] \\ &= 0.0719 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 1,378.3574 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378.3574) + 0 \\ &= 1.6097 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6097, 0.0625 ] \\ &= 1.6097 \text{ in}\end{aligned}$$

$$\begin{aligned}t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.2074, 1.6097 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0719, 0.2074 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

## Reinforcement Calculations for MAEP

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For Pe = 622.51 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

Calculations for external pressure 622.51 psi @ 140 °F

### Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

### Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28  $t_m = 0.1482$  in

From UG-37(d)(1) required thickness  $t_r = 1.75$  in

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

### UW-16(c) Weld Check

Fillet weld:  $t_{min} =$  lesser of 0.75 or  $t_n$  or  $t = 0.75$  in  
 $t_{c(min)} =$  lesser of 0.25 or  $0.7*t_{min} = \underline{0.25}$  in  
 $t_{c(actual)} = 0.7*Leg = 0.7*0.375 = 0.2625$  in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$t_{a \text{ UG-28}} = 0.1482 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.1482, 0 ] \\ &= 0.1482 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 622.5059 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 622.5059) + 0 \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2}, t_{b \text{ UG16}} ] \\ &= \max[ 0.7378, 0.0625 ] \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b2} ] \\ &= \min[ 0.2074, 0.7378 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.1482, 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

### External Pressure, (Corroded & at 140 °F) UG-28(c)

$$L / D_o = 8.0886 / 4.12 = 1.9632$$

$$D_o / t = 4.12 / 0.1482 = 27.7945$$

From table G:  $A = 0.004502$

From table HA-2:  $B = 12,976.6933 \text{ psi}$

$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 12,976.69 / (3 \cdot (4.12 / 0.1482)) \\ &= 622.51 \text{ psi} \end{aligned}$$

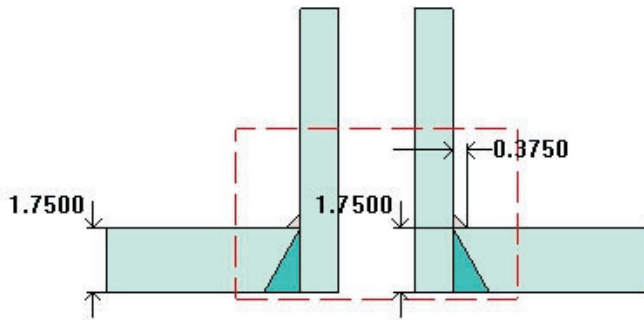
### Design thickness for external pressure $P_a = 622.51 \text{ psi}$

$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

## PSV (N4)

### ASME Section VIII Division 1, 2010 Edition, A11 Addenda

$$t_{w(\text{lower})} = 1.75 \text{ in}$$
$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

#### Location and Orientation

Located on:	48 OD SHELL
Orientation:	90°
Nozzle center line offset to datum line:	26 in
End of nozzle to shell center:	32 in
Passes through a Category A joint:	No

#### Nozzle

Access opening:	No
Material specification:	SA-182 F316 $\leq 5$ (II-D p. 70, In. 22)
Inside diameter, new:	2 in
Nominal wall thickness:	1.06 in
Corrosion allowance:	0 in
Projection available outside vessel, $L_{pr}$ :	6.25 in
Projection available outside vessel to flange face, $L_f$ :	8 in
Local vessel minimum thickness:	1.75 in
Liquid static head included:	0 psi
Longitudinal joint efficiency:	1

#### ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 LWN A182 F316
Bolt Material:	SA-193 B7 Bolt $\leq 2 \frac{1}{2}$ (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55°F
(Per UHA-51(d)(1)(a))	
(Flange rated MDMT = -320 °F	
Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F)	
Liquid static head:	0 psi
MAWP rating:	2,040 psi @ 140°F
MAP rating:	2,160 psi @ 50°F

Hydrotest rating:  
PWHT performed:

3,250 psi @ 50°F  
No



## Reinforcement Calculations for Chamber MAWP

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For P = 1,378 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
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 <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

### Calculations for internal pressure 1,378 psi @ 140 °F

Nozzle Impact test exempt per UHA-51(g)(coincident ratio = 0.0678).

#### Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

#### Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

#### Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

#### Required thickness t<sub>r</sub> from UG-37(a)

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378) \\
 &= 1.6092 \text{ in}
 \end{aligned}$$

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

### UW-16(c) Weld Check

Fillet weld:  $t_{\min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$

$t_{c(\min)} = \text{lesser of } 0.25 \text{ or } 0.7 \cdot t_{\min} = 0.25 \text{ in}$

$t_{c(\text{actual})} = 0.7 \cdot \text{Leg} = 0.7 \cdot 0.375 = 0.2625 \text{ in}$

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$\begin{aligned}t_{a \text{ UG-27}} &= P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion} \\ &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) + 0 \\ &= 0.0719 \text{ in}\end{aligned}$$

$$\begin{aligned}t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0719, 0 ] \\ &= 0.0719 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378) + 0 \\ &= 1.6092 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6092, 0.0625 ] \\ &= 1.6092 \text{ in}\end{aligned}$$

$$\begin{aligned}t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.2074, 1.6092 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0719, 0.2074 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

**Reinforcement Calculations for MAEP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For Pe = 622.51 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for external pressure 622.51 psi @ 140 °F**

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-28 t<sub>m</sub> = 0.1482 in**

**From UG-37(d)(1) required thickness t<sub>r</sub> = 1.75 in**

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

**UW-16(c) Weld Check**

Fillet weld: t<sub>min</sub> = lesser of 0.75 or t<sub>n</sub> or t = 0.75 in  
 t<sub>c(min)</sub> = lesser of 0.25 or 0.7\*t<sub>min</sub> = [0.25](#) in  
 t<sub>c(actual)</sub> = 0.7\*Leg = 0.7\*0.375 = 0.2625 in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$t_{a \text{ UG-28}} = 0.1482 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.1482, 0 ] \\ &= 0.1482 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 622.5059 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 622.5059) + 0 \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2}, t_{b \text{ UG16}} ] \\ &= \max[ 0.7378, 0.0625 ] \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b2} ] \\ &= \min[ 0.2074, 0.7378 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.1482, 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

### External Pressure, (Corroded & at 140 °F) UG-28(c)

$$L / D_o = 8.0886 / 4.12 = 1.9632$$

$$D_o / t = 4.12 / 0.1482 = 27.7945$$

From table G:  $A = 0.004502$

From table HA-2:  $B = 12,976.6933 \text{ psi}$

$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 12,976.69 / (3 \cdot (4.12 / 0.1482)) \\ &= 622.51 \text{ psi} \end{aligned}$$

### Design thickness for external pressure $P_a = 622.51 \text{ psi}$

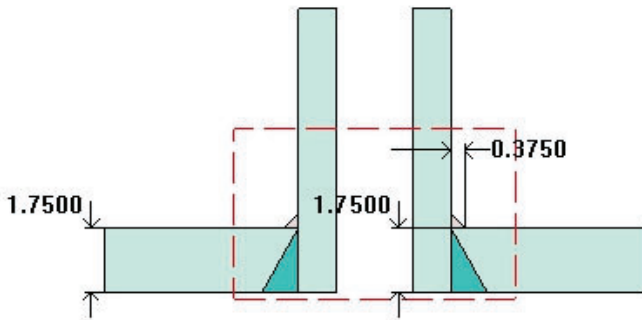
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

## Pressure Indicator (N5)

### ASME Section VIII Division 1, 2010 Edition, A11 Addenda

$$t_{w(\text{lower})} = 1.75 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

#### Location and Orientation

Located on:	48 OD SHELL
Orientation:	90°
Nozzle center line offset to datum line:	40 in
End of nozzle to shell center:	32 in
Passes through a Category A joint:	No

#### Nozzle

Access opening:	No
Material specification:	SA-182 F316 $\leq 5$ (II-D p. 70, In. 22)
Inside diameter, new:	2 in
Nominal wall thickness:	1.06 in
Corrosion allowance:	0 in
Projection available outside vessel, L <sub>pr</sub> :	6.25 in
Projection available outside vessel to flange face, L <sub>f</sub> :	8 in
Local vessel minimum thickness:	1.75 in
Liquid static head included:	0 psi
Longitudinal joint efficiency:	1

#### ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 LWN A182 F316
Bolt Material:	SA-193 B7 Bolt $\leq 2 \frac{1}{2}$ (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55°F
(Per UHA-51(d)(1)(a))	
(Flange rated MDMT = -320 °F)	
Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F)	
Liquid static head:	0 psi
MAWP rating:	2,040 psi @ 140°F
MAP rating:	2,160 psi @ 50°F

Hydrotest rating:  
PWHT performed:

3,250 psi @ 50°F  
No

## Reinforcement Calculations for Chamber MAWP

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For P = 1,378 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
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 <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

### Calculations for internal pressure 1,378 psi @ 140 °F

Nozzle Impact test exempt per UHA-51(g)(coincident ratio = 0.0678).

#### Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

#### Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

#### Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

#### Required thickness t<sub>r</sub> from UG-37(a)

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378) \\
 &= 1.6092 \text{ in}
 \end{aligned}$$

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

### UW-16(c) Weld Check

Fillet weld:  $t_{\min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$

$t_{c(\min)} = \text{lesser of } 0.25 \text{ or } 0.7 \cdot t_{\min} = 0.25 \text{ in}$

$t_{c(\text{actual})} = 0.7 \cdot \text{Leg} = 0.7 \cdot 0.375 = 0.2625 \text{ in}$

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$\begin{aligned}t_{a \text{ UG-27}} &= P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion} \\ &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) + 0 \\ &= 0.0719 \text{ in}\end{aligned}$$

$$\begin{aligned}t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0719, 0 ] \\ &= 0.0719 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378) + 0 \\ &= 1.6092 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6092, 0.0625 ] \\ &= 1.6092 \text{ in}\end{aligned}$$

$$\begin{aligned}t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.2074, 1.6092 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0719, 0.2074 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.



**Reinforcement Calculations for MAEP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For Pe = 622.51 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for external pressure 622.51 psi @ 140 °F**

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-28 t<sub>m</sub> = 0.1482 in**

**From UG-37(d)(1) required thickness t<sub>r</sub> = 1.75 in**

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

**UW-16(c) Weld Check**

Fillet weld: t<sub>min</sub> = lesser of 0.75 or t<sub>n</sub> or t = 0.75 in  
 t<sub>c(min)</sub> = lesser of 0.25 or 0.7\*t<sub>min</sub> = [0.25](#) in  
 t<sub>c(actual)</sub> = 0.7\*Leg = 0.7\*0.375 = 0.2625 in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$t_{a \text{ UG-28}} = 0.1482 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.1482, 0 ] \\ &= 0.1482 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 622.5059 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 622.5059) + 0 \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2}, t_{b \text{ UG16}} ] \\ &= \max[ 0.7378, 0.0625 ] \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b2} ] \\ &= \min[ 0.2074, 0.7378 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.1482, 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

### External Pressure, (Corroded & at 140 °F) UG-28(c)

$$L / D_o = 8.0886 / 4.12 = 1.9632$$

$$D_o / t = 4.12 / 0.1482 = 27.7945$$

From table G:  $A = 0.004502$

From table HA-2:  $B = 12,976.6933 \text{ psi}$

$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 12,976.69 / (3 \cdot (4.12 / 0.1482)) \\ &= 622.51 \text{ psi} \end{aligned}$$

### Design thickness for external pressure $P_a = 622.51 \text{ psi}$

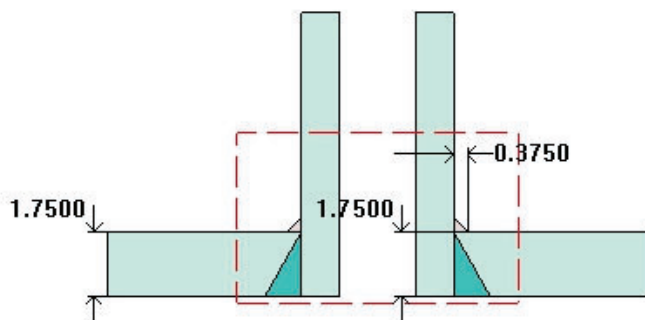
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

## Temperature Indicator (N6)

### ASME Section VIII Division 1, 2010 Edition, A11 Addenda

$$t_{w(\text{lower})} = 1.75 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

#### Location and Orientation

Located on:	48 OD SHELL
Orientation:	90°
Nozzle center line offset to datum line:	54 in
End of nozzle to shell center:	32 in
Passes through a Category A joint:	No

#### Nozzle

Access opening:	No
Material specification:	SA-182 F316 ≤ 5 (II-D p. 70, In. 22)
Inside diameter, new:	2 in
Nominal wall thickness:	1.06 in
Corrosion allowance:	0 in
Projection available outside vessel, L <sub>pr</sub> :	6.25 in
Projection available outside vessel to flange face, L <sub>f</sub> :	8 in
Local vessel minimum thickness:	1.75 in
Liquid static head included:	0 psi
Longitudinal joint efficiency:	1

#### ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 LWN A182 F316
Bolt Material:	SA-193 B7 Bolt ≤ 2 1/2 (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55°F
(Per UHA-51(d)(1)(a))	
(Flange rated MDMT = -320 °F)	
Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F)	
Liquid static head:	0 psi
MAWP rating:	2,040 psi @ 140°F
MAP rating:	2,160 psi @ 50°F

Hydrotest rating:  
PWHT performed:

3,250 psi @ 50°F  
No

**Reinforcement Calculations for Chamber MAWP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For P = 1,378 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

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

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for internal pressure 1,378 psi @ 140 °F**

Nozzle Impact test exempt per UHA-51(g)(coincident ratio = 0.0678).

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

**Required thickness t<sub>r</sub> from UG-37(a)**

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378) \\
 &= 1.6092 \text{ in}
 \end{aligned}$$

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

### UW-16(c) Weld Check

Fillet weld:  $t_{\min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$

$t_{c(\min)} = \text{lesser of } 0.25 \text{ or } 0.7 \cdot t_{\min} = 0.25 \text{ in}$

$t_{c(\text{actual})} = 0.7 \cdot \text{Leg} = 0.7 \cdot 0.375 = 0.2625 \text{ in}$

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$\begin{aligned}t_{a \text{ UG-27}} &= P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion} \\ &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) + 0 \\ &= 0.0719 \text{ in}\end{aligned}$$

$$\begin{aligned}t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0719, 0 ] \\ &= 0.0719 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378) + 0 \\ &= 1.6092 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6092, 0.0625 ] \\ &= 1.6092 \text{ in}\end{aligned}$$

$$\begin{aligned}t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.2074, 1.6092 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0719, 0.2074 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

**Reinforcement Calculations for MAEP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For Pe = 622.51 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for external pressure 622.51 psi @ 140 °F**

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-28 t<sub>m</sub> = 0.1482 in**

**From UG-37(d)(1) required thickness t<sub>r</sub> = 1.75 in**

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

**UW-16(c) Weld Check**

Fillet weld: t<sub>min</sub> = lesser of 0.75 or t<sub>n</sub> or t = 0.75 in  
 t<sub>c(min)</sub> = lesser of 0.25 or 0.7\*t<sub>min</sub> = [0.25](#) in  
 t<sub>c(actual)</sub> = 0.7\*Leg = 0.7\*0.375 = 0.2625 in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$t_{a \text{ UG-28}} = 0.1482 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.1482, 0 ] \\ &= 0.1482 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 622.5059 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 622.5059) + 0 \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2}, t_{b \text{ UG16}} ] \\ &= \max[ 0.7378, 0.0625 ] \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b2} ] \\ &= \min[ 0.2074, 0.7378 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.1482, 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

### External Pressure, (Corroded & at 140 °F) UG-28(c)

$$L / D_o = 8.0886 / 4.12 = 1.9632$$

$$D_o / t = 4.12 / 0.1482 = 27.7945$$

From table G:  $A = 0.004502$

From table HA-2:  $B = 12,976.6933 \text{ psi}$

$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 12,976.69 / (3 \cdot (4.12 / 0.1482)) \\ &= 622.51 \text{ psi} \end{aligned}$$

### Design thickness for external pressure $P_a = 622.51 \text{ psi}$

$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

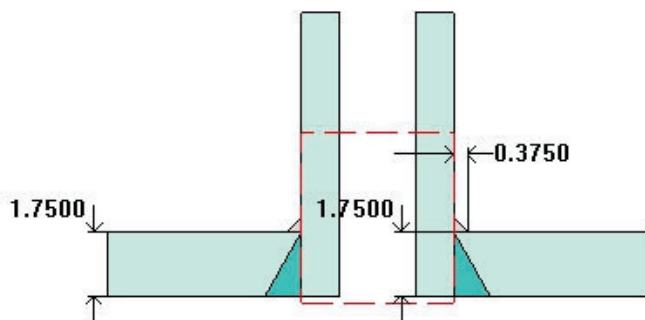


## Level Bridle - (Safety) High (N9A)

### ASME Section VIII Division 1, 2010 Edition, A11 Addenda

$$t_{w(\text{lower})} = 1.75 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

#### Location and Orientation

Located on:	48 OD SHELL
Orientation:	315°
Nozzle center line offset to datum line:	26 in
End of nozzle to shell center:	32 in
Passes through a Category A joint:	No

#### Nozzle

Access opening:	No
Material specification:	SA-182 F316 $\leq 5$ (II-D p. 70, In. 22)
Inside diameter, new:	2 in
Nominal wall thickness:	1.06 in
Corrosion allowance:	0 in
Projection available outside vessel, L <sub>pr</sub> :	6.25 in
Projection available outside vessel to flange face, L <sub>f</sub> :	8 in
Local vessel minimum thickness:	1.75 in
User input radial limit of reinforcement:	1.125 in
Liquid static head included:	0 psi
Longitudinal joint efficiency:	1

#### ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 LWN A182 F316
Bolt Material:	SA-193 B7 Bolt $\leq 2 \frac{1}{2}$ (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55°F
(Per UHA-51(d)(1)(a))	
(Flange rated MDMT = -320 °F	
Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F)	
Liquid static head:	0 psi
MAWP rating:	2,040 psi @ 140°F

MAP rating:	2,160 psi @ 50°F
Hydrotest rating:	3,250 psi @ 50°F
PWHT performed:	No

**Reinforcement Calculations for Chamber MAWP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For P = 1,378 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

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

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for internal pressure 1,378 psi @ 140 °F**

Nozzle Impact test exempt per UHA-51(g)(coincident ratio = 0.0678).

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

$$L_R = 1.125 \text{ in (User Defined)}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

**Required thickness t<sub>r</sub> from UG-37(a)**

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378) \\
 &= 1.6092 \text{ in}
 \end{aligned}$$

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

### UW-16(c) Weld Check

Fillet weld:  $t_{\min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$

$t_{c(\min)} = \text{lesser of } 0.25 \text{ or } 0.7 * t_{\min} = 0.25 \text{ in}$

$t_{c(\text{actual})} = 0.7 * \text{Leg} = 0.7 * 0.375 = 0.2625 \text{ in}$

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$\begin{aligned} t_{a \text{ UG-27}} &= P * R / (S * E - 0.6 * P) + \text{Corrosion} \\ &= 1,378 * 1 / (20,000 * 1 - 0.6 * 1,378) + 0 \\ &= 0.0719 \text{ in} \end{aligned}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0719, 0 ] \\ &= 0.0719 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= P * R_o / (S * E + 0.4 * P) + \text{Corrosion} \\ &= 1,378 * 24 / (20,000 * 1 + 0.4 * 1,378) + 0 \\ &= 1.6092 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6092, 0.0625 ] \\ &= 1.6092 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.2074, 1.6092 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0719, 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

## Reinforcement Calculations for MAEP

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For Pe = 622.51 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

Calculations for external pressure 622.51 psi @ 140 °F

### Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

### Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28  $t_m = 0.1482$  in

From UG-37(d)(1) required thickness  $t_r = 1.75$  in

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

### UW-16(c) Weld Check

Fillet weld:  $t_{min} =$  lesser of 0.75 or  $t_n$  or  $t = 0.75$  in  
 $t_{c(min)} =$  lesser of 0.25 or  $0.7*t_{min} = \underline{0.25}$  in  
 $t_{c(actual)} = 0.7*Leg = 0.7*0.375 = 0.2625$  in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$t_{a \text{ UG-28}} = 0.1482 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.1482, 0 ] \\ &= 0.1482 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 622.5059 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 622.5059) + 0 \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2}, t_{b \text{ UG16}} ] \\ &= \max[ 0.7378, 0.0625 ] \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b2} ] \\ &= \min[ 0.2074, 0.7378 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.1482, 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

### External Pressure, (Corroded & at 140 °F) UG-28(c)

$$L / D_o = 8.0886 / 4.12 = 1.9632$$

$$D_o / t = 4.12 / 0.1482 = 27.7945$$

From table G:  $A = 0.004502$

From table HA-2:  $B = 12,976.6933 \text{ psi}$

$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 12,976.69 / (3 \cdot (4.12 / 0.1482)) \\ &= 622.51 \text{ psi} \end{aligned}$$

### Design thickness for external pressure $P_a = 622.51 \text{ psi}$

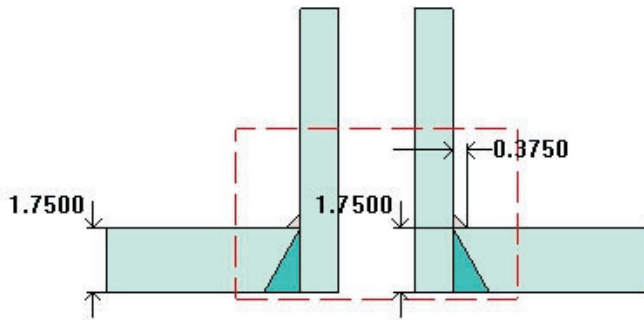
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

## Spare (N11)

### ASME Section VIII Division 1, 2010 Edition, A11 Addenda

$$t_{w(\text{lower})} = 1.75 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

#### Location and Orientation

Located on:	48 OD SHELL
Orientation:	225°
Nozzle center line offset to datum line:	8 in
End of nozzle to shell center:	32 in
Passes through a Category A joint:	No

#### Nozzle

Access opening:	No
Material specification:	SA-182 F316 ≤ 5 (II-D p. 70, In. 22)
Inside diameter, new:	2 in
Nominal wall thickness:	1.06 in
Corrosion allowance:	0 in
Projection available outside vessel, L <sub>pr</sub> :	6.25 in
Projection available outside vessel to flange face, L <sub>f</sub> :	8 in
Local vessel minimum thickness:	1.75 in
Liquid static head included:	0 psi
Longitudinal joint efficiency:	1

#### ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 LWN A182 F316
Bolt Material:	SA-193 B7 Bolt ≤ 2 1/2 (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55°F
(Per UHA-51(d)(1)(a))	
(Flange rated MDMT = -320 °F)	
Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F)	
Liquid static head:	0 psi
MAWP rating:	2,040 psi @ 140°F
MAP rating:	2,160 psi @ 50°F

Hydrotest rating:  
PWHT performed:

3,250 psi @ 50°F  
No



## Reinforcement Calculations for Chamber MAWP

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For P = 1,378 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
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 <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

### Calculations for internal pressure 1,378 psi @ 140 °F

Nozzle Impact test exempt per UHA-51(g)(coincident ratio = 0.0678).

#### Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

#### Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

#### Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

#### Required thickness t<sub>r</sub> from UG-37(a)

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378) \\
 &= 1.6092 \text{ in}
 \end{aligned}$$

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

### UW-16(c) Weld Check

Fillet weld:  $t_{\min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$

$t_{c(\min)} = \text{lesser of } 0.25 \text{ or } 0.7*t_{\min} = 0.25 \text{ in}$

$t_{c(\text{actual})} = 0.7*\text{Leg} = 0.7*0.375 = 0.2625 \text{ in}$

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$\begin{aligned}t_{a \text{ UG-27}} &= P*R / (S*E - 0.6*P) + \text{Corrosion} \\ &= 1,378*1 / (20,000*1 - 0.6*1,378) + 0 \\ &= 0.0719 \text{ in}\end{aligned}$$

$$\begin{aligned}t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0719, 0 ] \\ &= 0.0719 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= P*R_o / (S*E + 0.4*P) + \text{Corrosion} \\ &= 1,378*24 / (20,000*1 + 0.4*1,378) + 0 \\ &= 1.6092 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6092, 0.0625 ] \\ &= 1.6092 \text{ in}\end{aligned}$$

$$\begin{aligned}t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.2074, 1.6092 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0719, 0.2074 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

## Reinforcement Calculations for MAEP

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For Pe = 622.51 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

Calculations for external pressure 622.51 psi @ 140 °F

### Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

### Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28  $t_m = 0.1482$  in

From UG-37(d)(1) required thickness  $t_r = 1.75$  in

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

### UW-16(c) Weld Check

Fillet weld:  $t_{min} =$  lesser of 0.75 or  $t_n$  or  $t = 0.75$  in  
 $t_{c(min)} =$  lesser of 0.25 or  $0.7*t_{min} = \underline{0.25}$  in  
 $t_{c(actual)} = 0.7*Leg = 0.7*0.375 = 0.2625$  in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$t_{a \text{ UG-28}} = 0.1482 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.1482, 0 ] \\ &= 0.1482 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 622.5059 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 622.5059) + 0 \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2}, t_{b \text{ UG16}} ] \\ &= \max[ 0.7378, 0.0625 ] \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b2} ] \\ &= \min[ 0.2074, 0.7378 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.1482, 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

### External Pressure, (Corroded & at 140 °F) UG-28(c)

$$L / D_o = 8.0886 / 4.12 = 1.9632$$

$$D_o / t = 4.12 / 0.1482 = 27.7945$$

From table G:  $A = 0.004502$

From table HA-2:  $B = 12,976.6933 \text{ psi}$

$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 12,976.69 / (3 \cdot (4.12 / 0.1482)) \\ &= 622.51 \text{ psi} \end{aligned}$$

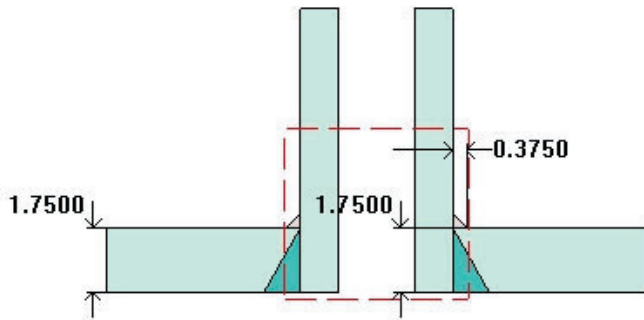
### Design thickness for external pressure $P_a = 622.51 \text{ psi}$

$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

## Purge (N12)

### ASME Section VIII Division 1, 2010 Edition, A11 Addenda

$$t_{w(\text{lower})} = 1.75 \text{ in}$$
$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

#### Location and Orientation

Located on:	48 OD SHELL
Orientation:	225°
Nozzle center line offset to datum line:	88 in
End of nozzle to shell center:	32 in
Passes through a Category A joint:	No

#### Nozzle

Access opening:	No
Material specification:	SA-182 F316 $\leq 5$ (II-D p. 70, In. 22)
Inside diameter, new:	2 in
Nominal wall thickness:	1.06 in
Corrosion allowance:	0 in
Projection available outside vessel, L <sub>pr</sub> :	6.25 in
Projection available outside vessel to flange face, L <sub>f</sub> :	8 in
Local vessel minimum thickness:	1.75 in
User input radial limit of reinforcement:	2.5 in
Liquid static head included:	0.3574 psi
Longitudinal joint efficiency:	1

#### ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 LWN A182 F316
Bolt Material:	SA-193 B7 Bolt $\leq 2 \frac{1}{2}$ (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55°F
(Per UHA-51(d)(1)(a))	
(Flange rated MDMT = -320 °F	
Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F)	
Liquid static head:	0.3177 psi
MAWP rating:	2,040 psi @ 140°F

MAP rating:	2,160 psi @ 50°F
Hydrotest rating:	3,250 psi @ 50°F
PWHT performed:	No

**Reinforcement Calculations for Chamber MAWP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For P = 1,378.36 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

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

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for internal pressure 1,378.36 psi @ 140 °F**

Nozzle Impact test exempt per UHA-51(g)(coincident ratio = 0.0788).

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

$$L_R = 2.5 \text{ in (User Defined)}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378.3574 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378.3574) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

**Required thickness t<sub>r</sub> from UG-37(a)**

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 1,378.3574 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378.3574) \\
 &= 1.6097 \text{ in}
 \end{aligned}$$

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

### UW-16(c) Weld Check

Fillet weld:  $t_{\min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$

$t_{c(\min)} = \text{lesser of } 0.25 \text{ or } 0.7 * t_{\min} = 0.25 \text{ in}$

$t_{c(\text{actual})} = 0.7 * \text{Leg} = 0.7 * 0.375 = 0.2625 \text{ in}$

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$\begin{aligned} t_{a \text{ UG-27}} &= P * R / (S * E - 0.6 * P) + \text{Corrosion} \\ &= 1,378.3574 * 1 / (20,000 * 1 - 0.6 * 1,378.3574) + 0 \\ &= 0.0719 \text{ in} \end{aligned}$$

$$t_{a \text{ UG-22}} = 0.0835 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0719, 0.0835 ] \\ &= 0.0835 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= P * R_o / (S * E + 0.4 * P) + \text{Corrosion} \\ &= 1,378.3574 * 24 / (20,000 * 1 + 0.4 * 1,378.3574) + 0 \\ &= 1.6097 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6097, 0.0625 ] \\ &= 1.6097 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.2074, 1.6097 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0835, 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.



## Applied Loads

Radial load:	$P_r = 334$	$lb_f$
Circumferential moment:	$M_c = 2,965$	$lb_f\text{-in}$
Circumferential shear:	$V_c = 409$	$lb_f$
Longitudinal moment:	$M_L = 2,965$	$lb_f\text{-in}$
Longitudinal shear:	$V_L = 409$	$lb_f$
Torsion moment:	$M_t = 4,160$	$lb_f\text{-in}$
Internal pressure:	$P = 1,378.357$	psi
Mean shell radius:	$R_m = 23.125$	in
Local shell thickness:	$t = 1.75$	in
Shell yield stress:	$S_y = 27,900$	psi

### Maximum stresses due to the applied loads at the nozzle OD (includes pressure)

$$R_m / t = 23.125 / 1.75 = 13.2143$$

Pressure stress intensity factor,  $I = 1.05703$  (derived from PVP-Vol. 399, pages 77-82)

$$\text{Local circumferential pressure stress} = I * P * R_i / t = 18,524 \text{ psi}$$

$$\text{Local longitudinal pressure stress} = I * P * R_i / (2 * t) = 9,262 \text{ psi}$$

$$\text{Maximum combined stress } (P_L + P_b + Q) = 18,785 \text{ psi}$$

$$\text{Allowable combined stress } (P_L + P_b + Q) = + - 3 * S = + - 60,000 \text{ psi}$$

Note: The allowable combined stress ( $P_L + P_b + Q$ ) is based on the strain hardening characteristics of this material.

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

$$\text{Maximum local primary membrane stress } (P_L) = 18,529 \text{ psi}$$

$$\text{Allowable local primary membrane stress } (P_L) = + - 1.5 * S = + - 30,000 \text{ psi}$$

The maximum local primary membrane stress ( $P_L$ ) is within allowable limits.

Stresses at the nozzle OD per WRC Bulletin 107										
Figure	value	$\beta$	$A_u$	$A_l$	$B_u$	$B_l$	$C_u$	$C_l$	$D_u$	$D_l$
3C*	2.5705	0.0779	0	0	0	0	-21	-21	-21	-21
4C*	2.6145	0.0779	-22	-22	-22	-22	0	0	0	0
1C	0.2014	0.0779	0	0	0	0	-132	132	-132	132
2C-1	0.1661	0.0779	-109	109	-109	109	0	0	0	0
3A*	0.1676	0.0779	0	0	0	0	-7	-7	7	7
1A	0.1061	0.0779	0	0	0	0	-342	342	342	-342
3B*	0.6597	0.0779	-27	-27	27	27	0	0	0	0
1B-1	0.0616	0.0779	-199	199	199	-199	0	0	0	0
<b>Pressure stress*</b>			18,524	18,524	18,524	18,524	17,525	17,525	17,525	17,525
<b>Total circumferential stress</b>			18,167	18,783	18,619	18,439	17,023	17,971	17,721	17,301
<b>Primary membrane circumferential stress*</b>			18,475	18,475	18,529	18,529	17,497	17,497	17,511	17,511
3C*	2.5705	0.0779	-21	-21	-21	-21	0	0	0	0
4C*	2.6145	0.0779	0	0	0	0	-22	-22	-22	-22
1C-1	0.2031	0.0779	-133	133	-133	133	0	0	0	0
2C	0.1599	0.0779	0	0	0	0	-105	105	-105	105
4A*	0.2212	0.0779	0	0	0	0	-9	-9	9	9
2A	0.063	0.0779	0	0	0	0	-203	203	203	-203
4B*	0.1671	0.0779	-7	-7	7	7	0	0	0	0
2B-1	0.098	0.0779	-316	316	316	-316	0	0	0	0
<b>Pressure stress*</b>			8,762	8,762	8,762	8,762	9,262	9,262	9,262	9,262
<b>Total longitudinal stress</b>			8,285	9,183	8,931	8,565	8,923	9,539	9,347	9,151
<b>Primary membrane longitudinal stress*</b>			8,734	8,734	8,748	8,748	9,231	9,231	9,249	9,249
<b>Shear from <math>M_t</math></b>			89	89	89	89	89	89	89	89
<b>Circ shear from <math>V_c</math></b>			36	36	-36	-36	0	0	0	0
<b>Long shear from <math>V_L</math></b>			0	0	0	0	-36	-36	36	36
<b>Total Shear stress</b>			125	125	53	53	53	53	125	125
<b>Combined stress (<math>P_L+P_b+Q</math>)</b>			18,169	18,785	18,619	18,439	17,023	17,971	17,723	17,303

Note: \* denotes primary stress.

### Longitudinal stress in the nozzle wall due to internal pressure + external loads

$$\begin{aligned} \sigma_{n(P_m)} &= P^*R_i / (2^*t_n) - P_r / (\pi^*(R_o^2 - R_i^2)) + M^*R_o / I \\ &= 1,378.36^*1 / (2^*1.06) - 334 / (\pi^*(2.06^2 - 1^2)) + 4,193.1^*2.06 / 13.3582 \\ &= 1,264 \text{ psi} \end{aligned}$$

The average primary stress  $P_m$  (see Division 2 5.6.a.1) across the nozzle wall due to internal pressure + external loads is acceptable ( $\leq S = 20,000$  psi)

### Shear stress in the nozzle wall due to external loads

$$\begin{aligned} \sigma_{\text{shear}} &= (V_L^2 + V_c^2)^{0.5} / (\pi^*R_i^2*t_n) \\ &= (409^2 + 409^2)^{0.5} / (\pi^*1^2*1.06) \\ &= 174 \text{ psi} \end{aligned}$$

$$\begin{aligned} \sigma_{\text{torsion}} &= M_t / (2^*\pi^*R_i^2*t_n) \\ &= 4,160 / (2^*\pi^*1^2*1.06) \end{aligned}$$

= 625 psi

$$\begin{aligned}\sigma_{\text{total}} &= \sigma_{\text{shear}} + \sigma_{\text{torsion}} \\ &= 174 + 625 \\ &= 798 \text{ psi}\end{aligned}$$

UG-45: The total combined shear stress (798 psi) is below than the allowable ( $0.7 \cdot S_n = 0.7 \cdot 20,000 = 14,000$  psi)

## Reinforcement Calculations for MAEP

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For Pe = 622.51 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

Calculations for external pressure 622.51 psi @ 140 °F

### Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

### Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28  $t_{rn} = 0.1482$  in

From UG-37(d)(1) required thickness  $t_r = 1.75$  in

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

### UW-16(c) Weld Check

Fillet weld:  $t_{min} =$  lesser of 0.75 or  $t_n$  or  $t = 0.75$  in  
 $t_{c(min)} =$  lesser of 0.25 or  $0.7*t_{min} = \underline{0.25}$  in  
 $t_{c(actual)} = 0.7*Leg = 0.7*0.375 = 0.2625$  in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$t_{a \text{ UG-28}} = 0.1482 \text{ in}$$

$$t_{a \text{ UG-22}} = 0.0489 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}} , t_{a \text{ UG-22}} ] \\ &= \max[ 0.1482 , 0.0489 ] \\ &= 0.1482 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 622.5059 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 622.5059) + 0 \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2} , t_{b \text{ UG16}} ] \\ &= \max[ 0.7378 , 0.0625 ] \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3} , t_{b2} ] \\ &= \min[ 0.2074 , 0.7378 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a , t_b ] \\ &= \max[ 0.1482 , 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

### External Pressure, (Corroded & at 140 °F) UG-28(c)

$$L / D_o = 8.0886 / 4.12 = 1.9632$$

$$D_o / t = 4.12 / 0.1482 = 27.7945$$

From table G: A = 0.004502

From table HA-2: B = 12,976.6933 psi

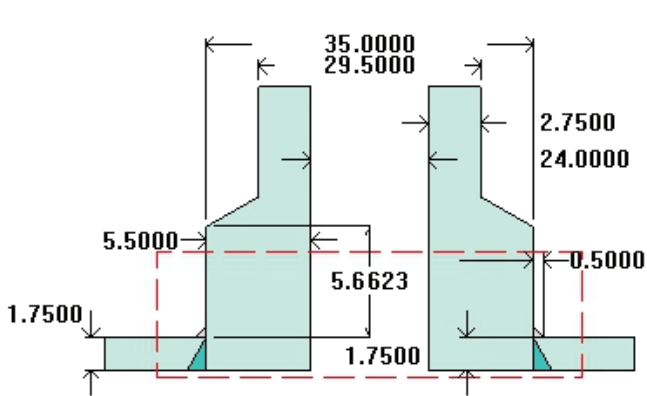
$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 12,976.69 / (3 \cdot (4.12 / 0.1482)) \\ &= 622.51 \text{ psi} \end{aligned}$$

**Design thickness for external pressure  $P_a = 622.51 \text{ psi}$**

$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482 \text{ in}$$

## Manway c/w Blind Flange (MW1)

ASME Section VIII Division 1, 2010 Edition, A11 Addenda



$$t_{w(\text{lower})} = 1.75 \text{ in}$$

$$\text{Leg}_{41} = 0.5 \text{ in}$$

Note: Per UW-16(b) minimum inside corner radius  $r_1 = \min [1 / 4t, 0.125 \text{ in}] = 0.125 \text{ in}$

### Location and Orientation

Located on:	48 OD SHELL
Orientation:	270°
Nozzle center line offset to datum line:	72 in
End of nozzle to shell center:	39.75 in
Passes through a Category A joint:	No

### Nozzle

Access opening:	Yes
Material specification:	SA-182 F316 > 5 (II-D p. 70, In. 18)
Inside diameter, new:	24 in
Wall thickness, $t_n$ :	5.5 in
Minimum wall thickness:	2.75 in
Corrosion allowance:	0 in
Projection available outside vessel, $L_{pr}$ :	10 in
Heavy barrel length, $L_{hb}$ :	5.6623 in
Projection available outside vessel to flange face, $L_f$ :	15.75 in
Local vessel minimum thickness:	1.75 in
User input radial limit of reinforcement:	20 in
Liquid static head included:	0.1588 psi
Longitudinal joint efficiency:	1

### ASME B16.5-2009 Flange

Description:	NPS 24 Class 900 V2 A182 F316 (Nut Relief)
Bolt Material:	SA-193 B7 Bolt $\leq 2 \frac{1}{2}$ (II-D p. 334, In. 32)
Blind included:	Yes
Rated MDMT:	-55°F
(Per UHA-51(d)(1)(a))	
(Flange rated MDMT = -320 °F	
Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F)	

Liquid static head:	0 psi
MAWP rating:	2,040 psi @ 140°F
MAP rating:	2,160 psi @ 50°F
Hydrotest rating:	3,250 psi @ 50°F
PWHT performed:	No

**Reinforcement Calculations for Chamber MAWP**

<b>UG-37 Area Calculation Summary (in<sup>2</sup>)</b> For P = 1,378.16 psi @ 140 °F The opening is adequately reinforced							<b>UG-45 Nozzle Wall Thickness Summary (in)</b> The nozzle passes UG-45	
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
<a href="#">38.6263</a>	<a href="#">43.0763</a>	<a href="#">2.2491</a>	<a href="#">40.5772</a>	--	--	<a href="#">0.25</a>	<a href="#">0.8626</a>	2.75

<b>UG-41 Weld Failure Path Analysis Summary</b>
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 <sub>41</sub> )	<a href="#">0.25</a>	0.35	weld size is adequate

**Calculations for internal pressure 1,378.16 psi @ 140 °F**

Nozzle rated MDMT per UHA-51(d)(1)(a) = -320 °F.

**Parallel Limit of reinforcement per UG-40 and Fig. UG-40 sketch (e-1)**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(24, 12 + (2.75 - 0) + (1.75 - 0)) \\
 &= 24 \text{ in}
 \end{aligned}$$

$$L_R = 20 \text{ in (User Defined)}$$

**Outer Normal Limit of reinforcement per UG-40 and Fig. UG-40 sketch (e-1)**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(2.75 - 0) + 4.7631) \\
 &= 4.375 \text{ in}
 \end{aligned}$$

$$\begin{aligned}
 t_e &= \text{MIN}( 5.6623 + 2.75*\tan(30) , 2.75*\tan(60) ) \\
 &= 4.7631 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_m &= P*R_n / (S_n*E - 0.6*P) \\
 &= 1,378.1588*12 / (20,000*1 - 0.6*1,378.1588) \\
 &= 0.8626 \text{ in}
 \end{aligned}$$



**Required thickness  $t_r$  from UG-37(a)**

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 1,378.1588 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378.1588) \\
 &= 1.6094 \text{ in}
 \end{aligned}$$

**Area required per UG-37(c)**

Allowable stresses:  $S_n = 20,000$ ,  $S_v = 20,000$  psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$\begin{aligned}
 A &= d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1}) \\
 &= 24 \cdot 1.6094 \cdot 1 + 2 \cdot 5.5 \cdot 1.6094 \cdot 1 \cdot (1 - 1) \\
 &= \underline{38.6263} \text{ in}^2
 \end{aligned}$$

**Area available from FIG. UG-37.1**

$A_1$ : (specified limit governs) = 2.2491 in<sup>2</sup>

$$\begin{aligned}
 &= (2 \cdot \text{limits} - d) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\
 &= (2 \cdot 20 - 24) \cdot (1 \cdot 1.75 - 1 \cdot 1.6094) - 2 \cdot 5.5 \cdot (1 \cdot 1.75 - 1 \cdot 1.6094) \cdot (1 - 1) \\
 &= \underline{2.2491} \text{ in}^2
 \end{aligned}$$

$A_2$  = smaller of the following = 40.5772 in<sup>2</sup>

$$\begin{aligned}
 &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t \\
 &= 5 \cdot (5.5 - 0.8626) \cdot 1 \cdot 1.75 \\
 &= 40.5772 \text{ in}^2 \\
 &= 2 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot L_{pr} - [(t_n - t_p)^2 \cdot \tan(30) + 2 \cdot (\text{LIMIT} - L_{hb} - L_{slope}) \cdot (t_n - t_p)] \cdot f_{r2} \\
 &= 2 \cdot (5.5 - 0.8626) \cdot 1 \cdot 10 - [(5.5 - 2.75)^2 \cdot \tan(30) + 2 \cdot (10 - 5.6623 - 1.5877) \cdot (5.5 - 2.75)] \cdot 1 \\
 &= 73.2568 \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 A_{41} &= \text{Leg}^2 \cdot f_{r2} \\
 &= 0.5^2 \cdot 1 \\
 &= \underline{0.25} \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 \text{Area} &= A_1 + A_2 + A_{41} \\
 &= 2.2491 + 40.5772 + 0.25 \\
 &= \underline{43.0763} \text{ in}^2
 \end{aligned}$$

As Area  $\geq$  A the reinforcement is adequate.

### UW-16(c) Weld Check

Fillet weld:  $t_{\min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$

$t_{c(\min)} = \text{lesser of } 0.25 \text{ or } 0.7 * t_{\min} = 0.25 \text{ in}$

$t_{c(\text{actual})} = 0.7 * \text{Leg} = 0.7 * 0.5 = 0.35 \text{ in}$

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check (Access Opening)

$$\begin{aligned} t_{a \text{ UG-27}} &= P * R / (S * E - 0.6 * P) + \text{Corrosion} \\ &= 1,378.1588 * 12 / (20,000 * 1 - 0.6 * 1,378.1588) + 0 \\ &= 0.8626 \text{ in} \end{aligned}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.8626, 0 ] \\ &= 0.8626 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 2.75 \text{ in}$

The nozzle neck thickness is adequate.

### Check Large Opening per Appendix 1-7(a)

Area required within 75 percent of the limits of reinforcement  
 $= 2 / 3 * A = (2 / 3) * 38.6263 = 25.7509 \text{ in}^2$

Area that is within 75 percent of the limits of reinforcement is:

$A_1 = \text{larger of } 2.0383 \text{ or}$

$$\begin{aligned} &= (2 * \text{limits} - d) * (E_1 * t - F * t_r) - 2 * t_n * (E_1 * t - F * t_r) * (1 - f_{r1}) \\ &= (2 * 18 - 24) * (1 * 1.75 - 1 * 1.6094) - 2 * 5.5 * (1 * 1.75 - 1 * 1.6094) * (1 - 1) \\ &= 1.6868 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_3 + A_{41} + A_{42} + A_{43} + A_5 \\ &= 2.0383 + 40.5772 + 0 + 0.25 + 0 + 0 + 0 \\ &= 42.8655 \text{ in}^2 \end{aligned}$$

The area replacement requirements of Appendix 1-7(a) are satisfied.

### Check Large Opening per Appendix 1-7(b)

1-7(b)(1)(a)  $D_i = 44.5 \text{ in} > 60 \text{ in}$  False

1-7(b)(1)(b)  $d = 24 \text{ in} > 40 \text{ in}$  False

1-7(b)(1)(b)  $d = 24 \text{ in} > 3.4 * (22.25 * 1.75)^{0.5} = 21.216 \text{ in}$  True

1-7(b)(1)(c)  $R_n / R = 12 / 22.25 = 0.5393 \leq 0.7$  True

The opening is not within the size range defined by 1-7(b)(1)(a) and (b) so it is exempt from the requirements of 1-7(b)(2),(3) and (4).

$R_n / R = 0.5393$  does not exceed 0.7 so a U-2(g) analysis is not required per 1-7(b)(1)(c).

**Reinforcement Calculations for MAEP**

<p><b>UG-37 Area Calculation Summary (in<sup>2</sup>)</b>                  For Pe = 622.51 psi @ 140 °F                  The opening is adequately reinforced</p>							<p><b>UG-45 Nozzle Wall Thickness Summary (in)</b>                  The nozzle passes UG-45</p>	
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
21	38.206	--	37.956	--	--	0.25	1.1622	2.75

<p><b>UG-41 Weld Failure Path Analysis Summary</b></p> <p>Weld strength calculations are not required for external pressure</p>
---

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	0.25	0.35	weld size is adequate

**Calculations for external pressure 622.51 psi @ 140 °F**

**Parallel Limit of reinforcement per UG-40 and Fig. UG-40 sketch (e-1)**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(24, 12 + (2.75 - 0) + (1.75 - 0)) \\
 &= 24 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40 and Fig. UG-40 sketch (e-1)**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(2.75 - 0) + 4.7631) \\
 &= 4.375 \text{ in}
 \end{aligned}$$

$$\begin{aligned}
 t_e &= \text{MIN}(5.6623 + 2.75*\tan(30), 2.75*\tan(60)) \\
 &= 4.7631 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-28 t<sub>m</sub> = 1.1622 in**

**From UG-37(d)(1) required thickness t<sub>r</sub> = 1.75 in**

**Area required per UG-37(d)(1)**

Allowable stresses: S<sub>n</sub> = 20,000, S<sub>v</sub> = 20,000 psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$\begin{aligned}
A &= 0.5*(d*t_r*F + 2*t_n*t_r*F*(1 - f_{r1})) \\
&= 0.5*(24*1.75*1 + 2*5.5*1.75*1*(1 - 1)) \\
&= \underline{21} \text{ in}^2
\end{aligned}$$

#### Area available from FIG. UG-37.1

$$A_1 = \text{larger of the following} = \underline{0} \text{ in}^2$$

$$\begin{aligned}
&= d*(E_1*t - F*t_r) - 2*t_n*(E_1*t - F*t_r)*(1 - f_{r1}) \\
&= 24*(1*1.75 - 1*1.75) - 2*5.5*(1*1.75 - 1*1.75)*(1 - 1) \\
&= 0 \text{ in}^2 \\
&= 2*(t + t_n)*(E_1*t - F*t_r) - 2*t_n*(E_1*t - F*t_r)*(1 - f_{r1}) \\
&= 2*(1.75 + 5.5)*(1*1.75 - 1*1.75) - 2*5.5*(1*1.75 - 1*1.75)*(1 - 1) \\
&= 0 \text{ in}^2
\end{aligned}$$

$$A_2 = \text{smaller of the following} = \underline{37.956} \text{ in}^2$$

$$\begin{aligned}
&= 5*(t_n - t_{rn})*f_{r2}*t \\
&= 5*(5.5 - 1.1622)*1*1.75 \\
&= 37.956 \text{ in}^2 \\
&= 2*(t_n - t_{rn})*f_{r2}*L_{pr} - [(t_n - t_p)^2*\tan(30) + 2*(LIMIT - L_{hb} - L_{slope})*(t_n - t_p)]*f_{r2} \\
&= 2*(5.5 - 1.1622)*1*10 - [(5.5 - 2.75)^2*\tan(30) + 2*(10 - 5.6623 - 1.5877)*(5.5 - 2.75)]*1 \\
&= 67.2653 \text{ in}^2
\end{aligned}$$

$$\begin{aligned}
A_{41} &= \text{Leg}^2*f_{r2} \\
&= 0.5^2*1 \\
&= \underline{0.25} \text{ in}^2
\end{aligned}$$

$$\begin{aligned}
\text{Area} &= A_1 + A_2 + A_{41} \\
&= 0 + 37.956 + 0.25 \\
&= \underline{38.206} \text{ in}^2
\end{aligned}$$

As Area  $\geq$  A the reinforcement is adequate.

#### UW-16(c) Weld Check

$$\begin{aligned}
\text{Fillet weld: } t_{\min} &= \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in} \\
t_{c(\min)} &= \text{lesser of } 0.25 \text{ or } 0.7*t_{\min} = \underline{0.25} \text{ in} \\
t_{c(\text{actual})} &= 0.7*\text{Leg} = 0.7*0.5 = 0.35 \text{ in}
\end{aligned}$$

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check (Access Opening)

$$t_{a \text{ UG-28}} = 1.1622 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 1.1622, 0 ] \\ &= 1.1622 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 2.75$  in

The nozzle neck thickness is adequate.

### Check Large Opening per Appendix 1-7(a)

Area required within 75 percent of the limits of reinforcement  
 $= 2 / 3 * A = (2 / 3) * 21 = 14 \text{ in}^2$

Area that is within 75 percent of the limits of reinforcement is:

$A_1 =$  larger of 0 or

$$\begin{aligned} &= (2 * \text{limits} - d) * (E_1 * t - F * t_r) - 2 * t_n * (E_1 * t - F * t_r) * (1 - f_{r1}) \\ &= (2 * 18 - 24) * (1 * 1.75 - 1 * 1.75) - 2 * 5.5 * (1 * 1.75 - 1 * 1.75) * (1 - 1) \\ &= 0 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_3 + A_{41} + A_{42} + A_{43} + A_5 \\ &= 0 + 37.956 + 0 + 0.25 + 0 + 0 + 0 \\ &= 38.206 \text{ in}^2 \end{aligned}$$

The area replacement requirements of Appendix 1-7(a) are satisfied.

### External Pressure, (Corroded & at 140 °F) UG-28(c)

$$\begin{aligned} L / D_o &= 23.3259 / 35 = 0.6665 \\ D_o / t &= 35 / 1.1622 = 30.1160 \\ \text{From table G: } A &= 0.013249 \\ \text{From table HA-2: } B &= 14,060.5232 \text{ psi} \end{aligned}$$

$$\begin{aligned} P_a &= 4 * B / (3 * (D_o / t)) \\ &= 4 * 14,060.52 / (3 * (35 / 1.1622)) \\ &= 622.51 \text{ psi} \end{aligned}$$

**Design thickness for external pressure  $P_a = 622.51$  psi**

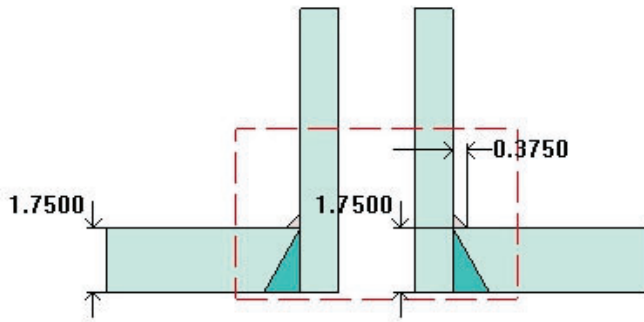
$$t_a = t + \text{Corrosion} = 1.1622 + 0 = 1.1622''$$

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$$t_{w(\text{lower})} = 1.75 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

**Location and Orientation**

Located on:	48 OD SHELL
Orientation:	180°
Nozzle center line offset to datum line:	8 in
End of nozzle to shell center:	32 in
Passes through a Category A joint:	No

**Nozzle**

Access opening:	No
Material specification:	SA-182 F316 <= 5 (II-D p. 70, In. 22)
Inside diameter, new:	2 in
Nominal wall thickness:	1.06 in
Corrosion allowance:	0 in
Projection available outside vessel, L <sub>pr</sub> :	6.25 in
Projection available outside vessel to flange face, L <sub>f</sub> :	8 in
Local vessel minimum thickness:	1.75 in
Liquid static head included:	0 psi
Longitudinal joint efficiency:	1

**ASME B16.5-2009 Flange**

Description:	NPS 2 Class 900 LWN A182 F316
Bolt Material:	SA-193 B7 Bolt <= 2 1/2 (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55°F
(Per UHA-51(d)(1)(a))	
(Flange rated MDMT = -320 °F	
Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F)	
Liquid static head:	0 psi
MAWP rating:	2,040 psi @ 140°F
MAP rating:	2,160 psi @ 50°F

Hydrotest rating:  
PWHT performed:

3,250 psi @ 50°F  
No



## Reinforcement Calculations for Chamber MAWP

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For P = 1,378 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
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 <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

### Calculations for internal pressure 1,378 psi @ 140 °F

Nozzle Impact test exempt per UHA-51(g)(coincident ratio = 0.0678).

#### Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

#### Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

#### Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

#### Required thickness t<sub>r</sub> from UG-37(a)

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378) \\
 &= 1.6092 \text{ in}
 \end{aligned}$$

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

### UW-16(c) Weld Check

Fillet weld:  $t_{\min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$

$t_{c(\min)} = \text{lesser of } 0.25 \text{ or } 0.7 \cdot t_{\min} = 0.25 \text{ in}$

$t_{c(\text{actual})} = 0.7 \cdot \text{Leg} = 0.7 \cdot 0.375 = 0.2625 \text{ in}$

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$\begin{aligned} t_{a \text{ UG-27}} &= P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion} \\ &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) + 0 \\ &= 0.0719 \text{ in} \end{aligned}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0719, 0 ] \\ &= 0.0719 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378) + 0 \\ &= 1.6092 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6092, 0.0625 ] \\ &= 1.6092 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.2074, 1.6092 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0719, 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

**Reinforcement Calculations for MAEP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For Pe = 622.51 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for external pressure 622.51 psi @ 140 °F**

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-28 t<sub>m</sub> = 0.1482 in**

**From UG-37(d)(1) required thickness t<sub>r</sub> = 1.75 in**

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

**UW-16(c) Weld Check**

Fillet weld: t<sub>min</sub> = lesser of 0.75 or t<sub>n</sub> or t = 0.75 in  
 t<sub>c(min)</sub> = lesser of 0.25 or 0.7\*t<sub>min</sub> = [0.25](#) in  
 t<sub>c(actual)</sub> = 0.7\*Leg = 0.7\*0.375 = 0.2625 in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$t_{a \text{ UG-28}} = 0.1482 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.1482, 0 ] \\ &= 0.1482 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 622.5059 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 622.5059) + 0 \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2}, t_{b \text{ UG16}} ] \\ &= \max[ 0.7378, 0.0625 ] \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b2} ] \\ &= \min[ 0.2074, 0.7378 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.1482, 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

### External Pressure, (Corroded & at 140 °F) UG-28(c)

$$L / D_o = 8.0886 / 4.12 = 1.9632$$

$$D_o / t = 4.12 / 0.1482 = 27.7945$$

From table G:  $A = 0.004502$

From table HA-2:  $B = 12,976.6933 \text{ psi}$

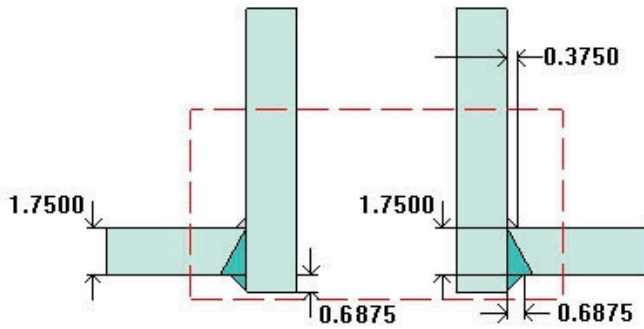
$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 12,976.69 / (3 \cdot (4.12 / 0.1482)) \\ &= 622.51 \text{ psi} \end{aligned}$$

### Design thickness for external pressure $P_a = 622.51 \text{ psi}$

$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

## Inlet (N1)

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$$t_{w(\text{lower})} = 1.75 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$

$$\text{Leg}_{43} = 0.6875 \text{ in}$$

$$h_{\text{new}} = 0.6875 \text{ in}$$

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

#### Location and Orientation

Located on:	48 OD SHELL
Orientation:	0°
Nozzle center line offset to datum line:	32 in
End of nozzle to shell center:	34 in
Passes through a Category A joint:	No

#### Nozzle

Access opening:	No
Material specification:	SA-182 F316 $\leq 5$ (II-D p. 70, In. 22)
Inside diameter, new:	8 in
Nominal wall thickness:	1.875 in
Corrosion allowance:	0 in
Projection available outside vessel, L <sub>pr</sub> :	7.25 in
Internal projection, h <sub>new</sub> :	0.6875 in
Projection available outside vessel to flange face, L <sub>f</sub> :	10 in
Local vessel minimum thickness:	1.75 in
Liquid static head included:	0 psi
Longitudinal joint efficiency:	1

#### ASME B16.5-2009 Flange

Description:	NPS 8 Class 900 LWN A182 F316
Bolt Material:	SA-193 B7 Bolt $\leq 2 \frac{1}{2}$ (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55 °F
(Per UHA-51(d)(1)(a))	
(Flange rated MDMT = -320 °F	
Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F)	
Liquid static head:	0 psi
MAWP rating:	2,040 psi @ 140 °F

MAP rating:	2,160 psi @ 50°F
Hydrotest rating:	3,250 psi @ 50°F
PWHT performed:	No

**Reinforcement Calculations for Chamber MAWP**

<b>UG-37 Area Calculation Summary (in<sup>2</sup>)</b> For P = 1,378 psi @ 140 °F The opening is adequately reinforced							<b>UG-45 Nozzle Wall Thickness Summary (in)</b> The nozzle passes UG-45	
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
<a href="#">12.874</a>	<a href="#">18.208</a>	<a href="#">1.126</a>	<a href="#">13.8906</a>	<a href="#">2.5781</a>	--	<a href="#">0.6133</a>	<a href="#">0.3281</a>	1.875

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

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for internal pressure 1,378 psi @ 140 °F**

Nozzle rated MDMT per UHA-51(d)(1)(a) = -320 °F.

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(8, 4 + (1.875 - 0) + (1.75 - 0)) \\
 &= 8 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.875 - 0) + 0) \\
 &= 4.375 \text{ in}
 \end{aligned}$$

**Inner Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_I &= \text{MIN}(2.5*(t - C), 2.5*(t_i - C_n - C)) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.875 - 0 - 0)) \\
 &= 4.375 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 4 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.2875 \text{ in}
 \end{aligned}$$

**Required thickness t<sub>r</sub> from UG-37(a)**

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378)
 \end{aligned}$$

$$= 1.6092 \text{ in}$$

### Area required per UG-37(c)

Allowable stresses:  $S_n = 20,000$ ,  $S_v = 20,000$  psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$\begin{aligned} A &= d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1}) \\ &= 8 \cdot 1.6093 \cdot 1 + 2 \cdot 1.875 \cdot 1.6093 \cdot 1 \cdot (1 - 1) \\ &= \underline{12.874} \text{ in}^2 \end{aligned}$$

### Area available from FIG. UG-37.1

$$A_1 = \text{larger of the following} = \underline{1.126} \text{ in}^2$$

$$\begin{aligned} &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 8 \cdot (1 \cdot 1.75 - 1 \cdot 1.6093) - 2 \cdot 1.875 \cdot (1 \cdot 1.75 - 1 \cdot 1.6093) \cdot (1 - 1) \\ &= 1.126 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2 \cdot (1.75 + 1.875) \cdot (1 \cdot 1.75 - 1 \cdot 1.6093) - 2 \cdot 1.875 \cdot (1 \cdot 1.75 - 1 \cdot 1.6093) \cdot (1 - 1) \\ &= 1.0204 \text{ in}^2 \end{aligned}$$

$$A_2 = \text{smaller of the following} = \underline{13.8906} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t \\ &= 5 \cdot (1.875 - 0.2875) \cdot 1 \cdot 1.75 \\ &= 13.8906 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (1.875 - 0.2875) \cdot 1 \cdot 1.875 \\ &= 14.8828 \text{ in}^2 \end{aligned}$$

$$A_3 = \text{smaller of the following} = \underline{2.5781} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot t_i \cdot f_{r2} \\ &= 5 \cdot 1.75 \cdot 1.875 \cdot 1 \\ &= \underline{16.4063} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 5 \cdot t_i \cdot t_i \cdot f_{r2} \\ &= 5 \cdot 1.875 \cdot 1.875 \cdot 1 \\ &= \underline{17.5781} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 2 \cdot h \cdot t_i \cdot f_{r2} \\ &= 2 \cdot 0.6875 \cdot 1.875 \cdot 1 \end{aligned}$$



$$= \underline{2.5781} \text{ in}^2$$

$$\begin{aligned} A_{41} &= \text{Leg}^2 * f_{r2} \\ &= 0.375^2 * 1 \\ &= \underline{0.1406} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} A_{43} &= \text{Leg}^2 * f_{r2} \\ &= 0.6875^2 * 1 \\ &= \underline{0.4727} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_3 + A_{41} + A_{43} \\ &= 1.126 + 13.8906 + 2.5781 + 0.1406 + 0.4727 \\ &= \underline{18.208} \text{ in}^2 \end{aligned}$$

As Area  $\geq$  A the reinforcement is adequate.

### UW-16(c) Weld Check

Fillet weld:  $t_{\min}$  = lesser of 0.75 or  $t_n$  or  $t = 0.75$  in

$t_{c(\min)}$  = lesser of 0.25 or  $0.7 * t_{\min} = \underline{0.25}$  in

$t_{c(\text{actual})} = 0.7 * \text{Leg} = 0.7 * 0.375 = 0.2625$  in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$\begin{aligned} t_{a \text{ UG-27}} &= P * R / (S * E - 0.6 * P) + \text{Corrosion} \\ &= 1,378 * 4 / (20,000 * 1 - 0.6 * 1,378) + 0 \\ &= 0.2875 \text{ in} \end{aligned}$$

$$t_{a \text{ UG-22}} = 0.2543 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.2875, 0.2543 ] \\ &= 0.2875 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= P * R_o / (S * E + 0.4 * P) + \text{Corrosion} \\ &= 1,378 * 24 / (20,000 * 1 + 0.4 * 1,378) + 0 \\ &= 1.6092 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6092, 0.0625 ] \\ &= 1.6092 \text{ in} \end{aligned}$$

$$t_b = \min[ t_{b3}, t_{b1} ]$$

$$\begin{aligned} &= \min[ 0.3281 , 1.6092 ] \\ &= 0.3281 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{UG-45} &= \max[ t_a , t_b ] \\ &= \max[ 0.2875 , 0.3281 ] \\ &= 0.3281 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.875$  in

The nozzle neck thickness is adequate.

## Applied Loads

Radial load:	$P_r = 2,720$	$lb_f$
Circumferential moment:	$M_c = 92,535$	$lb_f-in$
Circumferential shear:	$V_c = 3,332$	$lb_f$
Longitudinal moment:	$M_L = 92,535$	$lb_f-in$
Longitudinal shear:	$V_L = 3,332$	$lb_f$
Torsion moment:	$M_t = 130,858$	$lb_f-in$
Internal pressure:	$P = 1,378$	$psi$
Mean shell radius:	$R_m = 23.125$	$in$
Local shell thickness:	$t = 1.75$	$in$
Shell yield stress:	$S_y = 27,900$	$psi$

### Maximum stresses due to the applied loads at the nozzle OD (includes pressure)

$$R_m / t = 23.125 / 1.75 = 13.2143$$

Pressure stress intensity factor,  $I = 1.11447$  (derived from PVP-Vol. 399, pages 77-82)

$$\text{Local circumferential pressure stress} = I * P * R_i / t = 19,526 \text{ psi}$$

$$\text{Local longitudinal pressure stress} = I * P * R_i / (2 * t) = 9,763 \text{ psi}$$

$$\text{Maximum combined stress } (P_L + P_b + Q) = 21,128 \text{ psi}$$

$$\text{Allowable combined stress } (P_L + P_b + Q) = + - 3 * S = + - 60,000 \text{ psi}$$

Note: The allowable combined stress  $(P_L + P_b + Q)$  is based on the strain hardening characteristics of this material.

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

$$\text{Maximum local primary membrane stress } (P_L) = 20,047 \text{ psi}$$

$$\text{Allowable local primary membrane stress } (P_L) = + - 1.5 * S = + - 30,000 \text{ psi}$$

The maximum local primary membrane stress  $(P_L)$  is within allowable limits.

Stresses at the nozzle OD per WRC Bulletin 107										
Figure	value	$\beta$	$A_u$	$A_l$	$B_u$	$B_l$	$C_u$	$C_l$	$D_u$	$D_l$
3C*	1.7827	0.2223	0	0	0	0	-120	-120	-120	-120
4C*	2.1823	0.2223	-147	-147	-147	-147	0	0	0	0
1C	0.0959	0.2223	0	0	0	0	-511	511	-511	511
2C-1	0.0644	0.2223	-343	343	-343	343	0	0	0	0
3A*	0.4931	0.2223	0	0	0	0	-219	-219	219	219
1A	0.0915	0.2223	0	0	0	0	-3,227	3,227	3,227	-3,227
3B*	1.5029	0.2223	-668	-668	668	668	0	0	0	0
1B-1	0.0402	0.2223	-1,418	1,418	1,418	-1,418	0	0	0	0
<b>Pressure stress*</b>			19,526	19,526	19,526	19,526	17,520	17,520	17,520	17,520
<b>Total circumferential stress</b>			16,950	20,472	21,122	18,972	13,443	20,919	20,335	14,903
<b>Primary membrane circumferential stress*</b>			18,711	18,711	20,047	20,047	17,181	17,181	17,619	17,619
3C*	1.7827	0.2223	-120	-120	-120	-120	0	0	0	0
4C*	2.1823	0.2223	0	0	0	0	-147	-147	-147	-147
1C-1	0.0967	0.2223	-515	515	-515	515	0	0	0	0
2C	0.0642	0.2223	0	0	0	0	-342	342	-342	342
4A*	0.8225	0.2223	0	0	0	0	-366	-366	366	366
2A	0.051	0.2223	0	0	0	0	-1,799	1,799	1,799	-1,799
4B*	0.4859	0.2223	-216	-216	216	216	0	0	0	0
2B-1	0.0645	0.2223	-2,275	2,275	2,275	-2,275	0	0	0	0
<b>Pressure stress*</b>			8,760	8,760	8,760	8,760	9,763	9,763	9,763	9,763
<b>Total longitudinal stress</b>			5,634	11,214	10,616	7,096	7,109	11,391	11,439	8,525
<b>Primary membrane longitudinal stress*</b>			8,424	8,424	8,856	8,856	9,250	9,250	9,982	9,982
<b>Shear from <math>M_t</math></b>			345	345	345	345	345	345	345	345
<b>Circ shear from <math>V_c</math></b>			103	103	-103	-103	0	0	0	0
<b>Long shear from <math>V_L</math></b>			0	0	0	0	-103	-103	103	103
<b>Total Shear stress</b>			448	448	242	242	242	242	448	448
<b>Combined stress (<math>P_L+P_B+Q</math>)</b>			16,968	20,494	21,128	18,977	13,452	20,925	20,358	14,934

Note: \* denotes primary stress.

### Longitudinal stress in the nozzle wall due to internal pressure + external loads

$$\begin{aligned} \sigma_{n(P_m)} &= P \cdot R_i / (2 \cdot t_n) - P_r / (\pi \cdot (R_o^2 - R_i^2)) + M \cdot R_o / I \\ &= 1,378 \cdot 4 / (2 \cdot 1.875) - 2,720 / (\pi \cdot (5.875^2 - 4^2)) + 130,864.3 \cdot 5.875 / 734.6052 \\ &= 2,470 \text{ psi} \end{aligned}$$

The average primary stress  $P_m$  (see Division 2 5.6.a.1) across the nozzle wall due to internal pressure + external loads is acceptable ( $\leq S = 20,000$  psi)

### Shear stress in the nozzle wall due to external loads

$$\begin{aligned} \sigma_{\text{shear}} &= (V_L^2 + V_c^2)^{0.5} / (\pi \cdot R_i \cdot t_n) \\ &= (3,332^2 + 3,332^2)^{0.5} / (\pi \cdot 4 \cdot 1.875) \\ &= 200 \text{ psi} \end{aligned}$$

$$\begin{aligned} \sigma_{\text{torsion}} &= M_t / (2 \cdot \pi \cdot R_i^2 \cdot t_n) \\ &= 130,858 / (2 \cdot \pi \cdot 4^2 \cdot 1.875) \end{aligned}$$

= 694 psi

$$\begin{aligned}\sigma_{\text{total}} &= \sigma_{\text{shear}} + \sigma_{\text{torsion}} \\ &= 200 + 694 \\ &= 894 \text{ psi}\end{aligned}$$

UG-45: The total combined shear stress (894 psi) is below than the allowable ( $0.7 \cdot S_n = 0.7 \cdot 20,000 = 14,000$  psi)

**Reinforcement Calculations for MAEP**

<b>UG-37 Area Calculation Summary (in<sup>2</sup>)</b> For $P_e = 622.51 \text{ psi @ } 140 \text{ }^\circ\text{F}$ The opening is adequately reinforced							<b>UG-45 Nozzle Wall Thickness Summary (in)</b> The nozzle passes UG-45	
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
7	16.1125	--	12.9211	2.5781	--	0.6133	0.3983	1.875

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	0.25	0.2625	weld size is adequate

**Calculations for external pressure 622.51 psi @ 140 °F**

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(8, 4 + (1.875 - 0) + (1.75 - 0)) \\
 &= 8 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.875 - 0) + 0) \\
 &= 4.375 \text{ in}
 \end{aligned}$$

**Inner Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_I &= \text{MIN}(2.5*(t - C), 2.5*(t_i - C_n - C)) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.875 - 0 - 0)) \\
 &= 4.375 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-28  $t_{rn} = 0.3983 \text{ in}$**

**From UG-37(d)(1) required thickness  $t_r = 1.75 \text{ in}$**

**Area required per UG-37(d)(1)**

Allowable stresses:  $S_n = 20,000, S_v = 20,000 \text{ psi}$

$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$\begin{aligned} A &= 0.5 \cdot (d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1})) \\ &= 0.5 \cdot (8 \cdot 1.75 \cdot 1 + 2 \cdot 1.875 \cdot 1.75 \cdot 1 \cdot (1 - 1)) \\ &= \underline{7} \text{ in}^2 \end{aligned}$$

### Area available from FIG. UG-37.1

$$A_1 = \text{larger of the following} = \underline{0} \text{ in}^2$$

$$\begin{aligned} &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 8 \cdot (1 \cdot 1.75 - 1 \cdot 1.75) - 2 \cdot 1.875 \cdot (1 \cdot 1.75 - 1 \cdot 1.75) \cdot (1 - 1) \\ &= 0 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2 \cdot (1.75 + 1.875) \cdot (1 \cdot 1.75 - 1 \cdot 1.75) - 2 \cdot 1.875 \cdot (1 \cdot 1.75 - 1 \cdot 1.75) \cdot (1 - 1) \\ &= 0 \text{ in}^2 \end{aligned}$$

$$A_2 = \text{smaller of the following} = \underline{12.9211} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t \\ &= 5 \cdot (1.875 - 0.3983) \cdot 1 \cdot 1.75 \\ &= 12.9211 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (1.875 - 0.3983) \cdot 1 \cdot 1.875 \\ &= 13.844 \text{ in}^2 \end{aligned}$$

$$A_3 = \text{smaller of the following} = \underline{2.5781} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot t_i \cdot t \cdot f_{r2} \\ &= 5 \cdot 1.75 \cdot 1.875 \cdot 1 \\ &= \underline{16.4063} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 5 \cdot t_i \cdot t_i \cdot f_{r2} \\ &= 5 \cdot 1.875 \cdot 1.875 \cdot 1 \\ &= \underline{17.5781} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 2 \cdot h \cdot t_i \cdot f_{r2} \\ &= 2 \cdot 0.6875 \cdot 1.875 \cdot 1 \\ &= \underline{2.5781} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} A_{41} &= \text{Leg}^2 \cdot f_{r2} \\ &= 0.375^2 \cdot 1 \\ &= \underline{0.1406} \text{ in}^2 \end{aligned}$$

$$A_{43} = \text{Leg}^2 \cdot f_{r2}$$

$$= 0.6875^2 * 1$$

$$= \underline{0.4727} \text{ in}^2$$

$$\text{Area} = A_1 + A_2 + A_3 + A_{41} + A_{43}$$

$$= 0 + 12.9211 + 2.5781 + 0.1406 + 0.4727$$

$$= \underline{16.1125} \text{ in}^2$$

As Area  $\geq$  A the reinforcement is adequate.

### UW-16(c) Weld Check

Fillet weld:  $t_{\min}$  = lesser of 0.75 or  $t_n$  or  $t = 0.75$  in

$t_{c(\min)}$  = lesser of 0.25 or  $0.7 * t_{\min} = \underline{0.25}$  in

$t_{c(\text{actual})} = 0.7 * \text{Leg} = 0.7 * 0.375 = 0.2625$  in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$t_{a \text{ UG-28}} = 0.3983 \text{ in}$$

$$t_{a \text{ UG-22}} = 0.1555 \text{ in}$$

$$t_a = \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ]$$

$$= \max[ 0.3983, 0.1555 ]$$

$$= 0.3983 \text{ in}$$

$$t_{b2} = P * R_o / (S * E + 0.4 * P) + \text{Corrosion}$$

$$= 622.5059 * 24 / (20,000 * 1 + 0.4 * 622.5059) + 0$$

$$= 0.7378 \text{ in}$$

$$t_{b2} = \max[ t_{b2}, t_{b \text{ UG16}} ]$$

$$= \max[ 0.7378, 0.0625 ]$$

$$= 0.7378 \text{ in}$$

$$t_b = \min[ t_{b3}, t_{b2} ]$$

$$= \min[ 0.3281, 0.7378 ]$$

$$= 0.3281 \text{ in}$$

$$t_{\text{UG-45}} = \max[ t_a, t_b ]$$

$$= \max[ 0.3983, 0.3281 ]$$

$$= 0.3983 \text{ in}$$

Available nozzle wall thickness new,  $t_n = 1.875$  in

The nozzle neck thickness is adequate.



**External Pressure, (Corroded & at 140 °F) UG-28(c)**

$$L / D_o = 10.7302 / 11.75 = 0.9132$$

$$D_o / t = 11.75 / 0.3983 = 29.4998$$

From table G: A = 0.009593

From table  
HA-2: B = 13,772.846 psi

$$\begin{aligned} P_a &= 4*B / (3*(D_o / t)) \\ &= 4*13,772.85 / (3*(11.75 / 0.3983)) \\ &= 622.51 \text{ psi} \end{aligned}$$

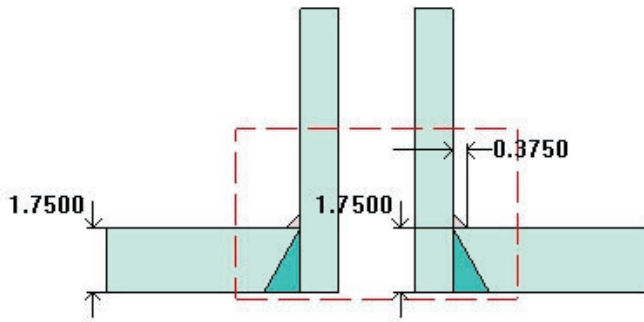
**Design thickness for external pressure  $P_a = 622.51$  psi**

$$t_a = t + \text{Corrosion} = 0.3983 + 0 = 0.3983''$$

PDI Low (N7B)

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$$t_{w(\text{lower})} = 1.75 \text{ in}$$
$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

**Location and Orientation**

Located on:	48 OD SHELL
Orientation:	180°
Nozzle center line offset to datum line:	26 in
End of nozzle to shell center:	32 in
Passes through a Category A joint:	No

**Nozzle**

Access opening:	No
Material specification:	SA-182 F316 <= 5 (II-D p. 70, In. 22)
Inside diameter, new:	2 in
Nominal wall thickness:	1.06 in
Corrosion allowance:	0 in
Projection available outside vessel, Lpr:	6.25 in
Projection available outside vessel to flange face, Lf:	8 in
Local vessel minimum thickness:	1.75 in
Liquid static head included:	0 psi
Longitudinal joint efficiency:	1

**ASME B16.5-2009 Flange**

Description:	NPS 2 Class 900 LWN A182 F316
Bolt Material:	SA-193 B7 Bolt <= 2 1/2 (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55°F
(Per UHA-51(d)(1)(a))	
(Flange rated MDMT = -320 °F	
Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F)	
Liquid static head:	0 psi
MAWP rating:	2,040 psi @ 140°F
MAP rating:	2,160 psi @ 50°F

Hydrotest rating:  
PWHT performed:

3,250 psi @ 50°F  
No

## Reinforcement Calculations for Chamber MAWP

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For P = 1,378 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
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 <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

### Calculations for internal pressure 1,378 psi @ 140 °F

Nozzle Impact test exempt per UHA-51(g)(coincident ratio = 0.0678).

#### Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

#### Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

#### Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

#### Required thickness t<sub>r</sub> from UG-37(a)

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378) \\
 &= 1.6092 \text{ in}
 \end{aligned}$$

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

### UW-16(c) Weld Check

Fillet weld:  $t_{\min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$

$t_{c(\min)} = \text{lesser of } 0.25 \text{ or } 0.7 \cdot t_{\min} = 0.25 \text{ in}$

$t_{c(\text{actual})} = 0.7 \cdot \text{Leg} = 0.7 \cdot 0.375 = 0.2625 \text{ in}$

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$\begin{aligned} t_{a \text{ UG-27}} &= P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion} \\ &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) + 0 \\ &= 0.0719 \text{ in} \end{aligned}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0719, 0 ] \\ &= 0.0719 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378) + 0 \\ &= 1.6092 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6092, 0.0625 ] \\ &= 1.6092 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.2074, 1.6092 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0719, 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

## Reinforcement Calculations for MAEP

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For Pe = 622.51 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

Calculations for external pressure 622.51 psi @ 140 °F

### Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

### Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28  $t_m = 0.1482$  in

From UG-37(d)(1) required thickness  $t_r = 1.75$  in

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

### UW-16(c) Weld Check

Fillet weld:  $t_{min} =$  lesser of 0.75 or  $t_n$  or  $t = 0.75$  in  
 $t_{c(min)} =$  lesser of 0.25 or  $0.7*t_{min} = \underline{0.25}$  in  
 $t_{c(actual)} = 0.7*Leg = 0.7*0.375 = 0.2625$  in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$t_{a \text{ UG-28}} = 0.1482 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.1482, 0 ] \\ &= 0.1482 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 622.5059 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 622.5059) + 0 \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2}, t_{b \text{ UG16}} ] \\ &= \max[ 0.7378, 0.0625 ] \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b2} ] \\ &= \min[ 0.2074, 0.7378 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.1482, 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

### External Pressure, (Corroded & at 140 °F) UG-28(c)

$$L / D_o = 8.0886 / 4.12 = 1.9632$$

$$D_o / t = 4.12 / 0.1482 = 27.7945$$

From table G:  $A = 0.004502$

From table HA-2:  $B = 12,976.6933 \text{ psi}$

$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 12,976.69 / (3 \cdot (4.12 / 0.1482)) \\ &= 622.51 \text{ psi} \end{aligned}$$

### Design thickness for external pressure $P_a = 622.51 \text{ psi}$

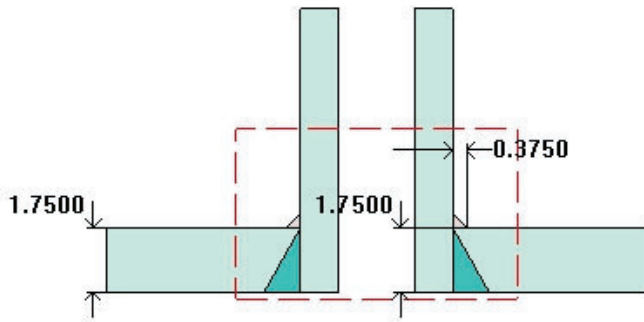
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

## Level Bridle - (Process) High (N8A)

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$$t_{w(\text{lower})} = 1.75 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

### Location and Orientation

Located on:	48 OD SHELL
Orientation:	135°
Nozzle center line offset to datum line:	26 in
End of nozzle to shell center:	32 in
Passes through a Category A joint:	No

### Nozzle

Access opening:	No
Material specification:	SA-182 F316 ≤ 5 (II-D p. 70, In. 22)
Inside diameter, new:	2 in
Nominal wall thickness:	1.06 in
Corrosion allowance:	0 in
Projection available outside vessel, L <sub>pr</sub> :	6.25 in
Projection available outside vessel to flange face, L <sub>f</sub> :	8 in
Local vessel minimum thickness:	1.75 in
Liquid static head included:	0 psi
Longitudinal joint efficiency:	1

### ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 LWN A182 F316
Bolt Material:	SA-193 B7 Bolt ≤ 2 1/2 (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55°F
(Per UHA-51(d)(1)(a))	
(Flange rated MDMT = -320 °F)	
Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F)	
Liquid static head:	0 psi
MAWP rating:	2,040 psi @ 140°F
MAP rating:	2,160 psi @ 50°F



Hydrotest rating:  
PWHT performed:

3,250 psi @ 50°F  
No

**Reinforcement Calculations for Chamber MAWP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For P = 1,378 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

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

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for internal pressure 1,378 psi @ 140 °F**

Nozzle Impact test exempt per UHA-51(g)(coincident ratio = 0.0678).

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

**Required thickness t<sub>r</sub> from UG-37(a)**

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378) \\
 &= 1.6092 \text{ in}
 \end{aligned}$$

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

### UW-16(c) Weld Check

Fillet weld:  $t_{\min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$

$t_{c(\min)} = \text{lesser of } 0.25 \text{ or } 0.7 \cdot t_{\min} = 0.25 \text{ in}$

$t_{c(\text{actual})} = 0.7 \cdot \text{Leg} = 0.7 \cdot 0.375 = 0.2625 \text{ in}$

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$\begin{aligned} t_{a \text{ UG-27}} &= P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion} \\ &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) + 0 \\ &= 0.0719 \text{ in} \end{aligned}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0719, 0 ] \\ &= 0.0719 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378) + 0 \\ &= 1.6092 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6092, 0.0625 ] \\ &= 1.6092 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.2074, 1.6092 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0719, 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

## Reinforcement Calculations for MAEP

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For Pe = 622.51 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

Calculations for external pressure 622.51 psi @ 140 °F

### Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

### Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28  $t_m = 0.1482$  in

From UG-37(d)(1) required thickness  $t_r = 1.75$  in

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

### UW-16(c) Weld Check

Fillet weld:  $t_{min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$   
 $t_{c(min)} = \text{lesser of } 0.25 \text{ or } 0.7*t_{min} = \underline{0.25} \text{ in}$   
 $t_{c(actual)} = 0.7*Leg = 0.7*0.375 = 0.2625 \text{ in}$

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$t_{a \text{ UG-28}} = 0.1482 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.1482, 0 ] \\ &= 0.1482 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 622.5059 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 622.5059) + 0 \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2}, t_{b \text{ UG16}} ] \\ &= \max[ 0.7378, 0.0625 ] \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b2} ] \\ &= \min[ 0.2074, 0.7378 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.1482, 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

### External Pressure, (Corroded & at 140 °F) UG-28(c)

$$L / D_o = 8.0886 / 4.12 = 1.9632$$

$$D_o / t = 4.12 / 0.1482 = 27.7945$$

From table G:  $A = 0.004502$

From table HA-2:  $B = 12,976.6933 \text{ psi}$

$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 12,976.69 / (3 \cdot (4.12 / 0.1482)) \\ &= 622.51 \text{ psi} \end{aligned}$$

### Design thickness for external pressure $P_a = 622.51 \text{ psi}$

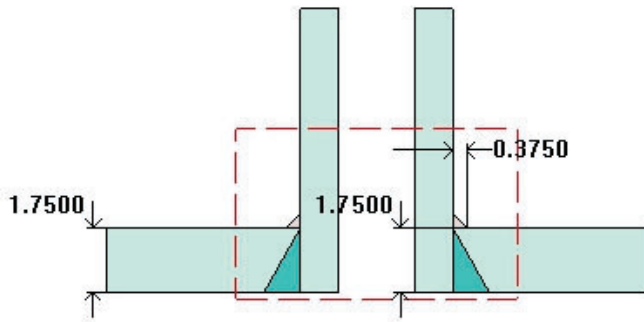
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

## Level Bridle - (Process) Low (N8B)

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$$t_{w(\text{lower})} = 1.75 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

### Location and Orientation

Located on:	48 OD SHELL
Orientation:	135°
Nozzle center line offset to datum line:	88 in
End of nozzle to shell center:	32 in
Passes through a Category A joint:	No

### Nozzle

Access opening:	No
Material specification:	SA-182 F316 $\leq 5$ (II-D p. 70, In. 22)
Inside diameter, new:	2 in
Nominal wall thickness:	1.06 in
Corrosion allowance:	0 in
Projection available outside vessel, L <sub>pr</sub> :	6.25 in
Projection available outside vessel to flange face, L <sub>f</sub> :	8 in
Local vessel minimum thickness:	1.75 in
Liquid static head included:	0.3574 psi
Longitudinal joint efficiency:	1

### ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 LWN A182 F316
Bolt Material:	SA-193 B7 Bolt $\leq 2 \frac{1}{2}$ (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55°F
(Per UHA-51(d)(1)(a))	
(Flange rated MDMT = -320 °F)	
Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F)	
Liquid static head:	0.3177 psi
MAWP rating:	2,040 psi @ 140°F
MAP rating:	2,160 psi @ 50°F

Hydrotest rating:  
PWHT performed:

3,250 psi @ 50°F  
No

**Reinforcement Calculations for Chamber MAWP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For P = 1,378.36 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

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

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for internal pressure 1,378.36 psi @ 140 °F**

Nozzle Impact test exempt per UHA-51(g)(coincident ratio = 0.0678).

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378.3574 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378.3574) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

**Required thickness t<sub>r</sub> from UG-37(a)**

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 1,378.3574 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378.3574) \\
 &= 1.6097 \text{ in}
 \end{aligned}$$

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



### UW-16(c) Weld Check

Fillet weld:  $t_{\min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$

$t_{c(\min)} = \text{lesser of } 0.25 \text{ or } 0.7 \cdot t_{\min} = 0.25 \text{ in}$

$t_{c(\text{actual})} = 0.7 \cdot \text{Leg} = 0.7 \cdot 0.375 = 0.2625 \text{ in}$

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$\begin{aligned} t_{a \text{ UG-27}} &= P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion} \\ &= 1,378.3574 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378.3574) + 0 \\ &= 0.0719 \text{ in} \end{aligned}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0719, 0 ] \\ &= 0.0719 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 1,378.3574 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378.3574) + 0 \\ &= 1.6097 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6097, 0.0625 ] \\ &= 1.6097 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.2074, 1.6097 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0719, 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

**Reinforcement Calculations for MAEP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For Pe = 622.51 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for external pressure 622.51 psi @ 140 °F**

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-28 t<sub>m</sub> = 0.1482 in**

**From UG-37(d)(1) required thickness t<sub>r</sub> = 1.75 in**

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

**UW-16(c) Weld Check**

Fillet weld: t<sub>min</sub> = lesser of 0.75 or t<sub>n</sub> or t = 0.75 in  
 t<sub>c(min)</sub> = lesser of 0.25 or 0.7\*t<sub>min</sub> = [0.25](#) in  
 t<sub>c(actual)</sub> = 0.7\*Leg = 0.7\*0.375 = 0.2625 in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$t_{a \text{ UG-28}} = 0.1482 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.1482, 0 ] \\ &= 0.1482 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 622.5059 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 622.5059) + 0 \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2}, t_{b \text{ UG16}} ] \\ &= \max[ 0.7378, 0.0625 ] \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b2} ] \\ &= \min[ 0.2074, 0.7378 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.1482, 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

### External Pressure, (Corroded & at 140 °F) UG-28(c)

$$L / D_o = 8.0886 / 4.12 = 1.9632$$

$$D_o / t = 4.12 / 0.1482 = 27.7945$$

From table G:  $A = 0.004502$

From table HA-2:  $B = 12,976.6933 \text{ psi}$

$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 12,976.69 / (3 \cdot (4.12 / 0.1482)) \\ &= 622.51 \text{ psi} \end{aligned}$$

### Design thickness for external pressure $P_a = 622.51 \text{ psi}$

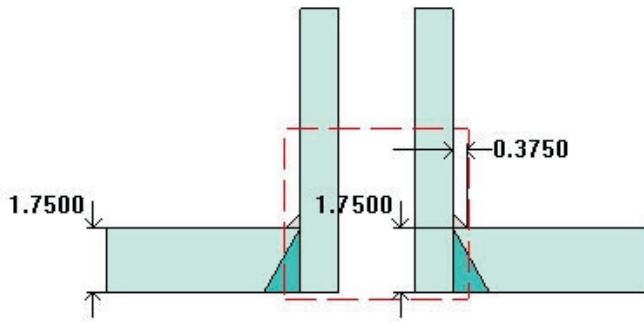
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

## Level Bridle - (Safety) Low (N9B)

### ASME Section VIII Division 1, 2010 Edition, A11 Addenda

$$t_{w(\text{lower})} = 1.75 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

#### Location and Orientation

Located on:	48 OD SHELL
Orientation:	315°
Nozzle center line offset to datum line:	88 in
End of nozzle to shell center:	32 in
Passes through a Category A joint:	No

#### Nozzle

Access opening:	No
Material specification:	SA-182 F316 $\leq 5$ (II-D p. 70, In. 22)
Inside diameter, new:	2 in
Nominal wall thickness:	1.06 in
Corrosion allowance:	0 in
Projection available outside vessel, L <sub>pr</sub> :	6.25 in
Projection available outside vessel to flange face, L <sub>f</sub> :	8 in
Local vessel minimum thickness:	1.75 in
User input radial limit of reinforcement:	2.5 in
Liquid static head included:	0.3574 psi
Longitudinal joint efficiency:	1

#### ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 LWN A182 F316
Bolt Material:	SA-193 B7 Bolt $\leq 2 \frac{1}{2}$ (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55°F
(Per UHA-51(d)(1)(a))	
(Flange rated MDMT = -320 °F	
Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F)	
Liquid static head:	0.3177 psi
MAWP rating:	2,040 psi @ 140°F

MAP rating:	2,160 psi @ 50°F
Hydrotest rating:	3,250 psi @ 50°F
PWHT performed:	No

**Reinforcement Calculations for Chamber MAWP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For P = 1,378.36 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

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

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for internal pressure 1,378.36 psi @ 140 °F**

Nozzle Impact test exempt per UHA-51(g)(coincident ratio = 0.0678).

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

$$L_R = 2.5 \text{ in (User Defined)}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378.3574 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378.3574) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

**Required thickness t<sub>r</sub> from UG-37(a)**

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 1,378.3574 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378.3574) \\
 &= 1.6097 \text{ in}
 \end{aligned}$$

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

### **UW-16(c) Weld Check**

Fillet weld:  $t_{\min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$

$t_{c(\min)} = \text{lesser of } 0.25 \text{ or } 0.7 * t_{\min} = 0.25 \text{ in}$

$t_{c(\text{actual})} = 0.7 * \text{Leg} = 0.7 * 0.375 = 0.2625 \text{ in}$

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### **UG-45 Nozzle Neck Thickness Check**

$$\begin{aligned} t_{a \text{ UG-27}} &= P * R / (S * E - 0.6 * P) + \text{Corrosion} \\ &= 1,378.3574 * 1 / (20,000 * 1 - 0.6 * 1,378.3574) + 0 \\ &= 0.0719 \text{ in} \end{aligned}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0719, 0 ] \\ &= 0.0719 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= P * R_o / (S * E + 0.4 * P) + \text{Corrosion} \\ &= 1,378.3574 * 24 / (20,000 * 1 + 0.4 * 1,378.3574) + 0 \\ &= 1.6097 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6097, 0.0625 ] \\ &= 1.6097 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.2074, 1.6097 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0719, 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

## Reinforcement Calculations for MAEP

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For Pe = 622.51 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

Calculations for external pressure 622.51 psi @ 140 °F

### Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

### Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28  $t_m = 0.1482$  in

From UG-37(d)(1) required thickness  $t_r = 1.75$  in

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

### UW-16(c) Weld Check

Fillet weld:  $t_{min} =$  lesser of 0.75 or  $t_n$  or  $t = 0.75$  in  
 $t_{c(min)} =$  lesser of 0.25 or  $0.7*t_{min} = 0.25$  in  
 $t_{c(actual)} = 0.7*Leg = 0.7*0.375 = 0.2625$  in

The fillet weld size is satisfactory.



Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$t_{a \text{ UG-28}} = 0.1482 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.1482, 0 ] \\ &= 0.1482 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 622.5059 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 622.5059) + 0 \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2}, t_{b \text{ UG16}} ] \\ &= \max[ 0.7378, 0.0625 ] \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b2} ] \\ &= \min[ 0.2074, 0.7378 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.1482, 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

### External Pressure, (Corroded & at 140 °F) UG-28(c)

$$L / D_o = 8.0886 / 4.12 = 1.9632$$

$$D_o / t = 4.12 / 0.1482 = 27.7945$$

From table G:  $A = 0.004502$

From table  
HA-2:  $B = 12,976.6933 \text{ psi}$

$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 12,976.69 / (3 \cdot (4.12 / 0.1482)) \\ &= 622.51 \text{ psi} \end{aligned}$$

### Design thickness for external pressure $P_a = 622.51 \text{ psi}$

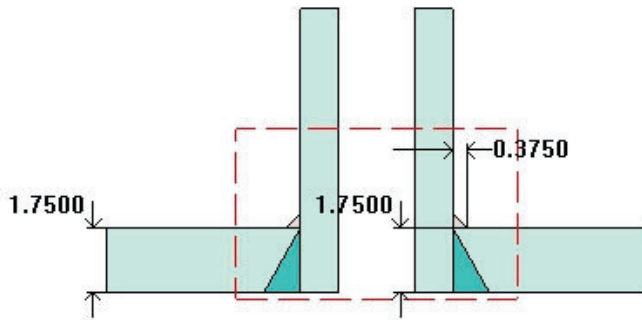
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

## Level Gauge Low (N10B)

### ASME Section VIII Division 1, 2010 Edition, A11 Addenda

$$t_{w(\text{lower})} = 1.75 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

#### Location and Orientation

Located on:	48 OD SHELL
Orientation:	45°
Nozzle center line offset to datum line:	88 in
End of nozzle to shell center:	32 in
Passes through a Category A joint:	No

#### Nozzle

Access opening:	No
Material specification:	SA-182 F316 ≤ 5 (II-D p. 70, In. 22)
Inside diameter, new:	2 in
Nominal wall thickness:	1.06 in
Corrosion allowance:	0 in
Projection available outside vessel, L <sub>pr</sub> :	6.25 in
Projection available outside vessel to flange face, L <sub>f</sub> :	8 in
Local vessel minimum thickness:	1.75 in
Liquid static head included:	0.3574 psi
Longitudinal joint efficiency:	1

#### ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 LWN A182 F316
Bolt Material:	SA-193 B7 Bolt ≤ 2 1/2 (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55°F
(Per UHA-51(d)(1)(a))	
(Flange rated MDMT = -320 °F)	
Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F)	
Liquid static head:	0.3177 psi
MAWP rating:	2,040 psi @ 140°F
MAP rating:	2,160 psi @ 50°F

Hydrotest rating:  
PWHT performed:

3,250 psi @ 50°F  
No

**Reinforcement Calculations for Chamber MAWP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For P = 1,378.36 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

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

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for internal pressure 1,378.36 psi @ 140 °F**

Nozzle Impact test exempt per UHA-51(g)(coincident ratio = 0.0788).

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378.3574 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378.3574) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

**Required thickness t<sub>r</sub> from UG-37(a)**

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 1,378.3574 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378.3574) \\
 &= 1.6097 \text{ in}
 \end{aligned}$$

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

### UW-16(c) Weld Check

Fillet weld:  $t_{\min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$

$t_{c(\min)} = \text{lesser of } 0.25 \text{ or } 0.7*t_{\min} = 0.25 \text{ in}$

$t_{c(\text{actual})} = 0.7*\text{Leg} = 0.7*0.375 = 0.2625 \text{ in}$

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$\begin{aligned}t_{a \text{ UG-27}} &= P*R / (S*E - 0.6*P) + \text{Corrosion} \\ &= 1,378.3574*1 / (20,000*1 - 0.6*1,378.3574) + 0 \\ &= 0.0719 \text{ in}\end{aligned}$$

$$t_{a \text{ UG-22}} = 0.0835 \text{ in}$$

$$\begin{aligned}t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0719, 0.0835 ] \\ &= 0.0835 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= P*R_o / (S*E + 0.4*P) + \text{Corrosion} \\ &= 1,378.3574*24 / (20,000*1 + 0.4*1,378.3574) + 0 \\ &= 1.6097 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6097, 0.0625 ] \\ &= 1.6097 \text{ in}\end{aligned}$$

$$\begin{aligned}t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.2074, 1.6097 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0835, 0.2074 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

## Applied Loads

Radial load:	$P_r = 334$	$lb_f$
Circumferential moment:	$M_c = 2,965$	$lb_f\text{-in}$
Circumferential shear:	$V_c = 409$	$lb_f$
Longitudinal moment:	$M_L = 2,965$	$lb_f\text{-in}$
Longitudinal shear:	$V_L = 409$	$lb_f$
Torsion moment:	$M_t = 4,160$	$lb_f\text{-in}$
Internal pressure:	$P = 1,378.357$	psi
Mean shell radius:	$R_m = 23.125$	in
Local shell thickness:	$t = 1.75$	in
Shell yield stress:	$S_y = 27,900$	psi

### Maximum stresses due to the applied loads at the nozzle OD (includes pressure)

$$R_m / t = 23.125 / 1.75 = 13.2143$$

Pressure stress intensity factor,  $I = 1.05703$  (derived from PVP-Vol. 399, pages 77-82)

$$\text{Local circumferential pressure stress} = I * P * R_i / t = 18,524 \text{ psi}$$

$$\text{Local longitudinal pressure stress} = I * P * R_i / (2 * t) = 9,262 \text{ psi}$$

$$\text{Maximum combined stress } (P_L + P_b + Q) = 18,785 \text{ psi}$$

$$\text{Allowable combined stress } (P_L + P_b + Q) = +-3 * S = +-60,000 \text{ psi}$$

Note: The allowable combined stress  $(P_L + P_b + Q)$  is based on the strain hardening characteristics of this material.

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

$$\text{Maximum local primary membrane stress } (P_L) = 18,529 \text{ psi}$$

$$\text{Allowable local primary membrane stress } (P_L) = +-1.5 * S = +-30,000 \text{ psi}$$

The maximum local primary membrane stress  $(P_L)$  is within allowable limits.

Stresses at the nozzle OD per WRC Bulletin 107										
Figure	value	$\beta$	$A_u$	$A_l$	$B_u$	$B_l$	$C_u$	$C_l$	$D_u$	$D_l$
3C*	2.5705	0.0779	0	0	0	0	-21	-21	-21	-21
4C*	2.6145	0.0779	-22	-22	-22	-22	0	0	0	0
1C	0.2014	0.0779	0	0	0	0	-132	132	-132	132
2C-1	0.1661	0.0779	-109	109	-109	109	0	0	0	0
3A*	0.1676	0.0779	0	0	0	0	-7	-7	7	7
1A	0.1061	0.0779	0	0	0	0	-342	342	342	-342
3B*	0.6597	0.0779	-27	-27	27	27	0	0	0	0
1B-1	0.0616	0.0779	-199	199	199	-199	0	0	0	0
<b>Pressure stress*</b>			18,524	18,524	18,524	18,524	17,525	17,525	17,525	17,525
<b>Total circumferential stress</b>			18,167	18,783	18,619	18,439	17,023	17,971	17,721	17,301
<b>Primary membrane circumferential stress*</b>			18,475	18,475	18,529	18,529	17,497	17,497	17,511	17,511
3C*	2.5705	0.0779	-21	-21	-21	-21	0	0	0	0
4C*	2.6145	0.0779	0	0	0	0	-22	-22	-22	-22
1C-1	0.2031	0.0779	-133	133	-133	133	0	0	0	0
2C	0.1599	0.0779	0	0	0	0	-105	105	-105	105
4A*	0.2212	0.0779	0	0	0	0	-9	-9	9	9
2A	0.063	0.0779	0	0	0	0	-203	203	203	-203
4B*	0.1671	0.0779	-7	-7	7	7	0	0	0	0
2B-1	0.098	0.0779	-316	316	316	-316	0	0	0	0
<b>Pressure stress*</b>			8,762	8,762	8,762	8,762	9,262	9,262	9,262	9,262
<b>Total longitudinal stress</b>			8,285	9,183	8,931	8,565	8,923	9,539	9,347	9,151
<b>Primary membrane longitudinal stress*</b>			8,734	8,734	8,748	8,748	9,231	9,231	9,249	9,249
<b>Shear from <math>M_t</math></b>			89	89	89	89	89	89	89	89
<b>Circ shear from <math>V_c</math></b>			36	36	-36	-36	0	0	0	0
<b>Long shear from <math>V_L</math></b>			0	0	0	0	-36	-36	36	36
<b>Total Shear stress</b>			125	125	53	53	53	53	125	125
<b>Combined stress (<math>P_L+P_b+Q</math>)</b>			18,169	18,785	18,619	18,439	17,023	17,971	17,723	17,303

Note: \* denotes primary stress.

### Longitudinal stress in the nozzle wall due to internal pressure + external loads

$$\begin{aligned} \sigma_{n(P_m)} &= P^*R_i / (2^*t_n) - P_r / (\pi^*(R_o^2 - R_i^2)) + M^*R_o / I \\ &= 1,378.36^*1 / (2^*1.06) - 334 / (\pi^*(2.06^2 - 1^2)) + 4,193.1^*2.06 / 13.3582 \\ &= 1,264 \text{ psi} \end{aligned}$$

The average primary stress  $P_m$  (see Division 2 5.6.a.1) across the nozzle wall due to internal pressure + external loads is acceptable ( $\leq S = 20,000$  psi)

### Shear stress in the nozzle wall due to external loads

$$\begin{aligned} \sigma_{\text{shear}} &= (V_L^2 + V_c^2)^{0.5} / (\pi^*R_i^2*t_n) \\ &= (409^2 + 409^2)^{0.5} / (\pi^*1^2*1.06) \\ &= 174 \text{ psi} \end{aligned}$$

$$\begin{aligned} \sigma_{\text{torsion}} &= M_t / (2^*\pi^*R_i^2*t_n) \\ &= 4,160 / (2^*\pi^*1^2*1.06) \end{aligned}$$

= 625 psi

$$\begin{aligned}\sigma_{\text{total}} &= \sigma_{\text{shear}} + \sigma_{\text{torsion}} \\ &= 174 + 625 \\ &= 798 \text{ psi}\end{aligned}$$

UG-45: The total combined shear stress (798 psi) is below than the allowable ( $0.7 \cdot S_n = 0.7 \cdot 20,000 = 14,000$  psi)



## Reinforcement Calculations for MAEP

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For Pe = 622.51 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

Calculations for external pressure 622.51 psi @ 140 °F

### Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

### Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28  $t_m = 0.1482$  in

From UG-37(d)(1) required thickness  $t_r = 1.75$  in

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

### UW-16(c) Weld Check

Fillet weld:  $t_{min} =$  lesser of 0.75 or  $t_n$  or  $t = 0.75$  in  
 $t_{c(min)} =$  lesser of 0.25 or  $0.7*t_{min} = \underline{0.25}$  in  
 $t_{c(actual)} = 0.7*Leg = 0.7*0.375 = 0.2625$  in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$t_{a \text{ UG-28}} = 0.1482 \text{ in}$$

$$t_{a \text{ UG-22}} = 0.0489 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}} , t_{a \text{ UG-22}} ] \\ &= \max[ 0.1482 , 0.0489 ] \\ &= 0.1482 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 622.5059 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 622.5059) + 0 \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2} , t_{b \text{ UG16}} ] \\ &= \max[ 0.7378 , 0.0625 ] \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3} , t_{b2} ] \\ &= \min[ 0.2074 , 0.7378 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a , t_b ] \\ &= \max[ 0.1482 , 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

### External Pressure, (Corroded & at 140 °F) UG-28(c)

$$L / D_o = 8.0886 / 4.12 = 1.9632$$

$$D_o / t = 4.12 / 0.1482 = 27.7945$$

From table G:  $A = 0.004502$

From table  
HA-2:  $B = 12,976.6933 \text{ psi}$

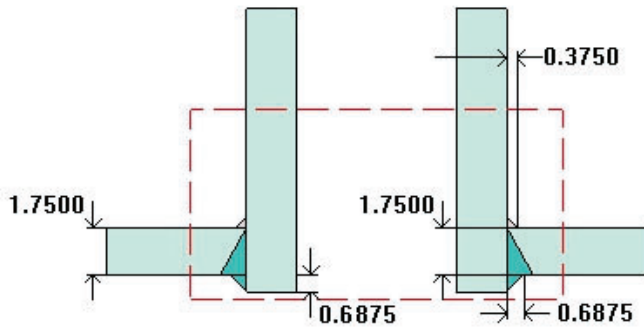
$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 12,976.69 / (3 \cdot (4.12 / 0.1482)) \\ &= 622.51 \text{ psi} \end{aligned}$$

**Design thickness for external pressure  $P_a = 622.51 \text{ psi}$**

$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482 \text{ in}$$

## Inspection c/w Blind Flange (N15)

### ASME Section VIII Division 1, 2010 Edition, A11 Addenda



$$t_{w(\text{lower})} = 1.75 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$

$$\text{Leg}_{43} = 0.6875 \text{ in}$$

$$h_{\text{new}} = 0.6875 \text{ in}$$

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

#### Location and Orientation

Located on:	48 OD SHELL
Orientation:	45°
Nozzle center line offset to datum line:	8 in
End of nozzle to shell center:	34 in
Passes through a Category A joint:	No

#### Nozzle

Access opening:	No
Material specification:	SA-182 F316 $\leq 5$ (II-D p. 70, In. 22)
Inside diameter, new:	8 in
Nominal wall thickness:	1.875 in
Corrosion allowance:	0 in
Projection available outside vessel, L <sub>pr</sub> :	7.25 in
Internal projection, h <sub>new</sub> :	0.6875 in
Projection available outside vessel to flange face, L <sub>f</sub> :	10 in
Local vessel minimum thickness:	1.75 in
Liquid static head included:	0 psi
Longitudinal joint efficiency:	1

#### ASME B16.5-2009 Flange

Description:	NPS 8 Class 900 LWN A182 F316
Bolt Material:	SA-193 B7 Bolt $\leq 2 \frac{1}{2}$ (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55°F
(Per UHA-51(d)(1)(a))	
(Flange rated MDMT = -320 °F	
Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F)	
Liquid static head:	0 psi
MAWP rating:	2,040 psi @ 140°F

MAP rating:	2,160 psi @ 50°F
Hydrotest rating:	3,250 psi @ 50°F
PWHT performed:	No

**Reinforcement Calculations for Chamber MAWP**

<b>UG-37 Area Calculation Summary (in<sup>2</sup>)</b> For P = 1,378 psi @ 140 °F The opening is adequately reinforced							<b>UG-45 Nozzle Wall Thickness Summary (in)</b> The nozzle passes UG-45	
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
<a href="#">12.874</a>	<a href="#">18.208</a>	<a href="#">1.126</a>	<a href="#">13.8906</a>	<a href="#">2.5781</a>	--	<a href="#">0.6133</a>	<a href="#">0.3281</a>	1.875

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

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg41)	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for internal pressure 1,378 psi @ 140 °F**

Nozzle rated MDMT per UHA-51(d)(1)(a) = -320 °F.

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(8, 4 + (1.875 - 0) + (1.75 - 0)) \\
 &= 8 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.875 - 0) + 0) \\
 &= 4.375 \text{ in}
 \end{aligned}$$

**Inner Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_I &= \text{MIN}(2.5*(t - C), 2.5*(t_i - C_n - C)) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.875 - 0 - 0)) \\
 &= 4.375 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 4 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.2875 \text{ in}
 \end{aligned}$$

**Required thickness t<sub>r</sub> from UG-37(a)**

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378)
 \end{aligned}$$

$$= 1.6092 \text{ in}$$

### Area required per UG-37(c)

Allowable stresses:  $S_n = 20,000$ ,  $S_v = 20,000$  psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$\begin{aligned} A &= d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1}) \\ &= 8 \cdot 1.6093 \cdot 1 + 2 \cdot 1.875 \cdot 1.6093 \cdot 1 \cdot (1 - 1) \\ &= \underline{12.874} \text{ in}^2 \end{aligned}$$

### Area available from FIG. UG-37.1

$$A_1 = \text{larger of the following} = \underline{1.126} \text{ in}^2$$

$$\begin{aligned} &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 8 \cdot (1 \cdot 1.75 - 1 \cdot 1.6093) - 2 \cdot 1.875 \cdot (1 \cdot 1.75 - 1 \cdot 1.6093) \cdot (1 - 1) \\ &= 1.126 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2 \cdot (1.75 + 1.875) \cdot (1 \cdot 1.75 - 1 \cdot 1.6093) - 2 \cdot 1.875 \cdot (1 \cdot 1.75 - 1 \cdot 1.6093) \cdot (1 - 1) \\ &= 1.0204 \text{ in}^2 \end{aligned}$$

$$A_2 = \text{smaller of the following} = \underline{13.8906} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t \\ &= 5 \cdot (1.875 - 0.2875) \cdot 1 \cdot 1.75 \\ &= 13.8906 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (1.875 - 0.2875) \cdot 1 \cdot 1.875 \\ &= 14.8828 \text{ in}^2 \end{aligned}$$

$$A_3 = \text{smaller of the following} = \underline{2.5781} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot t_i \cdot f_{r2} \\ &= 5 \cdot 1.75 \cdot 1.875 \cdot 1 \\ &= \underline{16.4063} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 5 \cdot t_i \cdot t_i \cdot f_{r2} \\ &= 5 \cdot 1.875 \cdot 1.875 \cdot 1 \\ &= \underline{17.5781} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 2 \cdot h \cdot t_i \cdot f_{r2} \\ &= 2 \cdot 0.6875 \cdot 1.875 \cdot 1 \end{aligned}$$

$$= \underline{2.5781} \text{ in}^2$$

$$\begin{aligned} A_{41} &= \text{Leg}^2 * f_{r2} \\ &= 0.375^2 * 1 \\ &= \underline{0.1406} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} A_{43} &= \text{Leg}^2 * f_{r2} \\ &= 0.6875^2 * 1 \\ &= \underline{0.4727} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_3 + A_{41} + A_{43} \\ &= 1.126 + 13.8906 + 2.5781 + 0.1406 + 0.4727 \\ &= \underline{18.208} \text{ in}^2 \end{aligned}$$

As Area  $\geq$  A the reinforcement is adequate.

### UW-16(c) Weld Check

Fillet weld:  $t_{\min}$  = lesser of 0.75 or  $t_n$  or  $t = 0.75$  in  
 $t_{c(\min)}$  = lesser of 0.25 or  $0.7 * t_{\min} = \underline{0.25}$  in  
 $t_{c(\text{actual})} = 0.7 * \text{Leg} = 0.7 * 0.375 = 0.2625$  in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$\begin{aligned} t_{a \text{ UG-27}} &= P * R / (S * E - 0.6 * P) + \text{Corrosion} \\ &= 1,378 * 4 / (20,000 * 1 - 0.6 * 1,378) + 0 \\ &= 0.2875 \text{ in} \end{aligned}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.2875, 0 ] \\ &= 0.2875 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= P * R_o / (S * E + 0.4 * P) + \text{Corrosion} \\ &= 1,378 * 24 / (20,000 * 1 + 0.4 * 1,378) + 0 \\ &= 1.6092 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6092, 0.0625 ] \\ &= 1.6092 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.3281, 1.6092 ] \\ &= 0.3281 \text{ in} \end{aligned}$$

$$\begin{aligned}t_{UG-45} &= \max[ t_a , t_b ] \\ &= \max[ 0.2875 , 0.3281 ] \\ &= 0.3281 \text{ in}\end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.875$  in

The nozzle neck thickness is adequate.



**Reinforcement Calculations for MAEP**

<b>UG-37 Area Calculation Summary (in<sup>2</sup>)</b> For Pe = 622.51 psi @ 140 °F The opening is adequately reinforced							<b>UG-45 Nozzle Wall Thickness Summary (in)</b> The nozzle passes UG-45	
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
7	16.1125	--	12.9211	2.5781	--	0.6133	0.3983	1.875

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	0.25	0.2625	weld size is adequate

**Calculations for external pressure 622.51 psi @ 140 °F**

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(8, 4 + (1.875 - 0) + (1.75 - 0)) \\
 &= 8 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.875 - 0) + 0) \\
 &= 4.375 \text{ in}
 \end{aligned}$$

**Inner Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_I &= \text{MIN}(2.5*(t - C), 2.5*(t_i - C_n - C)) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.875 - 0 - 0)) \\
 &= 4.375 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-28 t<sub>rn</sub> = 0.3983 in**

**From UG-37(d)(1) required thickness t<sub>r</sub> = 1.75 in**

**Area required per UG-37(d)(1)**

Allowable stresses: S<sub>n</sub> = 20,000, S<sub>v</sub> = 20,000 psi

f<sub>r1</sub> = lesser of 1 or S<sub>n</sub> / S<sub>v</sub> = 1

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$\begin{aligned} A &= 0.5 \cdot (d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1})) \\ &= 0.5 \cdot (8 \cdot 1.75 \cdot 1 + 2 \cdot 1.875 \cdot 1.75 \cdot 1 \cdot (1 - 1)) \\ &= \underline{7} \text{ in}^2 \end{aligned}$$

### Area available from FIG. UG-37.1

$$A_1 = \text{larger of the following} = \underline{0} \text{ in}^2$$

$$\begin{aligned} &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 8 \cdot (1 \cdot 1.75 - 1 \cdot 1.75) - 2 \cdot 1.875 \cdot (1 \cdot 1.75 - 1 \cdot 1.75) \cdot (1 - 1) \\ &= 0 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2 \cdot (1.75 + 1.875) \cdot (1 \cdot 1.75 - 1 \cdot 1.75) - 2 \cdot 1.875 \cdot (1 \cdot 1.75 - 1 \cdot 1.75) \cdot (1 - 1) \\ &= 0 \text{ in}^2 \end{aligned}$$

$$A_2 = \text{smaller of the following} = \underline{12.9211} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t \\ &= 5 \cdot (1.875 - 0.3983) \cdot 1 \cdot 1.75 \\ &= 12.9211 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (1.875 - 0.3983) \cdot 1 \cdot 1.875 \\ &= 13.844 \text{ in}^2 \end{aligned}$$

$$A_3 = \text{smaller of the following} = \underline{2.5781} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot t_i \cdot t_i \cdot f_{r2} \\ &= 5 \cdot 1.75 \cdot 1.875 \cdot 1 \\ &= \underline{16.4063} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 5 \cdot t_i \cdot t_i \cdot f_{r2} \\ &= 5 \cdot 1.875 \cdot 1.875 \cdot 1 \\ &= \underline{17.5781} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 2 \cdot h \cdot t_i \cdot f_{r2} \\ &= 2 \cdot 0.6875 \cdot 1.875 \cdot 1 \\ &= \underline{2.5781} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} A_{41} &= \text{Leg}^2 \cdot f_{r2} \\ &= 0.375^2 \cdot 1 \\ &= \underline{0.1406} \text{ in}^2 \end{aligned}$$

$$A_{43} = \text{Leg}^2 \cdot f_{r2}$$

$$= 0.6875^2 * 1$$

$$= \underline{0.4727} \text{ in}^2$$

$$\text{Area} = A_1 + A_2 + A_3 + A_{41} + A_{43}$$

$$= 0 + 12.9211 + 2.5781 + 0.1406 + 0.4727$$

$$= \underline{16.1125} \text{ in}^2$$

As Area  $\geq$  A the reinforcement is adequate.

### UW-16(c) Weld Check

Fillet weld:  $t_{\min}$  = lesser of 0.75 or  $t_n$  or  $t = 0.75$  in

$t_{c(\min)}$  = lesser of 0.25 or  $0.7 * t_{\min} = \underline{0.25}$  in

$t_{c(\text{actual})} = 0.7 * \text{Leg} = 0.7 * 0.375 = 0.2625$  in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$t_{a \text{ UG-28}} = 0.3983 \text{ in}$$

$$t_a = \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ]$$

$$= \max[ 0.3983, 0 ]$$

$$= 0.3983 \text{ in}$$

$$t_{b2} = P * R_o / (S * E + 0.4 * P) + \text{Corrosion}$$

$$= 622.5059 * 24 / (20,000 * 1 + 0.4 * 622.5059) + 0$$

$$= 0.7378 \text{ in}$$

$$t_{b2} = \max[ t_{b2}, t_{b \text{ UG16}} ]$$

$$= \max[ 0.7378, 0.0625 ]$$

$$= 0.7378 \text{ in}$$

$$t_b = \min[ t_{b3}, t_{b2} ]$$

$$= \min[ 0.3281, 0.7378 ]$$

$$= 0.3281 \text{ in}$$

$$t_{\text{UG-45}} = \max[ t_a, t_b ]$$

$$= \max[ 0.3983, 0.3281 ]$$

$$= 0.3983 \text{ in}$$

Available nozzle wall thickness new,  $t_n = 1.875$  in

The nozzle neck thickness is adequate.

**External Pressure, (Corroded & at 140 °F) UG-28(c)**

$$L / D_o = 10.7302 / 11.75 = 0.9132$$

$$D_o / t = 11.75 / 0.3983 = 29.4998$$

From table G: A = 0.009593

From table  
HA-2: B = 13,772.846 psi

$$\begin{aligned} P_a &= 4*B / (3*(D_o / t)) \\ &= 4*13,772.85 / (3*(11.75 / 0.3983)) \\ &= 622.51 \text{ psi} \end{aligned}$$

**Design thickness for external pressure  $P_a = 622.51$  psi**

$$t_a = t + \text{Corrosion} = 0.3983 + 0 = 0.3983"$$



$$= 15 \text{ psi}$$

**Design thickness for external pressure  $P_a = 15 \text{ psi}$**

$$t_a = t + \text{Corrosion} = 0.2194 + 0 = 0.2194''$$

**Maximum Allowable External Pressure, (Corroded & at 140 °F) UG-28(c)**

$$L / D_o = 107.4233 / 48 = 2.2380$$

$$D_o / t = 48 / 1.77 = 27.1186$$

$$\text{From table G: } A = 0.004031$$

$$\text{From table HA-2: } B = 12,828.9038 \text{ psi}$$

$$\begin{aligned} P_a &= 4*B / (3*(D_o / t)) \\ &= 4*12,828.9 / (3*(48 / 1.77)) \\ &= 630.75 \text{ psi} \end{aligned}$$

**% Forming strain - UHA-44(a)(2)(a)**

$$\begin{aligned} EFE &= (50*t / R_f) * (1 - R_f / R_o) \\ &= (50*1.77 / 23.115) * (1 - 23.115 / \infty) \\ &= 3.8287\% \end{aligned}$$

**Design thickness = 1.6101"**

The governing condition is due to internal pressure.

The cylinder thickness of 1.77" is adequate.

### 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 <sub>t</sub>	S <sub>c</sub>					
<a href="#">Operating, Hot &amp; Corroded</a>	1,378	20,000	<a href="#">13.729</a>	140	0	Wind	<a href="#">0.633</a>	<a href="#">0.6196</a>
						Seismic	<a href="#">0.6474</a>	<a href="#">0.6006</a>
<a href="#">Operating, Hot &amp; New</a>	1,378	20,000	<a href="#">13.729</a>	140	0	Wind	<a href="#">0.633</a>	<a href="#">0.6196</a>
						Seismic	<a href="#">0.6474</a>	<a href="#">0.6006</a>
<a href="#">Hot Shut Down, Corroded</a>	0	20,000	<a href="#">13.729</a>	140	0	Wind	<a href="#">0.0021</a>	<a href="#">0.0166</a>
						Seismic	<a href="#">0.0165</a>	<a href="#">0.0443</a>
<a href="#">Hot Shut Down, New</a>	0	20,000	<a href="#">13.729</a>	140	0	Wind	<a href="#">0.0021</a>	<a href="#">0.0166</a>
						Seismic	<a href="#">0.0165</a>	<a href="#">0.0443</a>
<a href="#">Empty, Corroded</a>	0	20,000	<a href="#">13.908</a>	70	0	Wind	<a href="#">0.0021</a>	<a href="#">0.0164</a>
						Seismic	<a href="#">0.0157</a>	<a href="#">0.0425</a>
<a href="#">Empty, New</a>	0	20,000	<a href="#">13.908</a>	70	0	Wind	<a href="#">0.0021</a>	<a href="#">0.0164</a>
						Seismic	<a href="#">0.0157</a>	<a href="#">0.0425</a>
<a href="#">Vacuum</a>	-15	20,000	<a href="#">13.729</a>	140	0	Wind	<a href="#">0.0071</a>	<a href="#">0.0267</a>
						Seismic	<a href="#">0.0095</a>	<a href="#">0.0544</a>
<a href="#">Hot Shut Down, Corroded, Weight &amp; Eccentric Moments Only</a>	0	20,000	<a href="#">13.729</a>	140	0	Weight	<a href="#">0.0018</a>	<a href="#">0.0188</a>

#### Allowable Compressive Stress, Hot and Corroded- S<sub>cHC</sub>, (table HA-2)

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (24 / 1.77) \\
 &= 0.009219 \\
 B &= 13,729 \text{ psi} \\
 S &= 20,000 / 1.00 = 20,000 \text{ psi} \\
 S_{cHC} &= \min(B, S) = \underline{13.729 \text{ psi}}
 \end{aligned}$$

#### Allowable Compressive Stress, Hot and New- S<sub>cHN</sub>

$$\begin{aligned}
 S_{cHN} &= S_{cHC} \\
 &= \underline{13.729 \text{ psi}}
 \end{aligned}$$

#### Allowable Compressive Stress, Cold and New- S<sub>cCN</sub>, (table HA-2)

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (24 / 1.77) \\
 &= 0.009219 \\
 B &= 13,908 \text{ psi} \\
 S &= 20,000 / 1.00 = 20,000 \text{ psi} \\
 S_{cCN} &= \min(B, S) = \underline{13.908 \text{ psi}}
 \end{aligned}$$

#### Allowable Compressive Stress, Cold and Corroded- S<sub>cCC</sub>

$$\begin{aligned}
 S_{cCC} &= S_{cCN} \\
 &= \underline{13.908 \text{ psi}}
 \end{aligned}$$

**Allowable Compressive Stress, Vacuum and Corroded-  $S_{cVC}$ , (table HA-2)**

$$\begin{aligned} A &= 0.125 / (R_o / t) \\ &= 0.125 / (24 / 1.77) \\ &= 0.009219 \\ B &= 13,729 \text{ psi} \\ S &= 20,000 / 1.00 = 20,000 \text{ psi} \\ S_{cVC} &= \min(B, S) = \underline{13.729 \text{ psi}} \end{aligned}$$

**Operating, Hot & Corroded, Wind, Bottom Seam**

$$\begin{aligned} t_p &= P \cdot R / (2 \cdot S_t \cdot K_s \cdot E_c + 0.40 \cdot |P|) && \text{(Pressure)} \\ &= 1,378 \cdot 22.23 / (2 \cdot 20,000 \cdot 1.20 \cdot 1.00 + 0.40 \cdot |1,378|) \\ &= 0.6309" \\ t_m &= M / (\pi \cdot R_m^2 \cdot S_t \cdot K_s \cdot E_c) && \text{(bending)} \\ &= 271,776 / (\pi \cdot 23.115^2 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\ &= 0.0067" \\ t_w &= W / (2 \cdot \pi \cdot R_m \cdot S_t \cdot K_s \cdot E_c) && \text{(Weight)} \\ &= 16,188.1 / (2 \cdot \pi \cdot 23.115 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\ &= 0.0046" \\ t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\ &= 0.6309 + 0.0067 - (0.0046) \\ &= \underline{0.633"} \\ t_c &= |t_{mc} + t_{wc} - t_{pc}| && \text{(total, net tensile)} \\ &= |0.0067 + (0.0046) - (0.6309)| \\ &= \underline{0.6196"} \end{aligned}$$

**Maximum allowable working pressure, Longitudinal Stress**

$$\begin{aligned} P &= 2 \cdot S_t \cdot K_s \cdot E_c \cdot (t - t_m + t_w) / (R - 0.40 \cdot (t - t_m + t_w)) \\ &= 2 \cdot 20,000 \cdot 1.20 \cdot 1.00 \cdot (1.77 - 0.0067 + (0.0046)) / (22.23 - 0.40 \cdot (1.77 - 0.0067 + (0.0046))) \\ &= 3,942.75 \text{ psi} \end{aligned}$$

**Operating, Hot & New, Wind, Bottom Seam**

$$\begin{aligned} t_p &= P \cdot R / (2 \cdot S_t \cdot K_s \cdot E_c + 0.40 \cdot |P|) && \text{(Pressure)} \\ &= 1,378 \cdot 22.23 / (2 \cdot 20,000 \cdot 1.20 \cdot 1.00 + 0.40 \cdot |1,378|) \\ &= 0.6309" \\ t_m &= M / (\pi \cdot R_m^2 \cdot S_t \cdot K_s \cdot E_c) && \text{(bending)} \\ &= 271,776 / (\pi \cdot 23.115^2 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\ &= 0.0067" \\ t_w &= W / (2 \cdot \pi \cdot R_m \cdot S_t \cdot K_s \cdot E_c) && \text{(Weight)} \\ &= 16,188.1 / (2 \cdot \pi \cdot 23.115 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\ &= 0.0046" \\ t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \end{aligned}$$



$$= 0.6309 + 0.0067 - (0.0046)$$

$$= \underline{0.633''}$$

$$t_c = |t_{mc} + t_{wc} - t_{pc}| \quad \text{(total, net tensile)}$$

$$= |0.0067 + (0.0046) - (0.6309)|$$

$$= \underline{0.6196''}$$

### Maximum allowable working pressure, Longitudinal Stress

$$P = 2 * S_t * K_s * E_c * (t - t_m + t_w) / (R - 0.40 * (t - t_m + t_w))$$

$$= 2 * 20,000 * 1.20 * 1.00 * (1.77 - 0.0067 + (0.0046)) / (22.23 - 0.40 * (1.77 - 0.0067 + (0.0046)))$$

$$= 3,942.75 \text{ psi}$$

### Hot Shut Down, Corroded, Wind, Bottom Seam

$$t_p = 0'' \quad \text{(Pressure)}$$

$$t_m = M / (\pi * R_m^2 * S_t * K_s * E_c) \quad \text{(bending)}$$

$$= 271,776 / (\pi * 23.115^2 * 20,000 * 1.20 * 1.00)$$

$$= 0.0067''$$

$$t_w = W / (2 * \pi * R_m * S_t * K_s * E_c) \quad \text{(Weight)}$$

$$= 16,188.1 / (2 * \pi * 23.115 * 20,000 * 1.20 * 1.00)$$

$$= 0.0046''$$

$$t_t = t_p + t_m - t_w \quad \text{(total required, tensile)}$$

$$= 0 + 0.0067 - (0.0046)$$

$$= \underline{0.0021''}$$

$$t_{mc} = M / (\pi * R_m^2 * S_c * K_s) \quad \text{(bending)}$$

$$= 271,776 / (\pi * 23.115^2 * 13,728.59 * 1.20)$$

$$= 0.0098''$$

$$t_{wc} = W / (2 * \pi * R_m * S_c * K_s) \quad \text{(Weight)}$$

$$= 16,188.1 / (2 * \pi * 23.115 * 13,728.59 * 1.20)$$

$$= 0.0068''$$

$$t_c = t_{mc} + t_{wc} - t_{pc} \quad \text{(total required, compressive)}$$

$$= 0.0098 + (0.0068) - (0)$$

$$= \underline{0.0166''}$$

### Hot Shut Down, New, Wind, Bottom Seam

$$t_p = 0'' \quad \text{(Pressure)}$$

$$t_m = M / (\pi * R_m^2 * S_t * K_s * E_c) \quad \text{(bending)}$$

$$= 271,776 / (\pi * 23.115^2 * 20,000 * 1.20 * 1.00)$$

$$= 0.0067''$$

$$t_w = W / (2 * \pi * R_m * S_t * K_s * E_c) \quad \text{(Weight)}$$

$$= 16,188.1 / (2 * \pi * 23.115 * 20,000 * 1.20 * 1.00)$$

$$= 0.0046''$$

$$t_t = t_p + t_m - t_w \quad \text{(total required, tensile)}$$

$$= 0 + 0.0067 - (0.0046)$$

$$= \underline{0.0021''}$$

$$\begin{aligned}
 t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\
 &= 271,776 / (\pi * 23.115^2 * 13,728.59 * 1.20) \\
 &= 0.0098" \\
 t_{wc} &= W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\
 &= 16,188.1 / (2 * \pi * 23.115 * 13,728.59 * 1.20) \\
 &= 0.0068" \\
 t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\
 &= 0.0098 + (0.0068) - (0) \\
 &= \underline{0.0166"}
 \end{aligned}$$

### Empty, Corroded, Wind, Bottom Seam

$$\begin{aligned}
 t_p &= 0" && \text{(Pressure)} \\
 t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\
 &= 271,776 / (\pi * 23.115^2 * 20,000 * 1.20 * 1.00) \\
 &= 0.0067" \\
 t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\
 &= 16,188.1 / (2 * \pi * 23.115 * 20,000 * 1.20 * 1.00) \\
 &= 0.0046" \\
 t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\
 &= 0 + 0.0067 - (0.0046) \\
 &= \underline{0.0021"} \\
 t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\
 &= 271,776 / (\pi * 23.115^2 * 13,907.75 * 1.20) \\
 &= 0.0097" \\
 t_{wc} &= W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\
 &= 16,188.1 / (2 * \pi * 23.115 * 13,907.75 * 1.20) \\
 &= 0.0067" \\
 t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\
 &= 0.0097 + (0.0067) - (0) \\
 &= \underline{0.0164"}
 \end{aligned}$$

### Empty, New, Wind, Bottom Seam

$$\begin{aligned}
 t_p &= 0" && \text{(Pressure)} \\
 t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\
 &= 271,776 / (\pi * 23.115^2 * 20,000 * 1.20 * 1.00) \\
 &= 0.0067" \\
 t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\
 &= 16,188.1 / (2 * \pi * 23.115 * 20,000 * 1.20 * 1.00) \\
 &= 0.0046" \\
 t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\
 &= 0 + 0.0067 - (0.0046) \\
 &= \underline{0.0021"} \\
 t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\
 &= 271,776 / (\pi * 23.115^2 * 13,907.75 * 1.20)
 \end{aligned}$$

$$= 0.0097''$$

$$\begin{aligned} t_{wc} &= W / (2\pi R_m S_c K_s) && \text{(Weight)} \\ &= 16,188.1 / (2\pi * 23.115 * 13,907.75 * 1.20) \\ &= 0.0067'' \end{aligned}$$

$$\begin{aligned} t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\ &= 0.0097 + (0.0067) - (0) \\ &= \underline{0.0164''} \end{aligned}$$

### Vacuum, Wind, Bottom Seam

$$\begin{aligned} t_p &= P * R / (2 * S_c * K_s + 0.40 * |P|) && \text{(Pressure)} \\ &= -15 * 22.23 / (2 * 13,728.59 * 1.20 + 0.40 * |15|) \\ &= -0.0101'' \end{aligned}$$

$$\begin{aligned} t_m &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\ &= 271,776 / (\pi * 23.115^2 * 13,728.59 * 1.20) \\ &= 0.0098'' \end{aligned}$$

$$\begin{aligned} t_w &= W / (2\pi R_m S_c K_s) && \text{(Weight)} \\ &= 16,188.1 / (2\pi * 23.115 * 13,728.59 * 1.20) \\ &= 0.0068'' \end{aligned}$$

$$\begin{aligned} t_t &= |t_p + t_m - t_w| && \text{(total, net compressive)} \\ &= |-0.0101 + 0.0098 - (0.0068)| \\ &= \underline{0.0071''} \end{aligned}$$

$$\begin{aligned} t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\ &= 0.0098 + (0.0068) - (-0.0101) \\ &= \underline{0.0267''} \end{aligned}$$

### **Maximum Allowable External Pressure, Longitudinal Stress**

$$\begin{aligned} P &= 2 * S_c * K_s * (t - t_{mc} - t_{wc}) / (R - 0.40 * (t - t_{mc} - t_{wc})) \\ &= 2 * 13,728.59 * 1.20 * (1.77 - 0.0098 - 0.0068) / (22.23 - 0.40 * (1.77 - 0.0098 - 0.0068)) \\ &= 2,683.51 \text{ psi} \end{aligned}$$

### Hot Shut Down, Corroded, Weight & Eccentric Moments Only, Bottom Seam

$$\begin{aligned} t_p &= 0'' && \text{(Pressure)} \\ t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\ &= 246,659 / (\pi * 23.115^2 * 20,000 * 1.00 * 1.00) \\ &= 0.0073'' \end{aligned}$$

$$\begin{aligned} t_w &= W / (2\pi R_m S_t K_s E_c) && \text{(Weight)} \\ &= 16,188.1 / (2\pi * 23.115 * 20,000 * 1.00 * 1.00) \\ &= 0.0056'' \end{aligned}$$

$$\begin{aligned} t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\ &= 0 + 0.0073 - (0.0056) \\ &= \underline{0.0018''} \end{aligned}$$

$$\begin{aligned} t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\ &= 246,659 / (\pi * 23.115^2 * 13,728.59 * 1.00) \\ &= 0.0107'' \end{aligned}$$

$$t_{wc} = W / (2\pi R_m S_c K_s) \quad (\text{Weight})$$

$$= 16,188.1 / (2\pi * 23.115 * 13,728.59 * 1.00)$$

$$= 0.0081"$$

$$t_c = t_{mc} + t_{wc} - t_{pc} \quad (\text{total required, compressive})$$

$$= 0.0107 + (0.0081) - (0)$$

$$= \underline{0.0188}"$$

### Operating, Hot & Corroded, Seismic, Bottom Seam

$$t_p = P * R / (2 * S_t * K_s * E_c + 0.40 * |P|) \quad (\text{Pressure})$$

$$= 1,378 * 22.23 / (2 * 20,000 * 1.20 * 1.00 + 0.40 * |1,378|)$$

$$= 0.6309"$$

$$t_m = M / (\pi * R_m^2 * S_t * K_s * E_c) \quad (\text{bending})$$

$$= 849,942 / (\pi * 23.115^2 * 20,000 * 1.20 * 1.00)$$

$$= 0.0211"$$

$$t_w = W / (2 * \pi * R_m * S_t * K_s * E_c) \quad (\text{Weight})$$

$$= 16,188.1 / (2 * \pi * 23.115 * 20,000 * 1.20 * 1.00)$$

$$= 0.0046"$$

$$t_t = t_p + t_m - t_w \quad (\text{total required, tensile})$$

$$= 0.6309 + 0.0211 - (0.0046)$$

$$= \underline{0.6474}"$$

$$t_{wc} = (1 + V_{\text{Accel}}) * W / (2 * \pi * R_m * S_t * K_s * E_c) \quad (\text{Weight})$$

$$= 2.00 * 16,188.1 / (2 * \pi * 23.115 * 20,000 * 1.20 * 1.00)$$

$$= 0.0093"$$

$$t_c = |t_{mc} + t_{wc} - t_{pc}| \quad (\text{total, net tensile})$$

$$= |0.0211 + (0.0093) - (0.6309)|$$

$$= \underline{0.6006}"$$

### **Maximum allowable working pressure, Longitudinal Stress**

$$P = 2 * S_t * K_s * E_c * (t - t_m + t_w) / (R - 0.40 * (t - t_m + t_w))$$

$$= 2 * 20,000 * 1.20 * 1.00 * (1.77 - 0.0211 + (0.0046)) / (22.23 - 0.40 * (1.77 - 0.0211 + (0.0046)))$$

$$= 3,909.7 \text{ psi}$$

### Operating, Hot & New, Seismic, Bottom Seam

$$t_p = P * R / (2 * S_t * K_s * E_c + 0.40 * |P|) \quad (\text{Pressure})$$

$$= 1,378 * 22.23 / (2 * 20,000 * 1.20 * 1.00 + 0.40 * |1,378|)$$

$$= 0.6309"$$

$$t_m = M / (\pi * R_m^2 * S_t * K_s * E_c) \quad (\text{bending})$$

$$= 849,942 / (\pi * 23.115^2 * 20,000 * 1.20 * 1.00)$$

$$= 0.0211"$$

$$t_w = W / (2 * \pi * R_m * S_t * K_s * E_c) \quad (\text{Weight})$$

$$= 16,188.1 / (2 * \pi * 23.115 * 20,000 * 1.20 * 1.00)$$

$$= 0.0046"$$

$$t_t = t_p + t_m - t_w \quad (\text{total required, tensile})$$

$$= 0.6309 + 0.0211 - (0.0046)$$

$$= 0.6474''$$

$$\begin{aligned} t_{wc} &= (1 + V_{\text{Accel}}) * W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\ &= 2.00 * 16,188.1 / (2 * \pi * 23.115 * 20,000 * 1.20 * 1.00) \\ &= 0.0093'' \end{aligned}$$

$$\begin{aligned} t_c &= |t_{mc} + t_{wc} - t_{pc}| && \text{(total, net tensile)} \\ &= |0.0211 + (0.0093) - (0.6309)| \\ &= 0.6006'' \end{aligned}$$

### Maximum allowable working pressure, Longitudinal Stress

$$\begin{aligned} P &= 2 * S_t * K_s * E_c * (t - t_m + t_w) / (R - 0.40 * (t - t_m + t_w)) \\ &= 2 * 20,000 * 1.20 * 1.00 * (1.77 - 0.0211 + (0.0046)) / (22.23 - 0.40 * (1.77 - 0.0211 + (0.0046))) \\ &= 3,909.7 \text{ psi} \end{aligned}$$

### Hot Shut Down, Corroded, Seismic, Bottom Seam

$$t_p = 0'' \quad \text{(Pressure)}$$

$$\begin{aligned} t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\ &= 849,942 / (\pi * 23.115^2 * 20,000 * 1.20 * 1.00) \\ &= 0.0211'' \end{aligned}$$

$$\begin{aligned} t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\ &= 16,188.1 / (2 * \pi * 23.115 * 20,000 * 1.20 * 1.00) \\ &= 0.0046'' \end{aligned}$$

$$\begin{aligned} t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\ &= 0 + 0.0211 - (0.0046) \\ &= 0.0165'' \end{aligned}$$

$$\begin{aligned} t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\ &= 849,942 / (\pi * 23.115^2 * 13,728.59 * 1.20) \\ &= 0.0307'' \end{aligned}$$

$$\begin{aligned} t_{wc} &= (1 + V_{\text{Accel}}) * W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\ &= 2.00 * 16,188.1 / (2 * \pi * 23.115 * 13,728.59 * 1.20) \\ &= 0.0135'' \end{aligned}$$

$$\begin{aligned} t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\ &= 0.0307 + (0.0135) - (0) \\ &= 0.0443'' \end{aligned}$$

### Hot Shut Down, New, Seismic, Bottom Seam

$$t_p = 0'' \quad \text{(Pressure)}$$

$$\begin{aligned} t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\ &= 849,942 / (\pi * 23.115^2 * 20,000 * 1.20 * 1.00) \\ &= 0.0211'' \end{aligned}$$

$$\begin{aligned} t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\ &= 16,188.1 / (2 * \pi * 23.115 * 20,000 * 1.20 * 1.00) \\ &= 0.0046'' \end{aligned}$$

$$\begin{aligned} t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\ &= 0 + 0.0211 - (0.0046) \end{aligned}$$

$$= 0.0165"$$

$$\begin{aligned} t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\ &= 849,942 / (\pi * 23.115^2 * 13,728.59 * 1.20) \\ &= 0.0307" \end{aligned}$$

$$\begin{aligned} t_{wc} &= (1 + V_{\text{Accel}}) * W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\ &= 2.00 * 16,188.1 / (2 * \pi * 23.115 * 13,728.59 * 1.20) \\ &= 0.0135" \end{aligned}$$

$$\begin{aligned} t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\ &= 0.0307 + (0.0135) - (0) \\ &= 0.0443" \end{aligned}$$

### Empty, Corroded, Seismic, Bottom Seam

$$t_p = 0" \quad \text{(Pressure)}$$

$$\begin{aligned} t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\ &= 817,665 / (\pi * 23.115^2 * 20,000 * 1.20 * 1.00) \\ &= 0.0203" \end{aligned}$$

$$\begin{aligned} t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\ &= 16,188.1 / (2 * \pi * 23.115 * 20,000 * 1.20 * 1.00) \\ &= 0.0046" \end{aligned}$$

$$\begin{aligned} t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\ &= 0 + 0.0203 - (0.0046) \\ &= 0.0157" \end{aligned}$$

$$\begin{aligned} t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\ &= 817,665 / (\pi * 23.115^2 * 13,907.75 * 1.20) \\ &= 0.0292" \end{aligned}$$

$$\begin{aligned} t_{wc} &= (1 + V_{\text{Accel}}) * W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\ &= 2.00 * 16,188.1 / (2 * \pi * 23.115 * 13,907.75 * 1.20) \\ &= 0.0134" \end{aligned}$$

$$\begin{aligned} t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\ &= 0.0292 + (0.0134) - (0) \\ &= 0.0425" \end{aligned}$$

### Empty, New, Seismic, Bottom Seam

$$t_p = 0" \quad \text{(Pressure)}$$

$$\begin{aligned} t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\ &= 817,665 / (\pi * 23.115^2 * 20,000 * 1.20 * 1.00) \\ &= 0.0203" \end{aligned}$$

$$\begin{aligned} t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\ &= 16,188.1 / (2 * \pi * 23.115 * 20,000 * 1.20 * 1.00) \\ &= 0.0046" \end{aligned}$$

$$\begin{aligned} t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\ &= 0 + 0.0203 - (0.0046) \\ &= 0.0157" \end{aligned}$$

$$t_{mc} = M / (\pi * R_m^2 * S_c * K_s) \quad \text{(bending)}$$

$$= 817,665 / (\pi * 23.115^2 * 13,907.75 * 1.20)$$

$$= 0.0292"$$

$$t_{wc} = (1 + V_{Accel}) * W / (2 * \pi * R_m * S_c * K_s) \quad (\text{Weight})$$

$$= 2.00 * 16,188.1 / (2 * \pi * 23.115 * 13,907.75 * 1.20)$$

$$= 0.0134"$$

$$t_c = t_{mc} + t_{wc} - t_{pc} \quad (\text{total required, compressive})$$

$$= 0.0292 + (0.0134) - (0)$$

$$= \underline{0.0425}"$$

### Vacuum, Seismic, Bottom Seam

$$t_p = P * R / (2 * S_t * K_s * E_c + 0.40 * |P|) \quad (\text{Pressure})$$

$$= -15 * 22.23 / (2 * 20,000 * 1.20 * 1.00 + 0.40 * |15|)$$

$$= -0.0069"$$

$$t_m = M / (\pi * R_m^2 * S_t * K_s * E_c) \quad (\text{bending})$$

$$= 849,942 / (\pi * 23.115^2 * 20,000 * 1.20 * 1.00)$$

$$= 0.0211"$$

$$t_w = W / (2 * \pi * R_m * S_t * K_s * E_c) \quad (\text{Weight})$$

$$= 16,188.1 / (2 * \pi * 23.115 * 20,000 * 1.20 * 1.00)$$

$$= 0.0046"$$

$$t_t = t_p + t_m - t_w \quad (\text{total required, tensile})$$

$$= -0.0069 + 0.0211 - (0.0046)$$

$$= \underline{0.0095}"$$

$$t_{pc} = P * R / (2 * S_c * K_s + 0.40 * |P|) \quad (\text{Pressure})$$

$$= -15 * 22.23 / (2 * 13,728.59 * 1.20 + 0.40 * |15|)$$

$$= -0.0101"$$

$$t_{mc} = M / (\pi * R_m^2 * S_c * K_s) \quad (\text{bending})$$

$$= 849,942 / (\pi * 23.115^2 * 13,728.59 * 1.20)$$

$$= 0.0307"$$

$$t_{wc} = (1 + V_{Accel}) * W / (2 * \pi * R_m * S_c * K_s) \quad (\text{Weight})$$

$$= 2.00 * 16,188.1 / (2 * \pi * 23.115 * 13,728.59 * 1.20)$$

$$= 0.0135"$$

$$t_c = t_{mc} + t_{wc} - t_{pc} \quad (\text{total required, compressive})$$

$$= 0.0307 + (0.0135) - (-0.0101)$$

$$= \underline{0.0544}"$$

### **Maximum Allowable External Pressure, Longitudinal Stress**

$$P = 2 * S_c * K_s * (t - t_{mc} - t_{wc}) / (R - 0.40 * (t - t_{mc} - t_{wc}))$$

$$= 2 * 13,728.59 * 1.20 * (1.77 - 0.0307 - 0.0135) / (22.23 - 0.40 * (1.77 - 0.0307 - 0.0135))$$

$$= 2,639.8 \text{ psi}$$

## 48 OD BOTTOM SE HEAD

### ASME Section VIII, Division 1, 2010 Edition, A11 Addenda

Component: Ellipsoidal Head  
Material Specification: SA-240 316 (II-D p.70, In. 26)  
[Straight Flange](#) governs MDMT

Internal design pressure:  $P = 1,378 \text{ psi @ } 140 \text{ }^\circ\text{F}$

External design pressure:  $P_e = 15 \text{ psi @ } 140 \text{ }^\circ\text{F}$

#### Static liquid head:

$P_s = 1.16 \text{ psi (SG=1.1, } H_s=29.135'' \text{ Operating head)}$

$P_{th} = 2.03 \text{ psi (SG=1, } H_s=56.27'' \text{ Horizontal test head)}$

Corrosion allowance: Inner C = 0" Outer C = 0"

Design MDMT =  $-20^\circ\text{F}$

Rated MDMT =  $-320^\circ\text{F}$

No impact test performed

Material is not normalized

Material is not produced to fine grain practice

PWHT is not performed

Do not Optimize MDMT / Find MAWP

Radiography: Category A joints - Seamless No RT  
Head to shell seam - Full UW-11(a) Type 1

Estimated weight\*: new = 1,408.1 lb corr = 1,408.1 lb

Capacity\*: new = 63.5 US gal corr = 63.5 US gal

\* includes straight flange

Outer diameter = 48"

Minimum head thickness = 1.73"

Head ratio D/2h = 2 (new)

Head ratio D/2h = 2 (corroded)

Straight flange length  $L_{sf}$  = 2"

Nominal straight flange thickness  $t_{sf}$  = 1.77"

#### Results Summary

The governing condition is internal pressure.

Minimum thickness per UG-16 =  $0.0625'' + 0'' = 0.0625''$

Design thickness due to internal pressure (t) = 1.5583''

Design thickness due to external pressure ( $t_e$ ) = 0.1193''

Maximum allowable working pressure (MAWP) = 1,540.53 psi

Maximum allowable external pressure (MAEP) = 566.01 psi

#### K (Corroded)

$$K = (1/6) * [2 + (D / (2 * h))^2] = (1/6) * [2 + (44.54 / (2 * 11.135))^2] = 1$$

#### K (New)

$$K = (1/6) * [2 + (D / (2 * h))^2] = (1/6) * [2 + (44.54 / (2 * 11.135))^2] = 1$$



**Design thickness for internal pressure, (Corroded at 140 °F) Appendix 1-4(c)**

$$\begin{aligned}
 t &= P \cdot D_o \cdot K / (2 \cdot S \cdot E + 2 \cdot P \cdot (K - 0.1)) + \text{Corrosion} \\
 &= 1,379.16 \cdot 48 \cdot 1 / (2 \cdot 20,000 \cdot 1 + 2 \cdot 1,379.16 \cdot (1 - 0.1)) + 0 \\
 &= 1.5583"
 \end{aligned}$$

The head internal pressure design thickness is [1.5583](#)".

**Maximum allowable working pressure, (Corroded at 140 °F) Appendix 1-4(c)**

$$\begin{aligned}
 P &= 2 \cdot S \cdot E \cdot t / (K \cdot D_o - 2 \cdot t \cdot (K - 0.1)) - P_s \\
 &= 2 \cdot 20,000 \cdot 1 \cdot 1.73 / (1 \cdot 48 - 2 \cdot 1.73 \cdot (1 - 0.1)) - 1.16 \\
 &= 1,540.53 \text{ psi}
 \end{aligned}$$

The maximum allowable working pressure (MAWP) is [1,540.53](#) psi.

**Design thickness for external pressure, (Corroded at 140 °F) UG-33(d)**

Equivalent outside spherical radius ( $R_o$ )

$$\begin{aligned}
 R_o &= K_o \cdot D_o \\
 &= 0.8395 \cdot 48 \\
 &= 40.2954 \text{ in}
 \end{aligned}$$

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (40.2954 / 0.119274) \\
 &= 0.00037
 \end{aligned}$$

From Table HA-2:  $B = 5,067.5892$  psi

$$\begin{aligned}
 P_a &= B / (R_o / t) \\
 &= 5,067.5892 / (40.2954 / 0.1193) \\
 &= 15 \text{ psi}
 \end{aligned}$$

$$t = 0.1193" + \text{Corrosion} = 0.1193" + 0" = 0.1193"$$

Check the external pressure per UG-33(a)(1) Appendix 1-4(c)

$$\begin{aligned}
 t &= 1.67 \cdot P_e \cdot D_o \cdot K / (2 \cdot S \cdot E + 2 \cdot 1.67 \cdot P_e \cdot (K - 0.1)) + \text{Corrosion} \\
 &= 1.67 \cdot 15 \cdot 48 \cdot 1 / (2 \cdot 20,000 \cdot 1 + 2 \cdot 1.67 \cdot 15 \cdot (1 - 0.1)) + 0 \\
 &= 0.03"
 \end{aligned}$$

The head external pressure design thickness ( $t_e$ ) is [0.1193](#)".

**Maximum Allowable External Pressure, (Corroded at 140 °F) UG-33(d)**

Equivalent outside spherical radius ( $R_o$ )

$$\begin{aligned}
 R_o &= K_o \cdot D_o \\
 &= 0.8395 \cdot 48 \\
 &= 40.2954 \text{ in}
 \end{aligned}$$

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (40.2954 / 1.73) \\
 &= 0.005367
 \end{aligned}$$

From Table HA-2:  $B = 13,183.56$  psi

$$\begin{aligned}
 P_a &= B / (R_o / t) \\
 &= 13,183.56 / (40.2954 / 1.73) \\
 &= 566.0093 \text{ psi}
 \end{aligned}$$

**Check the Maximum External Pressure, UG-33(a)(1) Appendix 1-4(c)**

$$\begin{aligned}
 P &= 2 * S * E * t / ((K * D_o - 2 * t * (K - 0.1)) * 1.67) - P_{s2} \\
 &= 2 * 20,000 * 1 * 1.73 / ((1 * 48 - 2 * 1.73 * (1 - 0.1)) * 1.67) - 0 \\
 &= 923.16 \text{ psi}
 \end{aligned}$$

The maximum allowable external pressure (MAEP) is [566.01](#) psi.

**% Forming strain - UHA-44(a)(2)(b)**

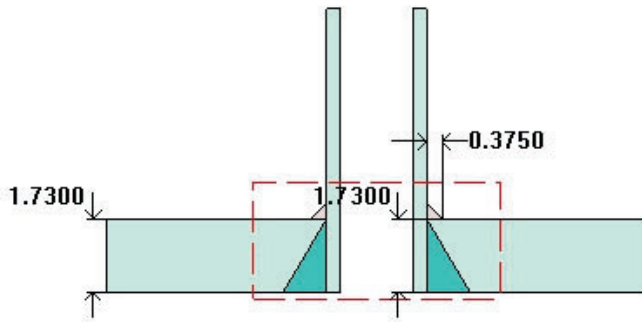
$$\begin{aligned}
 EFE &= (75 * t / R_i) * (1 - R_i / R_o) \\
 &= (75 * 1.77 / 8.4568) * (1 - 8.4568 / \infty) \\
 &= 15.6974\%
 \end{aligned}$$

## Bottom Drain (N13)

ASME Section VIII Division 1, 2010 Edition, A11 Addenda

$$t_{w(\text{lower})} = 1.73 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

### Location and Orientation

Located on:	48 OD BOTTOM SE HEAD
Orientation:	315°
End of nozzle to datum line:	119.1092 in
Calculated as hillside:	No
Distance to head center, R:	0 in
Passes through a Category A joint:	No

### Nozzle

Access opening:	No
Material specification:	SA-312 TP316L Smls pipe (low stress) (II-D p. 66, In. 40)
Description:	NPS 2 Sch 160
Inside diameter, new:	1.687 in
Nominal wall thickness:	0.344 in
Corrosion allowance:	0 in
Projection available outside vessel, L <sub>pr</sub> :	4.01 in
Projection available outside vessel to flange face, L <sub>f</sub> :	8.26 in
Local vessel minimum thickness:	1.73 in
Liquid static head included:	1.4842 psi
Longitudinal joint efficiency:	1

### ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 WN A182 F316
Bolt Material:	SA-193 B7 Bolt ≤ 2 1/2 (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55 °F
(Per UHA-51(d)(1)(a))	
(Flange rated MDMT = -320 °F)	
Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F)	
Liquid static head:	1.5529 psi

MAWP rating:	2,040 psi @ 140°F
MAP rating:	2,160 psi @ 50°F
Hydrotest rating:	3,250 psi @ 50°F
PWHT performed:	No
Circumferential joint radiography:	Full UW-11(a) Type 1

## Reinforcement Calculations for Chamber MAWP

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For P = 1,379.48 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary (in)</b> The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.1348</a>	0.301	

<b>UG-41 Weld Failure Path Analysis Summary</b>
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 <sub>41</sub> )	<a href="#">0.2408</a>	0.2625	weld size is adequate

### Calculations for internal pressure 1,379.48 psi @ 140 °F

Nozzle Impact test exempt per UHA-51(g)(coincident ratio = 0.2436).

#### Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(1.687, 0.8435 + (0.344 - 0) + (1.73 - 0)) \\
 &= 2.9175 \text{ in}
 \end{aligned}$$

#### Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.73 - 0), 2.5*(0.344 - 0) + 0) \\
 &= 0.86 \text{ in}
 \end{aligned}$$

#### Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,379.4842 \cdot 0.8435 / (15,700 \cdot 1 - 0.6 \cdot 1,379.4842) \\
 &= 0.0782 \text{ in}
 \end{aligned}$$

#### Required thickness t<sub>r</sub> from UG-37(a)(c)

$$\begin{aligned}
 t_r &= P \cdot K_1 \cdot D_o / (2 \cdot S \cdot E + 0.8 \cdot P) \\
 &= 1,379.4842 \cdot 0.9 \cdot 48 / (2 \cdot 20,000 \cdot 1 + 0.8 \cdot 1,379.4842) \\
 &= 1.4498 \text{ in}
 \end{aligned}$$

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

### UW-16(c) Weld Check

Fillet weld:  $t_{\min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.344 \text{ in}$

$t_{c(\min)} = \text{lesser of } 0.25 \text{ or } 0.7*t_{\min} = 0.2408 \text{ in}$

$t_{c(\text{actual})} = 0.7*\text{Leg} = 0.7*0.375 = 0.2625 \text{ in}$

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

Interpretation VIII-1-83-66 has been applied.

$$\begin{aligned}t_{a \text{ UG-27}} &= P*R / (S*E - 0.6*P) + \text{Corrosion} \\ &= 1,379.5529*0.8435 / (15,700*1 - 0.6*1,379.5529) + 0 \\ &= 0.0782 \text{ in}\end{aligned}$$

$$\begin{aligned}t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0782, 0 ] \\ &= 0.0782 \text{ in}\end{aligned}$$

$$t_{b1} = 1.5586 \text{ in}$$

$$\begin{aligned}t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.5586, 0.0625 ] \\ &= 1.5586 \text{ in}\end{aligned}$$

$$\begin{aligned}t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.1348, 1.5586 ] \\ &= 0.1348 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0782, 0.1348 ] \\ &= 0.1348 \text{ in}\end{aligned}$$

Available nozzle wall thickness new,  $t_n = 0.875*0.344 = 0.301 \text{ in}$

The nozzle neck thickness is adequate.

**Reinforcement Calculations for MAEP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For Pe = 566.01 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary (in)</b> The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.1348</a>	0.301	

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.2408</a>	0.2625	weld size is adequate

**Calculations for external pressure 566.01 psi @ 140 °F**

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(1.687, 0.8435 + (0.344 - 0) + (1.73 - 0)) \\
 &= 2.9175 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.73 - 0), 2.5*(0.344 - 0) + 0) \\
 &= 0.86 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-28 t<sub>m</sub> = 0.0949 in**

**From UG-37(d)(1) required thickness t<sub>r</sub> = 1.73 in**

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

**UW-16(c) Weld Check**

Fillet weld: t<sub>min</sub> = lesser of 0.75 or t<sub>n</sub> or t = 0.344 in  
t<sub>c(min)</sub> = lesser of 0.25 or 0.7\*t<sub>min</sub> = [0.2408](#) in  
t<sub>c(actual)</sub> = 0.7\*Leg = 0.7\*0.375 = 0.2625 in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

Interpretation VIII-1-83-66 has been applied.

$$t_{a \text{ UG-28}} = 0.0949 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0949, 0 ] \\ &= 0.0949 \text{ in} \end{aligned}$$

$$t_{b2} = 0.6623 \text{ in}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2}, t_{b \text{ UG16}} ] \\ &= \max[ 0.6623, 0.0625 ] \\ &= 0.6623 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b2} ] \\ &= \min[ 0.1348, 0.6623 ] \\ &= 0.1348 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0949, 0.1348 ] \\ &= 0.1348 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 0.875 \cdot 0.344 = 0.301 \text{ in}$

The nozzle neck thickness is adequate.

### External Pressure, (Corroded & at 140 °F) UG-28(c)

$$\begin{aligned} L / D_o &= 8.26 / 2.375 = 3.4779 \\ D_o / t &= 2.375 / 0.0949 = 25.0382 \\ \text{From table G: } A &= 0.002711 \\ \text{From table HA-4: } B &= 10,628.92 \text{ psi} \end{aligned}$$

$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 10,628.92 / (3 \cdot (2.375 / 0.0949)) \\ &= 566.01 \text{ psi} \end{aligned}$$

### Design thickness for external pressure $P_a = 566.01 \text{ psi}$

$$t_a = t + \text{Corrosion} = 0.0949 + 0 = 0.0949''$$



### 46-3/4" OD Skirt

Material: SA-240 316 (II-D p. 70, In. 26)  
 Design temperature, operating: 140 °F  
 Design temperature, vacuum: 140 °F  
 Inner diameter at top, new: 45.75 in  
 Inner diameter at bottom, new: 45.75 in  
 Overall length (includes base ring thickness): 20 in  
 Corrosion allowance inside: 0 in  
 Corrosion allowance outside: 0 in  
 Weld joint efficiency top: 0.55  
 Weld joint efficiency bottom: 0.8  
 Nominal thickness, new: 0.5 in  
 Skirt is attached to: 48 OD BOTTOM SE HEAD  
 Skirt attachment offset: 5.88 in down from the top seam

**Skirt design thickness, largest of the following + corrosion = 0.0579 in**

The governing condition is due to earthquake, compressive stress at the base, operating & corroded.

The skirt thickness of 0.5 in is adequate.

Loading	Vessel Condition (Stress)	Governing Skirt Location	Temperature (°F)	Allowable Stress (psi)	Calculated Stress/E (psi)	Required thickness (in)
Wind	operating, corroded (+)	top	140	26,000	114.57	<u>0.0022</u>
Wind	operating, corroded (-)	bottom	140	15,798.24	606.74	<u>0.0192</u>
Wind	empty, corroded (+)	top	50	26,000	154.67	<u>0.003</u>
Wind	empty, corroded (-)	bottom	50	16,049.74	584.68	<u>0.0182</u>
Wind	vacuum, corroded (+)	top	140	26,000	114.57	<u>0.0022</u>
Wind	vacuum, corroded (-)	bottom	140	15,798.24	606.74	<u>0.0192</u>
Seismic	operating, corroded (+)	top	140	26,000	1,437.7	<u>0.0276</u>
Seismic	operating, corroded (-)	bottom	140	15,798.24	1,827.93	<u>0.0579</u>
Seismic	empty, corroded (+)	top	50	26,000	1,402.29	<u>0.027</u>
Seismic	empty, corroded (-)	bottom	50	16,049.74	1,723.22	<u>0.0537</u>
Seismic	vacuum, corroded (+)	top	140	26,000	1,437.7	<u>0.0276</u>
Seismic	vacuum, corroded (-)	bottom	140	15,798.24	1,827.93	<u>0.0579</u>

### Loading due to wind, operating & corroded

#### Windward side (tensile)

**Required thickness, tensile stress at base:**

$$\begin{aligned}
 t &= -W / (\pi * D * S_t * E) + 48 * M / (\pi * D^2 * S_t * E) \\
 &= -19,538.66 / (\pi * 46.25 * 26,000 * 0.8) + 48 * 23,645.6 / (\pi * 46.25^2 * 26,000 * 0.8) \\
 &= 0.0017 \text{ in}
 \end{aligned}$$

**Required thickness, tensile stress at the top:**

$$\begin{aligned}t &= -W_t / (\pi * D_t * S_t * E) + 48 * M_t / (\pi * D_t^2 * S_t * E) \\&= -19,078.33 / (\pi * 46.25 * 26,000 * 0.55) + 48 * 22,793.7 / (\pi * 46.25^2 * 26,000 * 0.55) \\&= \underline{0.0022} \text{ in}\end{aligned}$$

**Leeward side (compressive)**

**Required thickness, compressive stress at base:**

$$\begin{aligned}t &= W / (\pi * D * S_c * E_c) + 48 * M / (\pi * D^2 * S_c * E_c) \\&= 19,538.66 / (\pi * 46.25 * 15,798 * 1) + 48 * 23,645.6 / (\pi * 46.25^2 * 15,798 * 1) \\&= \underline{0.0192} \text{ in}\end{aligned}$$

**Required thickness, compressive stress at the top:**

$$\begin{aligned}t &= W_t / (\pi * D_t * S_c * E_c) + 48 * M_t / (\pi * D_t^2 * S_c * E_c) \\&= 19,078.33 / (\pi * 46.25 * 15,798 * 1) + 48 * 22,793.7 / (\pi * 46.25^2 * 15,798 * 1) \\&= \underline{0.0186} \text{ in}\end{aligned}$$

## **Loading due to wind, empty & corroded**

**Windward side (tensile)**

**Required thickness, tensile stress at base:**

$$\begin{aligned}t &= -W / (\pi * D * S_t * E) + 48 * M / (\pi * D^2 * S_t * E) \\&= -17,936.17 / (\pi * 46.25 * 26,000 * 0.8) + 48 * 23,645.6 / (\pi * 46.25^2 * 26,000 * 0.8) \\&= \underline{0.0022} \text{ in}\end{aligned}$$

**Required thickness, tensile stress at the top:**

$$\begin{aligned}t &= -W_t / (\pi * D_t * S_t * E) + 48 * M_t / (\pi * D_t^2 * S_t * E) \\&= -17,475.84 / (\pi * 46.25 * 26,000 * 0.55) + 48 * 22,793.7 / (\pi * 46.25^2 * 26,000 * 0.55) \\&= \underline{0.003} \text{ in}\end{aligned}$$

**Leeward side (compressive)**

**Required thickness, compressive stress at base:**

$$\begin{aligned}t &= W / (\pi * D * S_c * E_c) + 48 * M / (\pi * D^2 * S_c * E_c) \\&= 17,936.17 / (\pi * 46.25 * 16,050 * 1) + 48 * 23,645.6 / (\pi * 46.25^2 * 16,050 * 1) \\&= \underline{0.0182} \text{ in}\end{aligned}$$

**Required thickness, compressive stress at the top:**

$$\begin{aligned}t &= W_t / (\pi * D_t * S_c * E_c) + 48 * M_t / (\pi * D_t^2 * S_c * E_c) \\&= 17,475.84 / (\pi * 46.25 * 16,050 * 1) + 48 * 22,793.7 / (\pi * 46.25^2 * 16,050 * 1) \\&= \underline{0.0176} \text{ in}\end{aligned}$$

## Loading due to wind, vacuum & corroded

### Windward side (tensile)

Required thickness, tensile stress at base:

$$\begin{aligned}t &= -W / (\pi * D * S_t * E) + 48 * M / (\pi * D^2 * S_t * E) \\&= -19,538.66 / (\pi * 46.25 * 26,000 * 0.8) + 48 * 23,645.6 / (\pi * 46.25^2 * 26,000 * 0.8) \\&= \underline{0.0017} \text{ in}\end{aligned}$$

Required thickness, tensile stress at the top:

$$\begin{aligned}t &= -W_t / (\pi * D_t * S_t * E) + 48 * M_t / (\pi * D_t^2 * S_t * E) \\&= -19,078.33 / (\pi * 46.25 * 26,000 * 0.55) + 48 * 22,793.7 / (\pi * 46.25^2 * 26,000 * 0.55) \\&= \underline{0.0022} \text{ in}\end{aligned}$$

### Leeward side (compressive)

Required thickness, compressive stress at base:

$$\begin{aligned}t &= W / (\pi * D * S_c * E_c) + 48 * M / (\pi * D^2 * S_c * E_c) \\&= 19,538.66 / (\pi * 46.25 * 15,798 * 1) + 48 * 23,645.6 / (\pi * 46.25^2 * 15,798 * 1) \\&= \underline{0.0192} \text{ in}\end{aligned}$$

Required thickness, compressive stress at the top:

$$\begin{aligned}t &= W_t / (\pi * D_t * S_c * E_c) + 48 * M_t / (\pi * D_t^2 * S_c * E_c) \\&= 19,078.33 / (\pi * 46.25 * 15,798 * 1) + 48 * 22,793.7 / (\pi * 46.25^2 * 15,798 * 1) \\&= \underline{0.0186} \text{ in}\end{aligned}$$

## Loading due to earthquake, operating & corroded

### Tensile side

Required thickness, tensile stress at base:

$$\begin{aligned}t &= -W / (\pi * D * S_t * E) + 48 * M / (\pi * D^2 * S_t * E) \\&= -19,538.66 / (\pi * 46.25 * 26,000 * 0.8) + 48 * 90,303.6 / (\pi * 46.25^2 * 26,000 * 0.8) \\&= \underline{0.0245} \text{ in}\end{aligned}$$

Required thickness, tensile stress at the top:

$$\begin{aligned}t &= -W_t / (\pi * D_t * S_t * E) + 48 * M_t / (\pi * D_t^2 * S_t * E) \\&= -19,078.33 / (\pi * 46.25 * 26,000 * 0.55) + 48 * 73,734.6 / (\pi * 46.25^2 * 26,000 * 0.55) \\&= \underline{0.0276} \text{ in}\end{aligned}$$

## Compressive side

Required thickness, compressive stress at base:

$$\begin{aligned}t &= (1 + V_{\text{Accel}}) * W / (\pi * D * S_c * E_c) + 48 * M / (\pi * D^2 * S_c * E_c) \\&= (1 + 1) * 19,538.66 / (\pi * 46.25 * 15,798 * 1) + 48 * 90,303.6 / (\pi * 46.25^2 * 15,798 * 1) \\&= \underline{0.0579} \text{ in}\end{aligned}$$

Required thickness, compressive stress at the top:

$$\begin{aligned}t &= (1 + V_{\text{Accel}}) * W_t / (\pi * D_t * S_c * E_c) + 48 * M_t / (\pi * D_t^2 * S_c * E_c) \\&= (1 + 1) * 19,078.33 / (\pi * 46.25 * 15,798 * 1) + 48 * 73,734.6 / (\pi * 46.25^2 * 15,798 * 1) \\&= \underline{0.05} \text{ in}\end{aligned}$$

## Loading due to earthquake, empty & corroded

### Tensile side

Required thickness, tensile stress at base:

$$\begin{aligned}t &= -W / (\pi * D * S_t * E) + 48 * M / (\pi * D^2 * S_t * E) \\&= -17,936.17 / (\pi * 46.25 * 26,000 * 0.8) + 48 * 86,062.1 / (\pi * 46.25^2 * 26,000 * 0.8) \\&= \underline{0.0236} \text{ in}\end{aligned}$$

Required thickness, tensile stress at the top:

$$\begin{aligned}t &= -W_t / (\pi * D_t * S_t * E) + 48 * M_t / (\pi * D_t^2 * S_t * E) \\&= -17,475.84 / (\pi * 46.25 * 26,000 * 0.55) + 48 * 70,827.3 / (\pi * 46.25^2 * 26,000 * 0.55) \\&= \underline{0.027} \text{ in}\end{aligned}$$

### Compressive side

Required thickness, compressive stress at base:

$$\begin{aligned}t &= (1 + V_{\text{Accel}}) * W / (\pi * D * S_c * E_c) + 48 * M / (\pi * D^2 * S_c * E_c) \\&= (1 + 1) * 17,936.17 / (\pi * 46.25 * 16,050 * 1) + 48 * 86,062.1 / (\pi * 46.25^2 * 16,050 * 1) \\&= \underline{0.0537} \text{ in}\end{aligned}$$

Required thickness, compressive stress at the top:

$$\begin{aligned}t &= (1 + V_{\text{Accel}}) * W_t / (\pi * D_t * S_c * E_c) + 48 * M_t / (\pi * D_t^2 * S_c * E_c) \\&= (1 + 1) * 17,475.84 / (\pi * 46.25 * 16,050 * 1) + 48 * 70,827.3 / (\pi * 46.25^2 * 16,050 * 1) \\&= \underline{0.0465} \text{ in}\end{aligned}$$

## Loading due to earthquake, vacuum & corroded

## Tensile side

### Required thickness, tensile stress at base:

$$\begin{aligned}t &= -W / (\pi * D_t * S_t * E) + 48 * M / (\pi * D_t^2 * S_t * E) \\&= -19,538.66 / (\pi * 46.25 * 26,000 * 0.8) + 48 * 90,303.6 / (\pi * 46.25^2 * 26,000 * 0.8) \\&= \underline{0.0245} \text{ in}\end{aligned}$$

### Required thickness, tensile stress at the top:

$$\begin{aligned}t &= -W_t / (\pi * D_t * S_t * E) + 48 * M_t / (\pi * D_t^2 * S_t * E) \\&= -19,078.33 / (\pi * 46.25 * 26,000 * 0.55) + 48 * 73,734.6 / (\pi * 46.25^2 * 26,000 * 0.55) \\&= \underline{0.0276} \text{ in}\end{aligned}$$

## Compressive side

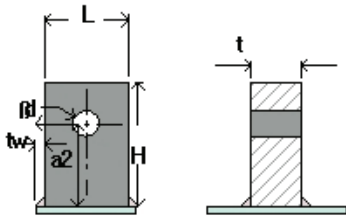
### Required thickness, compressive stress at base:

$$\begin{aligned}t &= (1 + V_{\text{Accel}}) * W / (\pi * D_t * S_c * E_c) + 48 * M / (\pi * D_t^2 * S_c * E_c) \\&= (1 + 1) * 19,538.66 / (\pi * 46.25 * 15,798 * 1) + 48 * 90,303.6 / (\pi * 46.25^2 * 15,798 * 1) \\&= \underline{0.0579} \text{ in}\end{aligned}$$

### Required thickness, compressive stress at the top:

$$\begin{aligned}t &= (1 + V_{\text{Accel}}) * W_t / (\pi * D_t * S_c * E_c) + 48 * M_t / (\pi * D_t^2 * S_c * E_c) \\&= (1 + 1) * 19,078.33 / (\pi * 46.25 * 15,798 * 1) + 48 * 73,734.6 / (\pi * 46.25^2 * 15,798 * 1) \\&= \underline{0.05} \text{ in}\end{aligned}$$

## Tail lug



### Geometry Inputs

Attached To	46-3/4" OD Skirt
Material	A36
Orientation	Longitudinal
Distance of Lift Point From Datum	118.38"
Angular Position	225.00 °
Length of Lug, L	5"
Height of Lug, H	7.5"
Thickness of Lug, t	1.5"
Hole Diameter, d	1.5625"
Pin Diameter, Dp	1.5"
Load Eccentricity, a <sub>1</sub>	0"
Distance from Load to Shell or Pad, a <sub>2</sub>	5"
Weld Size, t <sub>w</sub>	0.625"
Load Angle Normal to Vessel, β	90.0000 °
Load Angle from Vertical, φ	0.0000 °

### Intermediate Values

Load Factor	1.5000
Vessel Weight (new, incl. Load Factor), W	27406 lb
Lug Weight (new), $W_{lug}$	16 lb
Distance from Center of Gravity to Top Lug, $l_1$	70.4868"
Distance from Center of Gravity to Tail Lug, $l_2$	61.8933"
Distance from Vessel Center Line to Tail Lug, $l_3$	28.375"
Allowable Stress, Tensile, $\sigma_t$	19980 psi
Allowable Stress, Shear, $\sigma_s$	13320 psi
Allowable Stress, Bearing, $\sigma_p$	29970 psi
Allowable Stress, Bending, $\sigma_b$	22201 psi
Allowable Stress, Weld Shear, $\tau_{allowable}$	13320 psi
Allowable Stress set to 1/3 Sy per ASME B30.20	No

### Summary Values

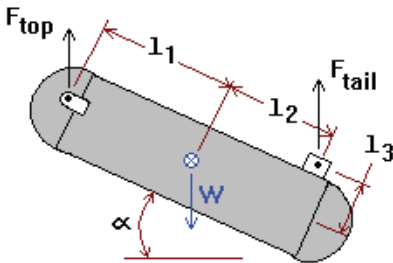
Required Lift Pin Diameter, $d_{reqd}$	<a href="#">0.8351"</a>
Required Lug Thickness, $t_{reqd}$	<a href="#">0.3246"</a>
Lug Stress Ratio, $\sigma_{ratio}$	<a href="#">0.37</a>
Weld Shear Stress Ratio, $\tau_{ratio}$	<a href="#">0.23</a>
Lug Design	Acceptable
Local Stresses	Acceptable
Base ring loading	Acceptable

### Lift Forces

Lift force on lugs during rotational lift ( $0^\circ \leq \alpha \leq 90^\circ$ ):

$$2 * F_{top} = W * (l_2 * \cos(\alpha) + l_3 * \sin(\alpha)) / (l_1 * \cos(\alpha) + l_2 * \cos(\alpha) + l_3 * \sin(\alpha))$$

$$F_{tail} = W - (2 * F)$$



$\alpha$ [°]	$F_{top}$ [lbf]	$F_{tail}$ [lbf]
0	6,407	14,592
15	6,803	13,800
30	7,210	12,985
45	7,694	12,017
60	8,382	10,642
75	9,649	8,107
90	13,703	0
54 <sup>1</sup>	8,069	11,268
0 <sup>2</sup>	6,407	14,592
<sup>1</sup> Lift angle at maximum lug stress.		
<sup>2</sup> Lift angle at maximum weld stress.		

### Lug Pin Diameter - Shear stress

$$d_{reqd} = (2 \cdot F_r / (\pi \cdot \sigma_s))^{0.5}$$

$$= (2 \cdot 14,592 / (\pi \cdot 13,320))^{0.5} = \underline{0.8351"}$$

$$d_{reqd} / D_p = 0.8351 / 1.5 = 0.56 \quad \text{Acceptable}$$

$$\sigma = F_r / A$$

$$= F_r / (2 \cdot (0.25 \cdot \pi \cdot D_p^2))$$

$$= 14,592 / (2 \cdot (0.25 \cdot \pi \cdot 1.5^2)) = 4,129 \text{ psi}$$

$$\sigma / \sigma_s = 4,129 / 13,320 = 0.31 \quad \text{Acceptable}$$

### Lug Thickness - Tensile stress

$$t_{reqd} = F_r / ((L - d) \cdot \sigma_t)$$

$$= 14,592 / ((5 - 1.5625) \cdot 19,980) = 0.2125"$$

$$t_{reqd} / t = 0.2125 / 1.5 = 0.14 \quad \text{Acceptable}$$

$$\sigma = F_r / A$$

$$= F_r / ((L - d) \cdot t)$$

$$= 14,592 / ((5 - 1.5625) \cdot 1.5) = 2,830 \text{ psi}$$

$$\sigma / \sigma_t = 2,830 / 19,980 = 0.14 \quad \text{Acceptable}$$

### Lug Thickness - Bearing stress

$$t_{reqd} = F_v / (D_p \cdot \sigma_p)$$

$$= 14,592 / (1.5 \cdot 29,970) = \underline{0.3246"}$$



$$t_{\text{reqd}} / t = 0.3246 / 1.5 = 0.22 \quad \text{Acceptable}$$

$$\begin{aligned} \sigma &= F_v / A_{\text{bearing}} \\ &= F_v / (D_p * t) \\ &= 14,592 / (1.5 * (1.5)) = 6,485 \text{ psi} \end{aligned}$$

$$\sigma / \sigma_p = 6,485 / 29,970 = 0.22 \quad \text{Acceptable}$$

### Lug Thickness - Shear stress

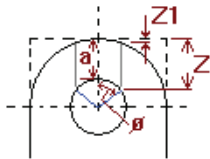
$$\begin{aligned} t_{\text{reqd}} &= [F_v / \sigma_s] / (2 * L_{\text{shear}}) \\ &= (14,592 / 13,320) / (2 * 2.0153) = \underline{0.2718"} \end{aligned}$$

$$t_{\text{reqd}} / t = 0.2718 / 1.5 = 0.18 \quad \text{Acceptable}$$

$$\begin{aligned} \tau &= F_v / A_{\text{shear}} \\ &= F_v / (2 * t * L_{\text{shear}}) \\ &= 14,592 / (2 * 1.5 * 2.0153) = 2,414 \text{ psi} \end{aligned}$$

$$\tau / \sigma_s = 2,414 / 13,320 = 0.18 \quad \text{Acceptable}$$

Shear stress length (per Pressure Vessel and Stacks, A. Keith Escoe)



$$\begin{aligned} \phi &= 55 * D_p / d \\ &= 55 * 1.5 / 1.5625 \\ &= 52.8^\circ \end{aligned}$$

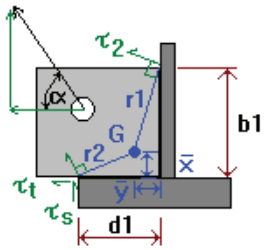
$$\begin{aligned} L_{\text{shear}} &= (H - a_2 - 0.5 * d) + 0.5 * D_p * (1 - \cos(\phi)) \\ &= (7.5 - 5 - 0.5 * 1.5625) + 0.5 * 1.5 * (1 - \cos(52.8)) \\ &= 2.0153" \end{aligned}$$

### Lug Plate Stress

Lug stress tensile + bending during lift:

$$\begin{aligned} \sigma_{\text{ratio}} &= [F_{\text{ten}} / (A_{\text{ten}} * \sigma_t)] + [M_{\text{bend}} / (Z_{\text{bend}} * \sigma_b)] \leq 1 \\ &= [(F_{\text{tail}}(\alpha) * \cos(\alpha)) / (t * L * \sigma_t)] + [(6 * \text{abs}(F_{\text{tail}}(\alpha) * \sin(\alpha) * \text{Hght} - F_{\text{tail}}(\alpha) * \cos(\alpha) * a_1)) / (t * L^2 * \sigma_b)] \leq 1 \\ &= 11,268 * \cos(54.0) / (1.5 * 5 * 19,980) + 6 * \text{abs}(11,268 * \sin(54.0) * 5 - 11,268 * \cos(54.0) * 0) / (1.5 * 5^2 * 22,201) \\ &= \underline{0.37} \quad \text{Acceptable} \end{aligned}$$

## Weld Stress



Weld stress, tensile, bending and shear during lift:

Direct shear:

Maximum shear stress occurs at lift angle  $0.00^\circ$ ; lift force = 14,592 lbf

$$\begin{aligned} A_{\text{weld}} &= 2 * (0.707) * t_w * (b_1 + d_1 + t) \\ &= 2 * (0.707) * 0.625 * (5 + 4.625 + 1.5) = 9.8317 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} \tau_t &= F_{\text{tail}} * \cos(\alpha) / A_{\text{weld}} \\ &= 14,592 * \cos(0.0) / 9.8317 = 1,484 \text{ psi} \end{aligned}$$

$$\begin{aligned} \tau_s &= F_{\text{tail}} * \sin(\alpha) / A_{\text{weld}} \\ &= 14,592 * \sin(0.0) / 9.8317 = 0 \text{ psi} \end{aligned}$$

Torsional shear:

Weld areas

$$\begin{aligned} A_i &= 0.707 * t_w * L_i \\ A_1 &= 0.707 * 0.625 * 4.625 = 2.0437 \text{ in}^2 \\ A_2 &= 0.707 * 0.625 * 5 = 2.2094 \text{ in}^2 \\ A_{\text{weld torsion}} &= \sum A_i = 4.253 \text{ in}^2 \end{aligned}$$

Weld centroid locations

$$\begin{aligned} x_1 &= 0" \\ y_1 &= 2.3125" \\ x_2 &= 2.5" \\ y_2 &= 0" \\ X_{\text{bar}} &= \frac{\sum (A_i * x_i)}{\sum A_i} \\ Y_{\text{bar}} &= \frac{\sum (A_i * y_i)}{\sum A_i} \\ X_{\text{bar}} &= \frac{(2.0437 * 0 + 2.2094 * 2.5)}{4.253} = 1.2987" \\ Y_{\text{bar}} &= \frac{(2.0437 * 2.3125 + 2.2094 * 0)}{4.253} = 1.1112" \end{aligned}$$

Radius to centroid locations

$$\begin{aligned} r_i &= \text{sqr}((X_{\text{bar}} - x_i)^2 + (Y_{\text{bar}} - y_i)^2) \\ r_1 &= \text{sqr}((1.2987 - 0)^2 + (1.1112 - 2.3125)^2) = 1.7691" \\ r_2 &= \text{sqr}((1.2987 - 2.5)^2 + (1.1112 - 0)^2) = 1.6364" \end{aligned}$$

**Radial distance from centroid to weld:**

$$r = \text{sqr}(\Delta X^2 + \Delta Y^2)$$

$$= \text{sqr}(3.7013^2 + 1.1112^2) = 3.8645''$$

$$\theta_r = \text{arctan}(\Delta Y / \Delta X)$$

$$= \text{arctan}(1.1112 / 3.7013) = 16.71^\circ$$

**Polar Moment of Area**

$$J_i = 0.707 \cdot t_w \cdot (L_i^3) / 12$$

$$J_1 = 0.707 \cdot 0.625 \cdot (4.625^3) / 12 = 3.643 \text{ in}^4$$

$$J_2 = 0.707 \cdot 0.625 \cdot (5^3) / 12 = 4.6029 \text{ in}^4$$

$$J = 2 \cdot \Sigma (J_i + A_i \cdot r_i^2) \quad \text{Parallel axis theorem (weld on both sides of lug)}$$

$$J = 2 \cdot [3.6430 + 2.0437 \cdot (1.7691)^2 + 4.6029 + 2.2094 \cdot (1.6364)^2] = 41.12 \text{ in}^4$$

**Secondary shear**

$$\tau_2 = M \cdot r / J$$

$$= [F(\alpha) \cdot \cos(\alpha) \cdot (X - X_{\text{bar}}) - F(\alpha) \cdot \sin(\alpha) \cdot (Y - Y_{\text{bar}})] \cdot r / J$$

$$= (14,592 \cdot \cos(0.0) \cdot (2.5 - 1.2987) - 14,592 \cdot \sin(0.0) \cdot (5 - 1.1112)) \cdot 3.8645 / 41.1169$$

$$= 1,648 \text{ psi}$$

$$\tau_{\text{ratio}} = \text{sqr}(\tau_t + \tau_2 \cdot \cos(\theta_r))^2 + (\tau_s + \tau_2 \cdot \sin(\theta_r))^2 / \tau_{\text{allowable}} \leq 1$$

$$= \text{sqr}((1,484 + 1,648 \cdot \cos(16.71))^2 + (0 + 1,648 \cdot \sin(16.71))^2) / 13,320$$

$$= \underline{0.23} \quad \text{Acceptable}$$

**WRC 107 Analysis****Geometry**

Height(radial):	7.5"	
Width (circumferential):	1.5"	
Length	5"	
Fillet Weld Size:	0.625"	
Located on:	46-3/4" OD Skirt	(1" from bottom end)
Location Angle:	225.00°	

**Applied Loads**

Maximum stress ratio occurs at lift angle = 29.00° with lift force = 13,043 lbf

Radial load:	$P_r = -11,407.38 \text{ lb}_f$
Circumferential moment:	$M_c = 0 \text{ lb}_f\text{-in}$
Circumferential shear:	$V_c = 0 \text{ lb}_f$
Longitudinal moment:	$M_L = 31,616.06 \text{ lb}_f\text{-in}$
Longitudinal shear:	$V_L = 6,323.21 \text{ lb}_f$
Torsion moment:	$M_t = 0 \text{ lb}_f\text{-in}$
Internal pressure:	$P = 0 \text{ psi}$

Mean shell radius:  $R_m = 23.125$  in  
Shell yield stress:  $S_y = 30,000$  psi

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

$$R_m / t = 23.125 / 0.5 = 46.25$$

$$C_1 = 1.375, C_2 = 3.125 \text{ in}$$

$$\text{Local circumferential pressure stress} = P \cdot R_i / t = 0 \text{ psi}$$

$$\text{Local longitudinal pressure stress} = P \cdot R_i / (2 \cdot t) = 0 \text{ psi}$$

$$\text{Maximum combined stress } (P_L + P_b + Q) = 58,761 \text{ psi}$$

$$\text{Allowable combined stress } (P_L + P_b + Q) = \pm 3 \cdot S = \pm 60,000 \text{ psi}$$

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

$$\text{Maximum local primary membrane stress } (P_L) = 12,675 \text{ psi}$$

$$\text{Allowable local primary membrane stress } (P_L) = \pm 1.5 \cdot S = \pm 30,000 \text{ psi}$$

The maximum local primary membrane stress  $(P_L)$  is within allowable limits.

Stresses at the lug edge per WRC Bulletin 107										
Figure	value	$\beta$	$A_u$	$A_l$	$B_u$	$B_l$	$C_u$	$C_l$	$D_u$	$D_l$
3C*	6.2981	0.1218	0	0	0	0	6,214	6,214	6,214	6,214
4C*	7.9394	0.103	7,833	7,833	7,833	7,833	0	0	0	0
1C	0.1384	0.0816	0	0	0	0	37,891	-37,891	37,891	-37,891
2C-1	0.1025	0.0816	28,062	-28,062	28,062	-28,062	0	0	0	0
3A*	1.2068	0.0782	0	0	0	0	0	0	0	0
1A	0.0982	0.0876	0	0	0	0	0	0	0	0
3B*	5.1811	0.1028	-4,842	-4,842	4,842	4,842	0	0	0	0
1B-1	0.046	0.094	-16,062	16,062	16,062	-16,062	0	0	0	0
Pressure stress*			0	0	0	0	0	0	0	0
Total circumferential stress			14,991	-9,009	56,799	-31,449	44,105	-31,677	44,105	-31,677
Primary membrane circumferential stress*			2,991	2,991	12,675	12,675	6,214	6,214	6,214	6,214
3C*	6.8994	0.103	6,807	6,807	6,807	6,807	0	0	0	0
4C*	7.6302	0.1218	0	0	0	0	7,528	7,528	7,528	7,528
1C-1	0.1162	0.1064	31,813	-31,813	31,813	-31,813	0	0	0	0
2C	0.0787	0.1064	0	0	0	0	21,546	-21,546	21,546	-21,546
4A*	1.6353	0.0782	0	0	0	0	0	0	0	0
2A	0.0504	0.109	0	0	0	0	0	0	0	0
4B*	1.4724	0.1028	-2,073	-2,073	2,073	2,073	0	0	0	0
2B-1	0.0631	0.1146	-18,068	18,068	18,068	-18,068	0	0	0	0
Pressure stress*			0	0	0	0	0	0	0	0
Total longitudinal stress			18,479	-9,011	58,761	-41,001	29,074	-14,018	29,074	-14,018
Primary membrane longitudinal stress*			4,734	4,734	8,880	8,880	7,528	7,528	7,528	7,528
Shear from $M_t$			0	0	0	0	0	0	0	0
Circ shear from $V_c$			0	0	0	0	0	0	0	0
Long shear from $V_L$			0	0	0	0	-1,012	-1,012	1,012	1,012
Total Shear stress			0	0	0	0	-1,012	-1,012	1,012	1,012
Combined stress ( $P_L+P_B+Q$ )			18,479	-9,011	58,761	-41,001	44,173	-31,735	44,173	-31,735

Note: \* denotes primary stress.

### Base Ring Sectional Properties

$t_1$	0.5"	$L_1$	2.6523"	
$t_2$	1"	$L_{2a}$	4.625"	
		$L_{2b}$	2.375"	
Base Ring Geometry				

Effective skirt length:

$$\begin{aligned}
 R_m &= (D_i + t_1) \cdot 0.5 \\
 &= (45.75 + 0.5) \cdot 0.5 = 23.125" \\
 L_1 &= \text{Min}(0.78 \cdot \text{sqr}(R_m \cdot t_1), 16 \cdot t_1) \\
 &= 0.78 \cdot \text{sqr}(23.125 \cdot 0.5) = 2.6523"
 \end{aligned}$$

Section Area:

$$A_1 = t_1 * L_1 = 0.5 * 2.6523 = 1.3261 \text{ in}^2$$

$$A_2 = t_2 * L_2 = 1 * (4.625 + 2.375) = 7 \text{ in}^2$$

$$A_{\text{total}} = A_1 + A_2 = 1.3261 + 7 = 8.3261 \text{ in}^2$$

Centroid, C:

$$h_1 = L_{2a} + 0.5 * t_1 = 4.625 + 0.5 * 0.5 = 4.875''$$

$$h_2 = 0.5 * (L_{2a} + L_{2b}) = 0.5 * (4.625 + 2.375) = 3.5''$$

$$C = ((A_1 * h_1) + (A_2 * h_2)) / A_{\text{total}} \\ = ((1.3261 * 4.875) + (7 * 3.5)) / 8.3261 = 3.719''$$

Moment of Inertia, I:

$$I_1 = (L_1 * t_1^3) / 12 + A_1 * (h_1 - C)^2 \\ = (2.6523 * 0.5^3) / 12 + 1.3261 * (4.875 - 3.719)^2 = 1.8 \text{ in}^4$$

$$I_2 = t_2 * (L_{2a} + L_{2b})^3 / 12 + A_2 * (h_2 - C)^2 \\ = 1 * (4.625 + 2.375)^3 / 12 + 7 * (3.5 - 3.719)^2 = 28.9 \text{ in}^4$$

$$I_{\text{ring}} = I_1 + I_2 \\ = 1.7998 + 28.9191 = 30.7 \text{ in}^4$$

Section Modulus, Z:

$$Z = I_{\text{ring}} / C_{\text{max}} = 30.7189 / 3.719 = 8.260 \text{ in}^3$$

### Base Ring Loads without stiffener beam

Base Ring Load

$$W_r = W = F_{\text{tail}} = 14,592 \text{ lbf}$$

### Base Ring Loading

Reference: Roark's Formulas for Stress & Strain - 6th Edition. Table 17, Case 20

For thin ring sections  $k_1 = k_2 = 1$

$$\text{Change in vertical diameter, } D_V = (-W) * R^3 * (\pi * k_1 / 8 - k_2^2 / \pi) / (E * I)$$

$$\text{Internal Moment, } M_A = W * R * (k_2 - 0.5) / (2 * \pi)$$

$$\text{Internal Force, } N_A = 0.75 * W / \pi$$

$$\text{Internal Shear Force, } V_A = 0$$

$$\text{Ring loading, } W_r = 14,592 \text{ lbf}$$

$$D_{Vr} = -14,592 * 24.281^3 * (\pi * 1 / 8 - 1^2 / \pi) / (29,000,000 * 30.7189) = -0.0174''$$

$$M_{Ar} = 14,592 * 24.281 * (1 - 0.5) / (2 * \pi) = 28195.5728 \text{ lbf-in}$$

$$N_{Ar} = 0.75 * 14,592 / \pi = 3,484 \text{ lbf}$$

Load Equations

$$LT_M = W * R * (1 - \cos(x) - 0.5 * x * \sin(x)) / \pi$$

$$LT_N = -W * (x * \sin(x)) / (2 * \pi)$$

$$LT_V = W * (\sin(x) - x * \cos(x)) / (2 * \pi)$$

$$M = M_A - N_A * R * (1 - \cos(x)) + V_A * R * \sin(x) + LT_M$$

$$N = N_A * \cos(x) + V_A * \sin(x) + LT_N$$

$$V = -N_A * \sin(x) + V_A * \cos(x) + LT_V$$

**Load Table for Load  $W_r$**

$x$ [°]	$LT_M$ [in-lbf]	$LT_N$ [lbf]	$LT_V$ [lbf]	$M$ [in-lbf]	$N$ [lbf]	$V$ [lbf]
180	0.00	-0.00	0.00	28195.57	3483.66	0.00
150	346.79	-608.01	108.11	17209.90	2408.92	-1633.72
120	5250.03	-2106.22	795.27	-8847.75	-364.39	-2221.67
90	24203.29	-3648.08	2322.44	-32187.86	-3648.08	-1161.22
60	66891.21	-4212.44	4443.34	-31793.29	-5954.27	1426.41
30	136638.78	-3040.07	6426.77	6993.39	-6057.00	4684.94
0	225564.58	-0.00	7296.16	84586.72	-3483.66	7296.16

(0 ° at lug)

**Maximum Stress in Base Ring Section**

Allowable Base Ring Stresses

$$F_a = 0.6 \cdot F_y = 21,600 \text{ psi}$$

$$F_b = 0.66 \cdot F_y = 23,760 \text{ psi}$$

$$F_s = 0.4 \cdot F_y = 14,400 \text{ psi}$$

Base Ring Stresses

Maximum combined stress occurs at 0.00 degrees

$$f_a = N / A = -3,484 / 8.3261 = -418 \text{ psi}$$

$$f_b = M / Z = 84,587 / 8.2600 = 10,241 \text{ psi}$$

$$f_a / F_a + f_b / F_b = 0.45 \quad \text{Acceptable}$$

Maximum shear stress occurs at 0.00 degrees

$$f_s = V / A = 7,296 / 8.3261 = 876 \text{ psi}$$

$$f_s / F_s = 0.06 \quad \text{Acceptable}$$

## Skirt Base Ring

Base configuration:	single base plate
Foundation compressive strength:	1,658 psi
Concrete ultimate 28-day strength:	3,000 psi
Anchor bolt material:	A-325
Anchor bolt allowable stress, $S_b$ :	20,000 psi
Bolt circle, BC:	51.25 in
Anchor bolt corrosion allowance (applied to root radius):	0 in
Anchor bolt clearance:	0.375 in
Base plate material:	SA-240 316
Base plate allowable stress, $S_p$ :	20,000 psi
Base plate inner diameter, $D_i$ :	42 in
Base plate outer diameter, $D_o$ :	56 in
Base plate thickness, $t_b$ :	1 in
Gusset separation, $w$ :	4 in
Gusset height, $h$ :	4.625 in
Gusset thickness, $t_g$ :	0.375 in
Initial bolt preload:	0 % (0 psi)
Number of bolts, $N$ :	8
Bolt size and type:	1.25 inch series 8 threaded
Bolt root area (corroded), $A_b$ :	0.929 in <sup>2</sup>
Diameter of anchor bolt holes, $d_b$ :	1.625 in

Load	Vessel condition	Base M (lb-ft)	W (lb)	Required bolt area (in <sup>2</sup> )	$t_r$ Base (in)	Foundation bearing stress (psi)
Wind	operating, corroded	23,645.6	19,872.9	<a href="#">0.0142</a>	<a href="#">0.3457</a>	<a href="#">42.81</a>
Wind	operating, new	23,645.6	19,872.9	<a href="#">0.0142</a>	<a href="#">0.3457</a>	<a href="#">42.81</a>
Wind	empty, corroded	23,645.6	18,270.4	<a href="#">0.0242</a>	<a href="#">0.3395</a>	<a href="#">41.3</a>
Wind	empty, new	23,645.6	18,270.4	<a href="#">0.0242</a>	<a href="#">0.3395</a>	<a href="#">41.3</a>
Wind	vacuum, corroded	23,645.6	19,872.9	<a href="#">0.0142</a>	<a href="#">0.3457</a>	<a href="#">42.81</a>
Seismic	operating, corroded	90,303.6	19,872.9	<a href="#">0.4044</a>	<a href="#">0.7867</a>	<a href="#">221.69</a>
Seismic	operating, new	90,303.6	19,872.9	<a href="#">0.4044</a>	<a href="#">0.7867</a>	<a href="#">221.69</a>
Seismic	empty, corroded	86,062.1	18,270.4	<a href="#">0.3896</a>	<a href="#">0.7649</a>	<a href="#">209.58</a>
Seismic	empty, new	86,062.1	18,270.4	<a href="#">0.3896</a>	<a href="#">0.7649</a>	<a href="#">209.58</a>
Seismic	vacuum, corroded	90,303.6	19,872.9	<a href="#">0.4044</a>	<a href="#">0.7867</a>	<a href="#">221.69</a>

### Anchor bolt load (operating, corroded + Wind)

$$\begin{aligned}
 P &= -W / N + 48 * M / (N*BC) \\
 &= -19,872.88 / 8 + 48 * 23,645.6 / (8*51.25) \\
 &= 284.16 \text{ lb}_f
 \end{aligned}$$

$$\text{Required area per bolt} = P / S_b = \underline{0.0142} \text{ in}^2$$

The area provided (0.929 in<sup>2</sup>) by the specified anchor bolt is adequate.

### Foundation bearing stress (operating, corroded + Wind)



$$\begin{aligned}
 A_c &= \pi(D_o^2 - D_i^2) / 4 - N\pi d_b^2 / 4 \\
 &= \pi(56^2 - 42^2) / 4 - 8\pi(1.625)^2 / 4 \\
 &= 1,060.9747 \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 I_c &= \pi(D_o^4 - D_i^4) / 64 \\
 &= \pi(56^4 - 42^4) / 64 \\
 &= 330,004.7 \text{ in}^4
 \end{aligned}$$

$$\begin{aligned}
 f_c &= N A_b \text{Preload} / A_c + W / A_c + 6 M D_o / I_c \\
 &= 8 \cdot 0.929 \cdot 0 / 1,060.9747 + 19,872.88 / 1,060.9747 + 6 \cdot 23,645.6 \cdot 56 / 330,004.7 \\
 &= 43 \text{ psi}
 \end{aligned}$$

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

#### Base plate required thickness (operating, corroded + Wind)

From Brownell & Young, Table 10.3:,  $l / b = 0.3008$

$$M_x = 0.007 \cdot 43 \cdot 15.3758^2 = 71.2 \text{ lb}_f$$

$$M_y = -0.435 \cdot 43 \cdot 4.625^2 = -398.3 \text{ lb}_f$$

$$\begin{aligned}
 t_r &= (6 M_{\max} / S_p)^{0.5} \\
 &= (6 \cdot 398.33 / 20,000)^{0.5} \\
 &= 0.3457 \text{ in}
 \end{aligned}$$

The base plate thickness is satisfactory.

#### Base plate bolt load (Jawad & Farr eq. 12.13, operating, corroded + Wind)

$$\text{Bolt load} = A_b \cdot f_s = 0.929 \cdot 306 = 284.16 \text{ lb}_f$$

$$\begin{aligned}
 t_r &= (3.91 \cdot F / (S_y \cdot (2 \cdot b / w + w / (2 \cdot l) - d_b \cdot (2 / w + 1 / (2 \cdot l))))))^{0.5} \\
 &= (3.91 \cdot 284.16 / (36,000 \cdot (2 \cdot 4.625 / 4 + 4 / (2 \cdot 2.25) - 1.625 \cdot (2 / 4 + 1 / (2 \cdot 2.25))))))^{0.5} \\
 &= 0.1234 \text{ in}
 \end{aligned}$$

The base plate thickness is satisfactory.

#### Check skirt for gusset reaction (Jawad & Farr eq. 12.14)

$$\begin{aligned}
 S_r &= 1.5 \cdot F \cdot b / (\text{gussets} \cdot \pi \cdot t_{sk}^2 \cdot h) \\
 &= 1.5 \cdot 284.16 \cdot 4.625 / (2 \cdot \pi \cdot 0.5^2 \cdot 4.625) \\
 &= 271.35 \text{ psi}
 \end{aligned}$$

As  $S_r \leq 30,000$  psi the skirt thickness is adequate to resist the gusset reaction.

#### Anchor bolt load (operating, new + Wind)

$$\begin{aligned}
 P &= -W / N + 48 \cdot M / (N \cdot BC) \\
 &= -19,872.88 / 8 + 48 \cdot 23,645.6 / (8 \cdot 51.25) \\
 &= 284.16 \text{ lb}_f
 \end{aligned}$$

$$\text{Required area per bolt} = P / S_b = 0.0142 \text{ in}^2$$

The area provided (0.929 in<sup>2</sup>) by the specified anchor bolt is adequate.

#### Foundation bearing stress (operating, new + Wind)

$$\begin{aligned}
 A_c &= \pi(D_o^2 - D_i^2) / 4 - N\pi d_b^2 / 4 \\
 &= \pi(56^2 - 42^2) / 4 - 8\pi(1.625)^2 / 4 \\
 &= 1,060.9747 \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 I_c &= \pi(D_o^4 - D_i^4) / 64 \\
 &= \pi(56^4 - 42^4) / 64 \\
 &= 330,004.7 \text{ in}^4
 \end{aligned}$$

$$\begin{aligned}
 f_c &= N A_b \text{Preload} / A_c + W / A_c + 6 M D_o / I_c \\
 &= 8 \cdot 0.929 \cdot 0 / 1,060.9747 + 19,872.88 / 1,060.9747 + 6 \cdot 23,645.6 \cdot 56 / 330,004.7 \\
 &= 43 \text{ psi}
 \end{aligned}$$

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

#### Base plate required thickness (operating, new + Wind)

From Brownell & Young, Table 10.3:  $l / b = 0.3008$

$$M_x = 0.007 \cdot 43 \cdot 15.3758^2 = 71.2 \text{ lb}_f$$

$$M_y = -0.435 \cdot 43 \cdot 4.625^2 = -398.3 \text{ lb}_f$$

$$\begin{aligned}
 t_r &= (6 M_{\max} / S_p)^{0.5} \\
 &= (6 \cdot 398.33 / 20,000)^{0.5} \\
 &= 0.3457 \text{ in}
 \end{aligned}$$

The base plate thickness is satisfactory.

#### Base plate bolt load (Jawad & Farr eq. 12.13, operating, new + Wind)

$$\text{Bolt load} = A_b \cdot f_s = 0.929 \cdot 306 = 284.16 \text{ lb}_f$$

$$\begin{aligned}
 t_r &= (3.91 \cdot F / (S_y \cdot (2 \cdot b / w + w / (2 \cdot l) - d_b \cdot (2 / w + 1 / (2 \cdot l))))))^{0.5} \\
 &= (3.91 \cdot 284.16 / (36,000 \cdot (2 \cdot 4.625 / 4 + 4 / (2 \cdot 2.25) - 1.625 \cdot (2 / 4 + 1 / (2 \cdot 2.25))))))^{0.5} \\
 &= 0.1234 \text{ in}
 \end{aligned}$$

The base plate thickness is satisfactory.

#### Check skirt for gusset reaction (Jawad & Farr eq. 12.14)

$$\begin{aligned}
 S_r &= 1.5 \cdot F \cdot b / (\text{gussets} \cdot \pi \cdot t_{sk}^2 \cdot h) \\
 &= 1.5 \cdot 284.16 \cdot 4.625 / (2 \cdot \pi \cdot 0.5^2 \cdot 4.625) \\
 &= 271.35 \text{ psi}
 \end{aligned}$$

As  $S_r \leq 30,000$  psi the skirt thickness is adequate to resist the gusset reaction.

#### Anchor bolt load (empty, corroded + Wind)

$$\begin{aligned}
 P &= -W / N + 48 \cdot M / (N \cdot BC) \\
 &= -18,270.39 / 8 + 48 \cdot 23,645.6 / (8 \cdot 51.25) \\
 &= 484.47 \text{ lb}_f
 \end{aligned}$$

$$\text{Required area per bolt} = P / S_b = 0.0242 \text{ in}^2$$

The area provided (0.929 in<sup>2</sup>) by the specified anchor bolt is adequate.

### Foundation bearing stress (empty, corroded + Wind)

$$\begin{aligned} A_c &= \pi(D_o^2 - D_i^2) / 4 - N\pi d_b^2 / 4 \\ &= \pi(56^2 - 42^2) / 4 - 8\pi(1.625)^2 / 4 \\ &= 1,060.9747 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} I_c &= \pi(D_o^4 - D_i^4) / 64 \\ &= \pi(56^4 - 42^4) / 64 \\ &= 330,004.7 \text{ in}^4 \end{aligned}$$

$$\begin{aligned} f_c &= N A_b \text{Preload} / A_c + W / A_c + 6 M D_o / I_c \\ &= 8 \cdot 0.929 \cdot 0 / 1,060.9747 + 18,270.39 / 1,060.9747 + 6 \cdot 23,645.6 \cdot 56 / 330,004.7 \\ &= 41 \text{ psi} \end{aligned}$$

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

### Base plate required thickness (empty, corroded + Wind)

From Brownell & Young, Table 10.3:,  $l / b = 0.3008$

$$M_x = 0.007 \cdot 41 \cdot 15.3758^2 = 68.7 \text{ lb}_f$$

$$M_y = -0.435 \cdot 41 \cdot 4.625^2 = -384.3 \text{ lb}_f$$

$$\begin{aligned} t_r &= (6 M_{\max} / S_p)^{0.5} \\ &= (6 \cdot 384.28 / 20,000)^{0.5} \\ &= 0.3395 \text{ in} \end{aligned}$$

The base plate thickness is satisfactory.

### Base plate bolt load (Jawad & Farr eq. 12.13, empty, corroded + Wind)

$$\text{Bolt load} = A_b \cdot f_s = 0.929 \cdot 521 = 484.47 \text{ lb}_f$$

$$\begin{aligned} t_r &= (3.91 \cdot F / (S_y \cdot (2 \cdot b / w + w / (2 \cdot l) - d_b \cdot (2 / w + 1 / (2 \cdot l))))))^{0.5} \\ &= (3.91 \cdot 484.47 / (36,000 \cdot (2 \cdot 4.625 / 4 + 4 / (2 \cdot 2.25) - 1.625 \cdot (2 / 4 + 1 / (2 \cdot 2.25))))))^{0.5} \\ &= 0.1611 \text{ in} \end{aligned}$$

The base plate thickness is satisfactory.

### Check skirt for gusset reaction (Jawad & Farr eq. 12.14)

$$\begin{aligned} S_r &= 1.5 \cdot F \cdot b / (\text{gussets} \cdot \pi \cdot t_{sk}^2 \cdot h) \\ &= 1.5 \cdot 484.47 \cdot 4.625 / (2 \cdot \pi \cdot 0.5^2 \cdot 4.625) \\ &= 462.63 \text{ psi} \end{aligned}$$

As  $S_r \leq 30,000$  psi the skirt thickness is adequate to resist the gusset reaction.

### Anchor bolt load (empty, new + Wind)

$$\begin{aligned} P &= -W / N + 48 \cdot M / (N \cdot BC) \\ &= -18,270.39 / 8 + 48 \cdot 23,645.6 / (8 \cdot 51.25) \\ &= 484.47 \text{ lb}_f \end{aligned}$$

$$\text{Required area per bolt} = P / S_b = 0.0242 \text{ in}^2$$

The area provided ( $0.929 \text{ in}^2$ ) by the specified anchor bolt is adequate.

### Foundation bearing stress (empty, new + Wind)

$$\begin{aligned} A_c &= \pi(D_o^2 - D_i^2) / 4 - N\pi d_b^2 / 4 \\ &= \pi(56^2 - 42^2) / 4 - 8\pi(1.625)^2 / 4 \\ &= 1,060.9747 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} I_c &= \pi(D_o^4 - D_i^4) / 64 \\ &= \pi(56^4 - 42^4) / 64 \\ &= 330,004.7 \text{ in}^4 \end{aligned}$$

$$\begin{aligned} f_c &= N A_b \text{Preload} / A_c + W / A_c + 6 M D_o / I_c \\ &= 8 \cdot 0.929 \cdot 0 / 1,060.9747 + 18,270.39 / 1,060.9747 + 6 \cdot 23,645.6 \cdot 56 / 330,004.7 \\ &= 41 \text{ psi} \end{aligned}$$

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

### Base plate required thickness (empty, new + Wind)

From Brownell & Young, Table 10.3:,  $l / b = 0.3008$

$$M_x = 0.007 \cdot 41 \cdot 15.3758^2 = 68.7 \text{ lb}_f$$

$$M_y = -0.435 \cdot 41 \cdot 4.625^2 = -384.3 \text{ lb}_f$$

$$\begin{aligned} t_r &= (6 M_{\max} / S_p)^{0.5} \\ &= (6 \cdot 384.28 / 20,000)^{0.5} \\ &= 0.3395 \text{ in} \end{aligned}$$

The base plate thickness is satisfactory.

### Base plate bolt load (Jawad & Farr eq. 12.13, empty, new + Wind)

$$\text{Bolt load} = A_b f_s = 0.929 \cdot 521 = 484.47 \text{ lb}_f$$

$$\begin{aligned} t_r &= (3.91 F / (S_y (2b / w + w / (2l) - d_b (2 / w + 1 / (2l))))))^{0.5} \\ &= (3.91 \cdot 484.47 / (36,000 (2 \cdot 4.625 / 4 + 4 / (2 \cdot 2.25) - 1.625 (2 / 4 + 1 / (2 \cdot 2.25))))))^{0.5} \\ &= 0.1611 \text{ in} \end{aligned}$$

The base plate thickness is satisfactory.

### Check skirt for gusset reaction (Jawad & Farr eq. 12.14)

$$\begin{aligned} S_r &= 1.5 F b / (\text{gussets} \cdot \pi t_{sk}^2 h) \\ &= 1.5 \cdot 484.47 \cdot 4.625 / (2 \cdot \pi \cdot 0.5^2 \cdot 4.625) \\ &= 462.63 \text{ psi} \end{aligned}$$

As  $S_r \leq 30,000$  psi the skirt thickness is adequate to resist the gusset reaction.

### Anchor bolt load (vacuum, corroded + Wind)

$$\begin{aligned} P &= -W / N + 48 \cdot M / (N \cdot BC) \\ &= -19,872.88 / 8 + 48 \cdot 23,645.6 / (8 \cdot 51.25) \\ &= 284.16 \text{ lb}_f \end{aligned}$$

$$\text{Required area per bolt} = P / S_b = 0.0142 \text{ in}^2$$

The area provided (0.929 in<sup>2</sup>) by the specified anchor bolt is adequate.

### Foundation bearing stress (vacuum, corroded + Wind)

$$\begin{aligned} A_c &= \pi(D_o^2 - D_i^2) / 4 - N\pi d_b^2 / 4 \\ &= \pi(56^2 - 42^2) / 4 - 8\pi(1.625)^2 / 4 \\ &= 1,060.9747 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} I_c &= \pi(D_o^4 - D_i^4) / 64 \\ &= \pi(56^4 - 42^4) / 64 \\ &= 330,004.7 \text{ in}^4 \end{aligned}$$

$$\begin{aligned} f_c &= N A_b \text{Preload} / A_c + W / A_c + 6 M D_o / I_c \\ &= 8 \times 0.929 \times 0 / 1,060.9747 + 19,872.88 / 1,060.9747 + 6 \times 23,645.6 \times 56 / 330,004.7 \\ &= 43 \text{ psi} \end{aligned}$$

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

### Base plate required thickness (vacuum, corroded + Wind)

From Brownell & Young, Table 10.3:,  $l / b = 0.3008$

$$M_x = 0.007 \times 43 \times 15.3758^2 = 71.2 \text{ lb}_f$$

$$M_y = -0.435 \times 43 \times 4.625^2 = -398.3 \text{ lb}_f$$

$$\begin{aligned} t_r &= (6 M_{\max} / S_p)^{0.5} \\ &= (6 \times 398.33 / 20,000)^{0.5} \\ &= 0.3457 \text{ in} \end{aligned}$$

The base plate thickness is satisfactory.

### Base plate bolt load (Jawad & Farr eq. 12.13, vacuum, corroded + Wind)

$$\text{Bolt load} = A_b f_s = 0.929 \times 306 = 284.16 \text{ lb}_f$$

$$\begin{aligned} t_r &= (3.91 F / (S_y (2b / w + w / (2l) - d_b (2 / w + 1 / (2l))))))^{0.5} \\ &= (3.91 \times 284.16 / (36,000 (2 \times 4.625 / 4 + 4 / (2 \times 2.25) - 1.625 (2 / 4 + 1 / (2 \times 2.25))))))^{0.5} \\ &= 0.1234 \text{ in} \end{aligned}$$

The base plate thickness is satisfactory.

### Check skirt for gusset reaction (Jawad & Farr eq. 12.14)

$$\begin{aligned} S_r &= 1.5 F b / (\text{gussets} \times \pi t_{sk}^2 h) \\ &= 1.5 \times 284.16 \times 4.625 / (2 \times \pi \times 0.5^2 \times 4.625) \\ &= 271.35 \text{ psi} \end{aligned}$$

As  $S_r \leq 30,000$  psi the skirt thickness is adequate to resist the gusset reaction.

### Anchor bolt load (operating, corroded + Seismic)

$$\begin{aligned} P &= -W / N + 48 M / (N \times BC) \\ &= -19,872.88 / 8 + 48 \times 90,303.6 / (8 \times 51.25) \\ &= 8,088.01 \text{ lb}_f \end{aligned}$$

$$\text{Required area per bolt} = P / S_b = 0.4044 \text{ in}^2$$

The area provided (0.929 in<sup>2</sup>) by the specified anchor bolt is adequate.

### Support calculations (Jawad & Farr chapter 12, operating, corroded + Seismic)

Base plate width,  $t_c$ : 7 in  
Average base plate diameter,  $d$ : 49 in  
Base plate elastic modulus,  $E_s$ : 29.0E+06 psi  
Base plate yield stress,  $S_y$ : 36,000 psi

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

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

$$\begin{aligned} t_s &= (N * A_b) / (\pi * d) \\ &= (8 * 0.929) / (\pi * 49) \\ &= 0.0483 \text{ in} \end{aligned}$$

#### From table 12.4 for $k = 0.264922$ :

$$\begin{aligned} K_1 &= 2.5185, \quad K_2 = 1.4124 \\ L_1 &= 11.5204, \quad L_2 = 27.899, \quad L_3 = 10.2954 \end{aligned}$$

#### Total tensile force on bolting

$$\begin{aligned} T &= (12 * M - W * (L_1 + L_3)) / (L_2 + L_3) \\ &= (12 * 90,303.6 - 19,872.88 * (11.5204 + 10.2954)) / (27.899 + 10.2954) \\ &= 17,020.84 \text{ lb}_f \end{aligned}$$

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

$$\begin{aligned} f_s &= T / (t_s * (d / 2) * K_1) \\ &= 17,020.84 / (0.0483 * (49 / 2) * 2.5185) \\ &= 5,714 \text{ psi} \end{aligned}$$

#### Total compressive load on foundation

$$\begin{aligned} C_c &= T + (1 + V\text{Accel}) * W + \text{Bolt Preload} \\ &= 17,020.84 + (1 + 1) * 19,872.88 + 0 \\ &= 56,766.59 \text{ lb}_f \end{aligned}$$

#### Foundation bearing stress

$$\begin{aligned} f_c &= C_c / (((t_c - t_s) + n * t_s) * (d / 2) * K_2) \\ &= 56,766.59 / (((7 - 0.0483) + 9.2889 * 0.0483) * (49 / 2) * 1.4124) \\ &= 222 \text{ psi} \end{aligned}$$

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

$$\begin{aligned} k &= 1 / (1 + f_s / (n * f_c)) \\ &= 1 / (1 + 5,714 / (9.2889 * 222)) \\ &= 0.264922 \end{aligned}$$

#### Base plate required thickness (operating, corroded + Seismic)

From Brownell & Young, Table 10.3:  $l / b = 0.3008$

$$M_x = 0.007 * 222 * 15.3758^2 = 369 \text{ lb}_f$$

$$M_y = -0.435 * 222 * 4.625^2 = -2,062.9 \text{ lb}_f$$

$$\begin{aligned} t_r &= (6 * M_{\max} / S_p)^{0.5} \\ &= (6 * 2,062.91 / 20,000)^{0.5} \\ &= \underline{0.7867} \text{ in} \end{aligned}$$

The base plate thickness is satisfactory.

#### Base plate bolt load (Jawad & Farr eq. 12.13, operating, corroded + Seismic)

$$\text{Bolt load} = A_b * f_s = 0.929 * 5,714 = 5,308.02 \text{ lb}_f$$

$$\begin{aligned} t_r &= (3.91 * F / (S_y * (2 * b / w + w / (2 * l) - d_b * (2 / w + 1 / (2 * l))))^{0.5} \\ &= (3.91 * 5,308.02 / (36,000 * (2 * 4.625 / 4 + 4 / (2 * 2.25) - 1.625 * (2 / 4 + 1 / (2 * 2.25))))^{0.5} \\ &= 0.5332 \text{ in} \end{aligned}$$

The base plate thickness is satisfactory.

#### Check skirt for gusset reaction (Jawad & Farr eq. 12.14)

$$\begin{aligned} S_r &= 1.5 * F * b / (\text{gussets} * \pi * t_{sk}^2 * h) \\ &= 1.5 * 5,308.02 * 4.625 / (2 * \pi * 0.5^2 * 4.625) \\ &= 5,068.78 \text{ psi} \end{aligned}$$

As  $S_r \leq 30,000$  psi the skirt thickness is adequate to resist the gusset reaction.

#### Anchor bolt load (operating, new + Seismic)

$$\begin{aligned} P &= -W / N + 48 * M / (N * BC) \\ &= -19,872.88 / 8 + 48 * 90,303.6 / (8 * 51.25) \\ &= 8,088.01 \text{ lb}_f \end{aligned}$$

$$\text{Required area per bolt} = P / S_b = \underline{0.4044} \text{ in}^2$$

The area provided (0.929 in<sup>2</sup>) by the specified anchor bolt is adequate.

#### Support calculations (Jawad & Farr chapter 12, operating, new + Seismic)

Base plate width, $t_c$ :	7	in
Average base plate diameter, $d$ :	49	in
Base plate elastic modulus, $E_s$ :	29.0E+06	psi
Base plate yield stress, $S_y$ :	36,000	psi

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

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

$$\begin{aligned} t_s &= (N * A_b) / (\pi * d) \\ &= (8 * 0.929) / (\pi * 49) \\ &= 0.0483 \text{ in} \end{aligned}$$

#### From table 12.4 for $k = 0.264922$ :

$$\begin{aligned} K_1 &= 2.5185, \quad K_2 = 1.4124 \\ L_1 &= 11.5204, \quad L_2 = 27.899, \quad L_3 = 10.2954 \end{aligned}$$

### Total tensile force on bolting

$$\begin{aligned} T &= (12 * M - W * (L_1 + L_3)) / (L_2 + L_3) \\ &= (12 * 90,303.6 - 19,872.88 * (11.5204 + 10.2954)) / (27.899 + 10.2954) \\ &= 17,020.84 \text{ lb}_f \end{aligned}$$

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

$$\begin{aligned} f_s &= T / (t_s * (d / 2) * K_1) \\ &= 17,020.84 / (0.0483 * (49 / 2) * 2.5185) \\ &= 5,714 \text{ psi} \end{aligned}$$

### Total compressive load on foundation

$$\begin{aligned} C_c &= T + (1 + V_{\text{Accel}}) * W + \text{Bolt Preload} \\ &= 17,020.84 + (1 + 1) * 19,872.88 + 0 \\ &= 56,766.59 \text{ lb}_f \end{aligned}$$

### Foundation bearing stress

$$\begin{aligned} f_c &= C_c / (((t_c - t_s) + n * t_s) * (d / 2) * K_2) \\ &= 56,766.59 / (((7 - 0.0483) + 9.2889 * 0.0483) * (49 / 2) * 1.4124) \\ &= \underline{222} \text{ psi} \end{aligned}$$

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

$$\begin{aligned} k &= 1 / (1 + f_s / (n * f_c)) \\ &= 1 / (1 + 5,714 / (9.2889 * 222)) \\ &= 0.264922 \end{aligned}$$

### Base plate required thickness (operating, new + Seismic)

From Brownell & Young, Table 10.3:,  $l / b = 0.3008$

$$M_x = 0.007 * 222 * 15.3758^2 = 369 \text{ lb}_f$$

$$M_y = -0.435 * 222 * 4.625^2 = -2,062.9 \text{ lb}_f$$

$$\begin{aligned} t_r &= (6 * M_{\text{max}} / S_p)^{0.5} \\ &= (6 * 2,062.91 / 20,000)^{0.5} \\ &= \underline{0.7867} \text{ in} \end{aligned}$$

The base plate thickness is satisfactory.

### Base plate bolt load (Jawad & Farr eq. 12.13, operating, new + Seismic)

$$\text{Bolt load} = A_b * f_s = 0.929 * 5,714 = 5,308.02 \text{ lb}_f$$

$$\begin{aligned} t_r &= (3.91 * F / (S_y * (2 * b / w + w / (2 * l) - d_b * (2 / w + 1 / (2 * l))))))^{0.5} \\ &= (3.91 * 5,308.02 / (36,000 * (2 * 4.625 / 4 + 4 / (2 * 2.25) - 1.625 * (2 / 4 + 1 / (2 * 2.25))))))^{0.5} \\ &= 0.5332 \text{ in} \end{aligned}$$

The base plate thickness is satisfactory.

### Check skirt for gusset reaction (Jawad & Farr eq. 12.14)



$$\begin{aligned}
 S_r &= 1.5 * F * b / (\text{gussets} * \pi * t_{sk}^2 * h) \\
 &= 1.5 * 5,308.02 * 4.625 / (2 * \pi * 0.5^2 * 4.625) \\
 &= 5,068.78 \text{ psi}
 \end{aligned}$$

As  $S_r \leq 30,000$  psi the skirt thickness is adequate to resist the gusset reaction.

### Anchor bolt load (empty, corroded + Seismic)

$$\begin{aligned}
 P &= -W / N + 48 * M / (N * BC) \\
 &= -18,270.39 / 8 + 48 * 86,062.1 / (8 * 51.25) \\
 &= 7,791.77 \text{ lb}_f
 \end{aligned}$$

$$\text{Required area per bolt} = P / S_b = \underline{0.3896} \text{ in}^2$$

The area provided (0.929 in<sup>2</sup>) by the specified anchor bolt is adequate.

### Support calculations (Jawad & Farr chapter 12, empty, corroded + Seismic)

Base plate width, $t_c$ :	7	in
Average base plate diameter, $d$ :	49	in
Base plate elastic modulus, $E_s$ :	29.0E+06	psi
Base plate yield stress, $S_y$ :	36,000	psi

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

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

$$\begin{aligned}
 t_s &= (N * A_b) / (\pi * d) \\
 &= (8 * 0.929) / (\pi * 49) \\
 &= 0.0483 \text{ in}
 \end{aligned}$$

#### From table 12.4 for $k = 0.259917$ :

$$\begin{aligned}
 K_1 &= 2.5294, \quad K_2 = 1.3981 \\
 L_1 &= 11.7657, \quad L_2 = 28.0786, \quad L_3 = 10.1027
 \end{aligned}$$

#### Total tensile force on bolting

$$\begin{aligned}
 T &= (12 * M - W * (L_1 + L_3)) / (L_2 + L_3) \\
 &= (12 * 86,062.1 - 18,270.39 * (11.7657 + 10.1027)) / (28.0786 + 10.1027) \\
 &= 16,584.11 \text{ lb}_f
 \end{aligned}$$

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

$$\begin{aligned}
 f_s &= T / (t_s * (d / 2) * K_1) \\
 &= 16,584.11 / (0.0483 * (49 / 2) * 2.5294) \\
 &= 5,543 \text{ psi}
 \end{aligned}$$

#### Total compressive load on foundation

$$\begin{aligned}
 C_c &= T + (1 + V\text{Accel}) * W + \text{Bolt Preload} \\
 &= 16,584.11 + (1 + 1) * 18,270.39 + 0 \\
 &= 53,124.89 \text{ lb}_f
 \end{aligned}$$

#### Foundation bearing stress

$$f_c = C_c / (((t_c - t_s) + n * t_s) * (d / 2) * K_2)$$

$$= 53,124.89 / (((7 - 0.0483) + 9.2889 * 0.0483) * (49 / 2) * 1.3981)$$

$$= 210 \text{ psi}$$

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

$$k = 1 / (1 + f_s / (n * f_c))$$

$$= 1 / (1 + 5,543 / (9.2889 * 210))$$

$$= 0.259917$$

### Base plate required thickness (empty, corroded + Seismic)

From Brownell & Young, Table 10.3:,  $l / b = 0.3008$

$$M_x = 0.007 * 210 * 15.3758^2 = 348.8 \text{ lb}_f$$

$$M_y = -0.435 * 210 * 4.625^2 = -1,950.2 \text{ lb}_f$$

$$t_r = (6 * M_{\max} / S_p)^{0.5}$$

$$= (6 * 1,950.22 / 20,000)^{0.5}$$

$$= 0.7649 \text{ in}$$

The base plate thickness is satisfactory.

### Base plate bolt load (Jawad & Farr eq. 12.13, empty, corroded + Seismic)

$$\text{Bolt load} = A_b * f_s = 0.929 * 5,543 = 5,149.51 \text{ lb}_f$$

$$t_r = (3.91 * F / (S_y * (2 * b / w + w / (2 * l) - d_b * (2 / w + 1 / (2 * l))))))^{0.5}$$

$$= (3.91 * 5,149.51 / (36,000 * (2 * 4.625 / 4 + 4 / (2 * 2.25) - 1.625 * (2 / 4 + 1 / (2 * 2.25))))))^{0.5}$$

$$= 0.5252 \text{ in}$$

The base plate thickness is satisfactory.

### Check skirt for gusset reaction (Jawad & Farr eq. 12.14)

$$S_r = 1.5 * F * b / (\text{gussets} * \pi * t_{sk}^2 * h)$$

$$= 1.5 * 5,149.51 * 4.625 / (2 * \pi * 0.5^2 * 4.625)$$

$$= 4,917.42 \text{ psi}$$

As  $S_r \leq 30,000$  psi the skirt thickness is adequate to resist the gusset reaction.

### Anchor bolt load (empty, new + Seismic)

$$P = -W / N + 48 * M / (N * BC)$$

$$= -18,270.39 / 8 + 48 * 86,062.1 / (8 * 51.25)$$

$$= 7,791.77 \text{ lb}_f$$

$$\text{Required area per bolt} = P / S_b = 0.3896 \text{ in}^2$$

The area provided (0.929 in<sup>2</sup>) by the specified anchor bolt is adequate.

### Support calculations (Jawad & Farr chapter 12, empty, new + Seismic)

Base plate width, $t_c$ :	7	in
Average base plate diameter, $d$ :	49	in
Base plate elastic modulus, $E_s$ :	29.0E+06	psi
Base plate yield stress, $S_y$ :	36,000	psi

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

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

$$\begin{aligned} t_s &= (N * A_b) / (\pi * d) \\ &= (8 * 0.929) / (\pi * 49) \\ &= 0.0483 \text{ in} \end{aligned}$$

**From table 12.4 for k = 0.259917:**

$$\begin{aligned} K_1 &= 2.5294, \quad K_2 = 1.3981 \\ L_1 &= 11.7657, \quad L_2 = 28.0786, \quad L_3 = 10.1027 \end{aligned}$$

**Total tensile force on bolting**

$$\begin{aligned} T &= (12 * M - W * (L_1 + L_3)) / (L_2 + L_3) \\ &= (12 * 86,062.1 - 18,270.39 * (11.7657 + 10.1027)) / (28.0786 + 10.1027) \\ &= 16,584.11 \text{ lb}_f \end{aligned}$$

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

$$\begin{aligned} f_s &= T / (t_s * (d / 2) * K_1) \\ &= 16,584.11 / (0.0483 * (49 / 2) * 2.5294) \\ &= 5,543 \text{ psi} \end{aligned}$$

**Total compressive load on foundation**

$$\begin{aligned} C_c &= T + (1 + V_{\text{Accel}}) * W + \text{Bolt Preload} \\ &= 16,584.11 + (1 + 1) * 18,270.39 + 0 \\ &= 53,124.89 \text{ lb}_f \end{aligned}$$

**Foundation bearing stress**

$$\begin{aligned} f_c &= C_c / (((t_c - t_s) + n * t_s) * (d / 2) * K_2) \\ &= 53,124.89 / (((7 - 0.0483) + 9.2889 * 0.0483) * (49 / 2) * 1.3981) \\ &= \underline{210} \text{ psi} \end{aligned}$$

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

$$\begin{aligned} k &= 1 / (1 + f_s / (n * f_c)) \\ &= 1 / (1 + 5,543 / (9.2889 * 210)) \\ &= 0.259917 \end{aligned}$$

**Base plate required thickness (empty, new + Seismic)**

From Brownell & Young, Table 10.3:,  $l / b = 0.3008$

$$M_x = 0.007 * 210 * 15.3758^2 = 348.8 \text{ lb}_f$$

$$M_y = -0.435 * 210 * 4.625^2 = -1,950.2 \text{ lb}_f$$

$$\begin{aligned} t_r &= (6 * M_{\text{max}} / S_p)^{0.5} \\ &= (6 * 1,950.22 / 20,000)^{0.5} \\ &= \underline{0.7649} \text{ in} \end{aligned}$$

The base plate thickness is satisfactory.

### Base plate bolt load (Jawad & Farr eq. 12.13, empty, new + Seismic)

$$\text{Bolt load} = A_b * f_s = 0.929 * 5,543 = 5,149.51 \text{ lb}_f$$

$$t_r = (3.91 * F / (S_y * (2 * b / w + w / (2 * l) - d_b * (2 / w + 1 / (2 * l))))))^{0.5}$$
$$= (3.91 * 5,149.51 / (36,000 * (2 * 4.625 / 4 + 4 / (2 * 2.25) - 1.625 * (2 / 4 + 1 / (2 * 2.25))))))^{0.5}$$
$$= 0.5252 \text{ in}$$

The base plate thickness is satisfactory.

### Check skirt for gusset reaction (Jawad & Farr eq. 12.14)

$$S_r = 1.5 * F * b / (\text{gussets} * \pi * t_{sk}^2 * h)$$
$$= 1.5 * 5,149.51 * 4.625 / (2 * \pi * 0.5^2 * 4.625)$$
$$= 4,917.42 \text{ psi}$$

As  $S_r \leq 30,000$  psi the skirt thickness is adequate to resist the gusset reaction.

### Anchor bolt load (vacuum, corroded + Seismic)

$$P = -W / N + 48 * M / (N * BC)$$
$$= -19,872.88 / 8 + 48 * 90,303.6 / (8 * 51.25)$$
$$= 8,088.01 \text{ lb}_f$$

$$\text{Required area per bolt} = P / S_b = 0.4044 \text{ in}^2$$

The area provided (0.929 in<sup>2</sup>) by the specified anchor bolt is adequate.

### Support calculations (Jawad & Farr chapter 12, vacuum, corroded + Seismic)

Base plate width, $t_c$ :	7	in
Average base plate diameter, $d$ :	49	in
Base plate elastic modulus, $E_s$ :	29.0E+06	psi
Base plate yield stress, $S_y$ :	36,000	psi

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

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

$$t_s = (N * A_b) / (\pi * d)$$
$$= (8 * 0.929) / (\pi * 49)$$
$$= 0.0483 \text{ in}$$

### From table 12.4 for $k = 0.264922$ :

$$K_1 = 2.5185, \quad K_2 = 1.4124$$
$$L_1 = 11.5204, \quad L_2 = 27.899, \quad L_3 = 10.2954$$

### Total tensile force on bolting

$$T = (12 * M - W * (L_1 + L_3)) / (L_2 + L_3)$$
$$= (12 * 90,303.6 - 19,872.88 * (11.5204 + 10.2954)) / (27.899 + 10.2954)$$
$$= 17,020.84 \text{ lb}_f$$

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

$$\begin{aligned}
 f_s &= T / (t_s * (d / 2) * K_1) \\
 &= 17,020.84 / (0.0483 * (49 / 2) * 2.5185) \\
 &= 5,714 \text{ psi}
 \end{aligned}$$

### Total compressive load on foundation

$$\begin{aligned}
 C_c &= T + (1 + V_{\text{Accel}}) * W + \text{Bolt Preload} \\
 &= 17,020.84 + (1 + 1) * 19,872.88 + 0 \\
 &= 56,766.59 \text{ lb}_f
 \end{aligned}$$

### Foundation bearing stress

$$\begin{aligned}
 f_c &= C_c / (((t_c - t_s) + n * t_s) * (d / 2) * K_2) \\
 &= 56,766.59 / (((7 - 0.0483) + 9.2889 * 0.0483) * (49 / 2) * 1.4124) \\
 &= \underline{222} \text{ psi}
 \end{aligned}$$

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

$$\begin{aligned}
 k &= 1 / (1 + f_s / (n * f_c)) \\
 &= 1 / (1 + 5,714 / (9.2889 * 222)) \\
 &= 0.264922
 \end{aligned}$$

### Base plate required thickness (vacuum, corroded + Seismic)

From Brownell & Young, Table 10.3:,  $l / b = 0.3008$

$$M_x = 0.007 * 222 * 15.3758^2 = 369 \text{ lb}_f$$

$$M_y = -0.435 * 222 * 4.625^2 = -2,062.9 \text{ lb}_f$$

$$\begin{aligned}
 t_r &= (6 * M_{\text{max}} / S_p)^{0.5} \\
 &= (6 * 2,062.91 / 20,000)^{0.5} \\
 &= \underline{0.7867} \text{ in}
 \end{aligned}$$

The base plate thickness is satisfactory.

### Base plate bolt load (Jawad & Farr eq. 12.13, vacuum, corroded + Seismic)

$$\text{Bolt load} = A_b * f_s = 0.929 * 5,714 = 5,308.02 \text{ lb}_f$$

$$\begin{aligned}
 t_r &= (3.91 * F / (S_y * (2 * b / w + w / (2 * l) - d_b * (2 / w + 1 / (2 * l))))))^{0.5} \\
 &= (3.91 * 5,308.02 / (36,000 * (2 * 4.625 / 4 + 4 / (2 * 2.25) - 1.625 * (2 / 4 + 1 / (2 * 2.25))))))^{0.5} \\
 &= 0.5332 \text{ in}
 \end{aligned}$$

The base plate thickness is satisfactory.

### Check skirt for gusset reaction (Jawad & Farr eq. 12.14)

$$\begin{aligned}
 S_r &= 1.5 * F * b / (\text{gussets} * \pi * t_{sk}^2 * h) \\
 &= 1.5 * 5,308.02 * 4.625 / (2 * \pi * 0.5^2 * 4.625) \\
 &= 5,068.78 \text{ psi}
 \end{aligned}$$

As  $S_r \leq 30,000$  psi the skirt thickness is adequate to resist the gusset reaction.

**Liquid Level bounded by Ellipsoidal Head #2**

Location from datum 80"

Operating Liquid Specific Gravity 1.1











