

## HISTORY DOCKET

CUSTOMER : ULTRAFAB INDUSTRIES LTD.,  
WO. NO. : 1173PQ  
A.W.C. SERIAL NO. : 7474  
ITEM : 48" O.D. VERTICAL OUTLET SEPARATOR TAG # 772-VESE-103

### 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 N13-038
- 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:** 7474  
**ITEM:** 48" O.D. VERTICAL OUTLET SEPARATOR TAG 772-VESE-103

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. 2011ADDENDA

SIGNATURE



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

DATE

OCT 03 2013

## ALL-WELD

COMPANY LIMITED

*Engineers Since 1920*

A TRADITION OF QUALITY

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

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 7474 M10135.5 1173-1-IN REV. 5 909 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., singl., lap, buttl) (R.T. (spot or full)) (Eff. %) (H.T. temp.) (Time, hr) (Girth (welded, dbl., singl., 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 (N13)	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 (N7B)	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 21226 expires MAY 07, 2016  
 Date 26 Sept 2013 Co. name ALL-WELD COMPANY LIMITED. Signed R B Bull  
(Manufacturer) (Representative)

CERTIFICATE OF SHOP/FIELD INSPECTION

Vessel constructed by ALL-WELD COMPANY LIMITED at 49 PASSMORE AVE. TORONTO, ONT.  
 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 ONTARIO and employed by T.S.S.A. OF ONTARIO  
 have inspected the component described in this Manufacturer's Data Report on SEP 26, 2013, 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 SEP 26, 2013 Signed [Signature] Commissions NB 13106A, ONT 915  
(Authorized Inspector) (National Board (incl. endorsements), State, Province and number)

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

- Manufactured and certified by ALL-WELD COMPANY LIMITED, 49 PASSMORE AVE., SCARBOROUGH, ONTARIO, M1V 4T1 CANADA  
(Name and address of Manufacturer)
- Manufactured for ULTRA FAB INDUSTRIES LTD., 261088 WAGON WHEEL CRES., ROCKY VIEW, ALBERTA, T4A 0E2 CANADA  
(Name and address of Purchaser)
- Location of installation OFF THE COAST OF ANGOLA  
(Name and address)
- Type VERTICAL TANK 7474  
(Horizontal, vertical, or sphere) (Tank, separator, heat exch, etc.) (Manufacturer's serial number)  
M10135.5 1173-1-IN REV. 5 909 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	
P1 (N5)	1	2" ID	Cl.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
PURGE (N11)	1	2" ID	Cl.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
LEVEL BRIDAL(SAFE TY)(N8A)	1	2" ID	Cl.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	Cl.900 V2/12	SA182 F316	SA182 F316	5.5"	0"	N/A	UW.16 1(e)	N/A	SHELL
PDI LOW (N6B)	1	2" ID	Cl.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
LEVEL BRIDAL(PROC ESS)(N7A)	1	2" ID	Cl.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
PDI (HIGH) (N6A)	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 (SAFETY) LOW (N8B)	1	2" ID	Cl.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
LEVEL GAUGE HIGH (N9A)	1	2" ID	Cl.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
INLET (N1)	1	8" ID	Cl.900 LWN	SA182 F316	SA182 F316	1.875"	0"	N/A	UW.16 1(e)	N/A	N/A
SPARE (N10)	1	2" ID	Cl.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
LEVEL GAUGE LOW (N9B)	1	2" ID	Cl.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
PSV (N4)	1	2" ID	Cl.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
INSP. C/W BLIND FLANGE (N14)	1	8" ID	Cl.900 LWN	SA182 F316	SA182 F316	1.875"	0"	N/A	UW.16 1(e)	N/A	SHELL
BOTTOM DRAIN (N12)	1	NPS 2"	Cl.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 Beatty  
 (Manufacturer) (Representative)  
 Date: SEP 26, 2013 Name: [Signature] Commission: NB 13106 A ONT 915  
 (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 1173Q	CUSTOMER PO 11112	REVIEWED <i>[Signature]</i>	BY A.I. <i>[Signature]</i>
SERIAL NO. 7474	C.R.N. M10135.5	DATE 2013-02-06	SIGN FETSOI.13	
NATIONAL BOARD NO. 909		CUSTOMER ULTRAFAB		
ULTIMATE OWNER		FOR DRAWINGS & DOCUMENTS/REV./DATE ISSUED TO Q.C.		
ASME CODE		2010		
SECTION		VIII DIV 1		
ADD		2011		
H = HOLD R = REVIEW				
DESCRIPTION 60" ID VERTICAL OUTLET SEPERATOR <b>OPERATIONS, INSPECTIONS &amp; TEST POINTS</b>				
REVIEW APPVD DRWGS, CALCS,		R H		
REVIEW TRAVELLER AND REVIEW INSPECTION AND TEST PLAN		R H		
REVIEW MATERIAL LIST		R H		
REVIEW W.P.S., P.Q.R SA W 3-2, 3-4, 9-4 + 2-1		R H		
INCOMING MATERIAL INSPECTION REPORT		R H		
CHECK ROUNDNESS OF VESSEL		R H		
FIT-UP INSPECTION		R H		
PARTICLE / LIQUID PEN TEST		R H		
APPROVAL OF RADIOGRAPH MAP BY AI		R H		
RADIOGRAPHIC TESTS - FULL		R H		
ULTRASONIC TEST		R H		
HARDNESS TESTS		R H		
REVIEW WELDERS QUALIFICATION		R H		
WELD MAP REPORT		R H		
FINAL INTERNAL INSPECTION		R H		
POST WELD HEAT TREATMENT		R H		
FINAL (ALL NCR'S HAVE BEEN CLEARED) <span style="border: 1px solid black; padding: 2px;">ASME NONE</span>		R H		
FINAL COMPLETED VESSEL INSPECTION		R H		
FINAL HYDROSTATIC TEST		R H		
FINAL HYDROSTATIC TEST JACKET		R H		
FINAL HYDROSTATIC TEST TUBE SIDE		R H		
APPLICATION OF CODE STAMP + ATTACH NAMEPLATE		R H		
DATA REPORT SIGN OFF		R H		
GLASS BEAD BLASTING		R H		
DATA PACKAGE SENT TO CUSTOMER		R H		



# ALL-WELD HYDROSTATIC TEST REPORT

**JOB NUMBER**  
1173 PQ

**DATE**  
SEPTEMBER 19, 2013

**CUSTOMER**  
ULTRA FAB INDUSTRIES LTD.

**SERIAL NO.**  
7474

**VESSEL DESCRIPTION**  
48" O.D. VERTICAL OUTLET SEPARATOR TAG # 772-VESE-103

**TEST PRESSURE**  
1792 PSIG

**TUBE**  
NA

**JACKET**  
NA

**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 MS  
 JAN 2013  
 FOR PDP  
 [Signature]  
 14/09/2013

**Q.A. SIGNATURE** *[Signature]*  
**DATE: SEPTEMBER 19, 2013**

MIKE KAMYAB  
 REVIEWED   
 WITNESSED   
 FOR: SBM DATE: 9/19/13

**ACCEPTED/REVIEWED/RELEASED** 046  
 for and on behalf of: SBM OFFSHORE  
 Print Name: GAURISH SAHA  
 Signature: *[Signature]*  
 Date: SEP 20 2013  
**Applus® VELOSI**  
 Velosi America LLC









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/NC SL 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

BCM  
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 #:** 608636-12  
**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 Pupinder Singh **TECHNICIAN**

909  
ALL-WEED

COMPANY  
SCARBOROUGH  
ENGINEERS

SHELL MAWP	1578	PSI	AT	110	F
SHELL MAEWP	15	PSI	AT	110	F
ENDS MONT	20	°F	AT	1.25	PSI
CHANNEL MAWP	N/A	PSI	AT	N/A	F
JACKET MAWP	N/A	PSI	AT	N/A	F
[REDACTED] MAEWP	N/A	PSI	AT	N/A	F
[REDACTED] MDMT	N/A	°F	AT	N/A	PSI

SERIAL NO. 7471 YEAR BUILT 2011

H 10 155.5  
TAG 722 VISE 105

CERTIFIED BY  
**ALL-WELD**

COMPANY LIMITED  
SCARBOROUGH, ONTARIO  
ENGINEERS SINCE 1920

W L  
RT 1  
  
AB

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. 7474 YEAR BUILT 2013

C.R.N. M 10/135.5 TO - 296008

TAG# 772-VESE-103

**RADIOGRAPH REVIEW FORM**

W.O. NO. 1173 PQ  
SERIAL NO. 7474

- 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 03 2013



*A Tradition of Quality*



# 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

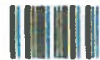


Name: **Edwin Dutschaever**  
 Nom:  
 Reg. No: **515**  
 No matricule:  
 Issue Date: **2011/11/28**  
 Date d'émission:

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 [X] near | | far vision  
 Verres correctifs pour la vision de [X] près | | distance.

Signature: *Edwin Dutschaever*



Natural Resources  
Canada

Ressources naturelles  
Canada

Certification: Certification: CAN 1558-46-9711

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 certification status, policies and deadlines, visit website:  
 http://nrc.can.ca/ Pour la vérification de la certification, les politiques, et les délais, visitez le site web: http://nrc.nrc.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

## CHRIS VEENEMAN

	Natural Resources Canada	Ressources naturelles Canada
	Name Nom	Christopher Veeneman
	Reg. No. No. matricule	6651
	Issue Date Date d'expiration	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			
Qualifié(e) en	CAW	1058 48 9732			
NO 2008	Qualifié(e) en	6651			
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
LT	2	EMC	2010/06/03		2013/12/31



# KV INSPECTION SERVICES LTD

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

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:



Natural Resources  
Canada

Ressources naturelles  
Canada

Certified to Certeifié selon CAN F/556 48 2312

8885

Method Méthode	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

For verification of certifications 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  
 Gérant/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

## SHERWIN SUYOM



Natural Resources  
Canada

Ressources naturelles  
Canada



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

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

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

Signature:



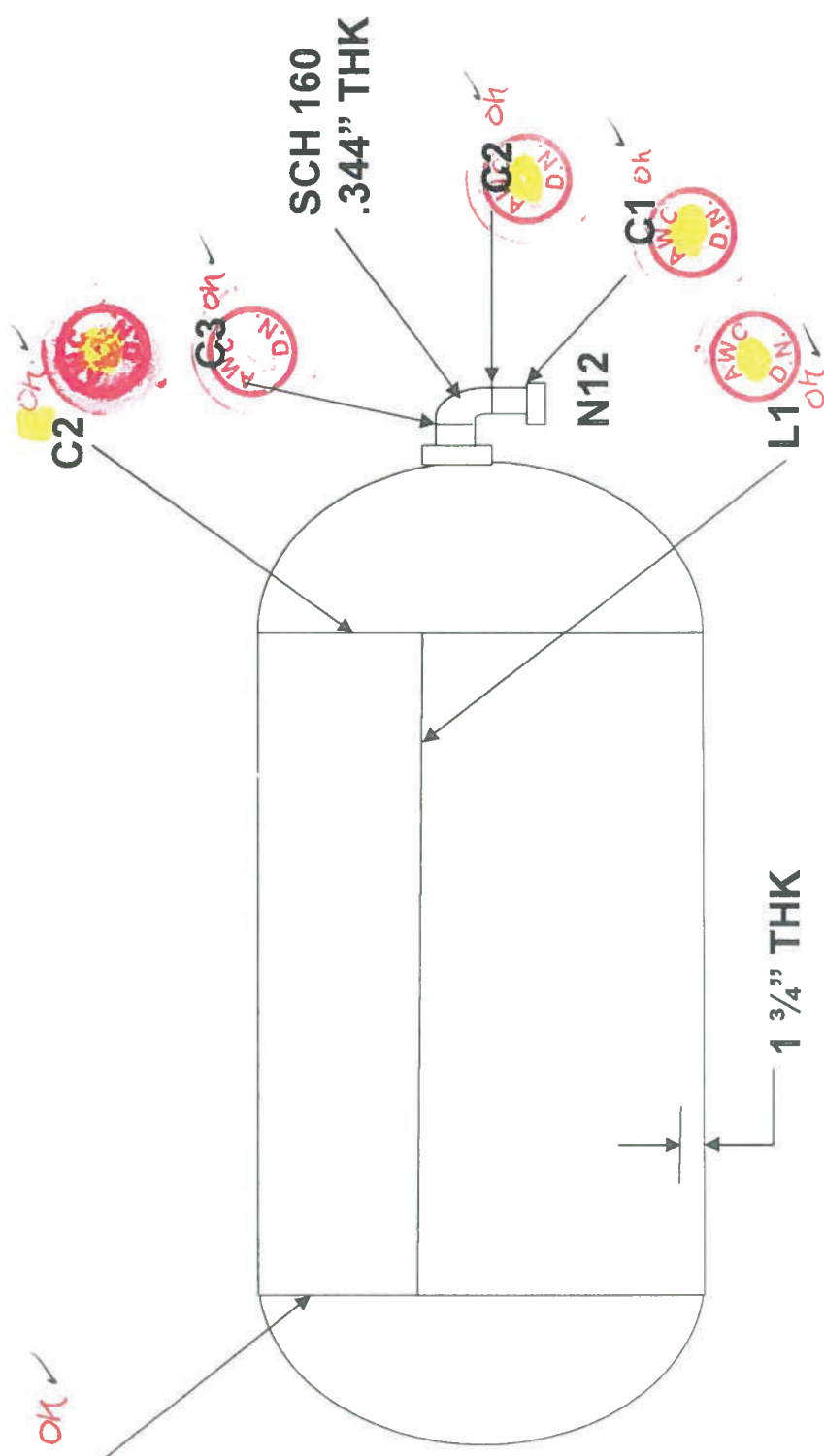
Natural Resources  
Canada

Ressources naturelles  
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

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 Consultez le site Internet de l'Agence



AI          Date MAR 15, 2013

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

CLIENT: ULTRAFAB  
 WORK ORDER #: 1173PQ SN 7474  
 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 SN7474
Procedure	KU #5 REV03	Worksheet #	36645
Technician	J. MACDONALD	CGSB Reg #	10375 ASNT/SNT-TC-1A Level 1

**Technical Data C660**

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 7474										
L1	0-1								✓	
	1-2								✓	
	2-3								✓	
	3-4								✓	
	4-5								✓	
	5-6								✓	
	6-END								✓	

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SBM OFFSHORE LTD 046  
Print Name: GABRIEL SAH  
Signature: [Signature]  
Date: 14 MARCH 2013  
**Applus<sup>®</sup> VELOSI**  
Velosi America LLC

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

AWC  
D.N.

KV Inspection Technician

Customer Representative

Date 14 MARCH 2013

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	AKU WELD COMPANY	Date	08/06/13
Location	SCARBOROUGH ONT	P. O. #	
Project	ULTRAFAB	Shop Order #	1173PQ-7474
Procedure	KW #5 REV3	Worksheet #	37169
Technician	M PERRON	CGSB Reg #	12283 ASNT/SNT-TC-1A Level 1

### Technical Data

Material Type	Carbon	Alloys <input checked="" type="checkbox"/>	Isotope	IR 192	Other	Physical/Focal Size	.199
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		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	17/8			

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
	48" Q									
C1	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"/>	

046

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

**ED DUISCHAEVER**  
 CGSB LEVEL II, Reg# 515  
 RT/MT/ET  
 SNT-TC-1A, LEVEL II  
 [Signature]

KV Inspection Technician	[Signature]	Date	08/06/13
Customer Representative	[Signature]	Date	AUG 13 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	AWeld	Date	04/04/13
Location	TORONTO	P. O. #	
Project	Vessel VENTURON OUTLET	Shop Order #	1173 PQ Ultrafab 7474
Procedure	KV5 Rev3	Worksheet #	36784
Technician	M Perron	CGSB Reg #	12283 ASNT/SNT-TC-1A Level 1

**Technical Data**

Material Type	Carbon <input type="checkbox"/> Alloys <input checked="" type="checkbox"/>	Isotope	Other <input checked="" type="checkbox"/> Physical/Focal Size	Co60 -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 <input type="checkbox"/> No <input checked="" type="checkbox"/>
Reinforcement	1/2+	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	2 1/4	

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
	48" Q									
C2	0-1								✓	
	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: SBM OFF SHORE GR  
 Print Name: LAURENCE SAHA  
 Signature: [Signature]  
 Date: [Date]  
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 SNT-TC-1A, LEVEL III  
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[Signature]

KV Inspection Technician

Date 04/04/13

Customer Representative

Date APR 08 2013



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 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 TO HTS.	Date	Aug 13/13
Location	SCARBOROUGH ONT	P. O. #	
Project	ULTRAFAB.	Shop Order #	1173 PR - 7474
Procedure	KW #6 RW2	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
N 12	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"/>	

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SPM OFF SHORE  
 Print Name: CHARISH SAH  
 Signature: [Signature]  
 Date: Aug 16/13  
 049  
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 CGSB LEVEL II, Reg# 515  
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 SNT-TC-1A, LEVEL III  
 RT/MT/PT

KV Inspection Technician	<u>[Signature]</u>	Date	Aug 13/13
Customer Representative	<u>[Signature]</u>	Date	AUG 20 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	AMWELD LTD	Date	Aug 31/13
Location	SCARBOROUGH ONT.	P. O. #	
Project	ULTRAFAB	Shop Order #	7474-1173
Procedure	KW #6 REV 2	Worksheet #	37542
Technician	B MONAGHAN	CGSB Reg #	439
		ASNT/SNT-TC-1A Level	I

**Technical Data**

Material Type	Carbon	Alloys <input checked="" type="checkbox"/>	Isotope	IR 192 <input checked="" type="checkbox"/> Other	Physical/Focal Size	.B	
Base Material Thickness	5/160		Exposure	Single Wall	Double Wall <input checked="" type="checkbox"/>	Film per Cassette	1
Weld Thickness	5/160		View	Single Wall	Double Wall <input checked="" type="checkbox"/>	PWHT	Yes No <input checked="" type="checkbox"/>
Reinforcement	.125		Number of Exposures	3/WELDS			
Film Mfg.	KODAK		Minimum Source to Object Distance	18"			
Film Type	AA		Maximum Distance from Source Side of Object to Film	0"			

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
N12	2"d									
C3	A									
	B							TI		
	C									

ACCEPTED/REVIEWED/RELEASED 046  
 for and on behalf of: SBM OFFSHORE  
 Print Name: CHRISTIE SMITH  
 Signature: [Signature]  
 Date: SEP 3/13  
**Applus<sup>®</sup> VELOSI**  
 Velosi America LLC

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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	Aug 31/13
Customer Representative		Date	SEP 03 2013



## ULTRAFAB PROJECT

SC PER VISIT BY HOSNEY SHETEIWY JULY 4, 2013

### 1176 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	<input checked="" type="checkbox"/> 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  
for and on behalf of: SBM OFFSHORE 046  
Print Name: GANESH SAHA  
Signature: [Signature] **Applus®**  
Date: July 25 2013 **VELOSI**  
Velosi America LLC



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

1486 Wallace Road  
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 FABS	Shop Order #	S/N 7474 Bottom Head	
Procedure	ASTM SE 797	Worksheet #	37218	
Technician	Frank Marunde	CGSB Reg #	8885	SNT-TC-IA Level III

### Technical Data

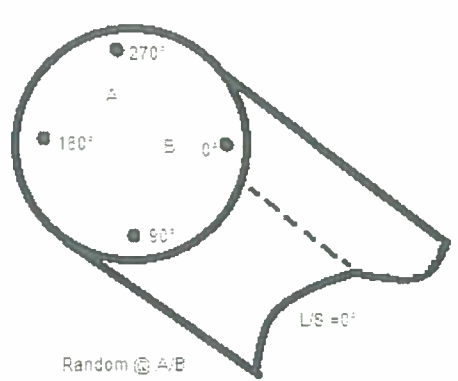
Material Type	<input checked="" type="radio"/> Stainless Steel <input type="radio"/> Carbon Steel <input type="radio"/> Other			
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### Test Equipment

Ultrasonic Thickness Gauge	<input checked="" type="radio"/> Panametrics MG2-DL Ser# 060296910 <input type="radio"/> Other			
Probe	<input checked="" type="radio"/> Standard <input type="radio"/> Other			
Couplant	<input checked="" type="radio"/> Krautkramer ultrasonic gel <input type="radio"/> 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°	1.752	 <p>Random @ A/B</p>
	90°	1.755	
	180°	1.762	
	270°	1.78	
Random	A	1.745	
	✓ B	1.742	

**ACCEPTED/REVIEWED/RELEASED** 046

for and on behalf of: SBM OFFSHORE

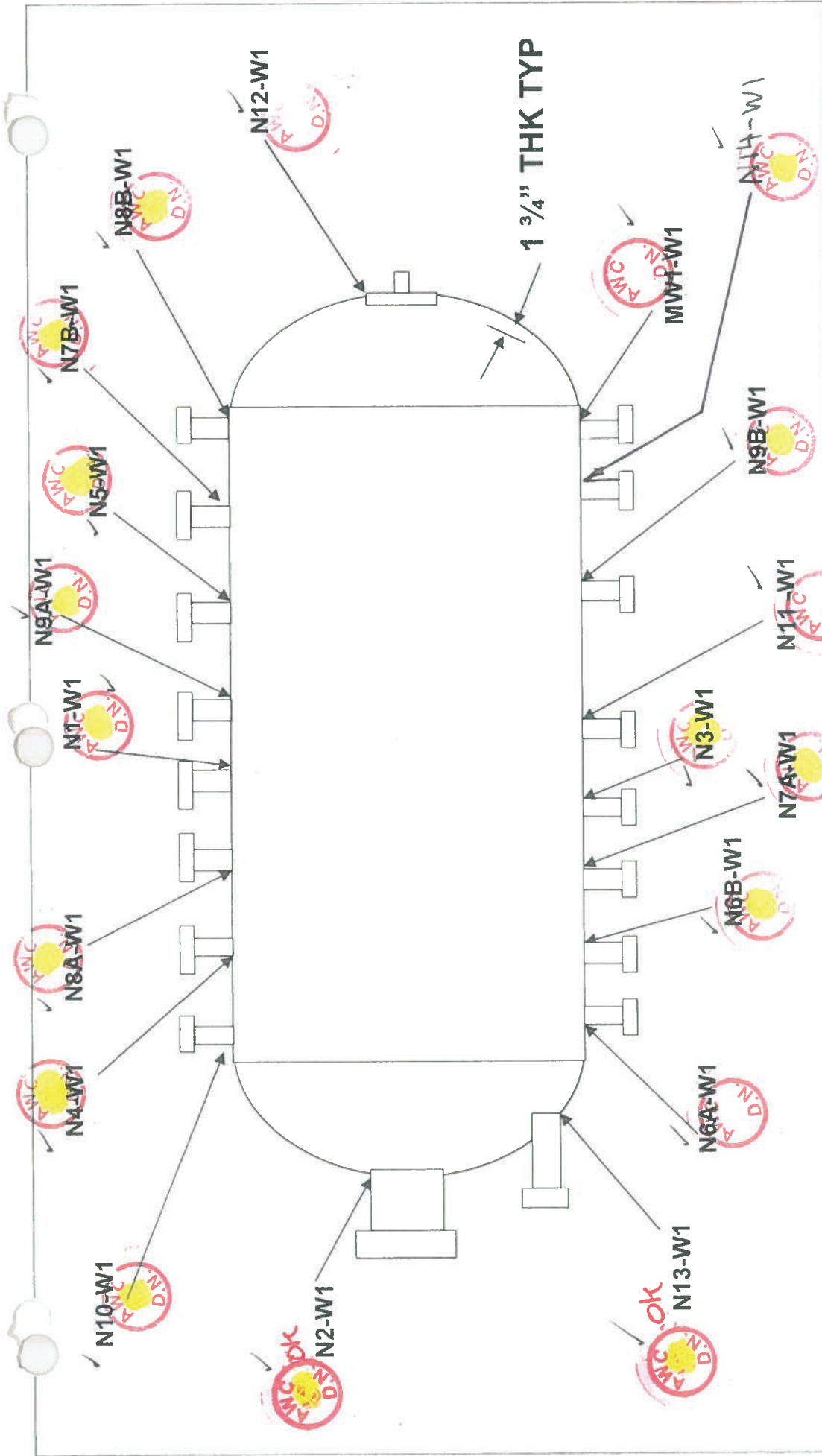
Print Name: GANESH SAHA

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		Date	July 10, 2013
Customer Representative		Date	III 11 2013



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

CLIENT: ULTRAFAB

WORK ORDER #: 1173PQ SN 7474

JOB DESCRIPTION: 48" O.D. VERTICAL OUTLET

DRAWING #: 1173-1-OU

PREPARED BY: D.NESCI

DATE: March 6, 2013

**UT MAP - 1173PQ**

OK TO UT

ASME SECTION VIII. DIV. 1

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

P.O. 13-0225

### General Data

Customer	All-Weld Company		Date	August 13, 2013		
Shop Order	1173	Ser#7474	Project			
Component			P.O. #			Worksheet #: 37394
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)	49dB/58dB			
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

Examination of Category 'D' attachment welds  
 Nozzle: N1-W1, N3-W1, N4-W1, N5-W1, N6B-W1, N7A-W1,  
 N7B-W1, N8A-W1, N8B-W1, N9A-W1, N9B-W1, N10-W1  
 & N14-W1

046

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 for and on behalf of: SBM OFF SHORE  
 Print Name: CA ANTESIT SAHIL  
 Signature: [Signature]  
 Date: SEP 11 11:13

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### Scanning

Test Area	Disposition	From	Length	Depth	Amplitude

### Evaluation - Acceptance

<input checked="" type="radio"/> Accepted	KV Inspection Services - Technician	<u>[Signature]</u>	Date	August 13, 2013
<input type="radio"/> Rejected	CGSB No. 48.9712-2000 Reg. No.	8885	Place	Scarborough, ON

## Ultrasonic Examination Report UT

### General Data

Customer	All-Weld Company		Date	April 4, 2013	
Shop Order	1173 PQ Serial # 7474		Project		
Component			P.O. #		Worksheet #: 36761
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)	50 dB / 58 dB		
Heat Treatment		Surface Conditions			

### Transducers/Calibration Blocks

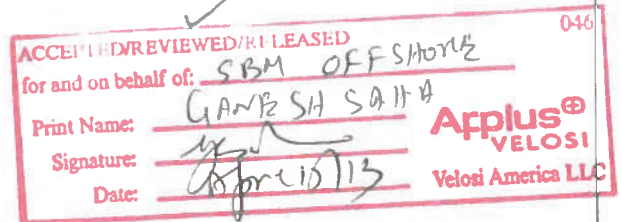
Diameter		Size	Beam Angle	Frequency	Manufacturer	Blocks
<input type="radio"/> 1/4"	<input type="radio"/> 3/4"	<input type="radio"/> 5/8" x 3/4"	<input checked="" type="radio"/> 45°	<input type="radio"/> 1.00 MHz	<input type="radio"/> Techsonic	<input type="radio"/> IIW A2
<input type="radio"/> 3/8"	<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

1173 PQ-7474: Examination of category D nozzle attachment welds  
N2-W1 & N13-W1



APR 11 2013



### Scanning

Test Area	Disposition	From	Length	Depth	Amplitude

### Evaluation – Acceptance

<input checked="" type="radio"/> Accepted	KV Inspection Services – Technician		Date	April 04, 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 # 7474		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	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-7474: Examination of category D attachment welds  
N13-W1

Per NCR N13-038

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



SEP 30 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	September 3, 2013		
Shop Order	1173 PQ S/N 7474	Project			
Component		P.O. #		Worksheet #:	37495
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 / 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

Examination of category 'D' attachment welds  
MW1-W1, N6A-W1, N11-W1, & N12-W1 ✓

ACCEPTED/REVIEWED/RELEASED 045  
 for and on behalf of: SCM OFFSHORE  
 Print Name: GAMPESIT SAHA  
 Signature: [Signature]  
 Date: SEP 11 2013  
**Applus®**  
**VELOSI**  
 Velosi America LLC



SEP 09 2013

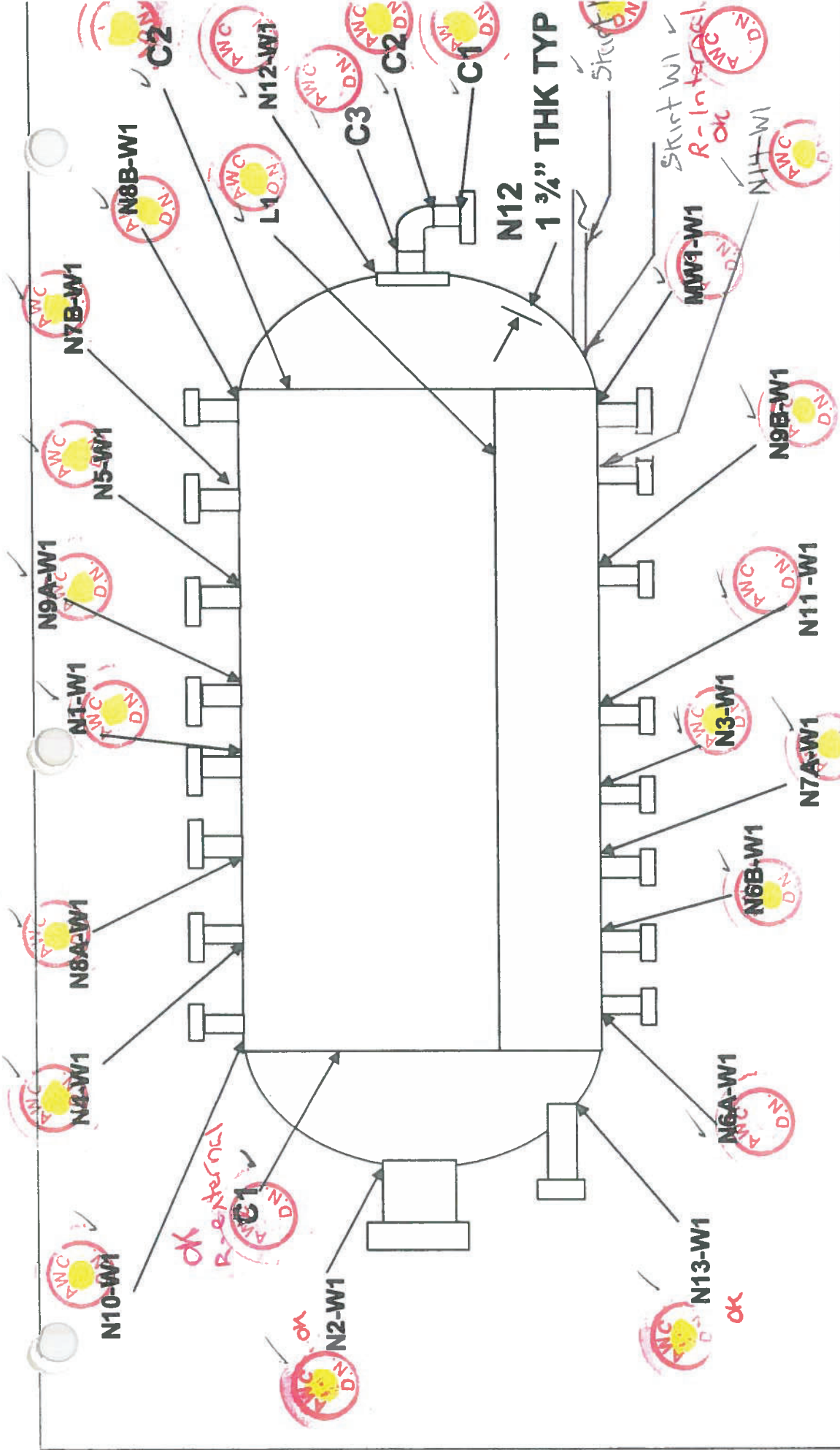
### Scanning

Test Area	Disposition	From	Length	Depth	Amplitude

### Evaluation - Acceptance

<input checked="" type="radio"/> Accepted	KV Inspection Services - Technician	<u>[Signature]</u>	Date	September 3, 2013
<input type="radio"/> Rejected	CGSB No. 48.9712-2000 Reg. No.	8885	Place	Scarborough, ON





**PT MAP - 1173PQ**  
**ASME SECTION VIII. DIV. 1**  
 ALL WELDS INTERNAL / EXTERNAL EXCEPT WHERE NOTED  
 N12- C1, C2, C3  
 MATERIAL SA-240 316/316L, SA-182 F316/316L  
 P.O. 13-0227

<b>ALL-WELD CO. LTD. - PT MAP</b>
CLIENT: ULTRAFAB
WORK ORDER #: 1173PQ SN 7474
<b>JOB DESCRIPTION: 48" O.D. VERTICAL OUTLET</b>
DRAWING #: 1173-1-OU
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**

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"
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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 970P25E	<input checked="" type="radio"/> Water Washable	Serial #: 070706809	
Developer	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<input type="radio"/> Solvent Removable	Intensity: 1200	Lx

Lighting Equipment Description: Flashlight

**Inspection**

Description: Long seam weld

Item #	Description of Weld/Test Area	Defect Location	Interpretation
Serial # 7474	Long seam weld - L1 Inside & out		Acceptable to specification

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SBM OFFSHORE CORP 046  
Print Name: CHANDRA SAHA  
Signature: [Signature] **Applus<sup>®</sup> VELOSI**  
Date: March 14, 2013 **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**

<b>Customer</b>	All-Weld Company	<b>Date</b>	August 6, 2013		
<b>Location</b>	Scarborough, Ontario	<b>P. O. #</b>			
<b>Project</b>	1173 PQ	<b>Shop Order #</b>	7474		
<b>Procedure</b>	KV# 16 Rev. 03	<b>Worksheet #</b>	37169		
<b>Technician</b>	Sherwin Suyom	<b>CGSB Level II, Reg #</b>	15133	<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 #: 80613518</b>		
<b>Developer</b>	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable	<b>Intensity: 1100</b>	<b>Lx</b>	

**Lighting Equipment Description:** Flashlight/Floodlight

**Inspection**

**Description:**

Item #	Description of Weld/Test Area	Defect Location	Interpretation
SN# 7474	C1 (Internal) 100%		Acceptable to specification
	C1 (external) 100%	See photo	Unacceptable to specification
	Skirt W1 (internal) 100%	See photo	Unacceptable to specification
	Skirt W1 (external) 100%		Acceptable to specification
	Skirt L1 (external & internal) 100%		Acceptable to specification

✓

**ACCEPTED/REVIEWED/RELEASED**  
for and on behalf of: Sherwin Suyom  
**Print Name:** GANESH SAHAI  
**Signature:** [Signature]  
**Date:** Aug 16/13

**046**  
**Applus®**  
**VELOSI**  
Velosi America LLC

<b>KV Inspection Technician</b>		<b>Date</b>	August 6, 2013
<b>Customer Representative</b>		<b>Date</b>	AUG 07 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 checked="" type="radio"/> Visible	Light meter	
	<input type="radio"/> Chemetall Oakite 996			
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 970P25E	<input type="radio"/> Fluorescent	Type: EA31	
	<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
Ser#7474	C1 (exterior)		Acceptable to specification.
	Nozzle attachment welds (exterior) N6A-W1, N11-W1, MW1-W1 & N12-W1		Acceptable to specification.
	N12-C3		Acceptable to specification.
	Skirt W1 (Interior)		Acceptable to specification.

046

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBM OFFSHORE  
 Print Name: GANESH SANKH  
 Signature: [Signature]  
 Date: SEP 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	August 13, 2013		
Location	@ KV Inspection, Oakville, ON	P. O. #			
Project	Ultrafab	Shop Order #	1173PQ-7474		
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	SCH 160		
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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		Serial #: 80613518		
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<input checked="" type="radio"/> Water Washable	Intensity: 1300 Lx		
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable			

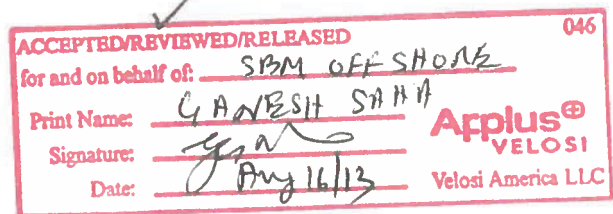
Lighting Equipment Description:

**Inspection**

Description: Nozzle 12

tem #	Description of Weld/Test Area	Defect Location	Interpretation
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SN# 7474	C1 – 2"Ø Butt weld		Acceptable to specification
	C2 – 2" Ø Butt weld		Acceptable to specification



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	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 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 #: 80613518	
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable	Intensity: 2500	Lx

Lighting Equipment Description: Flashlight & Shop lighting

### Inspection

Description: 48" OD Vertical Outlet

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

Ser# 7474	C2 100% -external and internal		Acceptable to specification.
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046

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

KV Inspection Technician	<u>[Signature]</u>	Date	April 04, 2013
Customer Representative	<u>[Signature]</u>	Date	APR 05 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 04, 2013		
Location	Scarborough, ON.	P. O. #			
Project	Vessel	Shop Order #	1173 PQ		
Procedure	KV# 16 Rev. 03	Worksheet #	36761		
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

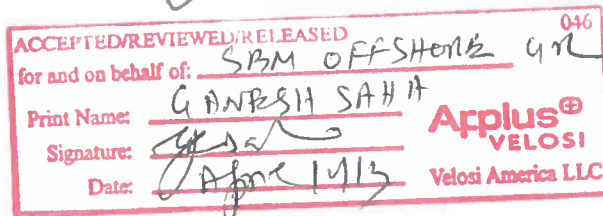
Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter	
	<input type="radio"/> Chemetall Oakite 996			
	<input type="radio"/> Chemetall Oakite 970P25E		<input checked="" type="radio"/> Fluorescent	
Cleaner	<input checked="" type="radio"/> 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: 1400	Lx

Lighting Equipment Description: Flashlight

### Inspection

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
Ser# 7474	N2-W1 -nozzle attachment weld (exterior and interior)		Acceptable to specification.
	N13-W1 -nozzle attachment weld (exterior and interior)		Acceptable to specification.



KV Inspection Technician		Date	April 04, 2013
Customer Representative		Date	APR 09 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 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 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: 1400	Lx

Lighting Equipment Description: Flashlight

### Inspection


Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
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Ser# 7474	N13-W1 attachment weld (interior and exterior)		2 1/2" long crack in exterior weld was repaired and re-tested. Acceptable to specification.
-----------	--	--	---

*Per NCR N13-038*

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBM OFFSHORE  
 Print Name: GARRETH SAHAT  
 Signature: [Signature]  
 Date: JUN 5 2013  
 046  
**Applus<sup>®</sup> VELOSI**  
 Velosi America LLC

KV Inspection Technician		Date	April 30, 2013
Customer Representative		Date	MAY 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	September 3, 2013		
Location	Scarborough, ON	P. O. #			
Project	Vessel	Shop Order #	1173 PQ S/N 7474		
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	Light meter	
	<input type="radio"/> Chemetall Oakite 996			
	<input type="radio"/> Chemetall Oakite 970P25E		<input checked="" type="radio"/> Fluorescent	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
1)	Category 'D' attachment welds MW1-W1, N6A-W1, N11-W1, & N12-W1 (Interior)		Acceptable to specifications
2)	Welds of vortex breaker assembly (loose)		Acceptable to specifications

✓

**ACCEPTED/REVIEWED/RELEASED** 046  
for and on behalf of: SBM OPERATIONS  
Print Name: GA MESH SAHJI  
Signature: [Signature]  
Date: SEP 10 2013  
**Applus<sup>®</sup> VELOSI**  
Velosi America LLC

KV Inspection Technician	<u>[Signature]</u>	Date	September 3, 2013
Customer Representative	<u>[Signature]</u>	Date	AUG 31 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 13, 2013		
Location	Scarborough, ON	P. O. #			
Project	Vessel	Shop Order #	1173 PQ 7474		
Procedure	KV# 16 Rev. 03	Worksheet #	37394		
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	1 3/4"
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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 #: 07076802
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable	Intensity: 1400 Lx

Lighting Equipment Description: Flashlight

### Inspection

Description:

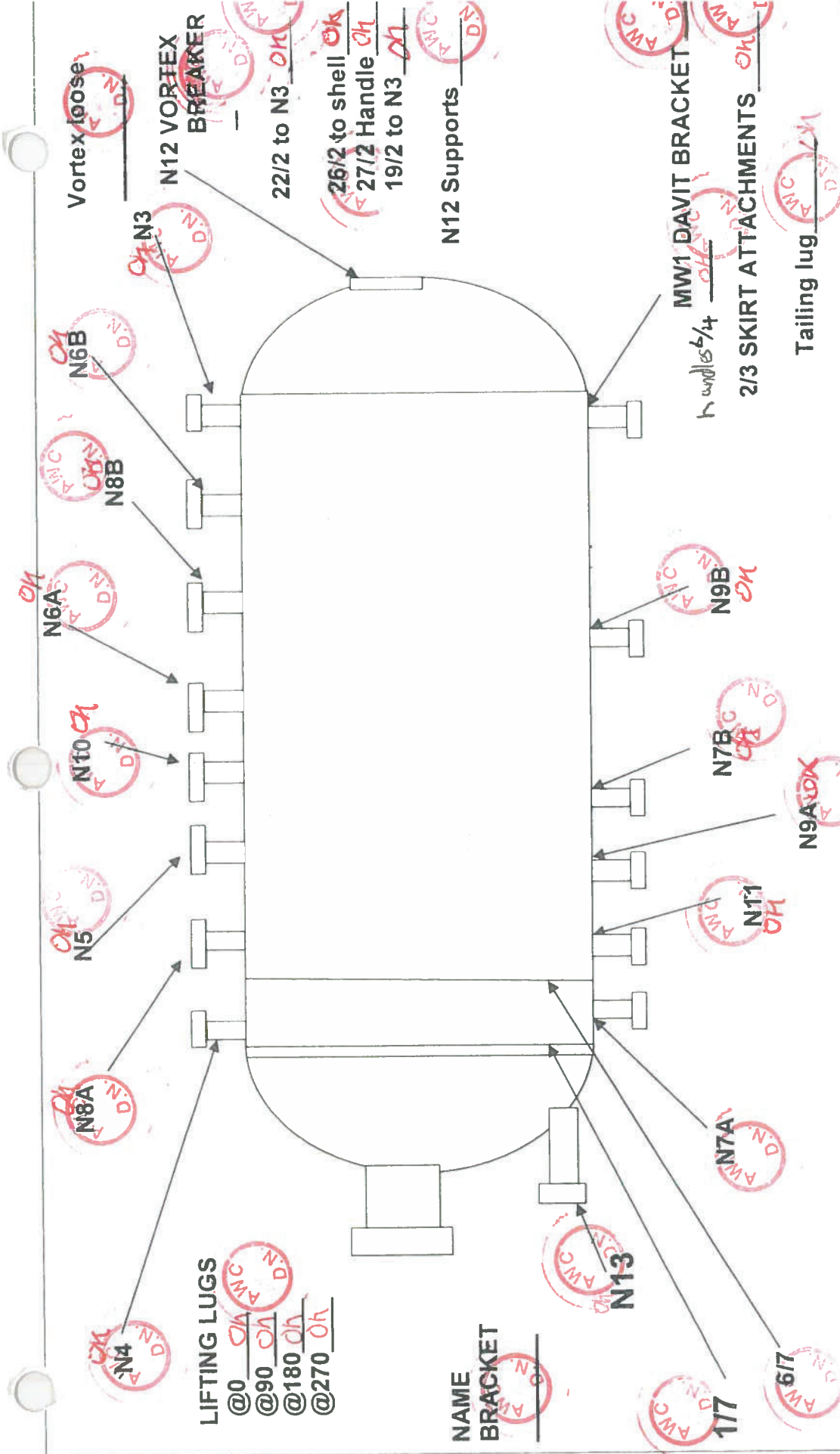
Item #	Description of Weld/Test Area	Defect Location	Interpretation
SN# 7474	Examination of nozzle attachment welds. (interior & exterior) Weld#N1-W1, N3-1, N4-W1, N5-W1, N7A-W1, N7B-W1, N8A-W1, N6B-W1, N8B-W1, N9A-W1, N9B-W1, N10-W1 & N14-W1		Several minor bleedout Indications were lightly dressed and retested. All welds acceptable to specification.

✓

ACCEPTED/REVIEWED/RELEASED 046  
 for and on behalf of: SBM OFFSHORE  
 Print Name: GANESH SAHAI  
 Signature: [Signature]  
 Date: 8/13/13

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

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



LIFTING LUGS

@0	OK
@90	OK
@180	OK
@270	OK

NAME	BRACKET

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

CLIENT: ULTRAFAB
WORK ORDER #: 1173PQ SN 7474
JOB DESCRIPTION: 48" O.D. VERTICAL OUTLET
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  
 ATTACHMENTS / BRACKETS  
 MATERIAL SA-240 316/316L

P.O.

**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 10, 2013		
Location	Scarborough, ON	P. O. #			
Project	Vessel	Shop Order #	1173 PQ S/N 7474		
Procedure	KV# 16 Rev. 03	Worksheet #	37500		
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		Type: EA31	
Cleaner	<input type="radio"/> Chemetall Oakite 970P25E	<input type="radio"/> Fluorescent	Serial #: 07076802	
	<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)	Item 2/3 baseplate weld		Acceptable to specifications
2)	Item 22/2 to N3 weld		Acceptable to specifications
3)	Nozzle support welds N3,N4, N5, N6A, N6B, N7B, N8A, N8B, N9A, N9B, N10, N11 and N12		Acceptable to specifications

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



KV Inspection Technician	<u>[Signature]</u>	Date	September 10, 2013
Customer Representative	<u>[Signature]</u>	Date	SEP 30 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		<input type="radio"/> Fluorescent	
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#7474	Item 19/2 to shell weld		A number of indications were lightly dressed and re-tested. All welds are acceptable to specification.
	Item 27/2 to shell weld		
	Item 26/2 to shell weld		
	Item 1/7 to shell weld		
	Item 6/7 to shell weld		
	4 lifting lug to head welds		
	N12 supports welds		

✓

ACCEPTED/REVIEWED/RELEASED 046  
for and on behalf of: SIBM OFF SHORE  
Print Name: GAVESH SAHA  
Signature: [Signature] **Applus® VELOSI**  
Date: SEP 13/13 **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 7474		
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		
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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 #: 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
	Vortex breaker attachment weld		Acceptable to specification
	MW1 Davit bracket attachment weld		Acceptable to specification
	Name plate bracket attachment weld		Acceptable to specification
	N7A support welds		Acceptable to specification

046

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBM OFFSHORE  
 Print Name: GAMESHA SAHA  
 Signature: [Signature]  
 Date: SEP 18/13  
**Applus®**  
**VELOSI**  
 Velosi America LLC

KV Inspection Technician	<u>[Signature]</u>	Date	September 11, 2013
Customer Representative		Date	SEP 16 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 16, 2013		
Location	Scarborough, ON	P. O. #			
Project	Vessel	Shop Order #	1173 PQ		
Procedure	KV# 16 Rev. 03	Worksheet #	67643		
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				
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 970P25E	<input checked="" type="radio"/> Water Washable	Serial #: 07076802		
	<input 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#7474	N13 Support Welds		Acceptable to specification
	Item 6/4 attachment welds		Acceptable to specification

✓

ACCEPTED/REVIEWED/RELEASED 046  
for and on behalf of: SBM OFF SHORE  
Print Name: CAROL SAHJ  
Signature: [Signature]  
Date: Sept 11/13  
**Applus®**  
**VELOSI**  
Velosi America LLC

KV Inspection Technician		Date	September 16, 2013
Customer Representative		Date	SEP 30 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 13, 2013		
Location	Scarborough, ON	P. O. #			
Project	Tailing lug	Shop Order #	1173 PQ		
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	
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### Equipment & Method

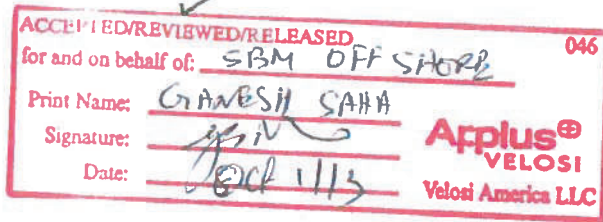
Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906 <input type="radio"/> Chemetall Oakite 996 <input type="radio"/> Chemetall Oakite 970P25E	<input checked="" type="radio"/> Visible <input type="radio"/> Fluorescent	Light meter		
	Cleaner	<input checked="" type="radio"/> Chemetall Oakite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

Lighting Equipment Description: Flashlight

### Inspection

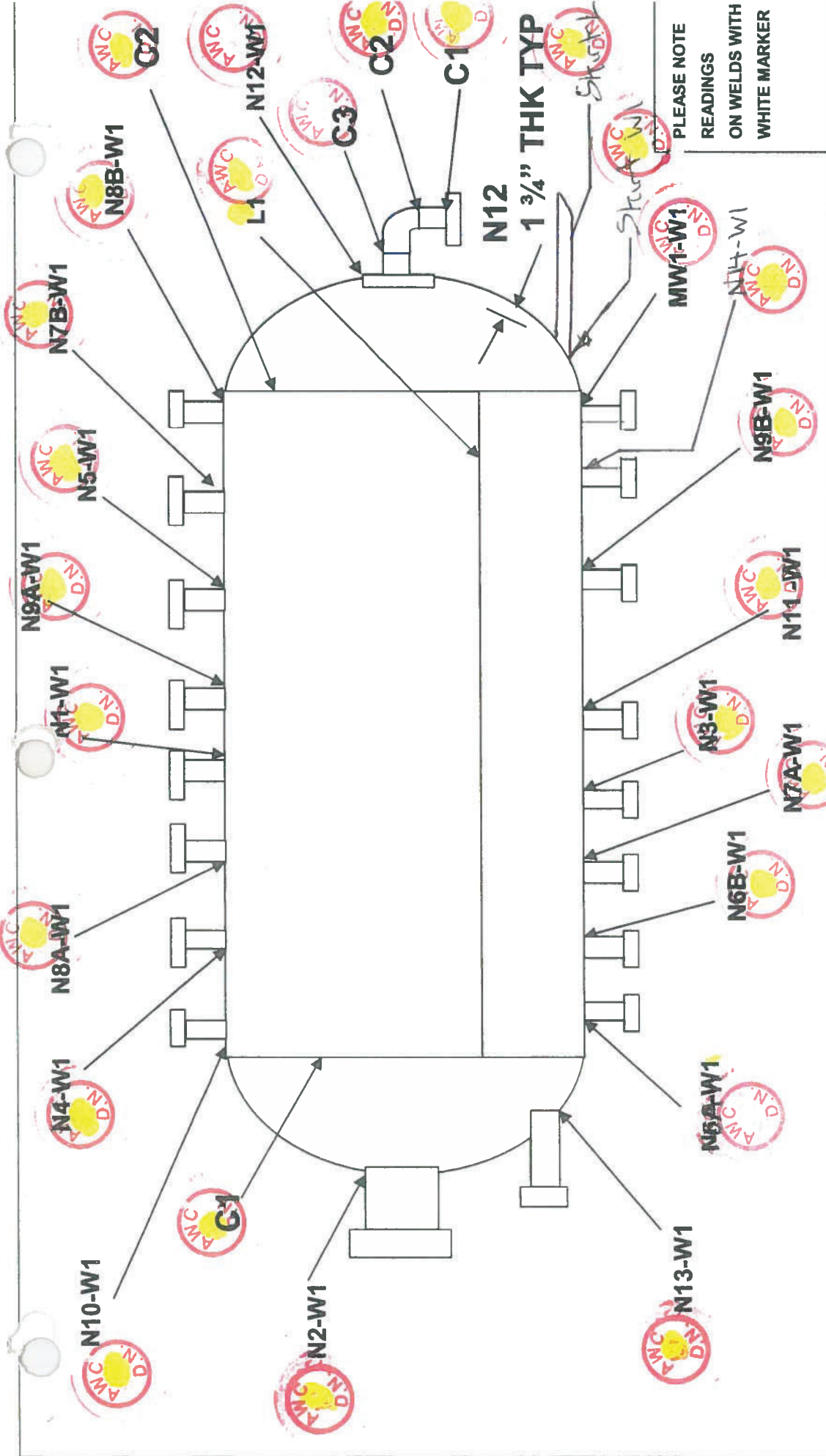
Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
Ser#7474	Tailing lug attachment weld.		Acceptable to specification



KV Inspection Technician		Date	September 13, 2013
Customer Representative		Date	SEP 30 2013





**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

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

CLIENT: ULTRAFAB

WORK ORDER #: 1173PQ SN 7474

JOB DESCRIPTION: 48" O.D. VERTICAL OUTLET

DRAWING #: 1173-1-OU

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 # 7474 – L1	Parent Material	235
	H.A.Z	241
	Weld	245
	H.A.Z	204
	Parent Material	199

046

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBM OFFSHORE C.Y.R.  
 Print Name: LIAN WESIA SAHWA  
 Signature: [Signature]  
 Date: APR 10/13

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



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

**Hardness Testing Report  
HT**

**Specification – Acceptance Criteria**

**General Data**

Customer	All-Weld Company	Date	August 8, 2013
Location	Scarborough, Ontario	P. O. #	
Project	Vessel	Shop Order #	1173 PQ Ser#7474
Procedure	KV HT# 35 Rev.00	Worksheet #	37392
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 – Optical 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"/> Other: HV

**Inspection**

Description:

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7474	N1-W1	160	147	152	174	160
	N3-W1	220	198	163	180	195
	N4-W1	159	167	173	164	188
	N5-W1	163	159	132	191	193
	N6A	Not Ready				
	N6B-W1	175	158	154	175	194
	N7A-W1	155	170	152	172	166
	N7B-W1	148	156	135	182	198
	C1	194	194	171	202	192

046  
 ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBA OF F-SHORE  
 Print Name: GARRETT SAH  
 Signature: [Signature]  
 Date: Aug 16/13  
**Applus®**  
**VELOSI**  
 Velosi America LLC

KV Inspection Technician

*[Signature]*

Date

August 8, 2013

Customer Representative



Date

AUG 12 2013

**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#7474
Procedure	KV HT# 35 Rev. 00	Worksheet #	37393
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"/> Other: HV Unit Setting: S.S.

**Inspection**

Description:

Item #	Description of Test Area	Weld	HAZ	HAZ	Parent Material	Parent Material
Ser# 7474	C2	159	186	196	162	204
	N10-W1	167	170	174	172	169
	N14-W1	157	171	167	161	185

✓

**ACCEPTED/REVIEWED/RELEASED**  
 for and on behalf of: SIM OFF STORE  
 Print Name: CHRISTINA SAHA  
 Signature: [Signature]  
 Date: AUG 16/13

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

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

#### 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# 7474	N2-W1	177	200	153	180	156
	N13-W1	194	183	142	166	166

✓

ACCEPTED/REVIEWED/RELEASED 046  
 for and on behalf of: SAM OFFSHORE  
 Print Name: CAMPBELL SAHA  
 Signature: [Signature] **Applus®**  
 Date: July 5 2013 **VELOSI**  
Velosi America LLC

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

**Hardness Testing Report  
 HT**

**Specification – Acceptance Criteria**

**248 HV Max**

**General Data**

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

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

<b>Material</b>	Stainless Steel
-----------------	-----------------

**Test Method & Equipment**

<b>Technique</b>	<input checked="" type="radio"/> Impact Load – Digital Readout
<b>Equipment</b>	<input checked="" type="radio"/> Equotip D Impact Device
<b>Readings Taken</b>	<input type="radio"/> Average of 5 readings <input checked="" type="radio"/> Average of 3 readings <input type="radio"/> Other
<b>Scale</b>	<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# 7474	N13-W1	201	211	158	161	159

Per NCR N13-038

ACCEPTED / REVIEWED / RELEASED  
 for and on behalf of: SAM OFFSHORE 046  
 Print Name: GABRIEL SAHA  
 Signature: [Signature]  
 Date: JUN 5 2013  
**Applus®**  
**VELOSI**  
 Velosi America LLC

<b>KV Inspection Technician</b>		<b>Date</b>	April 30, 2013
<b>Customer Representative</b>		<b>Date</b>	MAY 07 2013

**Hardness Testing Report  
HT**

**Specification – Acceptance Criteria**

**General Data**

Customer	All-Weld Company	Date	August 8, 2013
Location	Scarborough, Ontario	P. O. #	
Project	Vessel	Shop Order #	1173 PQ Ser#7474
Procedure	KV HT# 35 Rev.00	Worksheet #	37392
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 – Optical 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"/> Other: HV

**Inspection**

**Description:**

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7474	N8A-W1	197	203	166	183	204
	N8B-W1	173	174	133	172	196
	N9A-W1	183	213	133	172	188
	N9B-W1	197	197	128	183	192
	N10	Not Ready				
	N11-W1	183	184	166	186	195
	N12	Not Ready				
	Skirt L	176	172	132	151	158
	Skirt W1	166	178	178	179	192

Item #  
Ser# 7474  
 Approved for work by SBM AFFSHORE  
 Print name: C. P. WESSLI SAHA  
 Signature: [Signature]  
 Date: Aug 16/13  
 VELOSI  
 Wood America LLC

KV Inspection Technician		Date	August 8, 2013
Customer Representative		Date	AUG 12 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#7474
Procedure	KV HT# 35 Rev.00	Worksheet #	37440
Technician	Ed Duitschaever	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 515

### 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 checked="" type="radio"/> Brinell Hardness <span style="margin-left: 20px;"><input type="radio"/> Other</span>

### Inspection

Description:

Item #	Description of Test Area	Parent Material Flange	HAZ	Weld	HAZ	Parent Material
Ser# 7474	N12 – C1	183	167	181	169	143
	N12 – C2	157	153	143	171	157

ACCEPTED/REVIEWED/RELEASED 046



for and on behalf of: SBM OFF SHORE

Print Name: GAMBRI SAHJ

Signature: [Signature]

Date: AUG 16/13

**Applus®**  
VELOSI  
Velosi America LLC

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



**Hardness Testing Report  
HT**

**Specification – Acceptance Criteria**

2u8 MAX

**General Data**

Customer	All-Weld Company	Date	August 29, 2013
Location	Scarborough, ON	P. O. #	
Project	Vessel	Shop Order #	1173 PQ
Procedure	KV HT# 35 Rev.00	Worksheet #	37493
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:

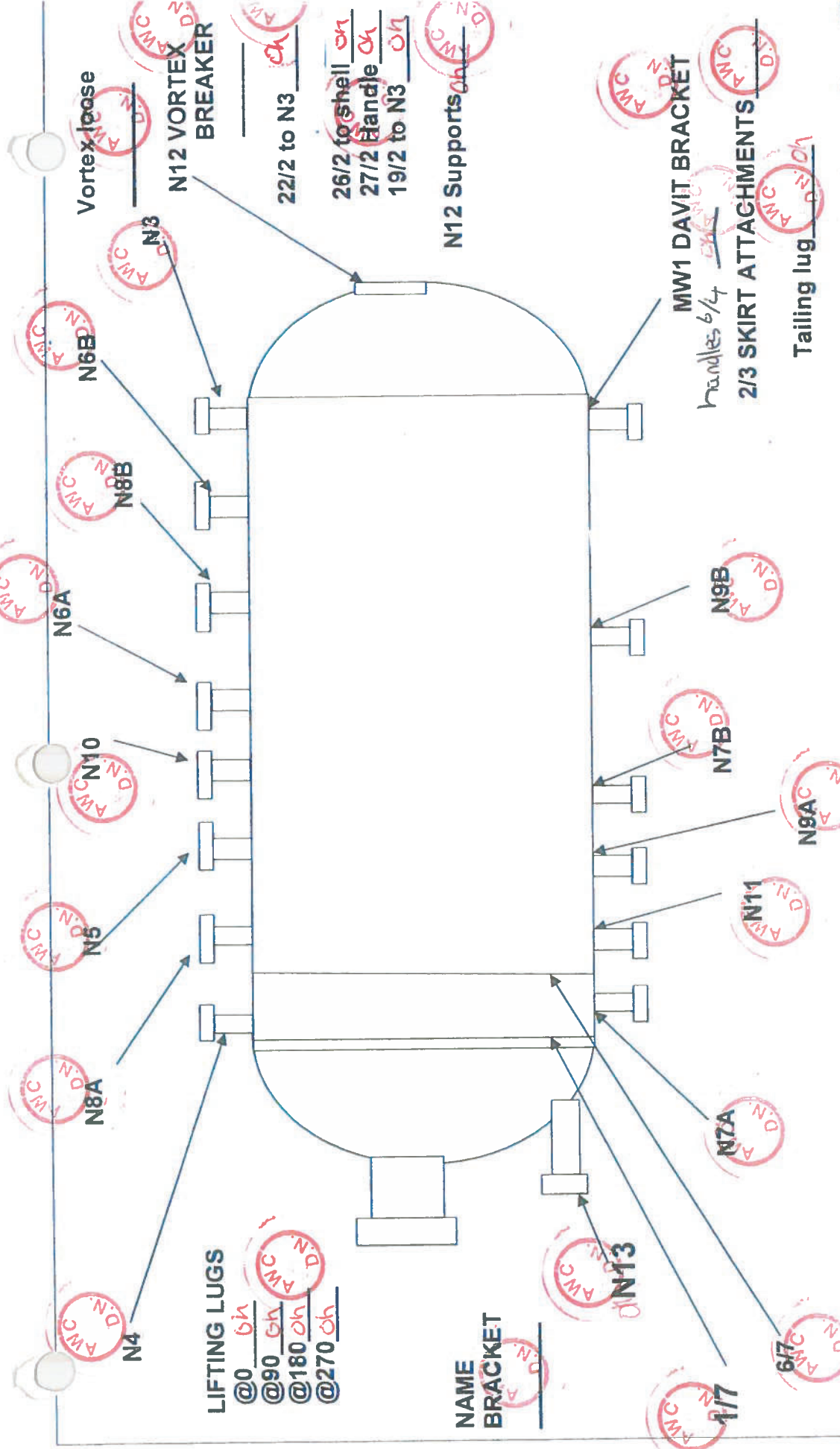
Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7474	MW1	160	167	159	177	211
	N11	189	172	155	183	174
	N6A	168	180	165	172	186
	N12	176	144	138	195	185
	N12-C3	182	151	136	155	187

046

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SBM OFFSHORE  
Print Name: GANESH SETHI  
Signature: [Signature]  
Date: SEP 10 2013

**Applus®**  
VELOSI  
Velosi America LLC

KV Inspection Technician		Date	August 29, 2013
Customer Representative		Date	SEP 04 2013



Vortex loose

N12 VORTEX BREAKER

22/2 to N3  
 26/2 for shell  
 27/2 Handle  
 19/2 to N3

N12 Supports

MW1 DAVIT BRACKET

handles 6/4

2/3 SKIRT ATTACHMENTS

Tailing lug

LIFTING LUGS

@0 bh  
 @90 oh  
 @180 oh  
 @270 oh

NAME BRACKET

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

CLIENT: ULTRAFAB

WORK ORDER #: 1173PQ SN 7474,

JOB DESCRIPTION: 48" O.D. VERTICAL OUTLET

DRAWING #: 1173-1-IN

PREPARED BY: D.NESCI

DATE: March 6, 2013

HT MAP - 1173PQ

ASME SECTION VIII, DIV. 1

ALL WELDS INTERNAL / EXTERNAL EXCEPT WHERE NOTED  
 ATTACHMENTS / BRACKETS

MATERIAL SA-240 316/316L

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 11, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7474
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:

Item #	Description of Test Area	Weld	HAZ	HAZ	Parent Material	Parent Material
Ser# 7474						
N3	Support Weld # 1	133	170	146	200	132
	Support Weld # 2	133	131	125	172	103
	Support Weld # 3	149	179	148	171	128
	Support Weld # 4	131	155	145	173	142
N4	Support Weld # 1	134	139	158	160	142
	Support Weld # 2	137	152	165	165	156
	Support Weld # 3	108	130	137	168	144
	Support Weld # 4	136	121	134	149	132

046  
 ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SPIM OFFSHORE  
 Print Name: GAYESH SAHA  
 Signature: *[Signature]*  
 Date: Sep 18 2013  
**Applus**  
**VELOSI**  
 Velosi America LLC

KV Inspection Technician	<i>[Signature]</i>	Date	September 11, 2013
Customer Representative		Date	SEP 16 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 7474
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:

Item #	Description of Test Area	Weld	HAZ	HAZ	Parent Material	Parent Material
Ser# 7474						
N5	Support Weld # 1	130	148	170	170	158
	Support Weld # 2	159	165	145	183	151
	Support Weld # 3	164	137	146	155	117
	Support Weld # 4	152	174	166	154	131
N6A	Support Weld # 1	141	131	148	201	202
	Support Weld # 2	127	129	142	146	136
	Support Weld # 3	142	153	151	141	143
	Support Weld # 4	156	160	173	182	134

046  
 ACCEPTED REVIEWED/RELEASED  
 for and on behalf of: SAM OFA SHORE  
 GAVES A SANA  
 Sep 18 2013  
**Applus**  
**VELOSI**  
 Veloc America LLC

KV Inspection Technician		Date	September 11, 2013
Customer Representative		Date	SEP 16 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 7474
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:

Item #	Description of Test Area	Weld	HAZ	HAZ	Parent Material	Parent Material
Ser# 7474						
N6B	Support Weld # 1	133	126	134	163	135
	Support Weld # 2	155	169	149	175	129
	Support Weld # 3	109	143	139	120	185
	Support Weld # 4	131	146	158	125	179
N7A	Support Weld # 1	130	136	169	142	123
	Support Weld # 2	138	151	135	146	142
	Support Weld # 3	100	131	150	133	137
	Support Weld # 4	123	148	150	148	145

046  
**ACCEPTED/REVIEWED/RELEASED**  
 for and on behalf of: *SAM OFF SHORE*  
*GAJESH SAHA*  
 Print Name: *GAJESH SAHA*  
 Signature: *[Signature]*  
 Date: *SEP 11 2013*  
**Applus®**  
**VELOSI**  
 Vehoi America LLC

KV Inspection Technician	<i>[Signature]</i>	Date	September 11, 2013
Customer Representative		Date	SEP 16 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 7474
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:

Item #	Description of Test Area	Weld	HAZ	HAZ	Parent Material	Parent Material
Ser# 7474						
N7B	Support Weld # 1	106	132	151	142	134
	Support Weld # 2	131	156	141	174	132
	Support Weld # 3	141	136	156	182	150
	Support Weld # 4	164	128	142	135	124
N8A	Support Weld # 1	126	149	170	147	147
	Support Weld # 2	147	131	167	159	135
	Support Weld # 3	124	117	148	156	121
	Support Weld # 4	136	152	172	153	155

046  
 ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SDM OFF STORE  
 Print Name: GYANESH SAHA  
 Signature: *[Signature]*  
 Date: 9 SEP 11 2013  
**Applus**  
**VELOSI**  
 Velosi America LLC

KV Inspection Technician

*[Signature]*

Date

September 11, 2013

Customer Representative

**AWC**

Date

SEP 16 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 7474
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

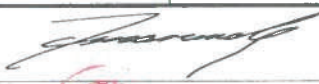

Technique	<input checked="" type="radio"/> Impact Load – Digital Readout <input type="radio"/> Impact Load – Ocular Viewing
Equipment	<input checked="" type="radio"/> Equotip D Impact Device
Readings Taken	<input type="radio"/> Average of 5 readings <input checked="" type="radio"/> Average of 3 readings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

#### Inspection

##### Description:

Item #	Description of Test Area	Weld	HAZ	HAZ	Parent Material	Parent Material
Ser# 7474						
N8B	Support Weld # 1	133	116	160	152	133
	Support Weld # 2	134	147	128	137	139
	Support Weld # 3	144	132	154	205	134
	Support Weld # 4	151	150	148	129	147
N9A	Support Weld # 1	114	137	147	142	121
	Support Weld # 2	129	139	174	152	146
	Support Weld # 3	117	135	137	168	133
	Support Weld # 4	124	151	157	169	141

046  
 ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SPM OFFSHORE  
 Print Name: Umesh Saha  
 Signature: [Signature]  
 Date: SEP 11 2013  
**Appius®**  
**VELOSI**  
 Velocity America LLC

KV Inspection Technician		Date	September 11, 2013
Customer Representative		Date	SEP 16 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 7474
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

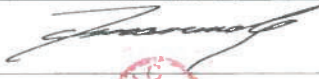

Technique	<input checked="" type="radio"/> Impact Load - Digital Readout <input type="radio"/> Impact Load - Ocular Viewing
Equipment	<input checked="" type="radio"/> Equotip D Impact Device
Readings Taken	<input type="radio"/> Average of 5 readings <input checked="" type="radio"/> Average of 3 readings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

#### Inspection

##### Description:

Item #	Description of Test Area	Weld	HAZ	HAZ	Parent Material	Parent Material
Ser# 7474						
N9B	Support Weld # 1	134	147	137	168	123
	Support Weld # 2	141	151	146	155	132
	Support Weld # 3	150	147	129	149	117
	Support Weld # 4	137	161	143	180	135
N10	Support Weld # 1	131	137	144	153	109
	Support Weld # 2	114	134	144	152	120
	Support Weld # 3	134	124	120	145	107
	Support Weld # 4	143	165	124	157	134

046  
 ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBM OFF SHORE  
 J. AYESH SAHA  
 Print Name: J. AYESH SAHA  
 Signature: [Signature]  
 Date: Sep 18 2013  
**Arplus®**  
**VELOSI**  
 Velocity America LLC

KV Inspection Technician		Date	September 11, 2013
Customer Representative		Date	SEP 16 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
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# 7474	N11 Support welds					
	Weld #1	166	131	132	131	121
	Weld #2	170	157	128	135	120
	Weld #3	189	130	140	160	115
	Weld #4	201	182	146	156	130
	N3 Support welds					
	Weld #1	109	109	114	119	123
	Weld #2	114	111	153	159	14
	Weld #3	106	125	119	129	143
	Weld #4	123	147	129	127	119
	Tailing Lug	121	114	118	142	141

046

Applus®  
VELOSI

Velosi America LLC

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SIBM OFF SHORE  
Print Name: GABRIEL SAM  
Signature: [Signature]  
Date: September 13

KV Inspection Technician		Date	September 13, 2013
Customer Representative		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 #	37496
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# 7474	Lifting lug					
	0°	162	155	146	174	161
	90°	158	159	159	150	162
	180°	177	162	153	157	167
	270°	162	157	154	149	158
	N12 support welds					
	#1	173	141	150	141	111
	#2	183	139	136	161	127
	#3	169	129	142	139	131
	#4	157	151	129	133	128

046  
 ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBSM OFFSHORE  
 Print Name: CAMERON SAH  
 Signature: [Signature]  
 Date: SEP 13/13  
**Applus®**  
**VELOSI**  
 Weld America LLC

KV Inspection Technician

*[Signature]*

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 16, 2013
Location	Scarborough, ON	P. O. #	
Project	Vessel	Shop Order #	1173 PQ
Procedure	KV HT# 35 Rev.00	Worksheet #	37643
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# 7474	Item 6/4					
	Weld #1	193	143	166	170	173
	Weld #2	159	145	143	165	181
	Weld #3	156	172	154	145	192
	Weld #4	170	164	139	170	179
	N13 Support Welds					
	Weld #1	146	170	133	135	125
	Weld #2	151	168	126	150	144
	Weld #3	160	141	131	166	129
	Weld #4	162	154	144	132	112

046

ACCEPTED/REVIEWED/RELEASED

for and on behalf of: SAM OFF-SHORE

Print Name: SAHIA SAHIA

Signature: [Signature]

Date: SEP 20 2013

**Appius®**  
VELOSI  
Velo America LLC

KV Inspection Technician		Date	September 16, 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 3, 2013
Location	Scarborough, ON	P. O. #	
Project	Vessel	Shop Order #	1173 PQ S/N 7474
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
----------	-----------------

**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# 7474	Vortex breaker loose	130	157	138	159	130

✓



ACCEPTED/REVIEWED/RELEASED 046

for and on behalf of: SIBM OFFSHORE

Print Name: GRANTISH SAHIL

Signature: [Signature] **Applus<sup>®</sup> VELOSI**

Date: SEP 1 2013 **Velosi America LLC**

KV Inspection Technician		Date	September 3, 2013
Customer Representative		Date	AUG 31 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
----------	-----------------

**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

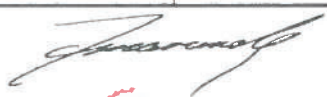

**Inspection**

Description:

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7474	Item 26/2	174	154	147	229	212
	Item 27/2	182	173	142	175	142
	Item 19/2	155	168	162	147	152
	Item 1/7	132	154	139	141	176
	Item 6/7	182	169	157	172	152
	Item 2/3	114	128	135	194	166

046

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SBM OFFSHORE  
Print Name: CAROL SAH  
Signature: [Signature]  
Date: SEP 13/13  
**Applus®**  
**VELOSI**  
Velosi America LLC

KV Inspection Technician		Date	September 4, 2013
Customer Representative		Date	SEP 11 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**

<b>Customer</b>	All-Weld Company	<b>Date</b>	September 10, 2013
<b>Location</b>	Scarborough, ON	<b>P. O. #</b>	
<b>Project</b>		<b>Shop Order #</b>	1173 PQ S/N 7474
<b>Procedure</b>	KV HT# 35 Rev.00	<b>Worksheet #</b>	37500
<b>Technician</b>	Frank Marunde	<b>HT Certified</b>	<input checked="" type="checkbox"/> CGSB Reg # 8885

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

<b>Material</b>	Stainless Steel
-----------------	-----------------

**Test Method & Equipment**



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

**Inspection**

Description:

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7474	Item 22/2 to N3	148	170	178	160	129

ACCEPTED/REVIEWED/RELEASED 046  
 for and on behalf of: SBM OFFSHORE  
 Print Name: CHRISTIE SAHA  
 Signature: [Signature]  
 Date: SEP 12 2013 **Applus<sup>®</sup> VELOSI**  
 Velocity America LLC

<b>KV Inspection Technician</b>		<b>Date</b>	September 10, 2013
<b>Customer Representative</b>		<b>Date</b>	SEP 12 2013

**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 7474
Procedure	KV HT# 35 Rev.00	Worksheet #	37591
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"/> HV         Unit Setting:

**Inspection**

Description:

Item #	Description of Test Area	Weld	HAZ	HAZ	Parent Material	Parent Material
Ser# 7474	Vortex Breaker	157	161	151	124	145
	Name Plate Bracket	151	169	--	130	151
	Davit Bracket	179	165	166	154	146

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBIN OFFSHORE 046  
 Print Name: G. ANPESH SAHA  
 Signature: [Signature] **Applus®**  
 Date: SEP 11 2013 **VELOSI**  
**Velosi America LLC**

KV Inspection Technician	<i>[Signature]</i>	Date	September 11, 2013
Customer Representative		Date	SEP 16 2013

<b>NON-CONFORMANCE REPORT</b>				NCR No. N13-038
Order 1173PQ	Serial Number 7474	Customer Utrafab	NCR Author DN	NCR Date 12-Apr-13

**NCR Background**

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

**Description**

N13 conn out of level 1.0 degrees max per ASME & SBM spec is 0.5

Immediate Action	
------------------	--

**NCR Disposition**

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

**Description**

Apply slight heat & jack into position  
 redo PT & UT NDE + HT  
 Repair if required.

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

**Disposition Verification**

(Sign and Date)						
Dwgs/Calcs		Prod-CPS		ISO		
Purchasing		QA <i>DN</i>	<i>1/05/13</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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# 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">ALL-WELD COMPANY LIMITED</td> </tr> <tr> <td>Address /</td> <td>49 PASSMORE AVE. PLANT 1      14 PASSMORE AVE. PLANT 2</td> </tr> <tr> <td colspan="2" style="text-align: center;">SCARBOROUGH, ONTARIO</td> </tr> <tr> <td>Postal Code ( PLANT 1 )</td> <td>Postal Code ( PLANT 2 )</td> </tr> <tr> <td>M1V-4T1</td> <td>M1V-2R6</td> </tr> </table>	<b>1</b>	<b>Company</b>	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	<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>WP 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>1-1</td> <td>Revision No. <b>6</b></td> </tr> <tr> <td>Code Section</td> <td>IX</td> <td>Date 14 April, 07</td> </tr> <tr> <td>PQR No.</td> <td colspan="2" style="text-align: center;">1, 1A &amp; 78</td> </tr> </table>	<b>2</b>	<b>Provincial Registration</b>	WP D700.5 R2363.5 / R2060.5	<b>3</b>	<b>Procedure Identification</b>		WPS NO.	1-1	Revision No. <b>6</b>	Code Section	IX	Date 14 April, 07	PQR No.	1, 1A & 78	
<b>1</b>	<b>Company</b>																											
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<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="text-align: center;"><b>4</b></td> <td><b>Welding Process(es)</b></td> </tr> <tr> <td>1</td> <td><b>SMAW</b></td> </tr> <tr> <td>2</td> <td></td> </tr> <tr> <td>3</td> <td></td> </tr> </table>	<b>4</b>	<b>Welding Process(es)</b>	1	<b>SMAW</b>	2		3		<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td>Manual</td> <td style="text-align: center;"><b>X</b></td> <td>Semi-auto.</td> <td></td> <td>Auto.</td> <td></td> </tr> <tr> <td>Manual</td> <td></td> <td>Semi-auto.</td> <td></td> <td>Auto.</td> <td></td> </tr> <tr> <td>Manual</td> <td></td> <td>Semi-auto.</td> <td></td> <td>Auto.</td> <td></td> </tr> </table>	Manual	<b>X</b>	Semi-auto.		Auto.		Manual		Semi-auto.		Auto.		Manual		Semi-auto.		Auto.	
<b>4</b>	<b>Welding Process(es)</b>																										
1	<b>SMAW</b>																										
2																											
3																											
Manual	<b>X</b>	Semi-auto.		Auto.																							
Manual		Semi-auto.		Auto.																							
Manual		Semi-auto.		Auto.																							

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

<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 SA-36, 53, 105, 106, 181, 234WPB, 285 & 516 to SA-36, 53, 105, 106, 181, 234WPB, 285 & 516		
or Chemical Analysis and Mech. Prop. <span style="float: right;">NONE</span>		
Thickness Range Qualified	Total 1) 1/16" 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.	E7018-1H4	RETURN LOW HYDROGEN ELECTRODES TO THE OVEN EVERY 4 HOURS	SFA	5.1	F-No	4	A-No.	1	Dia.	3/32" & 1/8"
2. AWS No.	E7018-1H4		SFA	5.1	F-No	4	A-No.	1	Dia.	5/32"
3. AWS No.	E7018-1H4		SFA	5.1	F-No	4	A-No.	1	Dia.	3/16" & 1/4"
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	

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

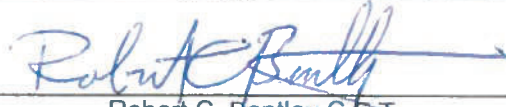
<b>11 Gas (QW-408)</b>	
Shielding Gas Composition	NONE
Gas Flow Rate	NONE
Backing Gas Composition	NONE
Trailing Shield Gas Composition	NONE
Other	NONE

**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.

<b>1 Supplementary Comments</b>	
NONE	

<b>14</b>	Company Representative Signature	 Robert C. Bentley C.E.T.	Date	14 April, 07
-----------	----------------------------------	--	------	--------------

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

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

**COPY**

**PROCEDURE QUALIFICATION RECORD**

**PQR - 1**

Date **APR 23, 1979**

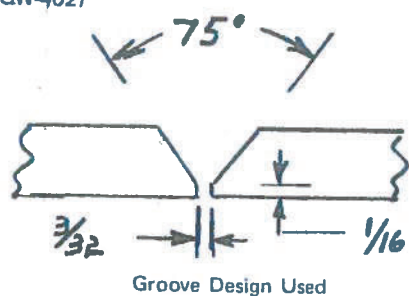
**ALL-WELD COMPANY LIMITED**  
(Manufacturer)

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><b>JOINTS (QW-402)</b></p>  <p>Groove Design Used</p>	<p><b>BASE METALS (QW-403)</b></p> <p>Material Spec. <b>Carbon Steel</b></p> <p>Type or Grade <b>SA53 GR.B</b></p> <p>P No. <b>1</b> to P No. <b>1</b></p> <p>Thickness <b>0.432"</b></p> <p>Diameter <b>6" Pipe</b></p> <p>Other <b>N/A</b> <i>NO SINGLE PASS GREATER THAN 1/2" THICK VOID</i> <i>7/6/79 3/3/75 (PQR) 3/3/75 @ 14/3/75</i></p>
<p><b>FILLER METALS (QW-404)</b></p> <p>Weld Metal Analysis A No. <b>A1</b></p> <p>Size of Electrode <b>3/32 1/8</b></p> <p>Filler Metal F No. <b>F4</b></p> <p>SFA Specification <b>5.1</b></p> <p>AWS Classification <b>E7018</b></p> <p>Other <b>N/A</b></p>	<p><b>POSITION (QW-405)</b></p> <p>Position of Groove <b>A11</b></p> <p>Weld Progression <b>UP</b> (Uphill, Downhill)</p> <p>Other <b>N/A</b></p> <p><b>PREHEAT (QW-406)</b></p> <p>Preheat Temp. <b>NONE 50°F</b> <i>JUN 23/79</i></p> <p>Interpass Temp. <b>N/A</b></p> <p>Other <b>N/A</b></p>
<p><b>POSTWELD HEAT TREATMENT (QW-407)</b></p> <p>Temperature <b>None</b></p> <p>Time <b>N/A</b></p> <p>Other <b>N/A</b></p>	<p><b>GAS (QW-408)</b></p> <p>Type of Gas or Gases <b>N/A</b></p> <p>Composition of Gas Mixture <b>N/A</b></p> <p>Other <b>N/A</b></p>
<p><b>ELECTRICAL CHARACTERISTICS (QW-409)</b></p> <p>Current <b>DC</b></p> <p>Polarity <b>Reverse</b></p> <p>Amps. <b>12(I) - 150</b> Volts <b>22 - 24</b></p> <p>Travel Speed <b>N/A</b></p> <p>Other <b>N/A</b></p>	<p><b>TECHNIQUE (QW-410)</b></p> <p>String or Weave Bead <b>String</b></p> <p>Oscillation <b>N/A</b></p> <p>Multipass or Single Pass <b>Multipass</b> (per side)</p> <p>Single or Multiple Electrodes <b>Single</b></p>

TENSILE TEST (QW-150)

PQR-1

SPECIMEN NO.	WIDTH	THICKNESS	AREA	ULTIMATE TOTAL LOAD LB.	ULTIMATE UNIT STRESS PSI	CHARACTER FAILUR LOC&T
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 P1x 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.



14 Tensile Tests/Essais à la traction						Reference: Référence:
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				
T1	0.748	0.243	0.1818	15640	86046	FRACTURED IN
T2	0.757	0.242	0.1832	15670	85538	BASE MET.

15 Guided Bend Tests/Essais de pliage guidé						Reference: Référence:			
Specimen Éprouvette	Face Face	Root Racine	Side Côté	Result Résultat	Specimen Éprouvette	Face Face	Root Racine	Side Côté	Result Résultat
S1	✓			ACCEPTABLE	S3	✓			ACCEPTABLE
S2		✓		ACCEPTABLE	S4		✓		ACCEPTABLE

16 Toughness Tests/Essais de résilience						Reference: Référence:		
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: Référence:
Result - Satisfactory Résultat satisfaisant	Yes <input type="checkbox"/> Oui	No <input type="checkbox"/> Non	Penetration Into Parent Metal Pénétration dans métal de base	Yes <input type="checkbox"/> Oui
Macro - Results Résultats macroscopiques				

18 Other Tests/Autres essais		Reference: Référence:

19 Welder's Name  
Nom du soudeur ISSA BKAYLEH Stamp No.  
N° de symbole 16

Tests conducted by  
Essais effectués par CAMBRIDGE MATERIALS TESTING LTD Laboratory Test No.  
Essai de laboratoire n° 125124-1995

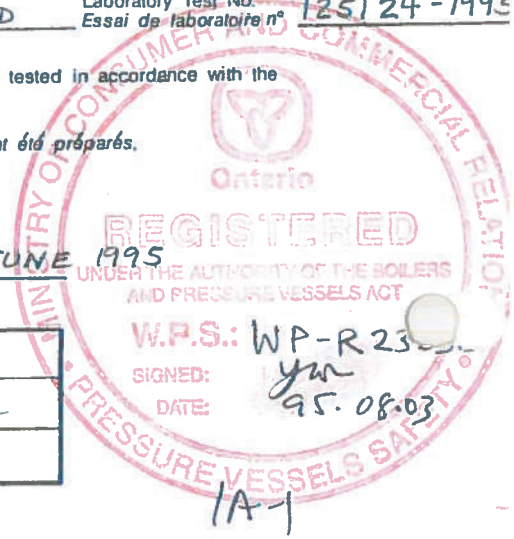
We certify that the statements in this record are correct and that the test welds were prepared, welded and tested in accordance with the requirements of section IX of the ASME Code.

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 27 JUNE 1995

Signature du représentant de l'entreprise

21 Department Use Only/Réservé au ministère	
Samples Welded on Pièces soudées le <u>JUNE 27/95</u>	Inspector Inspecteur <u>R. Kelly</u>
Record verified on Résultats vérifiés le <u>JULY 17/95</u>	Inspector Inspecteur <u>R. Kelly</u>





Consumer and  
Commercial  
Relations

Consommation  
et du  
Commerce

Vessels  
Safety  
Branch  
des appareils  
sous pression

Résultat de méthode de soudage (RM)

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

Company/Entreprise

Nom  
**ALL-WELD COMPANY LTD**  
Address/Adresse  
**49 PASSMORE AVE**  
**SCARBOROUGH ONTARIO**  
**CANADA** Postal Code/Code postal  
**M1L 1Y1 4T1 1**

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

⑥ Base Metals/Métaux de base (QW-403)  
P No. 1 Gr No. 1 & 2 of a P. No. 1 Gr No. 1 & 2  
Specification/Spécification Tensile/Tension  
SA-516-GR 70 TO 70000  
SA-516 GR 70 70,000  
Thickness/Épaisseur 1 1/2" Diameter/Diamètre

Other/autre NO SINGLE PASS TO BE GREATER THAN 1/2"TK

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

Classification (AWS)	SFA-No.	F - No.	A - No.
E 7018	5.1	4	1

Other/autre

⑧ Positions/Positions (QW-405)  
Position(s) of Groove/Position(s) du joint 1G  
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° MAX  
Other/autre

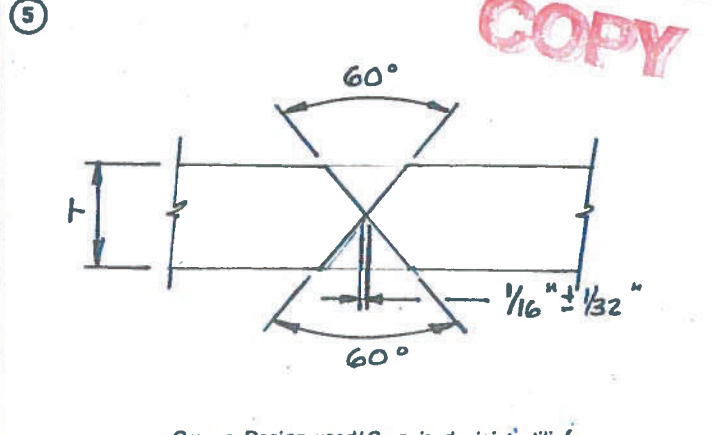
⑬ Electrical Characteristics and Technique/Caractéristiques électriques et techniques (QW-409) + (QW-410)

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	
1	SMAW	E 7018	1/8"	DC	RP	70-120	20-22	
2	— II —	— II —	3/16"	— II —	— II —	200-275	22-24	

② Provincial Registration/Enregistrement provincial WP MS R 2060.5

③ Record Identification/Désignation du résultat

PQR No. RMS N° 78  
WPS No. DMS N° 78-1



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

Temperature/Température NONE  
Time/Durée — II —  
Other/autre — II —

⑪ Gas/Gaz (QW-408)

Shielding Gas Composition/Composition du gaz de protection NONE  
Gas Flow Rate/Débit du gaz — II —  
Backing Gas Composition/Composition du gaz de soutien — II —  
Gas Flow Rate/Débit du gaz — II —  
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)/Passé unique ou multiple (par côté) MULTIPLE  
Single or Multiple Electrode/Électrode unique ou multiple SINGLE  
Other/autre

14 Tensile Tests/Essais à la traction						Reference: Référence:
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				
T1	0.715	1.487	1.0632	84700	79667	FRACTURED BASE METAL
T2	0.726	1.484	1.0774	86280	80082	FRACTURED BASE METAL

15 Guided Bend Tests/Essais de pliage guidé							Reference: Référence:		
Specimen Éprouvette	Face Face	Root Racine	Side Côté	Result Résultat	Specimen Éprouvette	Face Face	Root Racine	Side Côté	Result Résultat
S1			✓	ACCEPTABLE	S3			✓	ACCEPTABLE
S2			✓	ACCEPTABLE	S4			✓	ACCEPTABLE

16 Toughness Tests/Essais de résilience									Reference: Référence:
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	Millimeters 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:

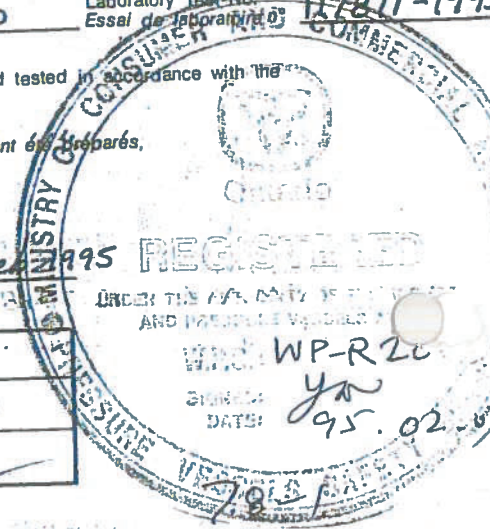
19 Welder's Name Nom du soudeur	<u>KELVIN RAMNATH</u>	Stamp No. N° de symbole	<u>34</u>
Tests conducted by Essais effectués par	<u>CAMBRIDGE MATERIALS TESTING LTD</u>	Laboratory Test No. Essai de laboratoire n°	<u>127871-1995</u>

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, soudés et exécutés conformément aux exigences de la section IX du Code ASME.

20 Company Representative's Signature Signature du représentant de l'entreprise	<u>Robert C Bentley</u>	Date Date	<u>1 Feb 1995</u>
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21 Department Used Only/Réservé au ministère			
Samples Welded on Pièces soudées le	<u>JAN 26/95</u>	Inspector Inspecteur	<u>[Signature]</u>
Record verified on Résultats vérifiés le	<u>Feb 1/95</u>	Inspector Inspecteur	<u>[Signature]</u>





# 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

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	E309-16	3/32"	DC	RP	65-95	N/A	N/A
ROOT	SMAW	E309-16	1/8"	DC	RP	90-120	N/A	N/A
FILL	SMAW	E309-16	5/32"	DC	RP	120-160	N/A	N/A
FILL	SMAW	E309-16	3/16"	DC	RP	155-195	N/A	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 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)	SINGLE AND OR 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. For P1 -Thickness and minimum temperature 0 to 3/4" thick preheat to 50° F, 1" thick and up 200° F.

(13)	<b>Supplementary Comments</b>
NONE	

(14) Company Representative Signature Stephen White Date 14 April, 07  
 Stephen White Q.I.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

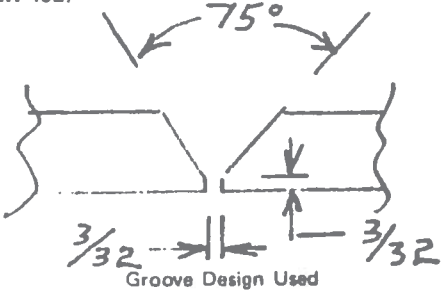
PROCEDURE QUALIFICATION RECORD

PQR-2

Date December 1, 1981

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

Weld Proc. Spec. No. P8XP1xF5 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> <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>

59815

**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/

# 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

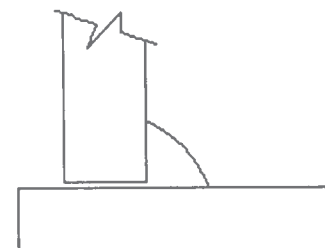
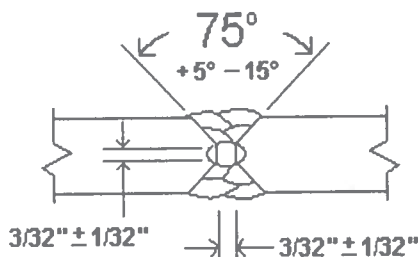
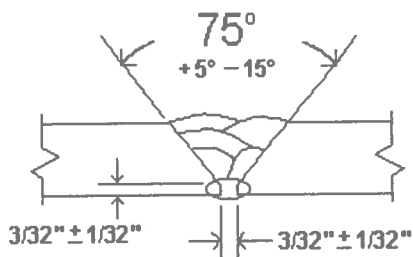
<b>2</b>	<b>Provincial Registration</b>	WP T4628.5
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<b>3</b>	<b>Procedure Identification</b>	
WPS NO.	3-4	Revision No. 1
Code Section	IX	Date 27 March, 2013
PQR No.	3-3X	

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

<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 NONE

Sketch



ALL FILLET WELDS

<b>6</b>	<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.	NONE	
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"	

<b>7</b>	<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	NONE	Electrode Flux Classification NONE
Consumable Insert	NONE	Other MAX DEPOSITED METAL 8 " & SEE SECTION # 12

<b>8</b>	<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	ALL
Other	NONE

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

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

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

<b>12 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	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								

<b>13 Supplementary Comments</b>	
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 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  
 Tests conducted by CAMBRIDGE MATERIAL TESTING LTD. Laboratory Test No. 634805-13 ( REVISED )  
 636411-2013, 636412-2013, 636413-2013  
 634851-2013, 634803-2013, 634805-13

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. Technical Standards and Safety Authority Boilers and Pressure Vessels Safety Program

21 Department Use only		<b>REGISTERED</b> WP-T4628.5 W.P.S.: ..... Signed: <u>S. Lew</u> Date: <u>MAR 26, 2013</u>
Samples Welded on	Inspector	
Record verified on	Inspector	
PQR: 3-3X WPS: 3-3B		



# Welding Procedure Specification (WPS)

STEEL

**Customer Work Order #**

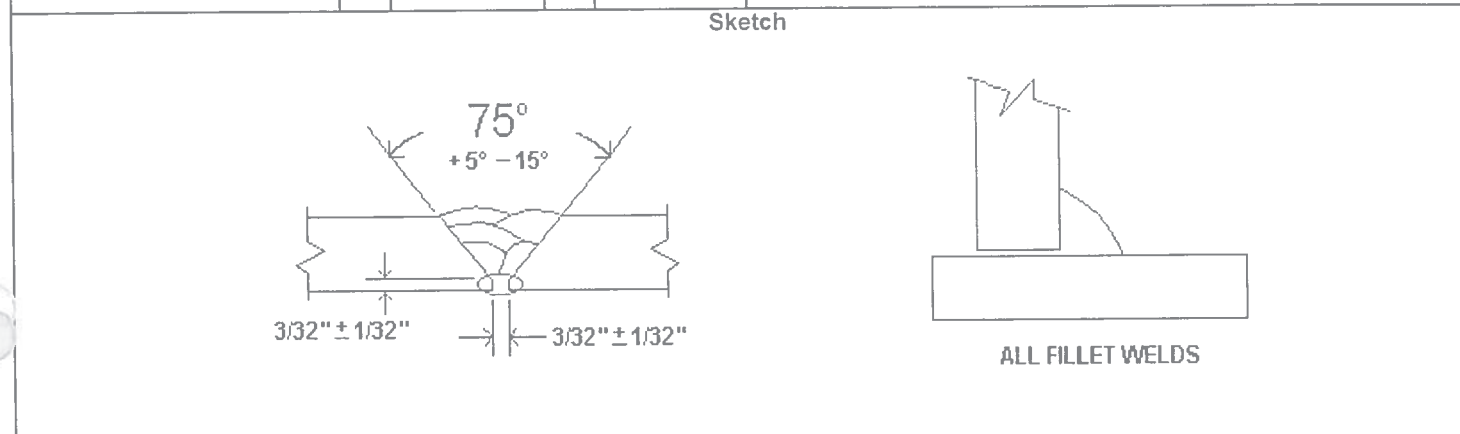
<b>1</b>	<b>Company</b>
Name/	ALL-WELD COMPANY LIMITED
Address /	49 PASSMORE AVE. , 14 PASSMORE AVE. PLANT 1 PLANT 2
	SCARBOROUGH, ONTARIO
Postal Code ( PLANT 1 )	Postal Code ( PLANT 2 )
M1V-4T1	M1V-2R6

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

<b>4</b>	<b>Welding Process(es)</b>	<b>1</b>	<b>GTAW</b>	Manual	<input checked="" type="checkbox"/>	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	SINGLE V GROOVE			Backing Material WELD METAL
Backing	Yes	No	<input checked="" type="checkbox"/>	Other NONE



<b>6</b>	<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-182, 240, 312, 403, 479-316L to SA-182, 240, 312, 403, 479, 304, 304L, 316 & 316L
	or Chemical Analysis and Mech. Prop.	NONE
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	ER316L	Product Form - Solid	SFA	5.9	F-No	6	A-No.	8	Dia.	1/16"
2. AWS No.	ER316L		SFA	5.9	F-No	6	A-No.	8	Dia.	3/32"
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" THICK NON Impact & 1/2" Impact							

<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

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) 965-4181  
 400 University Avenue  
 Toronto, Ontario  
 M5G 1S5  
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 PRESSURE VESSEL  
 SAFETY DIVISION

1979 OCT 16 PM 3:07

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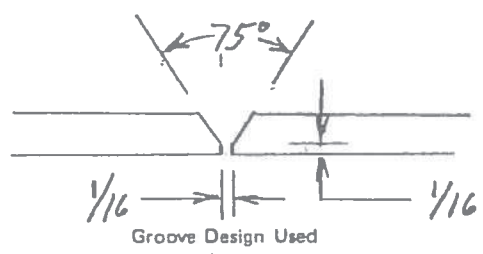
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PROCEDURE QUALIFICATION RECORD

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. 52:5 P.X.T. 03

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 Éprouvette	Dimensions Dimensions		Area Surface	Ultimate Total Load Charge limite	Ultimate Unit Stress Contrainte limite	Character of Failure 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 Éprouvette	Face Face	Root Racine	Side Côté	Result Résultat	Specimen Éprouvette	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 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: 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:

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.

20 Company Representative's Signature		Date	18, APRIL, 2002
Signature du représentant de l'entreprise	ROBERT C. BENTLEY	Signed:	
Department Use Only/Réservé au ministère			

REGISTERED  
W.P.S.:... W.P.R.76.7A.5  
2002  
Signed:   
Date: ... 20.02.02 ...  
9-A

Samples Welded on Pièces soudées le	Inspector Inspecteur
Record verified on Résultats vérifiés le	Inspector Inspecteur



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 ...

Guided Bend Tests/Essais de pilage 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			✓	— V —

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	Milli Millimètres	Break Cassé	No Break Non cassé

Fillet Weld Test/Essai de soudure d'angle			Reference: Référence:		
Result - Satisfactory Résultat satisfaisant	Yes <input type="checkbox"/> Oui	No <input type="checkbox"/> Non	Penetration into Parent Metal Pénétration dans métal de base	Yes <input type="checkbox"/>	No <input type="checkbox"/>

Other Tests/Autres essais		Reference: Référence:

19 Welder's Name: ROBIN GREER Stamp No. 9  
 Tests conducted by: CAMBRIDGE MATERIALS TESTING LTD Laboratory Test No. 152211-1996  
 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: 4 Oct 1996  
 Signature du représentant de l'entreprise

Department Use Only/Réservé au ministère	
Specimens Welded on Pièces soudées le	Inspector Inspecteur
Record verified on Résultats vérifiés le	Inspector Inspecteur

WP-R.35  
 ya  
 26.10.17  
 54-1



# Résultat de méthode de soudage (RMS)

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

<b>Company/Entreprise</b>			
Nom <b>ALL-WELD COMPANY LTD</b>			
Address/Adresse <b>49 PASSMORE AVE</b>			
<b>SCARBOROUGH</b>			
<b>ONTARIO</b>	Postal Code/Code postal <b>M1H 1T1</b>		
<b>4</b> <b>Welding Process(es)/Procédé(s) de soudage</b>			
1	Type <b>GTA W</b> <b>MANUAL</b>		
2	Type		
3	Type		
<b>6</b> <b>Base Metals/Métaux de base (QW-403)</b>			
P No. <b>8</b> Gr No. <b>1</b> lb/a	P. N° <b>8</b> Gr N° <b>1</b>		
Specification/Spécification <b>SA-240-316L TO 70,000</b>			
Tensile/Tension <b>SA-240-316L 70000</b>			
Thickness Épaisseur <b>1/4"</b>	Diameter/Diamètre		
Other Autre <b>NO SINGLE PASS &gt; 1/2"</b>			
<b>7</b> <b>Filler Metals/Métaux d'apport (QW-404)</b>			
Classification (AWS)	SFA-No.	F - No.	A - No.
<b>ER316L</b>	<b>5.9</b>	<b>6</b>	<b>8</b>
Other Autre <b>MAX DEPOSITED METAL 1/2"</b>			
<b>8</b> <b>Positions/Positions (QW-405)</b>			
Position(s) of Groove Position(s) du joint <b>1G THROUGH 6G</b>			
Welding Progression Progression du soudage		Up Montant <input checked="" type="checkbox"/>	Down Descendant <input type="checkbox"/>
Other Autre			
<b>9</b> <b>Preheat/Préchauffage (QW-406)</b>			
Preheat Temperature Température de préchauffage <b>50°F</b>			
Interpass Temperature Température de l'interpasse <b>300°F MAX</b>			
Other Autre			

<b>2</b> <b>Provincial Registration Enregistrement provincial</b>	WP MS <b>WP-R40505</b>
<b>3</b> <b>Record Identification/Désignation du résultat</b>	
PQR No. RMS N° <b>105</b>	
WPS No. DMS N° <b>105-1</b>	
<b>5</b>	
Groove Design used/Croquis du joint utilisé	

<b>10</b> <b>Postweld Heat Treatment/ Traitement thermique postsoudage (QW-407)</b>	
Temperature Température	<b>NONE</b>
Time Durée	<b>—</b>
Other Autre	<b>—</b>
<b>11</b> <b>Gas/Gaz (QW-408)</b>	
Shielding Gas Composition Composition du gaz de protection	<b>ARGON 98% + OXY 2%</b>
Gas Flow Rate Débit du gaz	<b>25 CFH</b>
Backing Gas Composition Composition du gaz de soutien	<b>NONE</b>
Gas Flow Rate Débit du gaz	<b>—</b>
Other Autre	<b>—</b>

<b>12</b> <b>Technique/Technique (QW-410)</b>	
String or Weave Bead Cordon droit ou oscillant	<b>STRING</b>
Oscillation Oscillation	<b>N/A</b>
Multipass or Single Pass (per side) Passe unique ou multiple (par côté)	<b>MULTI PASS</b>
Single or Multiple Electrode Électrode unique ou multiple	<b>SINGLE</b>
Other Autre	

<b>13</b> <b>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 Ampérage	Volt Voltage	
<b>T</b>	<b>GTA W</b>	<b>ER316L</b>	<b>1/16</b>	<b>DC</b>	<b>SP</b>	<b>80-110</b>	<b>11</b>	<b>7-8 IP</b>
<b>FILL</b>	<b>GTA W</b>	<b>ER316L</b>	<b>1/16"</b>	<b>DC</b>	<b>SP</b>	<b>110-140</b>	<b>14</b>	<b>7-8 IPM</b>

14 Tensile Tests/Essais à la traction						Reference: Référence:
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				
1	0.748	0.249	0.1863	16560	88924	FRACTURED IN BASE METAL
76	0.754	0.247	0.1862	16840	90440	FRACTURED IN BASE METAL

15 Guided Bend Tests/Essais de pliage guidé						Reference: Référence:			
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		✓		ACCEPTED	S4		✓		ACCEPTED

16 Toughness Tests/Essais de résilience						Reference: Référence:		
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	Millis 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 <input type="checkbox"/> Oui	No <input type="checkbox"/> Non	Penetration into Parent Metal Pénétration dans métal de base	Yes <input type="checkbox"/> Oui
Macro - Results Résultats macroscopiques				No <input type="checkbox"/> Non

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.

10 Company Representative's Signature Signature du représentant de l'entreprise	<u>Robert C Bentley</u>	Date Date	<u>13 JUNE 1997</u>
11 Department Use Only/Réservé au ministère			

TECHNICAL STANDARDS  
AUTHORITY  
SSA  
& SAFETY AUTHORITY

Boilers and  
Pressure  
Vessels  
Safety  
Division

REGISTERED

W.P.S.: WP-R4056.5

Signed: ya

Date: 97.06.17

12 Samples Welded on Vases soudées le	Inspector Inspecteur
Record verified on Résultats vérifiés le	Inspector Inspecteur

**Customer Work Order #**

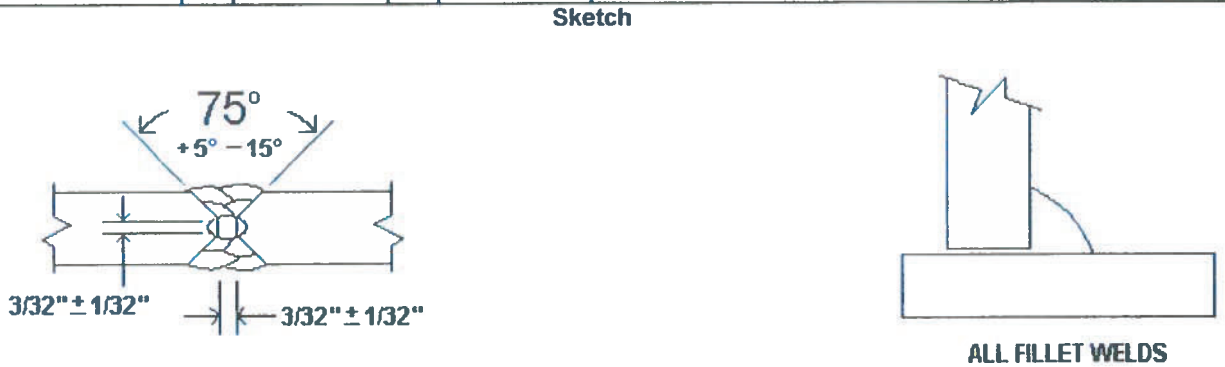
<b>1 Company</b>	
Name/	ALL-WELD COMPANY LIMITED
Address /	49 PASSMORE AVE. PLANT 1 / 14 PASSMORE AVE. PLANT 2
SCARBOROUGH, ONTARIO	
Postal Code ( PLANT 1 )	Postal Code ( PLANT 2 )
M1V-4T1	M1V-2R6

<b>2 Provincial Registration</b>	WP T4646.5
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<b>3 Procedure Identification</b>	
WPS NO. 50-3A	Revision No. 0
Code Section IX	Date 23 March, 13
PQR No.	50X

<b>4 Welding Process(es)</b>	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	DOUBLE V GROOVE & FILLETS	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. 8 Gr. No. 1 to P. No. 8 Gr. No. 1
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. Dia.
3. AWS No.	SFA F-No A-No. Dia.
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	<b>Supplementary Comments</b>
NONE	

14 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>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

<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>		
<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	

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 Weigh:	
					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-1464E-5	
			Signed: <i>[Signature]</i>	

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.	Laboratory Test No.	636448-2013, 636450-2013, 636452-2013, 636453-2013, 636454-2013, 636455-13(Report A) 636455-13(Report B)

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	<i>Robert Bentley</i>	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/ <b>ALL-WELD COMPANY LIMITED</b>	
Address / <b>49 PASSMORE AVE. , 14 PASSMORE AVE.</b> <b>PLANT 1 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 R4428.5</b>
<b>3</b>	<b>Procedure Identification</b>	
WPS NO.	<b>SAW-W-2-4</b>	Revision No. <b>0</b>
Code Section	<b>IX</b>	Date <b>21-Mar-13</b>
PQR No.	<b>SAW-2A1</b>	

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

<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-240, 316L to SA-240, 304, 304L, 316 &amp; 316L</b>
or Chemical Analysis and Mech. Prop.		<b>NONE</b>
Thickness Range Qualified	Total <b>5/8" TO 8" for Impact Test and 3/16" to 8" for Non Impact test</b>	
Other	<b>1) NO SINGLE PASS TO BE GREATER THAN 1/2"</b>	

<b>7</b>	<b>Filler Metals (QW-404)</b>	
1. AWS No. <b>ER316L</b>	SFA <b>5.9</b> F-No. <b>6</b> A-No. <b>8</b> Dia. <b>0.125</b>	
2. AWS No.	SFA F-No. A-No. Dia.	
3. AWS No.	SFA F-No. A-No. Dia.	
Flux Tradename <b>LINCONWELD ST100</b>	Electrode Flux Classification <b>NONE</b>	
Consumable Insert <b>NONE</b>	Other <b>MAX DEPOSITED METAL 8"</b>	

<b>8</b>	<b>Positions (QW-405)</b>
Position(s) of Groove	<b>1G</b>
Welding Progression	<b>UP</b>
Position(s) of Fillet	<b>1F</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>

<b>9</b>	<b>Preheat (QW-406)</b>	
Preheat Temperature	Min.	60° F
Interpass Temperature	Max.	350 ° F
Preheat Maintenance		350 ° F
Other	NONE	

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

<b>12</b>	<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 ; / 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							

<b>13</b>	<b>Supplementary Comments</b>
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 )	

<b>14</b>	Company Representative Signature		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 BASE

**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 Millèmes	Break Cassé	No Break Non cassé

**17 Fillet Weld Test/Essai de soudure d'angle** Reference: Réference:

Result - Satisfactory  Yes  No   
 Résultat satisfaisant Oui Non

Macro - Results  Penetration into Parent Metal   
 Résultats macroscopiques Pénétration dans métal de base Oui Non

**18 Other Tests/Autres essais** Reference: Réference:


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.

Company Representative's Signature Robert C. Bentley Date 7 JAN. 1998 REGISTERED  
 Signature du représentant de l'entreprise ROBERT C. BENTLEY

Department Use Only/Réservé au ministère

Samples Welded on  Inspector   
 Pièces soudées le Inspecteur

Record verified on  Inspector   
 Résultats vérifiés le Inspecteur

Boilers and Pressure Vessels Safety Division  
 W.P.S.: WR-R4428.5  
 Signed: [Signature]  
 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 2:14:09 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:	23R056	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").



W.O.N. 1173PG  
WPS 2-1

**HOBART BROTHERS**

McKay

**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:	21R046 ✓	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

Filler Metals Quality Assurance  
 Hobart Brothers  
 400 Trade Square  
 Troy, Ohio 45373

*Tin Wagner*

Authorized Signature :

Tin 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 application. 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.I.O.N' 1  
1173 PQ

SMAW  
WPS 3-4

(6)

**CERTIFICATE OF ANALYSIS**

CUSTOMER:  
MARKED FOR  
PACK SLIP/ORDER #:  
LBS SHIPPED:

P.O. #:  
DATE: 1/19/2013 5:28:19 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").

SMAW  
WPS. 3-4

(6)

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

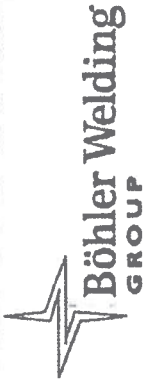
Certification and Limited Warranty - Data for the above supplied product are those obtained when welded and tested in accordance with the above specification. All tests for the above classification were satisfied. Other tests and procedures may produce different results. Hobart Brothers produces welding consumables under continuing quality assurance programs audited and approved by the American Bureau of Shipping ("ABS").

GTAW 9.4

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



Test Object: welding wire for GTAW

Trade Designation: AVESTA ER316/316L

Marking of Product

Standard Designation: AWS A5.9/ASME SFA5.9 ER316L

Dimensions: 3.2mm(1/8") x 914mm (35") x 4.5kg (10 lb)

Lot No : E48111

Delivery Qty:

Chemical Composition in %

All weld metal

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											

Tensile Test	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
Minimum:						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:
Maximum:						
Impact Test:	As per Test Temp T °C	ASTM E23 Absorbed Energy Minimum Values KV	Specimen Preparation Average J	AWS B4.0 Lateral Expansion MM	Shear Fracture %	
						Russel Fuchs Loc: Houston, TX Date:



PO# 13-0511

4



CW.O.NI 1173P0  
50-3A

**NOBELTO**

INSPECTION CERTIFICATE													
PURCHASER		DIMENSION		MFG. No.		APPLICABLE SPECIFICATION AND CLASSIFICATION							
DW-316L		0.045 Inch		F2G2315		ANS A5.22 E316LTO-1 A5.22 E316LTO-4 ASME SFA-5.22 E316LTO-1 ASME SFA-5.22 E316LTO-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	0.023	0.67	1.41	0.018	0.003	0.10	12.12	18.42	2.28	0.01	0.022	10	7
ELEMENTS	FMM												
DEPOSITED METAL	7												
MECHANICAL PROPERTY ACCORDING TO EN10204 TYPE 3.1													
TENSILE TEST OF DEPOSITED METAL					IMPACT TEST OF DEPOSITED METAL					HARDNESS TEST			
YIELD POINT	YIELD STRENGTH AT 0.2% OFFSET	TENSILE STRENGTH	ELONGATION	TEST TEMP.	AVG.					ASSUMED ENERGY			
- ksi	- ksi	81 ksi	38 %	- F	- ft-lbf					-			
WELDING CONDITIONS													
TYPE OF CURRENT	DC/EP	SHIELDING GAS	CO2 100%	POSTFIELD HEAT TREATMENT						BISMUTH(BI) CONTENT IN DEPOSIT METAL IS NO LESS THAN 0.002%.			
AMPLAGE	200 A			- F X - h						<div style="border: 1px solid black; border-radius: 50%; padding: 5px; display: inline-block;">           100% QC-8         </div>			
ARC VOLTAGE	29 V												
WE HEREBY CERTIFY THAT THE ABOVE TEST RESULTS ARE AS DESCRIBED HEREIN AND SATISFY THE REQUIREMENTS OF THE APPLICABLE SPECIFICATION.													
H. Sugawara WELDING BUSINESS FUJISAWA PLANT APPROVED BY CHIEF INSPECTOR													

12001800-01943101612000010-02104

REMARKS: CAPITAL LETTERS ARE USED EXCEPT FOR UNIT AND APPLICABLE SPECIFICATION / CLASSIFICATION.

W.O.N 11/27/12  
 S.M.W. 11/27/12  
 9

**CERTIFICATE OF CONFORMANCE**  
 (APPLIES ONLY TO U.S. PRODUCTS)



Product: Lincolnweld® 316/316L  
 Classification: ER316, ER316L  
 Specification: AWS A5.9:2006, 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

Dave Fink March 07, 2012  
 Dave Fink, Manager, Compliance Engineering, Consumable R&D Date

WPS SAW-WZ-4 FLUX

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>	18%	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

*Phillip J. Woodring*  
Phillip J. Woodring, Certification Supervisor, Date

Cert No. FST-100



Ministry of Consumer and Commercial Relations

Ministère de la Consommation et du Commerce

Pressure Vessels Safety Branch

Direction des appareils sous pression

Welder / Welding Operator Performance Test  
Essai de soudage

No. 12709

Welder's Last Name/Nom du soudeur: **GREER** Initial/Nom du (de la): **-** First Name/Soudeur(euse): **ROBIN** Signature: *Robin Greer* Stamp No /N° de symbole: **9**

Address/Adresse: **5 ASBUNTAIN ASH RD** Postal Code/Code postal: **M4K1J8** Provincial Registration No. /N° d'enregistrement provincial: **QW21425R**

Company Name/Entreprise: **ALL-WELD CO. LTD** Company POR No. /N° RMS de l'entreprise: **3**

Address/Adresse: **49 PASSMORE AVE** Postal Code/Code postal: **M1V4T1** Company WPS No. /N° DMS de l'entreprise: **3-1**

Location: **SCARBOROUGH ONT** Types(a)/Type(s): **MANUAL** Base Material(s): **SA-106-B/SA-106-B**

Process(es)/Procédé(s): **SMAW** Manual or Semiautomatic Variables for each Process / Variables à commande manuelle ou semi-automatique pour chaque procédé

Actual Values / Valeur réelle	Range Qualified / Gamme qualifiée
<b>NONE</b>	<b>WITH OR WITHOUT</b>
<b>PT TO PT</b>	<b>PI THRU P11 + P4X</b>
<b>0.218</b>	<b>R + PIPE - 24"</b>
<b>E308</b>	<b>1" OD TO 24" OD</b>
<b>FS</b>	<b>FS</b>
<b>NONE</b>	<b>-</b>
<b>0.218</b>	<b>0.436" MAX</b>
<b>6G</b>	<b>ALL R GROOVE</b>
<b>NONE</b>	<b>ALL PIPE 1" OD</b>
<b>NONE</b>	<b>AND ALL FILLETS.</b>
<b>NONE</b>	<b>-</b>
<b>NONE</b>	<b>-</b>

Machine welding Variables for Process used / Variables liées au soudage mécanisé pour le procédé utilisé

Actual Values / Valeur réelle	Range Qualified / Gamme qualifiée
<b>NONE</b>	
<b>NONE</b>	
<b>NONE</b>	
<b>NONE</b>	
<b>NONE</b>	

Guided Bend or Radiographic Results/Essai de pliage guidé ou radiographie - résultats

Specimen No. / N° d'éprouvette	Bend / Pliage	Radiography / Radiographie	Para. (QW -) / Par. (QW -)	Results/Résultats
<b>S1</b>	<b>FACE</b>		<b>462.3(a)</b>	<b>SATISFACTORY</b>
<b>S2</b>	<b>ROOT</b>		<b>4</b>	<b>ACCEPTABLE</b>
<b>S3</b>	<b>FACE</b>		<b>4</b>	<b>ACCEPTABLE</b>
<b>S4</b>	<b>ROOT</b>		<b>4</b>	<b>ACCEPTABLE</b>

Fillet Weld Test Results/Essai de soudure d'angle - résultats

Fracture Test / Essai de rupture: **NONE** Length and percentage of defects / Longueur et pourcentage de défauts: **-**

Macro Test Fusion / Macroscopie-fusion: **NONE** Fillet Leg Size / Dimension du côté: **-** in. x **-** in. po. Concavity/Convexity / Concavité/convexité: **-**

Welding Test conducted by / Essai effectué par: **ALL-WELD CO. LTD** Date: **2 MARCH 94** Laboratory Test No. / Essai de laboratoire n°: **-**

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  
Nous certifions que les renseignements concernant les présents résultats sont exacts et que les essais de soudage ont été préparés, soudés et exécutés conformément aux exigences de l'article IX du Code de l'ASME.

Organization / Organisation: **ALL-WELD CO. LTD** Signature: *Robert Bentley* Date: **2 March 94**

IDENTIFICATION OF WELDER  
Pursuant to the Boilers & Pressure Vessels Act  
CARTE DE SOUDEUR  
Conforme à la Loi sur les chaudières et appareils sous pression

Expiry Date / Date d'expiration: **AS PER ASME**  
**ROBIN GREER** **9**  
Soudeur(euse) Symbol/Sceau

authorized to weld for:  
est autorisé(e) à souder pour:

**ALL-WELD CO. LTD**

subject to the limitations of this certificate  
sous réserve des restrictions du présent certificat  
*Robert Bentley* 80  
Authorized Examiner / Examineur (trice) accrédité(e)

P Eng Chief Inspector / Ing. Inspecteur (trice) en chef

Ministry Use/Réservé au ministère

Test Requested By / Essai demandé: **Robert Bentley**  
(Print Name) (Nom en lettres moullées)

Tested At / Essai mené à: **49 PASSMORE AVE SCARB.**  
(Print Address) (Adresse en lettres moullées)

Inspector District # / N° du district d'inspection: **57** Fee / Droits: **95-**



Technical Standards and Safety Authority

14th Floor - Centre Tower  
1100 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 <b>GR</b>	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; R784.5</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>M 1 V 4 T 1</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-312-316</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)		<b>WITHOUT</b>		<b>WITH OR WITHOUT</b>
Base Metal P-Number to P-Number ( ) Plate ( X ) Pipe (enter diameter if pipe)		<b>8 to 8</b>		<b>P1 THRU P15F, P34, &amp; P4X PLATE AND PIPE 1/2" OD AND UP</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>0.378" MAX PLATE GROOVE + PIPE 1 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)

CORTICA ROW ONT 915 ROBERT BENTLEY MAR 07, 2012  
Inspector Name and Number (Print) Inspector Signature and Date



Technical Standards and Safety Authority

4th Floor - West Tower  
3300 Bloor Street West  
Toronto ON M8X 2X4

Boilers and Pressure Vessels Act

Welder/Welding Operator Identification Card

No. 72307

Welder's Last Name <b>PARKIN</b>		Initial	First Name <b>LAUGHTON</b>	Signature <i>Robert Bentley</i>	Stamp No. <b>16</b>
Res. Address <b>26 MULLEN DR., AJAX, ONT.</b>			Postal Code <b>L 1 T 2 A 5</b>	Provincial Registration No. <b>OW 2142.5R</b>	
Company Name <b>ALL-WELD CO. LTD.</b>			Company PQR No. <b>3</b>		
Street Address <b>49 PASSMORE AVENUE</b>			Company WPS No. used <b>3-1</b>		
<b>SCARBOROUGH, ONTARIO</b>			Postal Code <b>M 1 V 4 T 1</b>	<b>MANUAL</b>	
Welding Process(es) Used <b>SMAW</b>			Type(s) (manual, machine, etc.)	<b>MANUAL</b>	
Base Material(s) <b>SA-240-304 / SA-240-304</b>			Thickness(es) <b>3/8"</b>	Range Qualified	
Manual or Semi-automatic Variables for each Process (QW-350)					
Backing material (metal, weld metal, welded from both sides, flux, etc.)		Actual Values		Range Qualified	
ASME P-No. to ASME P.No.		<b>BASE METAL</b> P8 to P8		<b>WITH OR WITHOUT</b> P1 THRU P11 + P4X PLATE +	
<input checked="" type="checkbox"/> Plate <input type="checkbox"/> Pipe (enter diameter if pipe)		<b>3/8"</b>		<b>PIPE 2 7/8" OD + UP</b>	
Filler Metal Specification (SFA) Class (QW-404)		<b>E308-16</b>			
Filler Metal F- No. (QW-404)		<b>5.4</b>		<b>F5</b>	
Filler Metal Product Form for GTAW, PAW (QW-404)		<b>N/A</b>		<b>N/A</b>	
Consumable insert for GTAW or PAW (QW-404)		<b>N/A</b>		<b>N/A</b>	
Weld deposit thickness for each welding process (QW-404)		<b>3/8"</b>		<b>3/4" MAX</b>	
Welding Position (1G, 5G, etc.) (QW-405)		<b>2G</b>		<b>PLATE GROOVE + PIPE 2 7/8" OD</b>	
Progression (uphill/downhill) (QW-405)				<b>+ UP + ALL FILLETS</b>	
GTAW, PAW or GMAW backing gas; or OFW fuel gas (QW-408)		<b>N/A</b>		<b>N/A</b>	
GMAW transfer mode (QW-408)		<b>N/A</b>		<b>N/A</b>	
GTAW welding current type & polarity (QW-409)		<b>N/A</b>		<b>N/A</b>	
Machine Welding Variables for Process used (QW-360)					
Direct/remote visual control		<b>NONE</b>			
Automatic voltage control (GTAW)		<b>NONE</b>			
Automatic joint tracking		<b>NONE</b>			
Welding position (1G, 5G etc.)		<b>NONE</b>			
Consumable insert		<b>NONE</b>			
Backing material (metal, weld metal, welded from both sides, flux, etc.)		<b>NONE</b>			
Multiple or single pass per side		<b>NONE</b>			
Change from automatic to machine		<b>NONE</b>			
Filler for EBW or LBW		<b>NONE</b>			
Laser type		<b>NONE</b>			
Drive type for FRW		<b>NONE</b>			
Vacuum type for EBW		<b>NONE</b>			

Manufacturer's Copy

Note: Values in "Range Qualified" are valid only when used with a Qualified Welding Procedure.

Guided Bend or Radiographic Results (QW-462.2, 462.3 & QW-304 & 305)					Comments
Specimen No.	Bend	Radiography	Para. (QW - )	Results	
B1	ROOT	--	462.3a	ACCEPTED	
B2	FACE	--	462.3a	ACCEPTED	

All Other Tests

Visual examination results (QW-302.4) **ACCEPTED**

Fillet Weld Fracture Test --- Length and percentage of defects --- in.

Macro Test Fusion --- Fillet Leg Size --- in. x --- in. Concavity/Convexity --- in.

Welding Test conducted by (person name) **ROBERT BENTLEY** Date **24 APRIL 2001**

Mechanical Tests conducted by **ALL-WELD CO. LTD.** Laboratory Test No. ---

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 CO. LTD.** Signature *Robert Bentley* Date **24 APRIL 2001**



Issued under Ontario's Boilers & Pressure Vessels Act

Expiry Date: **PER ASME**  
**16**

**LAUGHTON PARKIN** Weider Symbol

Has passed the welding test required under Ontario's Boilers and Pressure Vessels Act and is hereby authorized to weld for:

**ALL-WELD CO. LTD.**  
Subject to the limitations of this certificate

Authorized Examiner

Director

Office Use Only

Test Requested By **MR. R. BENTLEY**  
(Print Person's Name)

Tested At **49 PASSMORE, SCARBOROUGH**  
(Print Address)

District # **50** Inspector # **66** Fee **95.00**



Technical Standards and Safety Authority

3300 Bloor Street West  
Toronto, Ontario M8X 2X4  
Web site: www.tssa.org

Welder/Welding Operator Certificate  
Boilers and Pressure Vessels Regulation

No. 258823

Welder's Last Name: PARKIN Initial: LAUGHTON Signature: [Signature] Stamp No.: 16

Res. Address: 38 MUSCAT CRESCENT, AJAX, ONTARIO Postal Code: L1Z0B9 Provincial Registration No.: R3578.5, D452.5 & R764.9 Company POR No.:

Employer Name: ALL - WELD COMPANY LIMITED Street Address: 49 PASSMORE AVE Postal Code: M1V4T1 Company WPS No. used: 9-3

SCARBOROUGH, ONT

Welding Process(es) Used: GTAW Type(s):  manual  machine  semi-automatic  automatic

Base Material(s): SA-312-316 Thickness(es): 0.188"  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: 3 to 6	P1 THRU P15F, P34, & P4X PLATE AND PIPE 1/2" OD AND UP
( ) Plate ( X ) Pipe (enter diameter if pipe): 1/2" SCH 160	
Filler Metal Specification (SFA) Class (QW-404) (Informational Only): 5.9 ER 316	
Consumable insert for GTAW or PAW (QW-404): NONE	
Welding Position (1G, 5G, etc.) (QW-405): 6G	6G
Manual or Semi-automatic Variables (QW-360)	Range Qualified
Filler Metal F-No. (QW-404): F8	F8
Filler Metal Product Form for GTAW, PAW (QW-404): SOLID	SOLID
Weld deposit thickness for each welding process (QW-404): 0.188"	0.376" MAX PLATE GROOVE + PIPE 1/2" OD + UP
Process 1: 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	+ ALL FILLETS
Process 2: 3 layers minimum <input type="checkbox"/> Yes <input type="checkbox"/> No	NONE
Vertical progression (uphill/downhill) (QW-405): UPHILL	NONE
GTAW, PAW or GMAW backing gas; or OFW fuel gas (QW-406): ARGON 99.9%	ARGON 99.9%
GMAW transfer mode (spray/globular or pulse to short circuit) (QW-406): NONE	NONE
GTAW welding current type & polarity (AC, DCEP, DCEN)(QW-406): DC / SP	DC / SP
Machine Welding Variables (QW-361.2)	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)	Range Qualified
Filler Metal (EBW or LBW): NONE	
Laser type for LBW (CO2 to YAG etc.): NONE	
Continuous drive or Inertial 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) (Face)	ACCEPTED	QW-462.3(a) (ROOT)	ACCEPTED	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 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 [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)

INSPECTOR COSSETTA ROSU OUTF 15

[Signature] : MAR 07, 2012

Inspector Name and Number (Print)

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: GABIDON Initial: \_\_\_\_\_ First Name: ALPHONSO Signature: \_\_\_\_\_ Stamp No.: 25

Res. Address: 49 HAVAGAL CRES MARKHAM, ONT Postal Code: L 3 P 7 G 6 Provincial Registration No.: R4428.5

Employer Name: ALL - WELD COMPANY LIMITED Company PQR No.: SAW - W-2-A1

Street Address: 49 PASSMORE AVE Company WPS No. used: SAW - W - 2 - 4

City: SCARBOROUGH, ONT Postal Code: M 1 V 4 T 1

Welding Process(es) Used: SAW Type(s):  manual  machine  semi-automatic  automatic

Base Material(s): SA - 240 - 316L Thickness(es): 1 3/4"  Test Coupon  Production Weld

Variables for All Processes	Actual Values	Range Qualified
Backing material (with/without)	<u>BASE &amp; WELD METAL</u>	<u>BASE &amp; WELD METAL</u>
Base Metal P-Number to P-Number	<u>P8 to P8</u>	<u>P1 THRU P19F, P34 &amp; P4X PLATE AND PIPE 2 7/8" OD AND UP</u>
( <input checked="" type="checkbox"/> ) Plate ( <input type="checkbox"/> ) Pipe (enter diameter if pipe)	<u>1 3/4"</u>	
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)	<u>5.9 ER316L</u>	
Consumable Insert for GTAW or PAW (QW-404)	<u>NONE</u>	
Welding Position (1G, 5G, etc.) (QW-405)	<u>1G</u>	<u>1G</u>

Manual or Semi-automatic Variables (QW-350)	Actual Values	Range Qualified
Filler Metal F- No. (QW-404)	<u>6</u>	<u>6</u>
Filler Metal Product Form for GTAW, PAW (QW-404)	<u>NONE</u>	
Weld deposit thickness for each welding process (QW-404)	<u>1 3/4"</u>	<u>MAX TO BE WELDED</u>
Process 1: _____ 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<u>14</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-361.2)	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-361.1)	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 inertia 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
<u>QW-462.2</u>	<u>ACCEPTED</u>	<u>QW-462.2</u>	<u>ACCEPTED</u>				

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 DOM ONT 315  
Inspector Name and Number (Print)

\_\_\_\_\_  
Inspector Signature and Date MAR 04 19. 2013





Technical Standards and Safety Authority

3300 Bloor Street West  
Toronto, Ontario M8X 2X4  
Web site: www.tssa.org

Welder/Welding Operator Identification Card  
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 PQR No.: **3**

Street Address: **49 PASSMORE AVE.** Company WPS No. used: **3-1**

**SCARBOROUGH, ONT.** 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; PIPE 2 7/8" O.D. &amp; UP</b>
( <input checked="" type="checkbox"/> ) Plate ( ) Pipe (enter diameter if pipe)	<b>5/16"</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>
<b>Manual or Semi-automatic Variables (QW-350)</b>	<b>Actual Values</b>	<b>Range Qualified</b>
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>
<b>Machine Welding Variables (QW-361-2)</b>	<b>Actual Values</b>	<b>Range Qualified</b>
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>
<b>Automatic Welding Variables (QW-361-1)</b>	<b>Actual Values</b>	<b>Range Qualified</b>
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
<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

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  
SECT. IX  
Expiry Date: **83**

**FAN YANG**  
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)

Dist. # 13 Inspector # QW.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 Identification Card

Technical Standards and Safety Act  
Boilers and Pressure Vessels Regulation

No. 169441

Welder's Last Name: **YANG** Initial: **FAN** First Name: **FAN** Signature: *Fan Yang* Stamp No.: **83**

Address: **1050 BRISTOL RD. W. MISSISSAUGA, ONTARIO** Postal Code: **L5V2E8** Provincial Registration No.: **D852.5 + R3578.5 R7674.5**

Company Name: **ALL-WELD COMPANY LIMITED** Company PQR No.: **9**

Street Address: **49 PASSMORE AVENUE** Company WPS No. used: **9-1**

City: **SCARBOROUGH, ONTARIO** Postal Code: **M1V4T1**

Welding Process(es) Used: **GTAW** Type(s):  manual  machine  semi-automatic  automatic

Base Material(s): **SA 312-304 / SA 312-304** Thickness(es): **0.218"**

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-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>0.218"</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>
GTAW 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, 2006**



Issued under Ontario's Technical Standards and Safety Act  
Boilers and Pressure Vessels Regulation

PER ASME  
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

Authorized Examiner

Director

### 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 # **awj/vst** Fee **105,-**



Welder's Last Name: **YANG** Initial: **FAN** First Name: **FAN** Signature: *Fan Yang* Stamp No.: **83**

Res. Address: **76 LUCIENT ST., MARKHAM, ONT.** Postal Code: **L3R 5E1** Province Registration No.: **WPR 3432.5**

Employer Name: **ALL-WELD COMPANY LIMITED** Company PQR No.: **50**

Street Address: **49 PASSMORE AVENUE** Company WPS No used: **50-1**

Postal Code: **M1V 4T1**

Welding Process(es) Used: **FCAW** Type(s):  manual  machine  semi-automatic  automatic

Base Material(s): **SA 240-316 / SA 240-316** Thickness(es): **3/8"**

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 <input type="checkbox"/> Yes <input type="checkbox"/> No		
Process 2: _____ 3 layers minimum <input type="checkbox"/> Yes <input type="checkbox"/> 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-361-2)	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-361-1)	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)

**YING WING WANG** **ONTL8**  
Inspector Name and Number (Print)

*[Signature]*  
Inspector Signature



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 Identification Card

Technical Standards and Safety Act  
Boilers and Pressure Vessels Regulation

No. 258718

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 Mound Crescent, Scarborough, Ontario</b>		Postal Code <b>M1H1W2</b>	Provincial Registration No. <b>D700.5 &amp; R2363.5 R2060.5</b>	
Employer Name <b>All-Weld Company Limited</b>		Company POR No. <b>78, 1 + 1-A</b>		Company WPS No. used <b>1 - 1</b>
Street Address <b>49 Passmore Ave</b>		Postal Code <b>M1V4T1</b>		
Welding Process(es) Used <b>SMW</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 516-GR 70 / SA 516-GR 70</b>		Thickness(es) <b>3/8"</b>		

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 P15, P34 & P4X Plate & all 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)	(5.1) E7018 - 1H4	
Consumable Insert for GTAW or PAW (QW-404)	--	
Welding Position (1G, 5G, etc.) (QW-405)	2G	2G
Manual or Semi-automatic Variables (QW-380)		
Filler Metal F- No. (QW-404)	Actual Values	Range Qualified
Filler Metal Product Form for GTAW, PAW (QW-404)	--	--
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	--
Process 2: _____ 3 layers minimum <input type="checkbox"/> Yes <input type="checkbox"/> No	--	--
Progression (uphill/downhill) (QW-405)	--	--
GTAW, PAW or GMAW backing gas; or OFW fuel gas (QW-408)	--	--
GMAW transfer mode (spray/globular or pulse to short circuit) (QW-409)	--	--
GTAW welding current type & polarity (AC, DCEP, DCEN) (QW-409)	--	--
Machine Welding Variables (QW-381-2)		
Direct or remote visual control	Actual Values	Range Qualified
Automatic arc voltage control (GTAW)	--	--
Automatic joint tracking	--	--
Multiple or single pass per side	--	--
Automatic Welding Variables (QW-381-1)		
Filler metal (EBW or LBW)	Actual Values	Range Qualified
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) (ROOT)	accepted	QW 462.3 (a) (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

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 R Bentley Date July 11, 2011  
(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 IX  
(mm-dd-yyyy)

DAVID SGM ONIC092  
Inspector Name and Number (Print)

[Signature]  
Inspector Signature



Technical Standards and Safety Authority

14th Floor - Centre Tower  
3300 Bloor Street West  
Toronto, Ontario M8X 2X4  
Web site: www.tssa.org

Technical Standards and Safety Act  
Boilers and Pressure Vessels Regulation

# Welder/Welding Operator Certificate

No. 262466

Welder's Last Name: LIEW Initial: STEVE First Name: STEVE Signature: [Signature] Stamp No.: 98  
 Res. Address: 11 INDIAN BOUND CRESCENT, ONTARIO Postal Code: M1H 1W2 Provincial Registration No.: WP-T4628.5  
 Employer Name: ALL - WELD COMPANY LIMITED Company PQR No.: 3-3X  
 Street Address: 40 PASSMORE AVE Postal Code: M1V 4T1 Company WPS No. used: 3-3B  
 Welding Process(es) Used: SMAW Type(s):  manual  machine  semi-automatic  automatic  
 Base Material(s): SA-340-316 TO SA-340-316 Thickness(es): 1 3/4"  Test Coupon  Production Weld

Variables for All Processes	Actual Values	Range Qualified
Backing material (with/without)	WITH	WITH
Base Metal P-Number to P-Number ( X ) Plate ( ) Pipe (enter diameter if pipe)	0 to 0 1 3/4"	P1 THRU P19F, P34 & P4X PLATE AND PIPE 2 7/8" OD AND UP AND ALL FILLETS
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)	5.4 E316-18	
Consumable Insert for GTAW or PAW (QW-404)	NONE	
Welding Position (1G, 5G, etc.) (QW-405)	2G	1G & 2G

Manual or Semi-automatic Variables (QW-388)	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)	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-405)	NONE	
GTAW, PAW or GMAW backing gas; or OPW fuel gas (QW-405)	NONE	
GMAW transfer mode (spray/globular or pulse to short circuit) (QW-405)	NONE	
GTAW welding current type & polarity (AC, DCEP, DCEP)(QW-405)	NONE	

Machine Welding Variables (QW-381.2)	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-381.1)	Actual Values	Range Qualified
Filler Metal (EBW or LSBW)	NONE	
Laser type for LSBW (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 (Side)	ACCEPTED	QW-462.2 (Side)	ACCEPTED	QW-462.2 (Side)	ACCEPTED	QW-462.2 (Side)	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 CAMBRIDGE MATERIAL TESTING LIMITED Laboratory test no. 634883-2913 & 634881-2913

Welding supervised by (Print name) ANDREW LEWIS

Test requested by (Print name) ROBERT BENTLEY Tested at (Print address) 40 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 03-15-2013  
(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)

[Signature] 01915  
Inspector Name and Number (Print)

[Signature] 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.: 90

Res. Address: 11 INDIAN BOUND CRESCENT, ONTARIO Postal Code: M1H1W2 Provincial Registration No.: WP-T4646.5

Employer Name: ALL - WELD COMPANY LIMITED Company PQR No.: 50-X

Street Address: 49 PASSMORE AVE Postal Code: M1V4T1 Company WPS No. used: 50-3A

Welding Process(es) Used: FCAW Type(s):  manual  machine  semi-automatic  automatic

Base Material(s): SA-240-318 TO SA-240-316 Thickness(es): 3/8"  Test Coupon  Production Weld

Variables for All Processes	Actual Values	Range Qualified
Backing material (with/without)	WITH	WITH
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)	1 3/4"	+ ALL FILLETS
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)	E322 E316L TD-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-385)	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-405)	NONE	
GTAW, PAW or GMAW backing 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-408)	NONE	
Machine Welding Variables (QW-387.2)	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-381.1)	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-462.2	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. 636448-2013 & 636450-2013

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 [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)

COSTICA [Signature] 020315

Inspector Name and Number (Print)

[Signature] MK2 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: ALROUBAYI Initial: A First Name: RAZZAK Signature: [Signature] Stamp No: 109  
 Res. Address: 140 QUANTRELL TRIAL SCARBOROUGH, ONT Postal Code: M1B1L6  
 Employer Name: ALL - WELD COMPANY LIMITED Company PQR No: SAW-2A1  
 Street Address: 49 PASSMORE AVE Company WPS No used: SAW-W-2-1  
 SCARBOROUGH, ONT Postal Code: M1V4T1  
 Welding Process(es) Used: SAW Type(s): manual machine semi-automatic  automatic  
 Base Material(s): SA-240-304 Thickness(es): 1"  Test Coupon Production Weld

Variables for All Processes	Actual Values	Range Qualified
Backing material (with/without)	BASE & WELD METAL	BASE & WELD METAL
Base Metal P-Number to P-Number	P8 to P8	P1 THRU P15F, P34 & P4X PLATE AND PIPE 2 7/8" OD AND UP
(X) Plate ( ) Pipe (enter diameter if pipe)	1"	
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)	5.9 ER308	
Consumable Insert for GTAW or PAW (QW-404)	NONE	
Welding Position (1G, 5G, etc.) (QW-405)	1G	1G
Manual or Semi-automatic Variables (QW-350)	Actual Values	Range Qualified
Filler Metal F-No. (QW-404)	6	6
Filler Metal Product Form for GTAW, PAW (QW-404)	NONE	
Weld deposit thickness for each welding process (QW-404)	1"	MAX TO BE WELDED
Process 1: _____ 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	12	
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-462.2.2	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 [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

[Signature] MAR 09, 2012  
 Inspector Signature and Date



Welder's Last Name: INNIS Initial: ANDREW First Name: ANDREW Signature: [Signature] Stamp No: 110

Res. Address: 21 BORNHOLM DRIVE TORONTO, ONTARIO Postal Code: M1C4P6 Provincial Registration No: QW2142.5R & R2180.5 Company PQR 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 (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-462.3 (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 [Signature] 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)

COSITCA ROSU ONT915  
Inspector Name and Number (Print)

[Signature]  
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. 262452

Welder's Last Name KIM	Initial TAE	First Name TAE	Signature <i>TAE</i>	Stamp No. 121
Res. Address 733 OSSINGTON AVE TORONTO, ONTARIO		Postal Code L1X2E1	Provincial Registration No. QW2142 SR & R2180.5	
Employer Name ALL - WELD COMPANY LIMITED		Company PQR No. 3 & 3A		
Street Address 49 PASSMORE AVE		Postal Code M1V4T1	Company WPS No. used 3-1	
Welding Process(es) Used SMAW		Type(s) <input checked="" type="checkbox"/> manual <input type="checkbox"/> machine <input type="checkbox"/> semi-automatic <input type="checkbox"/> automatic		
Base Material(s) SA-240-304 TO SA-240-304		Thickness(es) 3/8"	<input checked="" type="checkbox"/> Test Coupon <input type="checkbox"/> Production Weld	
Variables for All Processes				
Backing material (with/without)		WITHOUT		WITH OR WITHOUT
Base Metal P-Number to P-Number		S to S		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		1G & 2G
Manual or Semi-automatic Variables (QW-350)				
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)				
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)				
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-462.3(a) (Face)	ACCEPTED	QW-462.3(a) (ROOT)	ACCEPTED				

Alternative radiographic examination results (QW-191) NONE

Fillet weld — fracture test (QW-1B1.2) 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 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)

ROSTICA ROSU 017915  
Inspector Name and Number (Print)

*Robert Bentley* DEC 10, 2012  
Inspector Signature and Date

QA COPY



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. 262453

Welder's Last Name <b>KIM</b>	Initial <b>TAE</b>	First Name <b>TAE</b>	Signature 	Stamp No <b>121</b>
Res. Address <b>733 OSSINGTON AVE TORONTO, ONTARIO</b>		Postal Code <b>M 1 C 4 P 6</b>		Provincial Registration No. <b>R3578.5, D852.5 &amp; R764.5</b>
Employer Name <b>ALL - WELD COMPANY LIMITED</b>		Street Address <b>49 PASSMORE AVE</b>		Company PQR No. <b>54, 9, 9AB</b>
SCARBOROUGH, ONT		Postal Code <b>M 1 V 4 T 1</b>		Company WPS No used <b>9-1</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</b>		Thickness(es) <b>0.218"</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 ( ) Plate ( X ) Pipe (enter diameter if pipe)		8 to 8		P1 THRU P15F, P34 & P4X PLATE AND PIPE 1" OD AND UP
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)		<b>5.9 ER 308</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>0.218"</b>		<b>0.438" MAX PLATE GROOVE + PIPE 2 7/8" 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%</b>		<b>ARGON 99%</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 \_\_\_\_\_

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 **08-12-2012**  
(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)

**COSTICA ROSU ONF 915**  
Inspector Name and Number (Print)

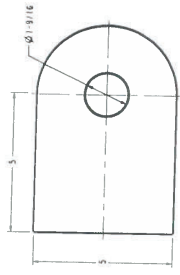
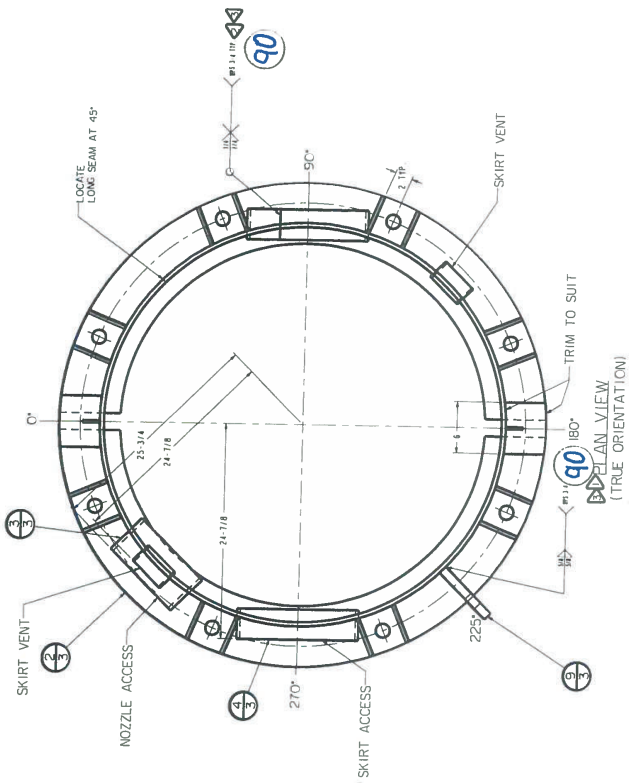
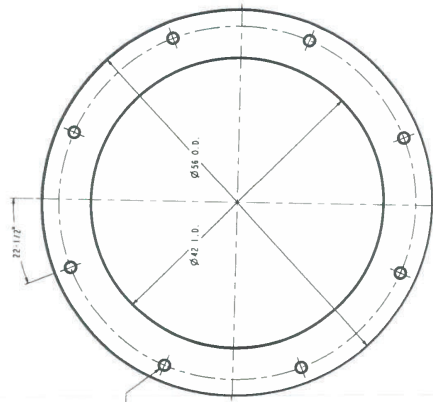
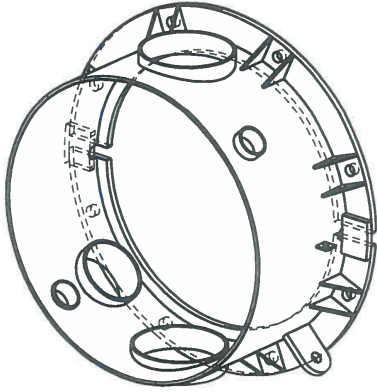
**DEC 10, 2012**  
Inspector Signature and Date



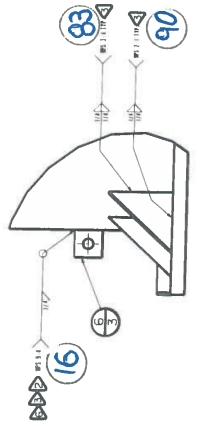


**BILL OF MATERIAL**

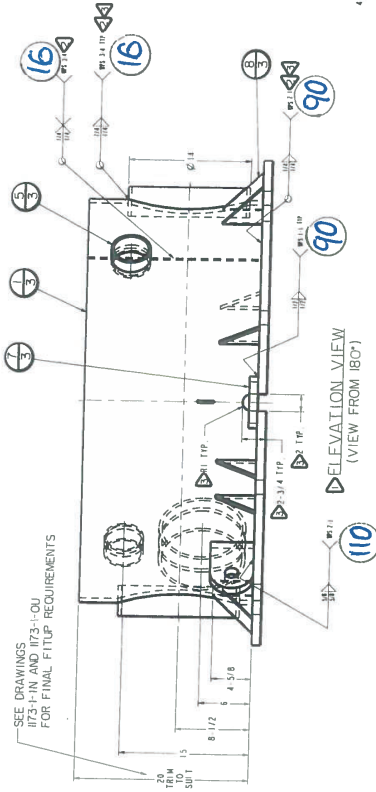
ITEM	QTY	DESCRIPTION	SPEC
18	1/3	1 1/2" DIA. 1/2" THK. STAINLESS STEEL FLANGE	AS PER Dwg.
19	2/3	1 1/2" DIA. 1/2" THK. STAINLESS STEEL FLANGE	AS PER Dwg.
20	2/3	1 1/2" DIA. 1/2" THK. STAINLESS STEEL FLANGE	AS PER Dwg.
21	5/3	2 1/2" DIA. 1/2" THK. STAINLESS STEEL FLANGE	AS PER Dwg.
16	6/3	2 1/2" DIA. 1/2" THK. STAINLESS STEEL FLANGE	AS PER Dwg.
67	8/3	1 1/2" DIA. 1/2" THK. STAINLESS STEEL FLANGE	AS PER Dwg.
67	9/3	1 1/2" DIA. 1/2" THK. STAINLESS STEEL FLANGE	AS PER Dwg.



DETAIL ITEM 9/3



DETAIL ITEM 2/3



DETAIL ITEM 8/3



DETAIL ITEM 6/3

PURCHASE ORDER NUMBER: 1112

(4) REQUIRED

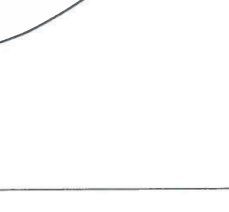
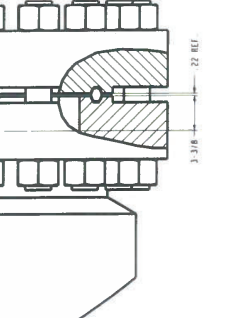
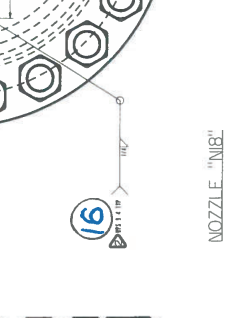
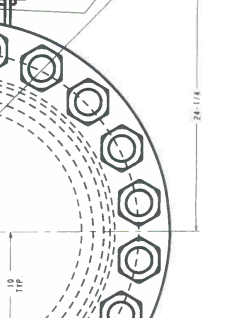
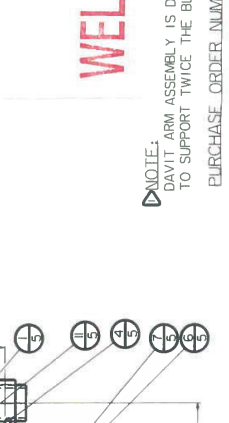
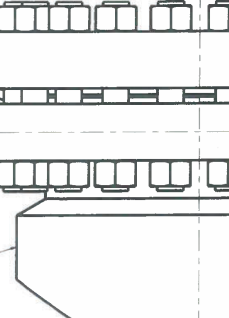
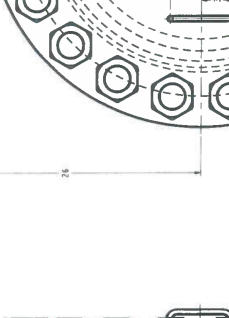
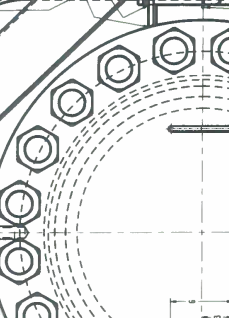
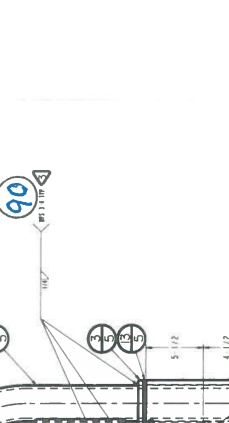
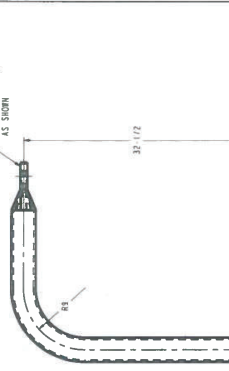
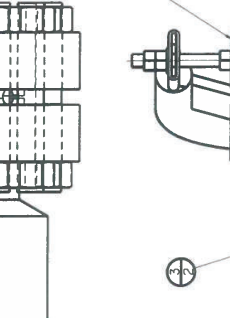
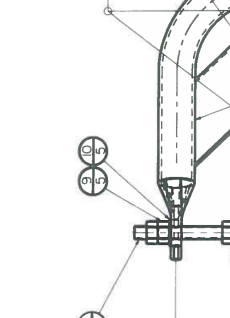
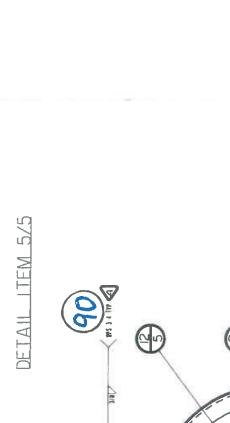
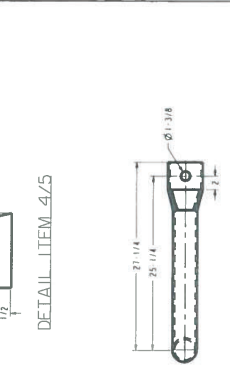
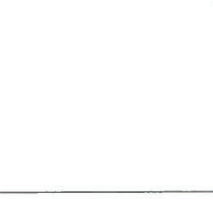
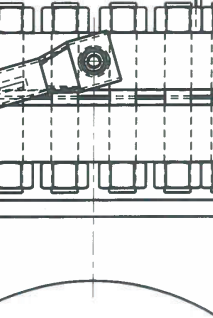
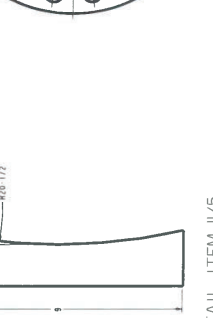
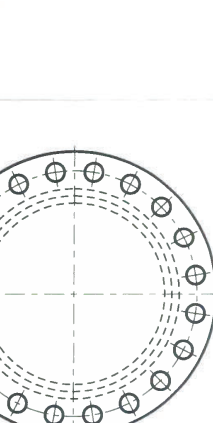
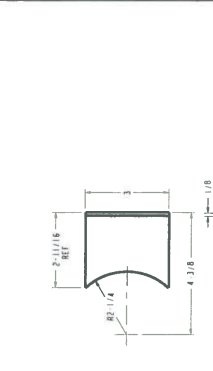
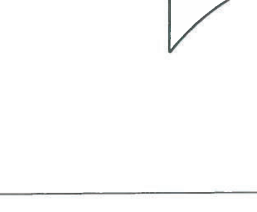
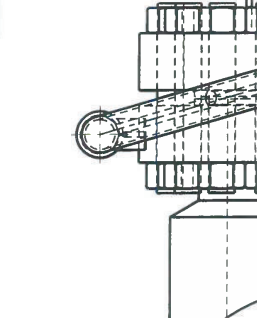
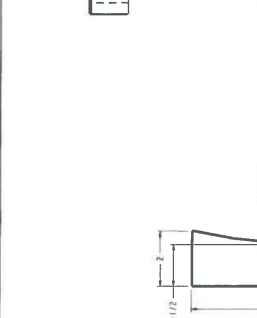
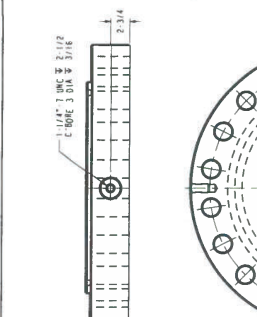
**WELD MAP**

**ALL-WELD COMPANY LIMITED**  
 WELDING & FABRICATION

NO.	REV.	DATE	DESCRIPTION
1	1	10/21/12	ISSUED FOR FABRICATION
2	1	10/21/12	ISSUED FOR FABRICATION
3	1	10/21/12	ISSUED FOR FABRICATION
4	1	10/21/12	ISSUED FOR FABRICATION
5	1	10/21/12	ISSUED FOR FABRICATION
6	1	10/21/12	ISSUED FOR FABRICATION
7	1	10/21/12	ISSUED FOR FABRICATION
8	1	10/21/12	ISSUED FOR FABRICATION
9	1	10/21/12	ISSUED FOR FABRICATION
10	1	10/21/12	ISSUED FOR FABRICATION

THIS DRAWING IS THE PROPERTY OF ALL-WELD COMPANY LTD. AND MAY NOT BE REPRODUCED OR DISCLOSED TO OTHERS WITHOUT WRITTEN PERMISSION.

ITEM QTY.	DESCRIPTION	SPEC.
23 1/2	1/2" SCH 40S STEEL PIPE 1/2" LONG	SA 106 GR. B
24 2/5	1/2" SCH 40S STEEL PIPE 1/2" LONG	SA 106 GR. B
25 2/5	1/2" SCH 40S STEEL PIPE 1/2" LONG	SA 106 GR. B
26 4/5	1/2" SCH 40S STEEL PIPE 1/2" LONG	SA 106 GR. B
9 1/5	1/2" SCH 40S STEEL PIPE 1/2" LONG	SA 106 GR. B
21 6/5	1/2" SCH 40S STEEL PIPE 1/2" LONG	SA 106 GR. B
28 7/5	1/2" SCH 40S STEEL PIPE 1/2" LONG	SA 106 GR. B
31 8/5	1/2" SCH 40S STEEL PIPE 1/2" LONG	SA 106 GR. B
32 9/5	1/2" SCH 40S STEEL PIPE 1/2" LONG	SA 106 GR. B
33 10/5	1/2" SCH 40S STEEL PIPE 1/2" LONG	SA 106 GR. B
26 11/5	1/2" SCH 40S STEEL PIPE 1/2" LONG	SA 106 GR. B
70 12/5	1/2" SCH 40S STEEL PIPE 1/2" LONG	SA 106 GR. B
71 13/5	1/2" SCH 40S STEEL PIPE 1/2" LONG	SA 106 GR. B



NOV 18 2013

DETAIL ITEM 2/5

(2) REQUIRED

PLOTTED:

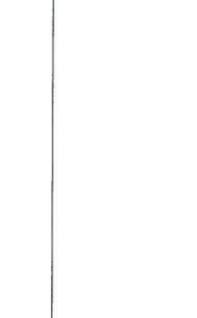
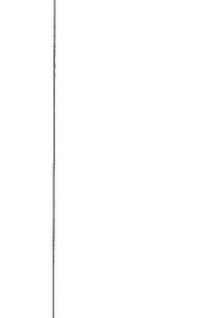
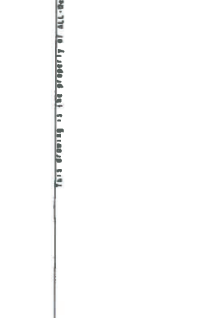
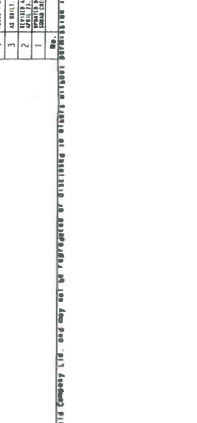
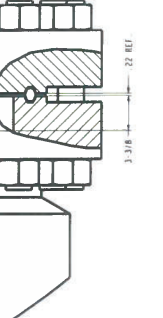
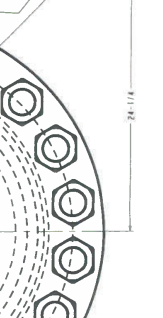
ALL-WELD COMPANY LIMITED

48 PAVAN RD, CANNON, VIC 3070

WELD MAP DRAWING

48" O.D. VERTICAL OUTLET SEPARATOR

24" HORIZONTAL ASSEMBLY C/P DAVIT ASSEMBLY



NOTE: DAVIT ARM ASSEMBLY IS DESIGNED TO SUPPORT TWICE THE BLIND FLANGE WEIGHT.

PURCHASE ORDER NUMBER: 11132

NOZZLE "N18"

NOZZLE "N18"

NOZZLE "N18"

NOZZLE "N18"

NOZZLE "N18"

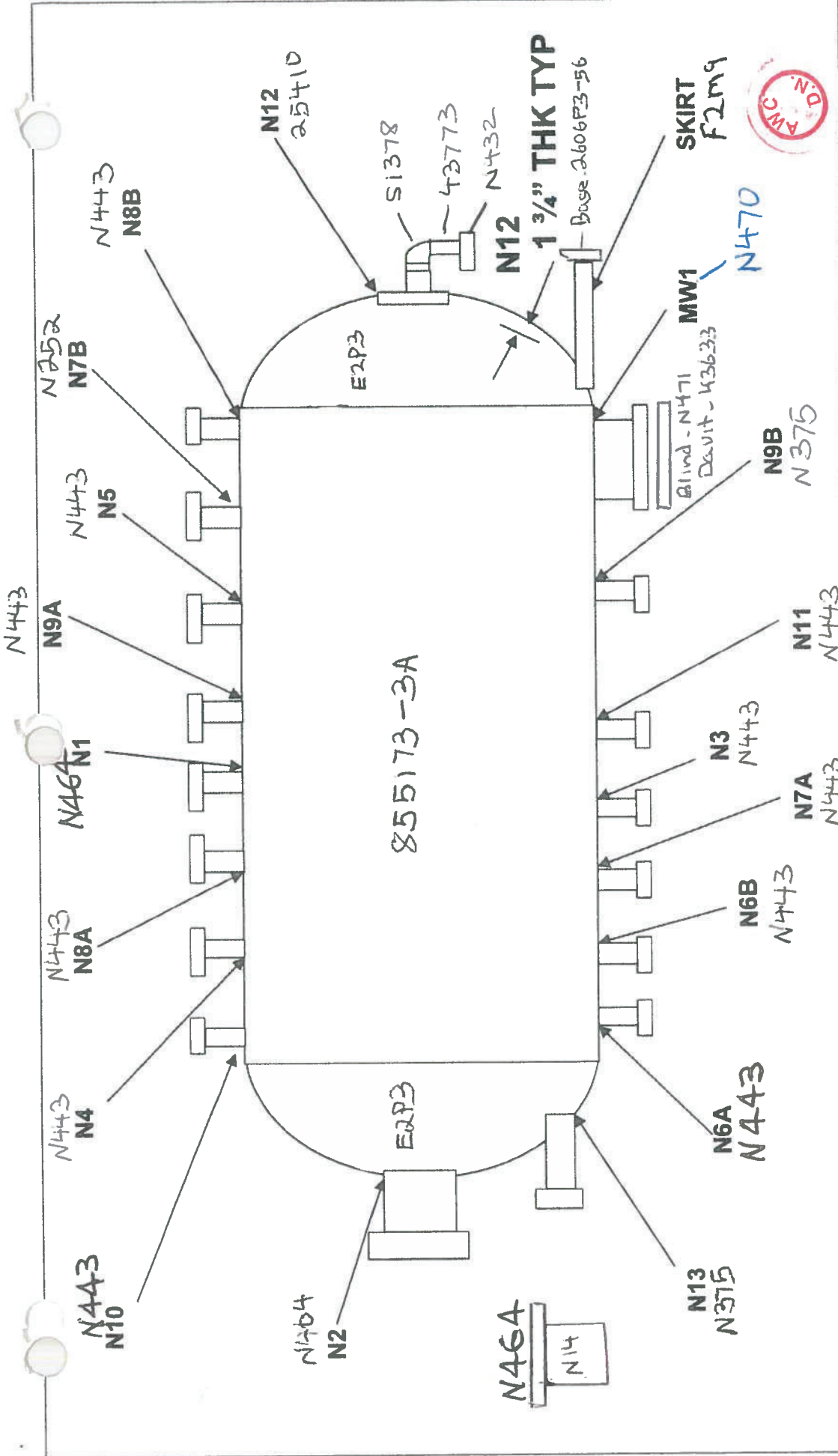
NOZZLE "N18"

NOZZLE "N18"

NOZZLE "N18"

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<b>ALL-WELD CO. LTD. - HEAT NUMBER MAP</b>
CLIENT: ULTRAFAB
WORK ORDER #: 1173PQ SN 7474
JOB DESCRIPTION: 48" O.D. VERTICAL OUTLET
DRAWING #: 1173-1-OU
PREPARED BY: D.NESCI
DATE: March 25, 2013

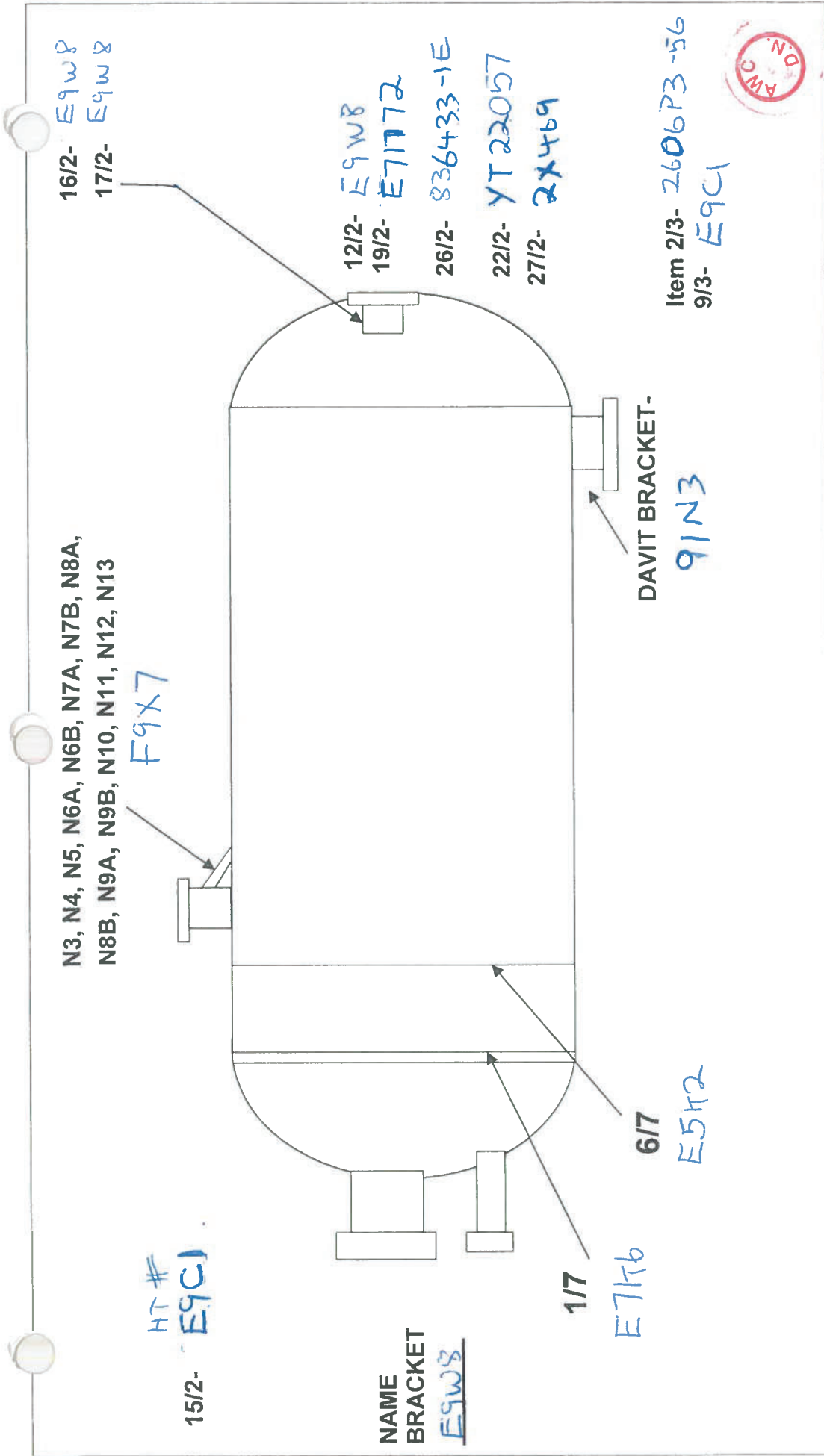
HEAT NUMBER MAP - 1173PQ

ASME SECTION VIII. DIV. 1

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

P.O. 13-0225





<p><b>ALL-WELD COMPANY LTD. - HEAT NUMBER MAP PARTS</b></p>		<p><b>HEAT NUMBER MAP PARTS- 1173PQ</b></p>	
<p>CLIENT: ULTRAFAB</p>		<p>ASME SECTION VIII. DIV. 1</p>	
<p>WORK ORDER #: 1173PQ SN 7474</p>		<p>MATERIAL SA-240 316/316L</p>	
<p>JOB DESCRIPTION: 48" O.D. VERTICAL OUTLET</p>			
<p>DRAWING #: 1173-1-OU</p>			
<p>PREPARED BY: D.NESCI</p>			
<p>DATE: September 17, 2013</p>			



# METALLURGICAL TEST REPORT

NORTH AMERICAN STAINLESS  
6870 HIGHWAY 42 EAST  
GHENT, KY 41045

6870 HIGHWAY 42 EAST

Certificate: 789232 2 Mail To:  
JACQUET MID ATLANTIC  
CUSTOMER PICKUP  
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-O

## 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 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

06E2P3 CA 06E2P3 CA 1.7575 60.0000 7,425 PLATE 240.00 2 1



CHEMICAL ANALYSIS CM(Country of Melt) ES(Spain) US(United States) ZA(South Africa) JP(Japan) Chemical Analysis per ASTM A751/08

HEAT 52P3 CM C % CR % CU % MN % MO % NI % P % S %  
US .0200 16.7990 .4640 1.4545 2.0220 .0434 10.0350 .0310 .0010

APR 04 2013

SI %  
.3810

W.O. # 11732  
M.L. #  
THK # SEE CUT REPORT

P.O. # 12-1612-11732

Certification of Material Per ASME B  
HT# E2P3  
Qualifies to all requirements of  
SA240-316/316L per  
Sect. II 10 Edition 11 Addenda

## MECHANICAL PROPERTIES

Product Id# Plate# .2% YS ELONG Hard R of A  
c r KSI KSI %-2" RB %  
06E2P3 CA 06E2P3 CA 86.93 45.00 56.70 80.00 62.45

HT # 52P3  
MTR APPROVED  
DATE 11/16/12  
ISP  
QUALITY CONTROL DEPT.

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: Velox America  
Print Name: LAMAR S. H. H. H.  
Signature: LAMAR S. H. H. H.  
Signature: LAMAR S. H. H. H.  
Signature: LAMAR S. H. H. H.

JACQUET INC.  
27161

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  
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: SIBM  
Print Name: GANESH SATHI  
Signature: [Signature]  
Date: Jan 26/13  
Applus®  
VELOSI  
Velosi America LLC



FEB 05 2013



# Certificate of Analysis and Tests

\*\*\*\*\*  
\* RE-CERTIFICATION \*  
\*\*\*\*\*

OUR ORDER 0282469 - 01

HEAT & PIECE 855173-3A 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 00000

00000

----- YOUR ORDER & DATE -----  
0032037ME 11/16/12

----- ITEM DESCRIPTION -----  
HEAT & PIECE 855173 - 3A  
WEIGHT 7564  
FINISH 1  
GRADE 316L / 316 UNS-S31603 / UNS-S31600  
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)

----- MECHANICAL & OTHER TESTS -----

HARDNESS HRBW 73  
GRAIN SIZE 6  
YIELD STRENGTH (PSI) 39700  
TENSILE STRENGTH (PSI) 77090  
INTERGRANULAR CORROSION OK  
ELONGATION % IN 2" 55.9  
REDUCTION OF AREA % 57.6

W.O. # 1173Q  
M.L. # 2  
THK. # 1 3/4"  
P.O. # 12-1613-1173Q

----- CHEMICAL COMPOSITION -----

CARBON (C) .012  
MANGANESE (MN) 1.57  
PHOSPHORUS (P) .032  
SULFUR (S) .001  
SILICON (SI) .32  
CHROMIUM (CR) 16.23  
NICKEL (NI) 10.11  
COBALT (CO) .26  
COPPER (CU) .33  
MOLY (MO) 2.04  
NITROGEN (N) .04  
COLUMBIUM (CB) .008  
TITANIUM (TI) .002  
ALUMINUM (AL) .007  
TIN (SN) .005  
TANTALUM (TA) .003

Certification of Material - Per ASME  
HT# 855173-3A  
Qualifies to all requirements of  
SA 240-316/316L per  
Sect. II 10 Edition IIIa 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

ACCEPTED/REVIEWED/RELEASED 046  
for and on behalf of: SBM  
Print Name: GAMESIL SAHA  
Signature: [Signature]  
Date: 26/11/13  
Applus® VELOSI  
Velosi America LLC

Outokumpu Stainless Plate, Inc.  
PO Box 370  
New Castle Indiana 47362

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 # 7474	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 checked="" 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	

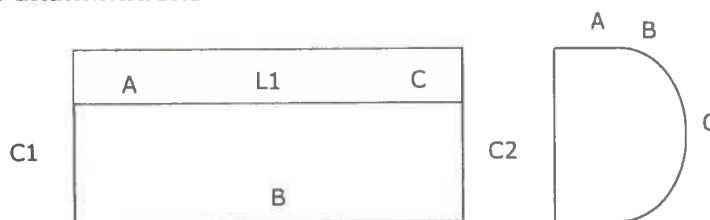
### Transducers/Calibration Blocks

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 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	1.771	1.788	1.829
B	1.781	1.715	1.738
C	1.778	1.740	1.745



All Dimensions are in inches

ACC: [REDACTED] REVIEWED/RELEASED  
for and on behalf of: *SIM*  
Print Name: **GAOVESH SAHA**  
Signature: *[Signature]*  
Date: *Feb 26/13*  
**Applus<sup>+</sup> VELOSI**  
Velosi America LLC

APW  
FEB 28 2013

### Scanning

Test Area	Disposition	From	Length	Depth	Amplitude

### Evaluation - Acceptance

<input type="radio"/> Accepted	KV Inspection Services - Technician	<i>[Signature]</i>	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:  
SA182F316L

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-F316L per  
Sect. II IC 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: GANESH SANKH  
Signature:   
Date: March 16/13  
Applus® VELOSI  
Velosi America LLC



14527 Smith Rd.  
Humble, Texas 77396  
TEL: (281) 441-4098  
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

Item	Quantity	Description	Notes
2	4	8" X 900 X 14" LG RTJ LWN	MTR REVISED 3/27/13 ITEM 1173-5
3	4	8" X 900 X 13.25" LG RTJ LWN	ITEM 1173-6

HEAT NUMBER:  
N464

MATERIAL TYPE:  
SA192F316/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	0.075

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  
SA192-F316/L per  
Sect. II TC Edition 11 Addenda

W.O. # 11730  
M.L. # 5(4) 6(5)  
THK. # 1.938  
P.O. # 13-0074

*Phyllis Holley*  
April 5, 2013  
V  
279  
Velocity America

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 RTJLWN

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 159 HBW ✓

Ni 10.000 ✓

.0800

**N13**  
Certification of Material - Per ASME  
HT# N375  
Qualifies to all requirements of  
SA182-F316/L per  
Sect. II TC Edition 11 Addenda

W.O. # 11730  
M.L. # 7 (6/12)  
THK. # 1.092  
P.O. # 13-0074

Q.C.I.  
N.D.

Heat Treatment SOLUTION ANNEALED  
Temperature 1925 °F  
Time at Temperature  
Cooling Media WATER

Q.C.I.  
E.Y.

MAR 20 2013

MAR 18 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 Ordonez Title: QA Representative

ACCEPTED/REVIEWED/RELEASED 046  
for and on behalf of: SBM  
Print Name: GABRIEL SABA  
Signature: [Signature]  
Date: 3/5/2013  
Applus® VELOSI  
Velosi America LLC





14527 Smith Rd.  
Humble, Texas 77396  
TEL: (281) 441-4088  
FAX: (281) 441-8899

REPORT NUMBER 72782

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  
ORDER/SHIPPED TO ALL-WELD CO., LTD.  
49 PASSMORE AVE.

SCARBOROUGH ONT MIV 4T1 CANADA

Item Quantity Description

4 1 2" X 900 X 11" LG RTJ LWN ITEM 1173-7

HEAT NUMBER: N375

MATERIAL TYPE: SA182F316/L

Material Origin: ITALY  
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

W.O. # 1173G  
M.S. # 7(6/2, 7/2)  
INK. # 1.073  
P.O. # 13-0074

**N9B**  
Certification of Material - Per ASME  
HT# N375  
Qualifies to all requirements of  
SA182-316L per  
Sect. II 10 Edition 11 Addenda

Q.C.I. N.D.  
Q.C.I. E.Y.  
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 046  
for and on behalf of: SASM  
Print Name: GAMBISH SAHA  
Signature: [Signature]  
Date: MAR 26/13  
Applus® VELOSI  
Velosi America LLC

FCI ORDER NUMBER 59176

Processed I.A.W. EN10204 3.1  
I.A.W. NACE MR0175

CUSTOMER ORDER NUMBER 13-0074  
OLD/SHIPPED TO ALL-WELD CO., LTD.  
49 PASSMORE AVE

SCARBOROUGH ONT M1V 4T1 CANADA

Item Quantity Description

4 2 2" X 900 X 11" LG HT/LWN

HEAT NUMBER: N252

MATERIAL TYPE: SA182F316/L

Manufactured in USA

I.A.W. ASME 2010 E6

CHEMICAL ANALYSIS

PHYSICAL PROPERTIES

C 0.03 ✓  
Mn 1.850 ✓  
P 0.020 ✓  
S 0.005 ✓  
Si 0.20 ✓  
Cr 16.120 ✓  
Mo 2.150 ✓

Yield PSI 43,700 ✓  
Tensile PSI 81,900 ✓  
Elongation 56 ✓  
Reduction of Area 77 ✓  
Hardness 134 HBW ✓



Ni 0.90 ✓  
N 0.0021

**NTB**

Certification of Material - Per ASME  
HT# N252  
Qualifies to all requirements of  
SA182 F316/L per  
Sect. II 10 Edition 11 Addenda

W.O. # 11730  
M.L. # 7112  
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 to the best of our knowledge and the records of the company.

Prepared by

*[Signature]*

Name

Title

QA Representative

ACCEPTED/REVIEWED/RELEASED 046  
for and on behalf of: SBM off shore  
Print Name: GANESH SHAH  
Signature: [Signature]  
Date: 7/24/13  
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  
ORDER/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

*N3,4,5,6A,6B,7A,8A,8B,9A,10,11*  
Certification of Material - Per ASME  
HT# N443  
Qualifies to all requirements of  
SA182-316/L per  
Sect. II 10 Edition 11 Addenda

W.O. # 11730  
M.L. # T(6/2/13)  
THK. # 1.078  
P.O. # 13-0074

Q.C.I. N.D.  
Q.C.I. E.Y.  
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: SBM  
Print Name: GAANESH SAHA  
Signature: *[Signature]*  
Date: Mar 26/13  
Applus<sup>®</sup> 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 ✓
	.0710 ✓

Certification of Material - Per ASME  
HT# N471  
Qualifies to all requirements of  
SA182-F316/L per  
Sect. II 10 Edition II Addenda

W.O. # 11730  
M.L. # 9(5/4)  
THK. # -  
P.O. # 13-0074

Heat Treatment SOLUTION ANNEALED  
Temperature 1925 °F  
Time at Temperature  
Cooling Media WATER

Q.C.I. E.Y.  
MAR 20 2013

Q.C.I. N.D.

MAR 18 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 Ordonez Title: QA Representative

ACCEPTED/REVIEWED/RELEASED 046  
for and on behalf of: S.B.M.  
Print Name: GAURESH SAHA  
Signature: [Signature]  
Date: March 26/13  
Applus® VELOSI  
Velosi America LLC

**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  
 SA182-F316/316L 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 SA182-04, 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 complies with the terms of order/contract.

**VIJAYA BANK**  
 5043 / FUDBP / FDSBY  
 23124  
 Overseas Branch, Mumbai-21.

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: Velosi America  
 Print Name: GANESH SAHA  
 Signature: [Signature]  
 Date: 14/13  
**Applus**  
 VEL OSI  
 Velosi America LLC

[Signature]  
 WORKS INSPECTOR  
 K R K MURTHY

File P056237

From: Alloy Piping Products, LLC  
Corporate Offices  
P O Box 7368  
Shreveport  
LA 71137-7368

To: PINACLE STAINLESS STEEL  
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	B/W LR 90° ELBOW	2.0000	160		
Alloy WP316/316L			Qty		4.0000
Short PN 00005393					

Ord Spec	SA403 WP S SEAMLESS	Mfg Dt	12/12
Itm Spec	ASTM Spec-A403	YR	2012
Itm Spec	ASME Spec-SA403	ED	2010

Made in USA

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	Elong %	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 1 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

TEDRE  
 In on behalf of SIBM OFFSHORE  
 name: LA WELLS 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.# 1173Q  
 M.L.# 13 (10/2)  
 ERK.# 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**

<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

W.O. # 11736  
M.L. # 14(11/2)  
THK. # 0.347  
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 II 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			Method	
Heat Nr:	Supplier		Electric furnace+AOB	
37015	ACERALAVA		Electric furnace+AOB	MAR 26 2013
43773	ACERALAVA		Electric furnace+AOB	

CHEMICAL COMPOSITION (%)		*In. Ladle C: Products									
* Heat	Seq	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

Reviewed  
6/27  
Velosi America  
KJS  
April 11, 2013



TUBACEX TUBOS  
INOXIDABLES  
INGENIERIA DE CALIDAD

*[Signature]*



**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 °C	Rp0.2 N/mm2	Rp1.0 N/mm2	Rm N/mm2	A2" %	A5 %
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*  
*April 1, 2013*  
Velosi America  
279

MAR 26 2013

Q.C.I.  
N.D.

**MARKING**

TUBACEX 2" SCH 160 ASME SA312 ASTM A312 TP316 TP316L CD SHLS NH ET  
HEAT/ PMT 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 SÜDDEUTSCHLAND (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:	Modified on:
Date: 09.05.2011	

**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  
CHENT, KY 41045

153070

6870 HIGHWAY 42 EAST

Certificate: 805566 2 Mail To:  
C.V.F. STAINLESS STEEL, INC.  
1840 BURLINGTON STREET E.  
HAMILTON, ON L8H3L4

Ship To:  
C.V.F. STAINLESS STEEL, INC.  
1840 BURLINGTON STREET E.  
HAMILTON, ON L8H3L4

Date: 1/29/2013 Page: 1

Customer: 007060 001

Steel: 316/316L  
Finish: BRAP

Corrosion: ASTM A262/02a, 180Bend-OK

Your Order: C87097 HAS 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, A604/11, A312/11  
CHEM ONLY ON FOLLOWING ASME: SA312/11, SA479/11  
AMS 5507F/5524L X MRK;  
NACE MR0175/180 15156-3:2003 A, MR0103/07, Q36766D-A X MAG PREEN  
NIT. SOLUTION ANNEAL TEMP 1900F, WATER QUENCHED

## REMARKS:

Mat'l is Free of Mercury Contamination. No void repairs.  
EN 10204:2004 3.1; POSM 1 & 2 Compliant  
Material is Free of Radioactive Contamination  
HAS Steel Making Process: EAF, AOD, & Cast. 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 per ASTM A751/08

CHEMICAL ANALYSIS	CM(Country of Melt)	ES(Spain)	US(United States)	ZA(South Africa)	JP(Japan)
HEAT					
E9W8	0.0139	16.6330	.4580	1.5125	2.0060
				.0409	10.0750
					.0365
					.0010

Q.C.I. N.D.

W.O. # 11730  
M.L. # 16(13, 14, 15, 18) (13)  
P.O. # 13-0165

## MECHANICAL PROPERTIES

Product Id#	Coil #	UTS	Y8	ELONG	Hard	Tell
04E9W8 A	04E9W8 A	88.77	47.88	49.59	84.00	07.50

Q.C.I. E.Y.

Certification of Material - Per ASME  
HT# E9258  
Qualifies to all requirements of  
SA240-316/316L per  
Sect. II 10 Edition Addenda

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SAM OFFSHORE  
Print Name: GARETH SULLIVAN  
Signature: [Signature]  
Date: 12/2013

Applus®  
VELOSI  
Valori America LLC

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 reported and cannot be reproduced, except in its entirety, without the written approval of NAS.

Technical Dept. Mgr. ERIC HESS

1/31/2013



# METALLURGICAL TEST REPORT

NORTH AMERICAN STAINLESS  
6870 HIGHWAY 42 EAST  
GHENT, KY 41045

45K 54016

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

Date: 2/11/2013 Page: 1

Steel: 316/316L

Finish: HRAP

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,A480/11b,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

## 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 3.1.1-B

ACCP: DIRTY/UNRELEASED  
for and on behalf of: Velosi America  
TRAFFIC SALES  
046  
Product Code: APLIUS  
Signature: [Signature]  
Date: March July 2013  
Commodity Code: VELOSI  
Velocity 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

Chemical Analysis per ASTM A751/08

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. # 117308  
M.C. # 17(1/3)  
THK. # .502  
P.O. # 13-0203

## MECHANICAL PROPERTIES

Product Id#	Plate#	UTS KSI	.2% YS KSI	ELONG %-2"	Hard RB	R of A %
05F2M9 AA	05F2M9 AA	85.73	39.06	56.10	72.00	75.52

Q.C.I. E.V.  
Certification of Material - Per ASME  
RT# F2M9  
Qualifies to all requirements of SA480-316/316L per Sect. II IC 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  
2/11/2013



ESSAR STEEL ALGOMA INC., 105 West Street, Sault Ste. Marie, Ontario, Canada P6A 7B4

0005918

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 2C ABERFOYLE, Ontario, Canada N1H 6H9	Customer PO No./Item	P007755 / 2 1000023647
Customer Specification:	HR STEEL PLATE Carbon Mnb 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 °F 34 min CWI. Req. 5/12 FT. LBF at 0.500 F Sid Thickness Tol PVQ Top and Bottom Standard Surface Finish 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)				

Supplementary instructions: Test Cert 11519-837-2227  
 Insp TR: 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 OR REPRINTED IN FULL WITHOUT WRITTEN APPROVAL OF ESSAR STEEL ALGOMA INC. IF YOU RECEIVE THIS DOCUMENT AND ARE NOT THE INTENDED RECEIVER PLEASE CALL 1705-945-4054 FOR INSTRUCTIONS ON METHOD OF DISPOSAL OF DOCUMENT.  
 MEETS EN 10204 2004 TYPE 3.1  
 QUALITY AND PERFORMANCE INDICATORS AVAILABLE AT WWW.ESSARSTEELALGOMA.COM

Dimensions (T x W x L)	Heat No.-MS	Quantity	No. of Pcs	Dimensions (T x W x L)	Batch No.	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"	AB8770	2606P3-56	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	1.08	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

Heat No.	SROE	LAB	GAUGE	COND	LOC	MTHD	HARDNESS
2606P3	AB8769	166"	ALG	1.0000	NORM B	HBW	153
2606P3	AB8770	166"	ALG	1.0000	NORM B	HBW	153
2797P3	AB8771	166"	ALG	1.0000	NORM B	HBW	150

W.O. # 11739  
 M.I. # 19 (73)  
 I.I.K. # 14  
 P.O. # 13-0220

MILL TEST REPORTS APPROVED BY Q.C. P.O. \_\_\_\_\_

K. UGHADPAGA  
 MANAGER METALLURGICAL SERVICES

Q.C.I. E.Y.  
 Q.C.I. N.D.

LIMITS OF UNSPECIFIED ELEMENTS PER ASME SECTION II (SA-20)  
 CU + NI + CR + MO = 0.2  
 CR + MO = 0.03

Certification of Material - Per ASME  
 HT# 2606P3-56  
 Qualifies to all requirements of SA516 GR 70  
 Sect. II 10 Edition Addenda

WARNING: THESE TEST RESULTS REPORTED HEREIN INDICATE ONLY THAT THE MATERIAL IS STEEL FOR WHICH THIS CERTIFICATE IS ISSUED MEETS THE MINIMUM SPECIFIED YIELD STRENGTH AND TENSILE AND PHYSICAL PROPERTIES OF SUCH STEEL. ARE IN CONFORMANCE WITH THE REQUIREMENTS OF THE SPECIFICATION INDICATED. THESE VALUES DO NOT INDICATE THAT THE STEEL MEETS ALL THE REQUIREMENTS OF THE SPECIFICATION AND 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) WITHOUT THE ACTUAL STRENGTH OF SUCH STEEL.



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:	100023647 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./Item:	P007755 / 2
Customer Specification:	HR STEEL PLATE Carbon Multi Cert ASTM A516 GR 70 (10) / ASME SA516 GR 70 (11A) Meets NACE MR 0103 latest Ed. BHN < 200. D.O.CEQ. 43 max. Inclusion Shape Control Calcium Treated Normalized 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			BOL NO:	1000023647
Supplementary Instructions:	Test Cert 1:519-837-2227			Cust. Part No:	
Temp Tst:	Test Report As Per Spec			Carrier:	ROBINSON TRANSPORT LTD - 205(661)
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) 945-4025 FOR INSTRUCTIONS ON METHOD OF DISPOSAL OF DOCUMENT.					
MEETS EN 10204 2004 TYPE 3.1 ISO QUALITY AND ENVIRONMENTAL CERTIFICATE AVAILABLE AT WWW.ESSARSTEELALGOMA.COM					
. . . . . M E C H A N I C A L P R O P E R T I E S . . . . .					
Impact Tests	Batch No.	SRCO LAB GAUGE COND METH DIR LOC SIZE	TEMP (°F) ENERGY (ft-lb)	ENERGY AVG (ft-lb)	
2606P3	AB8769	166" ALG 1 0000 NORM CVN L B FULL -50	71 69 77	72	
2606P3	AB8770	166" ALG 1 0000 NORM CVN L B FULL -50	59 61 73	64	
2797P3	AB8771	166" ALG 1 0000 NORM CVN L B FULL -50	84 86 65	79	
Tensile Tests	Batch No.	SRCO LAB GAUGE COND METH DIR LOC YIELD(KSI) TENSILE(KSI) EL SCALE	ELONG(%)		
2606P3	AB8769	166" ALG 1 0000 NORM 2 T B 40 5	78 2	2"	33
2606P3	AB8770	166" ALG 1 0000 NORM 2 T B 49 0	77 1	2"	32
2797P3	AB8771	166" ALG 1 0000 NORM 2 T B 50 7	77 2	2"	31

*Velocity America*  
 279  
 April 1, 2013

MAR 27 2013



APR 03 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.



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

NORTH AMERICAN STAINLESS  
6870 HIGHWAY 42 EAST  
GHENT, KY 41045

Your Order: 53951 NAS Order: DS 0002765 03 Corrosion: ASTM A262/02aE;180Bend-OK

PRODUCT DESCRIPTION:

STAINLESS STEEL CONT. MILL 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 5507P/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 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 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

Q.C.I. N.D.

Q.C.I. E.Y.

W.O.# 11730  
M.L.# 20 (3/3, 4/3)  
I.F.K.# 382  
P.O.# (3-0221)

MECHANICAL PROPERTIES

Product Id#	Coil #	YTS	YS	ELONG	Hard	Tail
DE0841	05F3K0	85.55	52.63	49.68	83.50	83.50
		KSI	KSI	%-2"	RB	Hard
		DTS	%-2"			

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    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 I.lodio (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: 1" SCH 40  
 HOT FINISHED  
 NACE MRO103-10 / MRC175 / ISO 15156-3 : 2009

W.O. # 1173  
 M.L. # 21 (5/3)  
 INK. # 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

<b>RAW MATERIAL</b>		
Heat Nr:	Supplier	Method
43633	ACERIALAVA	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

**Q.C.I.**  
**E.Y.**

**HEAT TREATMENT**  
 SOLUT. ANNEALED 1040 °C RAPIDLY COOLED

TENSILE TEST		Sample T		Rp0.2	Rp1.0	Rm	A2"	A5
Prod. Order	Ins. Lot		°C	N/mm2	N/mm2	N/mm2	%	%
100323274	200038013	1	20	385	418	598	52	48

MAR 26 2013  
**Q.C.I.**  
**N.D.**

Reviewed  
 Velosi America  
 V  
 279  
 R/S  
 11/11/2013



**TUBACEX TUBOS INOXIDABLES**  
 INGENIERIA DE CALIDAD

*[Handwritten Signature]*



**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 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 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*  
*11/11, 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.smsl-tubes.com

INSPECTION CERTIFICATE  
Abnahmeprüfzeugnis  
Certificat de réception

EN 10204: 2004 TYPE 3.1

(A02)

Page/Selle

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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)

0000245463

SMST-Tubes Item

0000245463-000009

Product Description/Produkt Beschreibung/Déscription du produit (B01) (B02) (B04)

Seamless stainless hot finished pipe pickled and passivated / Tubes fins 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 15156-3 2009

Grade/Werkstoff/Nuance TP 316 / TP 316L

Tolerances/Toleranzen/Tolérances A 312

Marking of the product/Kennzeichnung des Produktes/Marquage du produit (B05-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 - CL30037484 - FRANCE

Quantity/Menge/Quantité						Dimensions		Abmessungen	
Heat no Schmelze Nr. N° de Coulée	Quality lot Qualitätslos Lot qualité	SMST Item	Pieces Stück Pièces (B05)	Total weight Gesamtgewicht Masse totale (B13)	Total length Gesamtlänge Longueur totale	OD (B08)	WT (B10)	Tube length Rohrlänge Longueur tube	
								min	max
449090	QL30037484	000009	7	1454.00 Kg 3206 Lbs	49.370 m 161.98 Ft	114.30 mm NPS 4	11.13 mm SCH 120	8098 mm 20.00 Ft	7315 mm 24.00 Ft

Chemical Analysis / Chemische Zusammensetzung / Analyse chimique (C71 - C92)

Heat no./Schmelze Nr./N° de coulée 449090

Melting Process/Erschmelzungsart/Élaboration (C70) VOD

Heat Origin/Urap. der Schmelze/Origine de la Coule Germany

Heat Analysis / Analyse de coulée

	C	Si	Mn	P	S	Cr	Ni	Mo
Min	0.00	0.00	0.00	0.00	0.00	16.00	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	16.75	11.44	2.14

Certification of Material - Per ASME

HT# 449090

Qualifies to all requirements of  
SA 312-316/316L per  
Sect. II 10 Edition 11 Addenda

APR 24 2011

Q.C.I.  
N.D.

Q.C.I.  
E.Y.

W.O. # 1173  
M.L. # 23 (14, 314)  
THK. # 443  
P.O. # 13-0243-REV1

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 not allowed use. Any alterations or falsification will be subject to law.

Dieses Zeugnis bzw. Diese Bescheinigung wurde mithilfe 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 la falsification de documents et fraude et sera sujet à la juridiction pénale.

Salzgitter Mannesmann Stainless Tubes France SAS ISO9001 - LRQA N°928475

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SPDM off-shore  
Print Name: HANESH SAH  
Signature: [Signature]  
Date: 04/11/11  
Applus VELOSI  
Velosi America LLC  
046



Salzgitter Mannesmann Stainless Tubes France SAS (A01)  
 B.P.10 - F 21501 Monibard Cedex - FRANCE  
 www.amsl-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/Limito 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	6,65 √So	4D	
		ksi	/	/	ksi	%	/	/	/	/	/
	Min	30	/	/	75	35	/	/	/	/	/
	Max	/	/	/	/	/	/	/	/	/	/
30128250	LONGITUDINAL	47.67	/	/	87.20	49.76	/	/	/	/	/

Hardness test/Härteprüfung/Essai de dureté (C30)

NACE MR0175/ISO 15156-3 NACE MR0103

Test no Proben Nr. N° d'échantillon	Load /																	
	HB			HRC			HV			HRB			HR 15-T			HR 30-T		
Min	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
Max	/	/	/	22	22	22	/	/	/	/	/	/	/	/	/	/	/	/
	min	max	avg	min	max	avg	min	max	avg	min	max	avg	min	max	avg	min	max	avg
30128250	/	/	/	<18	<18	<18	/	/	/	/	/	/	/	/	/	/	/	/

Flattening test/Faltversuch/Essai d'aplatissement (C50)

ASTM A 999

Test Number	Result
30128249	OK
30128250	OK

Other testing

Quality Lot : QL30037484

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Dieses Zeugnis bzw. diese Bescheinigung wurde mit Hilfe der EDV erstellt und ist ohne Unterschrift gültig. Veränderungen sowie Verwendung für andere Erzeugnisse werden als Unkundenleistung bei Betrug strafrechtlich verfolgt.

Ce certificat est rédigé à l'aide d'un balaisent électronique de données et est applicable sans signature. Tout usage non autorisé ou application pour d'autres produits seront considérés comme falsification de documents et soustraits à la juridiction pénale.

APR 24 2013



Salzgitter Mannesmann Stainless Tubes France SAS ISO9001 - LROA N° 825473

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: S.B.M. OFFSHORE  
 Print Name: GANESH SAHAI  
 Signature: [Signature]  
 Date: July 10/13  
 Applus<sup>®</sup> VELOSI  
 Velosi America LLC

046



No/Nr/N° (A03)

24548300937484

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)

Page/Selle  
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Intergranular corrosion test/Prüfung Interkristalliner Korrosion/Essai de corrosion Intergranulaire

MIL-P-24891/3 Feb, 1991 Ad 1 ASTM A 262 PRACTICE E

Test Number	Result
30128249	Satisfactory
30128260	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 misuse or not attested use. Any alterations or falsification will be subject to law.

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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 fraudes et seront sujet 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)

Pago/Solte

4/4

Other Tests and Declarations / Andere Prüfungen und Prüferstellungen / Autres tests et déclarations

QL30037484

Visual and dimensional inspection (VT) / Besichtigung und Maßekontrolle / Examen visuel et dimensionnel : Satisfactory/Bestanden/Satisfaisant

Heat Treatment / Wärmebehandlung / Traitement Thermique / Annealed : Temperature : > 1040°C / 1904°F Rapid cooling

Hydrostatic Test / Wasserdichtendruckversuch / Essai Hydraulique : 190 BARS / 5 sec

Analysis check (PMI) of all tubes by spectrographic analysis / Verwechslungsprüfung an allen Rohren mittels Spektralprüfung / Contrôle anti-mélange par PMI 100% : Satisfactory/Bestanden/Satisfaisant

No Weld repair / Keine Reparaturschweißung / Aucune réparation par soudure

The material is conforming to directive 2000/63/EC, 2002/95/EC and CD 2005/618/EC. / Das Material entspricht den Anforderungen der Richtlinien 2000/63/EC, 2002/95/EC und CD 2005/618/EC. / Le matériau est conforme aux directives 2000/63/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 vom radioaktiver Verunreinigung / Les tubes sont exempte 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)

Besätigung 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 in 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

Mill's Inspector  
Werkstachverständiger T POMMERY  
Le contrôleur usine

Date of edition  
Ausgabedatum 11/10/2012  
Date d'édition

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Dieses Zeugnis bzw. diese Bescheinigung wurde mit Hilfe der EDV erstellt und ist ohne Unterschrift gültig. Veränderungen sowie Verwendung für andere Erzeugnisse werden als Unwahrheitlichung 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 utilisation pour d'autres produits seront considérés comme falsification de documents et fraudes et seront sujet à la justice pénale.



TUBACEX

**INSPECTION CERTIFICATE**  
**EN 10204 3.1**

Number: 516297  
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 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 MRO103-10 / MR0175 / ISO 15156-3 : 2009

Q.C.I.  
E.Y.

Q.C.I.  
N.D.

MAR 26 2013

W.O. # 11735  
M.S. # 24 (2/4)  
THK. # 436  
P.O. # 13-0243-REV 1

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
180		8110006752	100323250	200037778	43633	8	1 091 KG	47,95 M	5791-7315 MM

Heat Nr:	Supplier	Method
43633	ACHRAI AVA	Electric furnace+AOD

CHEMICAL COMPOSITION (%)										
* Heat	Seq	C	Mn	Si	P	S	Ni	Cr	Mo	*L. Ladle C-Products
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	Ins. Lot	Sample T	Rp0.2	Rpl.0	Rm	A2"	A5		
			N/mm2	N/mm2	N/mm2	%	%		
100323250	200037778	1 20	432	472	625	54	48		

Q.C.I.  
N.D.

Review  
Rid  
April 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:                      Modified on:  
Date: 01.04.2011

**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*  
  
*Apr 1, 2011*

**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 I  
POINT 4.3

MATERIAL CHARACTERISTICS COMPLY WITH POINT 7.5 OF ANNEX I 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



# METALLURGICAL TEST REPORT

NORTH AMERICAN STAINLESS  
801 TWIN RAIL DRIVE  
MUNOOKA, IL 60447

Date: 3/21/2006 Page: 1  
Steel: 316/316L  
Finish: BRAP  
Corrosion: ASTM A262/02aE, 1808end-OK

Ship To:  
ROLLED ALLOYS  
125 W. STEWIS RD.  
TEMPERANCE, MI 48103

Mail To:  
ROLLED ALLOYS  
125 W. STEWIS RD.  
TEMPERANCE, MI 48103

Customer: 002830 001

Your Order: T56490

NAS Order: IN 0006185 01

**REMARKS:**  
Material free from Mercury contamination. No weld repairs.  
EN 10204 3.1 PED 97/23/EC Annex1, Para. 4.3 Q98763F Cond A  
Material is ROHS-Compliant  
NACE MR0 175 EN 10204 3.1.B  
Melted & Manufactured in the USA

## 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), Q98766D-A X MG PERM, AMS55078/AMS5524K X MKK  
Chem only for following: ASTM A276/A312/A479, ASME SA312/SA479

Product Id	Coil #	Thickness	Width	Weight	Length	Mark	Pieces	Commodity Code
0991N3 EC	0991N3 EC	.4960	48.0000	1,005 PLATE	144.00	4	1	

## CHEMICAL ANALYSIS

Heat	CM	C	CR	CU	MN	MO	N	P	S	SI	US(United States)
91N3	US	.017	16.952	.712	1.527	2.096	.046	10.232	.033	.002	.130

## MECHANICAL PROPERTIES

Product Id#	Coil #	UTS KSI	.2% Y8 KSI	ELONG %-2"	Hard RB
0991N3 EC	0991N3 EC	80.82	37.73	58.95	76.50

Certification of Material - Per ASME  
HT# 91N3  
Qualifies to all requirements of  
SA240-316/316L per  
Sect II Edition II Addenda

W.O. # 1173811A  
M.L. # 26441A  
TIK. # 503  
P.O. # C46570500

ROLLED ALLOYS QUALITY ASSURANCE  
APPROVED [Signature]  
DATE 3-22-06

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SPAM OFFSHORE  
FRUIT NAME: JAMESH SAHA  
SIGNATURE: [Signature]  
DATE: 4/11/13  
Applus+ VELOSI America LLC



TRACER# 129838

Q.C.I. N.D.

Q.C.I. N.D.

APR 7 4 2019

JUN 12 2006

Q.C.I. E.V.

3/21/2006

QC ENGINEER [Signature]  
ERIC HESS

DET 722006

**VIRAJ IMPOEXPO LIMITED**

10, IMPERIAL CHAMBERS, 1ST FLOOR  
WILSON ROAD, BALLARO 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'	225	1850

**CHEMICAL ANALYSIS**

HEAT NO. 57624											
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 CONFORMS TO ASTM A276-00/A 476-01, A484-00, A282-00 PRACTICE E, RMS 60, ASTM A182-01b BSM CL1, A308-06ED, A182-01a AWS B486/5053E, ASME SA-182 B06D, SA-476-06ED, SA-193-00 BSM C L1, QQ-S-763F, MILL-S-7720A AM2, NACE-MR-01-75-03, UNS#S316 80/S31603, ASTM E 112-00(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  
SA 476-316/316L per  
Sect. II 10 Edition 11 Addenda

W.O. # 11730  
M.L. # 270614  
THK. # 499  
P.O. # B604-110411

*[Signature]*  
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: SJM OFFSHORE  
Print Name: WAMPESH SAHIL  
Signature: *[Signature]*  
Date: 2 JULY 2013  
**Applus<sup>®</sup> VELOSI**  
Velosi America LLC



CUSTOMER ORDER NUMBER 13-0266  
D/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



Ni	10.310 ✓
	.0980

Certification of Material - Per ASME  
HT# N434  
Qualifies to all requirements of  
SA182-F316/L per  
Sect. II 10 Edition 11 Addenda

W.O. # 1173Q  
M.L. # 40(5/2)41C(5/1)  
THK. # 1.960  
P.O. # 13-0366

Heat Treatment SOLUTION ANNEALED  
Temperature 1900 °F  
Time at Temperature  
Cooling Media WATER

ACCEPTED/REVIEWED/RELEASED 046  
for and on behalf of: SBM OFF Shore MAY 27 2013  
Print Name: G.A. VELOSI SAH#  
Signature: [Signature] **Applus<sup>®</sup> VELOSI**  
Date: July 19 13 **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  
OLD/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. # 3/4 160-407  
P.O. # 13-0279

N12  
Certification of Material - Per ASME  
HT# N432  
Qualifies to all requirements of  
SA182 F316/L per  
Sect. II 11 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 SHORE  
Print Name: GANESH SAHA  
Signature: [Signature]  
Date: July 17 2013  
Applus® VELOSI  
Velosi America LLC

Classification of Material - Per ASME  
 Sect. II, Edition 11 Addenda  
 SA312-316/316L  
 Qualifies to all requirements of  
 5120057

# L PALACE PIPE CO., LTD

## TEST CERTIFICATE

W.O. # 11739  
 M.L. # 49 (1/2, 2 1/2, 1 1/2, 1 1/2)  
 THK. # 150  
 P.O. # 13-0707

DATE OF ISSUE: 2013/7/17

DATE (No.: QAC0021058/A)

DATE (No.: QAC0021058/A)

CRYS

APPLIED VERIFIED STAINLESS  
 West America LLC  
 Signature: [Signature]  
 Date: 8/21/13  
 ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: [Signature]

CERTIFICATE NO.: 2013-05-021-I-17  
 ORDER NO.: 2013-05-021-I  
 GRADE: ASTM A312-12 TP316/316L  
 HEAT NO.: YT22057

COMMODITY: STAINLESS STEEL SEAMLESS PIPE.  
 CONDITION: COLD FINISH / SOLUTION TREATED / PICKLED / PLAIN END

CHEMICAL CONTENTS (WT%)

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

Dimensions	Weight (kg)	0.2%YS (Mpa)	T S (Mpa)	EL (%)	FLATTENING TEST	HARDNESS HRB	EDDY CURRENT TEST (100%)
W.T (SCH) Length (feet) 2" 40S 20	8428	≥ 205	≥ 515	≥ 35	OK	≤ 90	OK
Bundle No. Z13-5-295	250	AUG 1 2 2013		Q.C.I. E.V.			

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

SHANGHAI CRYSTAL PALACE PIPE CO.,LTD  
 Dingpin Guo  
 MANAGER OF QUALITY ASSURANCE DEPARTMENT / DING WEI-GUO



**9570 HIGHWAY 42 EAST**  
 Certificate: 728046 15  
 Customer: 007050 001

# METALLURGICAL TEST REPORT

Ship to:

Date: 4/12/2012 Page: 1

Steel: 316/316L

Finish: MAP

Corrosion: ASTM A263/A262; 190Head-02

Your Order: 50966

NAS Order: DS 0000209 02

## PRODUCT DESCRIPTION

FLANGES FROM CORR. NEAL PLATE, MAP; UNS 31600/31603  
 ASTM A240/11b, A480/11b, A566/10/11b, A566/11a, A566/11a  
 CORR. COAT ON FOLLOWING ASTM: A276/10, A479/11, A484/11, A312/11  
 CORR. COAT ON FOLLOWING ASTM: A312/11, A579/11  
 UNS 3077/55245 X UNS;  
 SPEC: MS0175/140 15156-3i2003 A, MS0103/071 0057600-A X UNS FROM  
 NIT. SOLUTION ANNEAL TEMP 1900F, WATER QUENCHED

## REMARKS

Mat'l is free of Mercury Contamination. No void repairs.  
 UNS 10204/2004 3.1; 0057637 Cond A; RDS Compliant  
 Material is free of Radioactive Contamination  
 NAS Steel Making Process: MAP, AOD, & Cont. Casting  
 Product Mfg. by a Quality Mgt. Sys. in Conf. w/ISO 9001  
 Sourced & Manufactured in the USA; Mat'l is N7849 Compliant  
 UNS 10204 3.1.3

Product ID	Coil #	Std #	Thickness	Width	Weight	Length	Mark	Pieces	Commodity Code
DA0060	050529 1		.2460	60.0000	3.000	144.00		9	5

## CHEMICAL ANALYSIS

City (Country of Birth) (EPA) (United States) Z (Rough Area) J (Japan)

FEAT	VS	C	CR	CU	NI	MO	SI	P	S
0057		.0296	16.0325	.5025	1.0335	2.0064	.0436	10.0300	.0017
		SE							
			.4430						

W.O. # 11730  
 M.L. # 5002721 (2)  
 THK. # 248  
 P.O. # 12-1367-102R

Q.C.I.  
 N.D.

## MECHANICAL PROPERTIES

Product ID	Coil #	T	UTS	YS	ELONG	RED	TEMP	Hard	Temp
DA0060	050529	7 2	84.23	43.69	48.97	84.00	83.00		

Certification of Material - Per ASME

H# B924  
 Qualifies to all requirements of  
 SA 240-216316 per  
 Sect. II 10 Edition II Addenda

AUG 16 2013

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBM OF SMOKE  
 Print Name: G. M. S. V. S. P. H. F.  
 Signature: G. M. S. V. S. P. H. F.  
 Appius® VELOSI

NAS hereby certifies that the analysis on this certification is correct and that the material meets the specifications stated.

Technical Page: Mgr.

ERIC HESS

4/2/2012

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 ITEM DESCRIPTION  
 WEIGHT 2782 COUNTRY OF ORIGIN BRITAIN  
 FINISH 1  
 GRADE 316L / 316 UNS-S31603 / UNS-S31600  
 DIMENSIONS .375 X 96.000 X 253.000 EXACT

SPECIFICATIONS  
 FROM SLABS IMPORTED FROM BRITAIN  
 ASTM A240-06  
 ASTM A262-02A PRACTICE A  
 NO GRIPPER 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 ASTM  
 HT# 836433-1E  
 Qualifies to all requirements of  
 SA 240-316L per  
 Sect. II 10 Edition 11 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
NOLY	(MO)	2.05
NITROGEN	(N)	.04
COLUMBIUM	(CB)	.022
TITANIUM	(TI)	.003
ALUMINUM	(AL)	.006
TIN	(SN)	.007

W.O. # 1173Q  
 M.L. # 51 (23/2) (25)  
 THK. # 0386  
 P.O. # D545-110411

52 (24/2) (26)  
 61 (8/3)

Q.C.I.  
 E.Y.  
 AUG 16 2013

APplus® VELOSI  
 Velocity America LLC  
 ACCURATELY REVIEWED AND RELEASED  
 for and on behalf of: BSM OFF SHORE  
 Print Name: (AARON H SPAIN)  
 Signature: [Signature]  
 Date: Sept 3/13

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 Douberman*

Date: Aug 13/13  
 Signature: [Signature]  
 Print Name: GABRYL SAMA  
 For and on behalf of: SAM OF FISHING  
 ACCEPTED/REVIEWED/RELEASED  
 046

Applus®  
 VELOSI  
 Velos America LLC

Q.C.I.  
E.Y.

AUG 16 2013

Q.C.I.  
N.D.

**WALSIN** WALSIN LIHWA CORPORATION YENSHUI PLANT  
 ISO-9001, ISO-14001 CERTIFIED  
 MILL TEST / INSPECTION CERTIFICATE

Customer		ENERGY STEEL PRODUCTS, INC.		Date	2008/06/27	File	2408070925				
Steel Grade	AISI 316L	Commodity	Authentic Stainless Steel Round Bar	Order No.	289681	P.O. NO.	22804				
Item	Item No.	Shape	Size	Quantity (Pcs)	Weight (lbs)	Condition	Workmanship				
1	2X469	R	1.905	129	2323	PL	Material is free from mercury contamination				
2	2X919	R	31.75	41	2048	PL	No welding repair				
3	2X471	R	38.10	32	2292	PL	Solution treatment at 1040°C · 1-2 hour · water quenched Grain size test by ASTM E112-96e1 : Doc Macro and micro structure : ok Material : V.O.D and hot rolled, annealed. Cert to EN 10204/3.1.B. Country of Origin: Taiwan, Melt in Taiwan				
Kind of Test	Chemical Composition (WT%)										
Spec.	C	Si	Mn	P	S	Ni	Cr	Mo	Cu	N	Co
1	0.03	1.00	1.25	0.040	0.02	10.00	16.00	2.00	0.75	0.10	0.75
2	MAX	MAX	MAX	MAX	MAX	MAX	MAX	MAX	MAX	MAX	MAX
3	0.02	0.38	1.69	0.029	0.028	10.00	16.70	2.03	0.57	0.06	0.20
4	0.02	0.42	1.68	0.028	0.028	10.02	16.93	2.04	0.57	0.06	0.19
5	0.02	0.37	1.80	0.030	0.028	10.02	16.70	2.02	0.60	0.05	0.20
Condition	Invoice No. 08JUN-L19626GTOR L/C No.										
S-Solution Treated	A-Annealed										
HR-Hot Rolled	Acc. To ASTM A193-94b B8M Class, A376-04s cond.A, A479-04 cond.A										
CD-Cold Drawn	ASTM A314-97 (REAPPROVED 2002), A183-02s, A444-02s, A320-01 B8M Class										
ST-Strain Treated	ASTM A262-A2 Practice B, ASME SA479-R01 cond.A, SA182-E01 A03										
CC-Caseless Grinding	SA183-E01 A02 B8M Class, SA320-01s B8M Class										
	NACE MR 0175, MIL 7701, SAE-AMS QQS-763F cond.A, AMS 5640K, 5653F UNS S31600/31603 For 31603/16L										
	MANAGER OF QUALITY ASSURANCE DEPARTMENT										
	Shape: R: Round H: Hexagonal S: Square SR: Square-Round R: Ellipse RB: Rectangular										
	Here we certify that the material described herein has been manufactured and tested with satisfactory results in accordance with the requirement of the above material specification.										

MANAGER OF QUALITY ASSURANCE DEPARTMENT

W.O. # 11730  
 M.L. # 53(25-2-2-1)  
 THK. # 750(27-2-0)  
 P.O. # H110-8451Q

Certification of Material - Per ASME  
 HT# 2X469  
 Qualifies to all requirements of  
SA 479-316/316 per  
 Sect. II, Edition 7 Addenda

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: **SAM OFFSHORE**  
**APPLUS**  
**VELOSI**  
 Print Name: **GARY SAH**  
 Signature: *[Signature]*  
 Date: **3/13/2013**  
 Velocity America LLC



**SUNGKWANG BEND CO., LTD. (SKB)**  
 1720, Songjeong-Dong, Gangseo-Ku, Busan, Korea  
 TEL : 82-051-3300-450  
 FAX : 82-051-3300-335  
 http://www.skband.com

# MATERIAL TEST & INSPECTION CERTIFICATE

According to  
 DIN 50049 3.1 / EN 10204-3.1 / ISO 10474 3.1

CUSTOMER: SOUTHWEST STAINLESS, INC.  
 PROJECT NAME: N/A

CERTIFICATE NO. DCL2007090114  
 DATE OF ISSUE 2007.06.23  
 VISUAL & DIMENSION SATISFACTORY  
 MILL MAKER POR/CODE/TAG NO  
 DAEKYUNG CORP.

PURCHASE ORDER NO.	173882	SPEC. FOR MATERIAL	ASTM/A516/A516-16/W 0404ED		
PJT JOB NO.	N/A	SPEC. FOR INSPECTION	ASME B16.9		
STARTING MATERIAL	STEEL PLATE	SKB JOB NO.	2007051119		
NO.	SEQ LINE ITEM NO	DESCRIPTION	QTY	HEAT NO.	MFG ID NO.
B41	500 ELBOW SHORT	S80S	4	E7172	E7172

HEAT NO.	CHEMICAL COMPOSITION (% L : LADLE, P : PRODUCT)													
	C	Si	Mn	P	S	NI	Cr	Mo	Cu	V	Nb	N	Al	B
E7172	0.030	1.00	2.00	0.045	0.030	14.00	16.00	2.00						
	0.010	0.44	0.83	0.026	0.001	10.22	16.21	2.10						

HEAT NO.	ABSORBED ENERGY		LATERAL EXPANSION		PERCENT SHEAR		HARDNESS		HEAT TREATMENT		TENSILE TEST				
	STD./	VALUE	STD./	VALUE	STD./	VALUE	MIN	MAX	R.T:GOOD	PHI	N/A	Y.S	T.S	EL	RA
E7172							H8	155	N/A	N/A	N/A	30.0	75.0	28.0	
									FLATTENING TEST	N/A	N/A	40.9	86.4	60.0	
									BENDING TEST	N/A	N/A				
									HYDROSTATIC TEST	N/A	N/A				
									CORROSION TEST	N/A	N/A				
									GRAIN SIZE TEST	N/A	N/A				
									HIC TEST	N/A	N/A				

W.O. # **11730**  
 M.L. # **540262**  
 THK. # **57892**  
 P.O. # **13-0707**

SOLUTION TREATED: 1050°C, 40Min, "Water"

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

*[Signature]*  
 QM DIV. SENIOR MANAGING DIRECTOR

AUG 16 2013



Certification of Material - Per ASME  
 HT # **E7172**  
 Qualifies to all requirements of  
**SA403-316 PL** per  
 Sect. II 70 Edition II Addenda

REVIEWED BY :  
 WITNESSED BY :

# MATERIAL TEST & INSPECTION CERTIFICATE

**SUNGKWANG BEND CO., LTD.(SK)**  
 1720 Songjeong-Dong, Gangseo-Ku, Busan, Korea

CUSTOMER: SOUTHWEST STAINLESS, INC  
 PROJECT NAME: N/A

According to  
 DIN 50049 3.1 / EN 10204 3.1 / ISO 10474 3.1

TEL: 82-051-3300-450  
 FAX: 82-051-3300-335  
 http://www.sk bend.com

PURCHASE ORDER NO	75061	SPEC. FOR MATERIAL	ASTM/A516-60	CERTIFICATE NO.	QCL/2012011134
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/LIN/ITEM NO	DESCRIPTION	QTY	HEAT NO	MFG ID NO	POR/CODE/TAG NO	TENSILE TEST		
							Y S 0.2% offset	T.S	EL
841		90D ELBOW(S)	3	035085	035085		KSI	KSI	%
842		90D ELBOW(S)	4	035085	035085		30.0	75.0	28.0
849		90D ELBOW(S)	2	035085	035085				
925		STRAIGHT TEE	2	035085	035085				

HEAT NO.	STD	SPEC	CHEMICAL COMPOSITION(%) (L: LADE, P: PRODUCT)																		
			C	Si	Mn	P	S	Ni	Cr	Mo	Cu	V	Nb	N	Al	B	Zr	Fe	Ti	CE	
035085	L	0.030	1.00	2.00	0.045	0.030	14.00	18.00	3.00												
	P	0.025	0.32	1.28	0.037	0.002	10.11	16.74	2.03												

IMPACT TEST	TEST TEMP.	SIZE OF SPECIMEN(mm)	ABSORBED ENERGY			LATERAL EXPANSION			PERCENT SHEAR			HARDNESS HRC		HEAT TREATMENT	SOLUTION TREATED 1060°C 40Min Water
			STD /	VALUE	AVE	STD /	VALUE	AVE	STD /	VALUE	AVE	MIN	MAX		
035085		BIM										22.0		FLATTENING TEST	N/A
		HAZ												BENDING TEST	N/A
		W/M												HYDROSTATIC TEST	N/A
		BIM												CORROSION TEST	N/A
		HAZ												GRAIN SIZE TEST	N/A
		W/M												HIC TEST	N/A

MATERIAL MEETS THE REQUIREMENTS OF NACE MR0175

WE CERTIFY THIS MATERIAL HAS BEEN MANUFACTURED AND EXAMINED IN ACCORDANCE WITH A REQUIREMENTS OF THE SPECIFICATION AND THE RESULTS OF ALL EXAMINATION ARE ACCEPTAE

ACCEPTED BY REVIEWER: [Signature] BASED ON  
 for and on behalf of: WEST SH SAH A  
 Print Name: WEST SH SAH A  
 Signature: [Signature] Date: Feb 13 2013  
**APplus®**  
 VLOST  
 Velosi America LLC

11730  
 54 (249-1)  
 532 (2-6)  
[Signature]  
 P.O. # 13-0707  
 QM DIV. SENIOR MANAGING DIRECTOR





SHIP TO: FRANKIS HUGHES  
LAFAYETTE, MISSISSIPPI

Joseph Speciality Products  
500 Greer Street  
Washington, PA 15301

CERTIFIED MATERIAL  
TEST REPORT

INTERIS WELDES  
161 THE WEST MALL  
ETHELBERG, ON CANADA

YOUR ORDER NO. 104230  
MEMO NO. 493398  
DATE 08/16/2013  
SALESMAN NO. 1584

*P.M. Cladette*  
P.M. Cladette - Product Quality Engineer

ALC 316/316L STAINLESS HRAP  
ASTM A240/3040 - ASME SA 3040-2-99

Heat: 820113  
FROM SLIP 1728J PART# 7581-2540  
820237  
FROM SLIP 19218 PART# 7581-2542

Heat: 820113  
820237  
Gauge: .7500  
154586 .7500

Size: .7500 x 96.0000 x 250.0000  
.7500 x 96.0000 x 246.0000

SI NT CR RD  
.47 10.10 16.20 2.06  
.57 10.13 16.25 2.05

Yield Tensile  
Strength Elong  
43.9 KSI 87.0 KSI 56.6  
90.2 KSI 84.5 KSI 58.0

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 MILDENED)  
UN 50049 3.1.8 AND EN 10204 3.1.8 CERTIFICATE

Certification of Material - Per ASME  
BY 820113  
Qualifies to all requirements of  
SA 316-316L per  
Part II of ASME II  
Addenda

ACCEPTED BY USWELDED 100% OFF SITE  
for and on behalf of: WAMSIP SAHA  
Print Name: WAMSIP SAHA  
Signature: [Signature]  
Date: 08/16/2013  
Applus  
VELOSI  
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

ITEM DESCRIPTION

HEAT & PIECE 831846 - 2B  
WEIGHT 5654  
FINISH 1  
GRADE 316L / 316  
DIMENSIONS 750 X 96.000 X 264.000 EXACT  
COUNTRY OF ORIGIN BRT  
UNS-S31603 / UNS-S31600

SPECIFICATIONS

\*\*\* MFG IN NEW CASTLE, IN, USA  
ASME SA240 04 EDITION  
ASTM A480/A480M-03C  
ASTM A262-02A PRACTICE E  
NO WELD REPAIRS  
FROM SLABS IMPORTED FROM BRITAIN  
ASTM A240-05  
ASTM A262-02A PRACTICE A  
NO GREYER 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 (HRMP)

Q.C.I.  
N.D.

MECHANICAL & OTHER TESTS

HARDNESS RB 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, 19 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. # 11730  
M.L. # 55  
THK. # 768  
P.O. # D545-110411

1 pc

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: AUG 10 2013 SBM OFFSHORE  
Print Name: GAOVESH SAHA  
Signature: [Signature]  
Date: Sep 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 DIN50049 3.1.B/EN10204 3.1.B

*James Douberman*

✓ NO. P54189  
 NORTH AMERICAN STAINLESS  
 6870 HIGHWAY 42 EAST  
 GHENT, KY 41045

# METALLURGICAL TEST REPORT

6870 HIGHWAY 42 EAST

Certificate: 824674 3 Mail To: Ship To: Date: 4/05/2013 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: 54189 NAS Order: DS 0002988 08  
 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, 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'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 Id	Coil #	Skid #	Thickness	Width	Weight	Length	Mark	Pieces	Commodity Code
DE6858	02F9X7 D		.2460	48.0000	4,890 SHEETS	240.00	20	6	

**CHEMICAL ANALYSIS** CW(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
F9X7	US	.0189	16.6075	.5330	1.5035	2.0350	.0455	10.0350	.0350	.0010

SI %  
 .2640

**MECHANICAL PROPERTIES**

Product Id#	Coil #	UTS	YIELD	ELONG	Hard	Tail
DE6858	02F9X7	87.91	48.72	50.01	82.00	83.00

APPLUS VELOSI  
 W.O. # 11730  
 M.L. # 58 (30/24/33/12)  
 P.O. # 13-0713  
 Q.C.I. N.D.  
 Certification of Material - Per ASME  
 HT# F9X7  
 Qualifies to all requirements of SA312-316 1516  
 Sect. II Edition 11 Addenda  
 AUG 19 2013  
 Q.C.I. E.Y.

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 Mgr. *[Signature]*  
 Dept. Mgr. *[Signature]*  
 ERIC HESS



9135511 (1) DATE 16/12/2011

### MILL TEST REPORT

IN ACCORDANCE TO EN 10204 3.1

KANZEN TETSU SDN BHD

### Kanzen Tetsu Sdn Bhd

Company No: 1922274W  
17, Box 27, Lot 4, Presintan Perindustri,  
40700 Seremban, Negeri Sembilan, Malaysia  
Tel: 603 5543 0200 Fax: 603 5543 0201  
http://www.kanzen-tetsu.com e-mail: info@kanzen-tetsu.com

PINACLE STAINLESS STEEL INC.

STAINLESS STEEL BUTT WELDING  
FITTINGS ASTM A403/ASME SA403M-01a

QTY	SIZE	TOTAL LENGTH	WEIGHT	HEAT NO.	MS	TS	Y	RA	REMARKS
PCS			KG		%	MPa	%	%	
20	AP316/316. W X R X SCH10S X 45 LR ELBOW	-	160	63Y605	292	598	59	81	-
20	AP316/316. W X R X SCH40S X 45 LR ELBOW	-	7	5305605	292	598	59	81	-
20	MP304/304L W X R X J X SCH10S X ECC REDUCER	-	51	43X7401	312	665	52	86	-

CHEMICAL COMPOSITION (%)

C	Mn	P	S	Ni	Cr	Mg
2.2	43	82	30	1	1002	1653
2.2	43	82	30	1	1002	1653
3.0	52	96	36	6	804	1812

W.O. # 117304  
M.L. # 59(24/27/28/29)  
THK. # 147  
P.O. # 13-0707

Q.C.I. N.D.

Q.C.I. E.Y.

AUG 12 2013

Certification of Material - Per ASME  
HT# 6308605  
Qualifies to all requirements of  
SA403-316/316L per  
Sect. II 10 Edition II Addenda

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SAM OFFSHORE  
Print Name: SAMIR SATHI  
Signature: [Signature]  
Date: 13 Sept 2013  
**Applus+**  
**VELOSI**  
Velosi America LLC

1050 DEGREE CEILING MOUNTED IN WATER

FOR FEEDBACK  
CONTACT NUMBER

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: Ship to Customer Name and Address: 18651-STK / 1  
 CANADIAN PLATE AND PROFILES IN CANADIAN PLATE AND PROFILES IN 1000012968  
 KAMATO ROAD 920 KAMATO ROAD 920  
 MISSISSAUGA, Ontario, Canada MISSISSAUGA, Ontario, Canada  
 L4W 2R6 L4W 2R6

Customer Specification: HR STEEL PLATE Carbon Multi-Cert ASTM A516 GR 70 (11A) 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 / 12 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

Carrier: TRIPLE K TRANSPORT LTD - 35099 (250)

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 (H) 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
1.0000" 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										
	C	Mn	P	S	Si	Cr	Ni	Mo	Al	Nb	TI
0811P3*	0.19	1.08	0.009	0.004	0.330	0.05	0.16	0.01	0.030	0.000	0.003

Heat No.	Batch No.	SRCE LAB			COND			LOC			HARDNESS					
		166"	ALG	1.0000	N	B	HBW	153	166"	ALG	1.0000	N	B	HBW	150	
0811P3	AB0907															
0811P3	AB0908															

W.O. # 11739  
 M.L. # 60 (1/13)  
 TRK. # 1"  
 P.O. # 13-0720

ACCEPTED BY: [Signature] DATE: 3/1/13  
 for and on behalf of: [Signature] S.A.H.  
 Print Name: U.A. WEST S.A.H.  
 Signature: [Signature]  
 Date: 3/1/13

Appius® VELOSI  
 Velocity America LU

**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-GR 70 per Sect. II, Edition 11 Addenda



K. UGHADPAGA  
 MANAGER METALLURGICAL SERVICES  
 AUG 20 2013

**\*\*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

100 P55450  
L

6870 HIGHWAY 42 EAST

Certificate: 806076 1  
Customer: 007050 001

Ship To:  
ROLLARK STAINLESS STEEL, INC.  
71 CONAIR PARKWAY  
WOODBIDGE, ON L4H0S4

Date: 1/30/2013 Page: 1

Mail To:  
ROLLARK STAINLESS STEEL, INC.  
71 CONAIR PARKWAY  
WOODBIDGE, ON L4H0S4

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; 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

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

Chemical Analysis per ASTM A751/08

HEAT	CM	C %	CR %	CU %	MN %	MO %	N %	NI %	P %	S %
E9C1	US	0.193	16.5860	0.4350	1.5900	2.1020	0.0498	10.0400	0.0340	0.0010

APPLUS<sup>®</sup> VETOSI  
Velosi America LLC  
Print Name: GIANESVI SAH OF  
for analysis by: 5 PM OFF SHORE  
APPLUS<sup>®</sup> VETOSI  
Velosi America LLC

W.O. # (1739)  
M.L. # 02(913)  
P.O. # 13-5713

## MECHANICAL PROPERTIES

Product Id#	Plate#	1 d C I	UTS KSI	.2% YS KSI	ELONG % - 2"	Hard RB	R of A %
05E9C1 AA	05E9C1 AA	F T	90.42	46.74	58.88	78.00	73.14

Certification of Material - Per ASME  
IT# E9C1  
Qualifies to all requirements of SA240-316/316L per Sect. II 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 Mgr. Dept. Mgr. ERIC HESS  
1/30/2013



6870 HIGHWAY 42 EAST

Certificate: 791192 7

Customer: 007050 001

Your Order: 53232

PRODUCT DESCRIPTION:

STAINLESS STEEL CONT. MILL PLATE, HRAIP; 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

Ship To:

ROLARK STAINLESS STEEL, INC.
71 CONAIR PARKWAY
WOODBIDGE, ON L4H0S4

NAS Order: DS 0002154 07

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

Date: 12/03/2012 Page: 1

Steel: 316/316L

Finish: HRAIP

Corrosion: ASTM A262/02aE;180Bend-OK

METALLURGICAL TEST REPORT

NORTH AMERICAN STAINLESS
6870 HIGHWAY 42 EAST
GHENT, KY 41045

VNORT 7 P5

Table with columns: Product Id, Coil #, Skid #, Thickness, Width, Weight, Mark, Pieces, Commodity Code. Row 1: 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

Table with columns: HEAT, CM, C %, CR %, CU %, MN %, MO %, NI %, P %, S %. Row 1: 25K2, US, .0154, 16.5720, .4135, 1.4470, 2.0650, .0461, 10.0450, .0310, .0192

ACCEPTED/REVIEWED/RELEASED
for use on behalf of: SPM COFFS A006
Print Name: GABRIELA SAHA
Signature: [Signature]
Date: 12/13/12
Velocity America LLC

MECHANICAL PROPERTIES
Product Id# Coil # .2% YS ELONG Hard Tail
c r KSI %-2" RB Hard

Table with columns: Product Id#, Coil #, .2% YS, ELONG, Hard, Tail. Row 1: DD2371, 06E5K2, 85.68, 48.52, 51.53, 87.00, 89.00

Certification of Material - Per ASME
HT# ESKY
Qualifies to all requirements of SA 270-316 B16 per Sect. II Edition 11 Addenda
AUG 16 2013
Q.C.I. N.D. BY

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
12/03/2012



# METALLURGICAL TEST REPORT

6870 HIGHWAY 42 EAST  
GHENT, KY 41045

6870 HIGHWAY 42 EAST

Certificate: 794815 1  
Customer: 007050 001

Mail To:  
ROLARK STAINLESS STEEL, INC.  
71 CONAIR PARKWAY  
WOODBIDGE, OH 44054

Ship To:  
ROLARK STAINLESS STEEL, INC.  
71 CONAIR PARKWAY  
WOODBIDGE, OH 44054

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, SA666/11a  
CHEM ONLY ON FOLLOWING ASTM: A276/10, A479/11, A404/11, 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, Q35765D-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	0227K6 A		.3748	60.0000	4,750	SHEETS 240.00	9	3	

### CHEMICAL ANALYSIS

HEAT	CM	C %	CR %	CU %	MN %	MO %	N %	NI %	P %	S %
E7K6	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"	HB	Hard
DD4383	0227K6	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. ERIC 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 (1/16/10/11)  
THK. # 376  
P.O. # 13-0713



AUG 16 2013

ACCEPTED/REVIEWED/RELEASED 046

for and on behalf of: SIBM OFFSHORE

Print Name: L. A. N. S. H. S. H. H.

Signature: [Signature] **Applus<sup>®</sup> VELOSI**

Date: Sept 3/13 **Velosi America LLC**





6870 HIGHWAY 42 EAST

# METALLURGICAL TEST REPORT

NORTH AMERICAN STAINLESS  
6870 HIGHWAY 42 EAST  
GHENT, KY 41045

Certificate: 798933 1 MAIL TO:  
ROLLMARK STAINLESS STEEL, INC.

SHIP TO:  
ROLLMARK STAINLESS STEEL, INC.

Date: 1/04/2013 Page: 1

Customer: 007050 012

Steel: 316/316L

Finish: HRAP

Corrosion: ASTM A262/02aE; 180Bend-OK

Your Order: 53412

NAS Order: DS 0002333 01

## PRODUCT DESCRIPTION:

STAINLESS STEEL COIL, HRAP; UNS 31600/31603  
ASTM A240/11b, A480/11b, A666/107/ASME SA240/11a, SA480/11a, SA666/11a  
CHEM ONLY ON FOLLOWING ASME: A376/10, A479/11, A486/11, A312/11  
CHEM ONLY ON FOLLOWING ASME: SA312/11, SA479/11  
AMS 5507F/5526L X NFK;  
NACE MR0175/ISO 15156-3:2003 A, MR0103/07; Q08766D-A X MAG 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  
\*Malted & Manufactured in the USA; Mat'l is DfARS Compliant

Product Id	Coil #	Slid #	Thickness	Width	Weight	Length	Mark	Pieces	Commodity Code
0589B3 C	0589B3 C		.3748	60.0000	22.730	COIL		1	1

## CHEMICAL ANALYSIS

Chemical Analysis per ASTM A751/08

Element	C %	Cr %	CU %	MN %	MO %	N %	NI %	P %	S %
DS	.0207	16.8085	.4240	1.4520	2.0375	.0412	10.0055	.0330	.0010

SI % .3575

W.O. # 11739  
M.L. # 63(17 to 10/17)  
THK # 378  
P.O. # 13-0713

## MECHANICAL PROPERTIES

Product Id#	Coil #	UTS	YPI	.2% VS	ELONG	Hard	Tail
		ksi	ksi	ksi	%-2"	RB	Hard
0589B3 C	0589B3 C	87.49	54.04	49.86	87.00	90-50	

Certification of Material - Per ASME  
HT# E9 03  
Qualifies to all requirements of  
SA 240-316/316L  
Sect. II - 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 presented on this report and are not intended to be used as a substitute for a written approval of NAS.

Technical Dept. Mgr. ERIC HESS

1/06/2013

APPLIUS®  
VELOSI  
Velos America LLC  
Date: 8/16/13  
Signature: [Signature]  
Print Name: [Name]

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: [Signature]  
Date: 8/16/13

**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

Ship 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 (1/10/13)  
 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.

*William Uguiza*

1185 WIN DR, BETHLEHEM, PA., 19017 - (610) 665-5537  
 FAX NUMBER: 610-865-4073

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SIM OFFSHORE  
 Print Name: CAMPBELL SAHAI  
 Signature: [Signature]  
 Date: SEP 24 2013  
 046  
**Applus<sup>®</sup> VELOSI**  
 Velosi America LLC

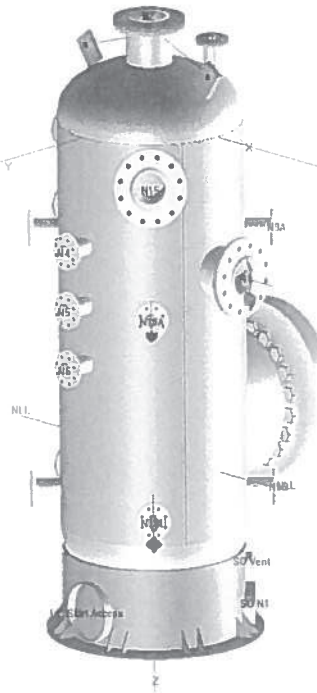
# ALL-WELD COMPANY LIMITED

49 Passmore Avenue,

Toronto, Ontario,

Canada M1V 4T1

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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38. [48 OD BOTTOM SE HEAD](#)
39. [Bottom Drain \(N13\)](#)
40. [46-3/4" OD Skirt](#)
41. [Tail lug](#)
42. [Skirt Base Ring](#)
43. [Liquid Level bounded by Ellipsoidal Head #2](#)

## 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.

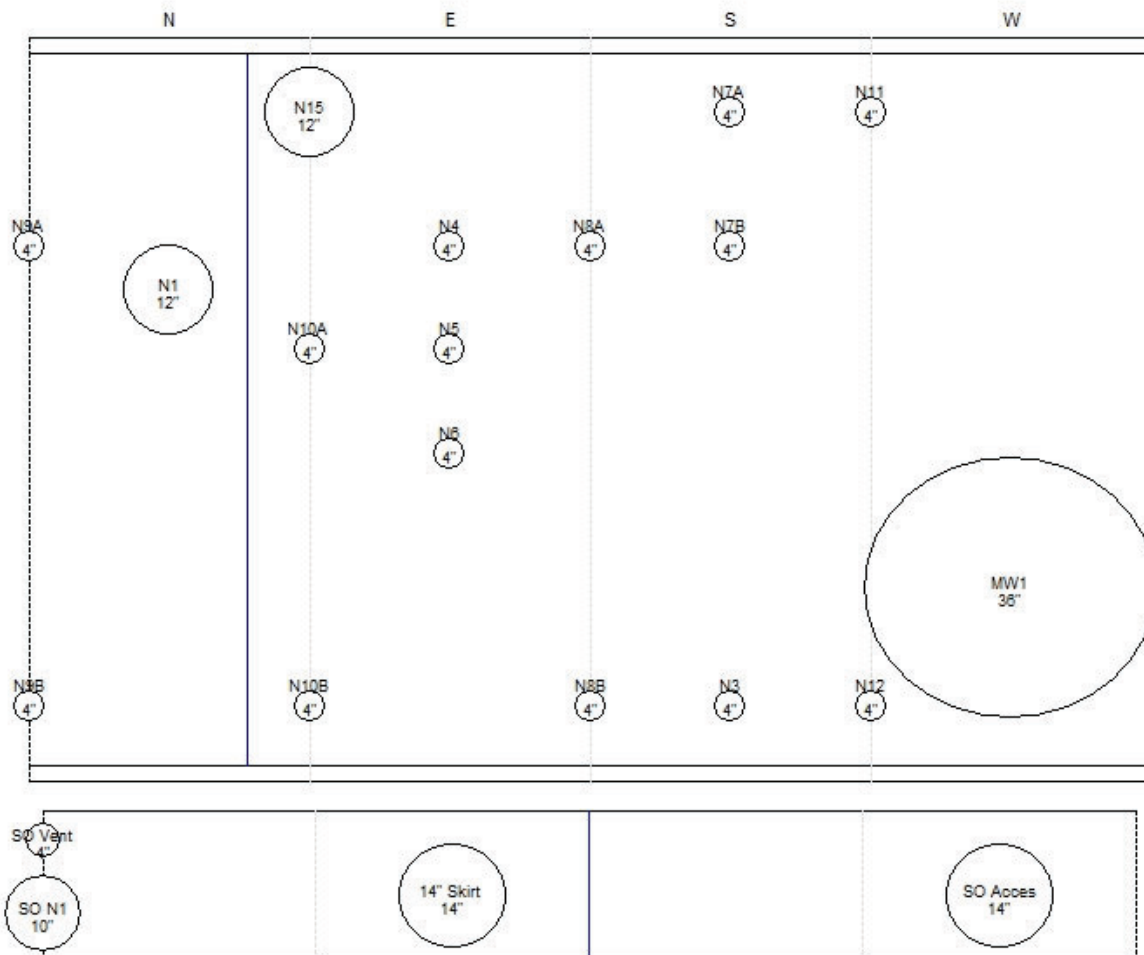
## Long Seam Summary

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<sub>Accel</sub>**

Factor is applied to dead load.

Compressive Side: = 1.0 + V<sub>Accel</sub>

V <sub>Accel</sub> Term is: greater of (Force Mult * Base Shear / Weight) or (Min. Weight Mult.)				
Force multiplier = 1.4738		Minimum Weight Multiplier = 1.0000		
Condition	Base Shear ( lbf)	Weight ( lb)	Force Mult * Shear / Weight	V <sub>Accel</sub>
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:  $P = 1,378 \text{ psi @ } 140 \text{ }^\circ\text{F}$

External design pressure:  $P_e = 15 \text{ psi @ } 140 \text{ }^\circ\text{F}$

#### Static liquid head:

$P_s = 0 \text{ psi}$  (SG=1.1,  $H_s=0$ " Operating head)

$P_{th} = 2.03 \text{ psi}$  (SG=1,  $H_s=56.27$ " 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 = 1,349.3 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

$$\begin{aligned} t &= P \cdot R_o / (S \cdot E + 0.40 \cdot P) + \text{Corrosion} \\ &= 1,378 \cdot 24 / (20,000 \cdot 1.00 + 0.40 \cdot 1,378) + 0 \\ &= 1.6093'' \end{aligned}$$

#### Maximum allowable working pressure, (at 140 °F) Appendix 1-1

$$\begin{aligned} P &= S \cdot E \cdot t / (R_o - 0.40 \cdot t) - P_s \\ &= 20,000 \cdot 1.00 \cdot 1.77 / (24 - 0.40 \cdot 1.77) - 0 \\ &= 1,519.84 \text{ psi} \end{aligned}$$

#### 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

$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 2,460.98 / (3 \cdot (48 / 0.2194)) \end{aligned}$$

$$= 15 \text{ psi}$$

**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)**

$$\begin{aligned} EFE &= (50*t / R_i)^*(1 - R_i / R_o) \\ &= (50*1.77 / 23.115)^*(1 - 23.115 / \infty) \\ &= 3.8287\% \end{aligned}$$

**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

$$t_p = P R / (2 S_c K_s + 0.40 |P|) \quad (\text{Pressure})$$

$$= -15 \cdot 22.23 / (2 \cdot 13,728.59 \cdot 1.20 + 0.40 \cdot |15|)$$

$$= -0.0101''$$

$$t_m = M / (\pi R_m^2 S_c K_s) \quad (\text{bending})$$

$$= 1,145 / (\pi 23.115^2 13,728.59 1.20)$$

$$= 0''$$

$$t_w = W / (2\pi R_m S_c K_s) \quad (\text{Weight})$$

$$= 1,759.7 / (2\pi 23.115 13,728.59 1.20)$$

$$= 0.0007''$$

$$t_t = |t_p + t_m - t_w| \quad (\text{total, net compressive})$$

$$= |-0.0101 + 0 - (0.0007)|$$

$$= \underline{0.0108''}$$

$$t_c = t_{mc} + t_{wc} - t_{pc} \quad (\text{total required, compressive})$$

$$= 0 + (0.0007) - (-0.0101)$$

$$= \underline{0.0109''}$$



### 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

$$\begin{aligned}t_p &= P \cdot R / (2 \cdot S_t \cdot K_s \cdot E_c + 0.40 \cdot |P|) && \text{(Pressure)} \\&= 1,378 \cdot 22.23 / (2 \cdot 20,000 \cdot 1.20 \cdot 1.00 + 0.40 \cdot |1,378|) \\&= 0.6309'' \\t_m &= M / (\pi \cdot R_m^2 \cdot S_t \cdot K_s \cdot E_c) && \text{(bending)} \\&= 26,243 / (\pi \cdot 23.115^2 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\&= 0.0007'' \\t_w &= W / (2 \cdot \pi \cdot R_m \cdot S_t \cdot K_s \cdot E_c) && \text{(Weight)} \\&= 1,759.7 / (2 \cdot \pi \cdot 23.115 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\&= 0.0005'' \\t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\&= 0.6309 + 0.0007 - (0.0005) \\&= \underline{0.6311''} \\t_{wc} &= (1 + V_{Accel}) \cdot W / (2 \cdot \pi \cdot R_m \cdot S_t \cdot K_s \cdot E_c) && \text{(Weight)} \\&= 2.00 \cdot 1,759.7 / (2 \cdot \pi \cdot 23.115 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\&= 0.001'' \\t_c &= |t_{mc} + t_{wc} - t_{pc}| && \text{(total, net tensile)} \\&= |0.0007 + (0.001) - (0.6309)| \\&= \underline{0.6293''}\end{aligned}$$

### **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

$$\begin{aligned}t_p &= 0'' && \text{(Pressure)} \\t_m &= M / (\pi \cdot R_m^2 \cdot S_t \cdot K_s \cdot E_c) && \text{(bending)} \\&= 26,243 / (\pi \cdot 23.115^2 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\&= 0.0007'' \\t_w &= W / (2 \cdot \pi \cdot R_m \cdot S_t \cdot K_s \cdot E_c) && \text{(Weight)} \\&= 1,759.7 / (2 \cdot \pi \cdot 23.115 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\&= 0.0005'' \\t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\&= 0 + 0.0007 - (0.0005) \\&= \underline{0.0001''} \\t_{mc} &= M / (\pi \cdot R_m^2 \cdot S_c \cdot K_s) && \text{(bending)} \\&= 26,243 / (\pi \cdot 23.115^2 \cdot 13,728.59 \cdot 1.20) \\&= 0.0009'' \\t_{wc} &= (1 + V_{Accel}) \cdot W / (2 \cdot \pi \cdot R_m \cdot S_c \cdot K_s) && \text{(Weight)} \\&= 2.00 \cdot 1,759.7 / (2 \cdot \pi \cdot 23.115 \cdot 13,728.59 \cdot 1.20) \\&= 0.0015'' \\t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\&= 0.0009 + (0.0015) - (0)\end{aligned}$$

$$= 0.0024"$$

### 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

$$\begin{aligned}t_p &= 0'' && \text{(Pressure)} \\t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\&= 24,740 / (\pi * 23.115^2 * 20,000 * 1.20 * 1.00) \\&= 0.0006'' \\t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\&= 1,759.7 / (2 * \pi * 23.115 * 20,000 * 1.20 * 1.00) \\&= 0.0005'' \\t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\&= 0 + 0.0006 - (0.0005) \\&= \underline{0.0001''} \\t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\&= 24,740 / (\pi * 23.115^2 * 13,907.75 * 1.20) \\&= 0.0009'' \\t_{wc} &= (1 + V_{Accel}) * W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\&= 2.00 * 1,759.7 / (2 * \pi * 23.115 * 13,907.75 * 1.20) \\&= 0.0015'' \\t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\&= 0.0009 + (0.0015) - (0) \\&= \underline{0.0023''}\end{aligned}$$

### Vacuum, Seismic, Bottom Seam

$$\begin{aligned}t_p &= P * R / (2 * S_c * K_s + 0.40 * |P|) && \text{(Pressure)} \\&= -15 * 22.23 / (2 * 13,728.59 * 1.20 + 0.40 * |15|) \\&= -0.0101'' \\t_m &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\&= 26,243 / (\pi * 23.115^2 * 13,728.59 * 1.20) \\&= 0.0009'' \\t_w &= W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\&= 1,759.7 / (2 * \pi * 23.115 * 13,728.59 * 1.20) \\&= 0.0007'' \\t_t &= |t_p + t_m - t_w| && \text{(total, net compressive)} \\&= |-0.0101 + 0.0009 - (0.0007)| \\&= \underline{0.0099''} \\t_{wc} &= (1 + V_{Accel}) * W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\&= 2.00 * 1,759.7 / (2 * \pi * 23.115 * 13,728.59 * 1.20) \\&= 0.0015'' \\t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\&= 0.0009 + (0.0015) - (-0.0101) \\&= \underline{0.0125''}\end{aligned}$$

### **Maximum Allowable External Pressure, Longitudinal Stress**

$$\begin{aligned}P &= 2 * S_c * K_s * (t - t_{mc} - t_{wc}) / (R - 0.40 * (t - t_{mc} - t_{wc})) \\&= 2 * 13,728.59 * 1.20 * (1.77 - 0.0009 - 0.0015) / (22.23 - 0.40 * (1.77 - 0.0009 - 0.0015))\end{aligned}$$

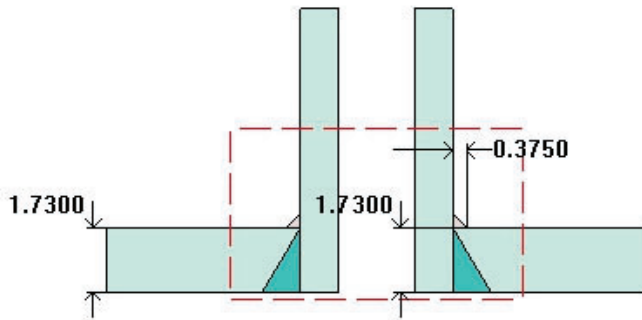
= 2,705.92 psi

## 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 $\leq 5$ (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 $\leq 2 \frac{1}{2}$ (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**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.2234, 1.1117 + (1.06 - 0) + (1.73 - 0)) \\
 &= 3.9017 \text{ in}
 \end{aligned}$$

**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 $P_a = 566.01 \text{ psi}$

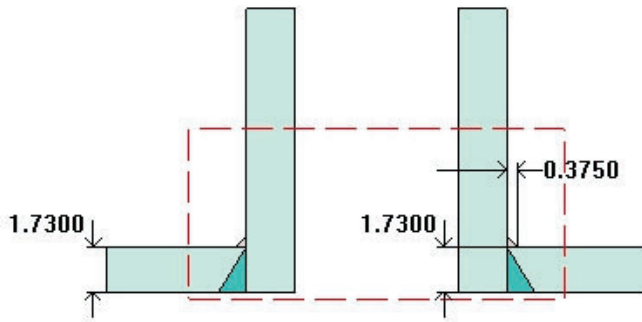
$$t_a = t + \text{Corrosion} = 0.1383 + 0 = 0.1383''$$

## 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

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg41)	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

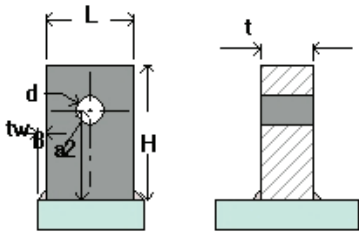
From table  
HA-2: B = 13,725.7301 psi

$$\begin{aligned} P_a &= 4*B / (3*(D_o / t)) \\ &= 4*13,725.73 / (3*(11.75 / 0.3634)) \\ &= 566.01 \text{ psi} \end{aligned}$$

### 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, Dp	1.5"
Load Eccentricity, $a_1$	0"
Distance from Load to Shell or Pad, $a_2$	5"
Weld Size, $t_w$	0.5"
Load Angle Normal to Vessel, $\beta$	145.3411 °
Load Angle from Vertical, $\phi$	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

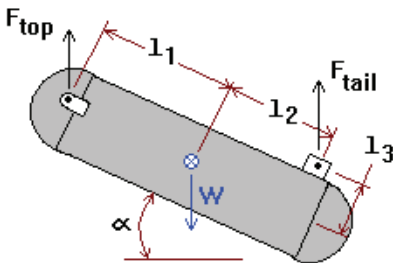
Required Lift Pin Diameter, $d_{reqd}$	<a href="#">0.8093"</a>
Required Lug Thickness, $t_{reqd}$	<a href="#">0.3048"</a>
Lug Stress Ratio, $\sigma_{ratio}$	<a href="#">0.21</a>
Weld Shear Stress Ratio, $\tau_{ratio}$	<a href="#">0.36</a>
Lug Design	Acceptable
Local Stresses	Acceptable

### 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

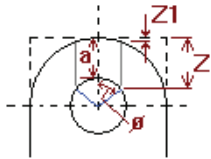
$$\begin{aligned} t_{\text{reqd}} &= [F_v / \sigma_s] / (2 * L_{\text{shear}}) \\ &= (13,703 / 13,320) / (2 * 2.0153) = \underline{0.2552"} \end{aligned}$$

$$t_{\text{reqd}} / t = 0.2552 / 1.5 = 0.17 \quad \text{Acceptable}$$

$$\begin{aligned} \tau &= F_v / A_{\text{shear}} \\ &= F_v / (2 * t * L_{\text{shear}}) \\ &= 13,703 / (2 * 1.5 * 2.0153) = 2,266 \text{ psi} \end{aligned}$$

$$\tau / \sigma_s = 2,266 / 13,320 = 0.17 \quad \text{Acceptable}$$

Shear stress length (per Pressure Vessel and Stacks, A. Keith Escoe)



$$\begin{aligned} \phi &= 55 * D_p / d \\ &= 55 * 1.5 / 1.5625 \\ &= 52.8^\circ \\ L_{\text{shear}} &= (H - a - 0.5 * d) + 0.5 * D_p * (1 - \cos(\phi)) \\ &= (7.5 - 5 - 0.5 * 1.5625) + 0.5 * 1.5 * (1 - \cos(52.8)) \\ &= 2.0153" \end{aligned}$$

### 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

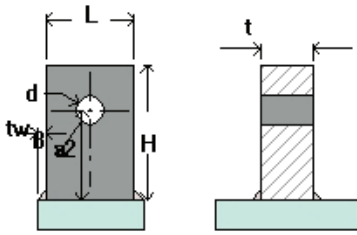
$$\begin{aligned} K_1 &= (1 - v_2^2) / ( (1/3 + v_1 * v_2) + \text{sqr}( (1/3 + v_1 * v_2)^2 + (1 - v_2^2) * v_1^2 ) ) \\ &= (1 - 0^2) / ( (1/3 + 0.0554 * 0) + \text{sqr}( (1/3 + 0.0554 * 0)^2 + (1 - 0^2) * 0.0554^2 ) ) \\ &= 1.4898 \end{aligned}$$

$$\begin{aligned} \sigma_b &= K_1 * K_2 * f \\ &= 1.4898 * 1.25 * 20,000 \\ &= 37,244 \text{ psi} \end{aligned}$$

### 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

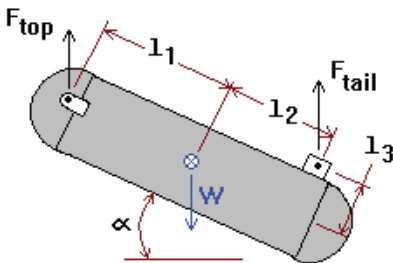
Required Lift Pin Diameter, $d_{reqd}$	<a href="#">0.8093"</a>
Required Lug Thickness, $t_{reqd}$	<a href="#">0.3048"</a>
Lug Stress Ratio, $\sigma_{ratio}$	<a href="#">0.22</a>
Weld Shear Stress Ratio, $\tau_{ratio}$	<a href="#">0.39</a>
Lug Design	Acceptable
Local Stresses	Acceptable

### 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

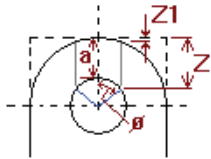
$$\begin{aligned} t_{\text{reqd}} &= [F_v / \sigma_s] / (2 * L_{\text{shear}}) \\ &= (13,703 / 13,320) / (2 * 2.0153) = \underline{0.2552"} \end{aligned}$$

$$t_{\text{reqd}} / t = 0.2552 / 1.5 = 0.17 \quad \text{Acceptable}$$

$$\begin{aligned} \tau &= F_v / A_{\text{shear}} \\ &= F_v / (2 * t * L_{\text{shear}}) \\ &= 13,703 / (2 * 1.5 * 2.0153) = 2,266 \text{ psi} \end{aligned}$$

$$\tau / \sigma_s = 2,266 / 13,320 = 0.17 \quad \text{Acceptable}$$

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

$$\begin{aligned} K_1 &= (1 - v_2^2) / ( (1/3 + v_1 * v_2) + \text{sqr}( (1/3 + v_1 * v_2)^2 + (1 - v_2^2) * v_1^2 ) ) \\ &= (1 - 0^2) / ( (1/3 + 0.0564 * 0) + \text{sqr}( (1/3 + 0.0564 * 0)^2 + (1 - 0^2) * 0.0564^2 ) ) \\ &= 1.4894 \end{aligned}$$

$$\begin{aligned} \sigma_b &= K_1 * K_2 * f \\ &= 1.4894 * 1.25 * 20,000 \\ &= 37,235 \text{ psi} \end{aligned}$$

### Maximum Allowable Load

$$\begin{aligned} F_{Rmax} &= \sigma_b * e_n^2 / (K_{13} * |\cos(\beta)| + K_{14} * |a_2 * \sin(\beta) - a_1 * \cos(\beta)| / b_1) \\ &= 37,235 * (1.73)^2 / (0.8212 * |\cos(143.1925)| + 1.6544 * |5 * \sin(143.1925) - 0 * \cos(143.1925)| / 5) \\ &= [67,596 lbf](#) \end{aligned}$$

## 48 OD SHELL

### ASME Section VIII Division 1, 2010 Edition, A11 Addenda

Component: Cylinder  
Material specification: SA-240 316 (II-D p. 70, ln. 26)  
Rated MDMT per UHA-51(d)(1)(a) = -320 °F

Internal design pressure:  $P = 1,378$  psi @ 140 °F

External design pressure:  $P_e = 15$  psi @ 140 °F

#### Static liquid head:

$P_s = 0.64$  psi (SG = 1.1,  $H_s = 16$ ", Operating head)

$P_{th} = 2.03$  psi (SG = 1,  $H_s = 56.25$ ", 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 -                      Full UW-11(a) Type 1  
                            Top circumferential joint -              Full UW-11(a) Type 1  
                            Bottom circumferential joint - Full UW-11(a) Type 1

Estimated weight New = 6,385.9 lb      corr = 6,385.9 lb

Capacity              New = 646.35 US gal      corr = 646.35 US gal

OD = 48"

Length = 96"

$L_c$

$t = 1.75$ "

#### Design thickness, (at 140 °F) Appendix 1-1

$$\begin{aligned} t &= P \cdot R_o / (S \cdot E + 0.40 \cdot P) + \text{Corrosion} \\ &= 1,378.64 \cdot 24 / (20,000 \cdot 1.00 + 0.40 \cdot 1,378.64) + 0 \\ &= 1.61" \end{aligned}$$

#### Maximum allowable working pressure, (at 140 °F) Appendix 1-1

$$\begin{aligned} P &= S \cdot E \cdot t / (R_o - 0.40 \cdot t) - P_s \\ &= 20,000 \cdot 1.00 \cdot 1.75 / (24 - 0.40 \cdot 1.75) - 0.64 \\ &= 1,501.51 \text{ psi} \end{aligned}$$

#### External Pressure, (Corroded & at 140 °F) UG-28(c)

$$\begin{aligned} L / D_o &= 107.4233 / 48 = 2.2380 \\ D_o / t &= 48 / 0.2194 = 218.7532 \\ \text{From table G: } A &= 0.000180 \\ \text{From table HA-2: } B &= 2,460.9773 \text{ psi} \end{aligned}$$

$$P_a = 4 \cdot B / (3 \cdot (D_o / t))$$

$$= 4 * 2,460.98 / (3 * (48 / 0.2194))$$

$$= 15 \text{ psi}$$

**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)**

$$\text{EFE} = (50 * t / R_f) * (1 - R_f / R_o)$$

$$= (50 * 1.75 / 23.125) * (1 - 23.125 / \infty)$$

$$= 3.7838\%$$

**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)**

$$P_v = (1 + V_{\text{Accel}}) * W / (2 * \pi * R_m) + M / (\pi * R_m^2)$$

$$= 2.00 * 16,039 / (2 * \pi * 23.125) + 830,156 / (\pi * 23.125^2)$$

$$= 714.9091 \text{ lb/in}$$

$$\alpha = P_v / (P_e * D_o)$$

$$= 714.9091 / (15 * 48)$$

$$\begin{aligned}
 &= 0.9929 \\
 n &= 3 \\
 m &= 1.23 / (L / D_o)^2 \\
 &= 1.23 / (107.4233 / 48)^2 \\
 &= 0.2456 \\
 \text{Ratio } P_e &= (n^2 - 1 + m + m*\alpha) / (n^2 - 1 + m) \\
 &= (3^2 - 1 + 0.2456 + 0.2456*0.9929) / (3^2 - 1 + 0.2456) \\
 &= 1.0296
 \end{aligned}$$

Ratio  $P_e * P_e \leq$  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**

$$P = 2 * S_c * K_s * (t - t_{mc} - t_{wc}) / (R - 0.40 * (t - t_{mc} - t_{wc}))$$

$$= 2 * 13,715.98 * 1.20 * (1.75 - 0.03 - 0.0134) / (22.25 - 0.40 * (1.75 - 0.03 - 0.0134))$$

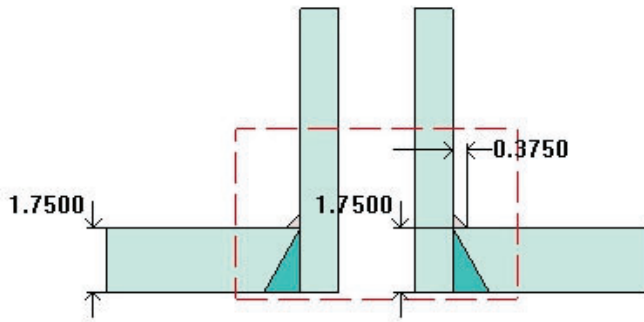
$$= 2,604.73 \text{ psi}$$

## 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

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

$$t_{a \text{ UG-28}} = 0.1482 \text{ in}$$

$$t_{a \text{ UG-22}} = 0.0489 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}} , t_{a \text{ UG-22}} ] \\ &= \max[ 0.1482 , 0.0489 ] \\ &= 0.1482 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 622.5059 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 622.5059) + 0 \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2} , t_{b \text{ UG16}} ] \\ &= \max[ 0.7378 , 0.0625 ] \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3} , t_{b2} ] \\ &= \min[ 0.2074 , 0.7378 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a , t_b ] \\ &= \max[ 0.1482 , 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

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  $P_a = 622.51 \text{ psi}$**

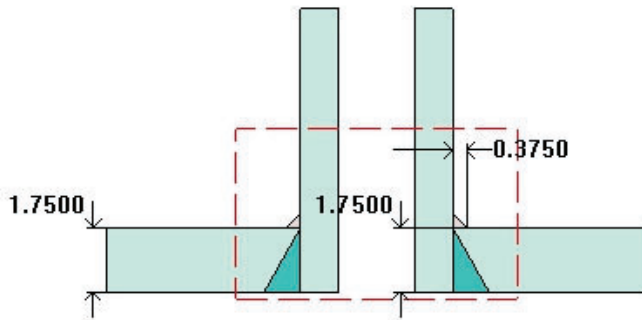
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482 \text{ in}$$

## 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 $\leq 5$ (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

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:  $B = 12,976.6933 \text{ psi}$

$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 12,976.69 / (3 \cdot (4.12 / 0.1482)) \\ &= 622.51 \text{ psi} \end{aligned}$$

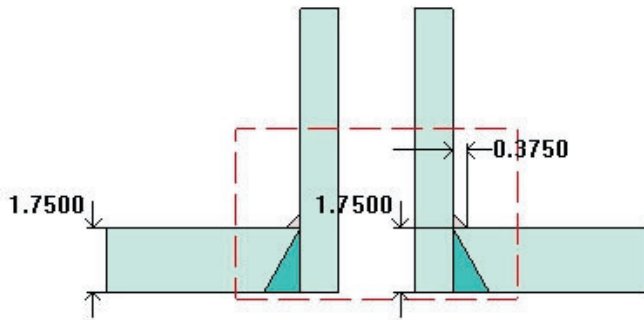
### Design thickness for external pressure $P_a = 622.51 \text{ psi}$

$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

## 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 $P_a = 622.51 \text{ psi}$

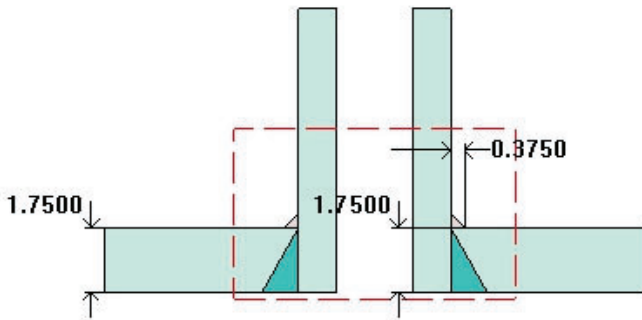
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

## 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)

<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:  $t_{\min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$

$t_{c(\min)} = \text{lesser of } 0.25 \text{ or } 0.7*t_{\min} = 0.25 \text{ in}$

$t_{c(\text{actual})} = 0.7*\text{Leg} = 0.7*0.375 = 0.2625 \text{ in}$

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

<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 $P_a = 622.51 \text{ psi}$

$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

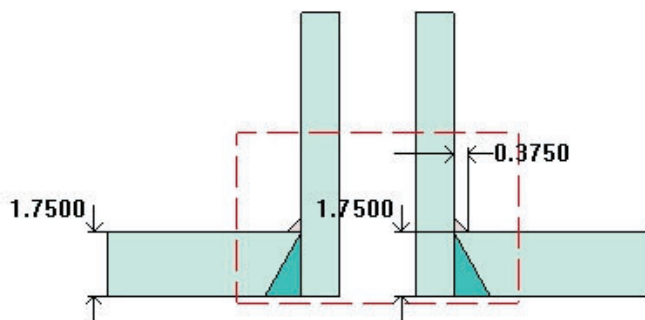


## Temperature Indicator (N6)

### 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)

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:  $t_{\min}$  = 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

$$\begin{aligned}t_{a \text{ UG-27}} &= P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion} \\ &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) + 0 \\ &= 0.0719 \text{ in}\end{aligned}$$

$$\begin{aligned}t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0719, 0 ] \\ &= 0.0719 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378) + 0 \\ &= 1.6092 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6092, 0.0625 ] \\ &= 1.6092 \text{ in}\end{aligned}$$

$$\begin{aligned}t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.2074, 1.6092 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0719, 0.2074 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06$  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 $P_a = 622.51 \text{ psi}$

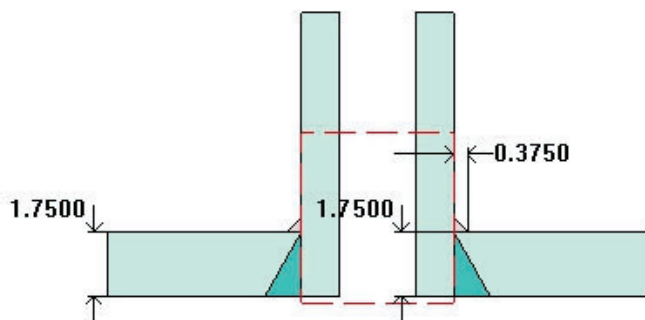
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

## Level Bridle - (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)

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

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

$$L_R = 1.125 \text{ in (User Defined)}$$

#### 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:  $t_{min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$   
 $t_{c(min)} = \text{lesser of } 0.25 \text{ or } 0.7*t_{min} = \underline{0.25} \text{ in}$   
 $t_{c(actual)} = 0.7*Leg = 0.7*0.375 = 0.2625 \text{ in}$

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 $P_a = 622.51 \text{ psi}$

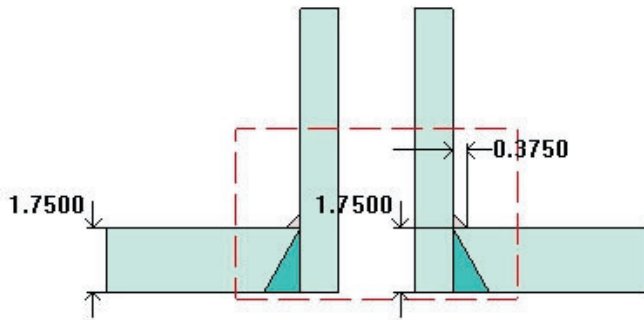
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

## 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 $\leq 5$ (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:  $t_{\min}$  = 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

$$\begin{aligned}t_{a \text{ UG-27}} &= P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion} \\ &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) + 0 \\ &= 0.0719 \text{ in}\end{aligned}$$

$$\begin{aligned}t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0719, 0 ] \\ &= 0.0719 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378) + 0 \\ &= 1.6092 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6092, 0.0625 ] \\ &= 1.6092 \text{ in}\end{aligned}$$

$$\begin{aligned}t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.2074, 1.6092 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0719, 0.2074 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06$  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  $t_{rn} = 0.1482$  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

$$t_{a \text{ UG-28}} = 0.1482 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.1482, 0 ] \\ &= 0.1482 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 622.5059 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 622.5059) + 0 \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2}, t_{b \text{ UG16}} ] \\ &= \max[ 0.7378, 0.0625 ] \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b2} ] \\ &= \min[ 0.2074, 0.7378 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.1482, 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

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:  $B = 12,976.6933 \text{ psi}$

$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 12,976.69 / (3 \cdot (4.12 / 0.1482)) \\ &= 622.51 \text{ psi} \end{aligned}$$

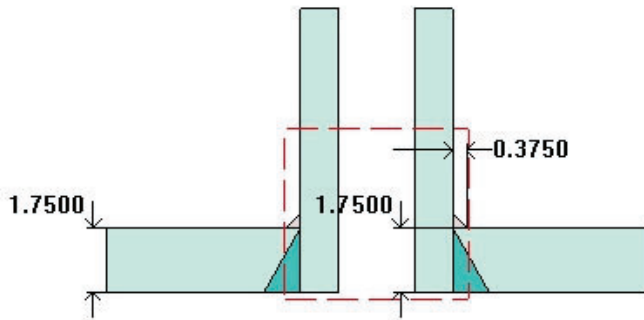
### Design thickness for external pressure $P_a = 622.51 \text{ psi}$

$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

## 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)

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 1,378.36 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)

$$\begin{aligned}
 t_m &= P * R_n / (S_n * E - 0.6 * P) \\
 &= 1,378.3574 * 1 / (20,000 * 1 - 0.6 * 1,378.3574) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

#### Required thickness t<sub>r</sub> from UG-37(a)

$$\begin{aligned}
 t_r &= P * R_o / (S * E + 0.4 * P) \\
 &= 1,378.3574 * 24 / (20,000 * 1 + 0.4 * 1,378.3574) \\
 &= 1.6097 \text{ in}
 \end{aligned}$$

**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:  $t_{min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$   
 $t_{c(min)} = \text{lesser of } 0.25 \text{ or } 0.7*t_{min} = \underline{0.25} \text{ in}$   
 $t_{c(actual)} = 0.7*Leg = 0.7*0.375 = 0.2625 \text{ in}$

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

$$t_{a \text{ UG-28}} = 0.1482 \text{ in}$$

$$t_{a \text{ UG-22}} = 0.0489 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}} , t_{a \text{ UG-22}} ] \\ &= \max[ 0.1482 , 0.0489 ] \\ &= 0.1482 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 622.5059 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 622.5059) + 0 \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2} , t_{b \text{ UG16}} ] \\ &= \max[ 0.7378 , 0.0625 ] \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3} , t_{b2} ] \\ &= \min[ 0.2074 , 0.7378 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a , t_b ] \\ &= \max[ 0.1482 , 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

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:  $B = 12,976.6933 \text{ psi}$

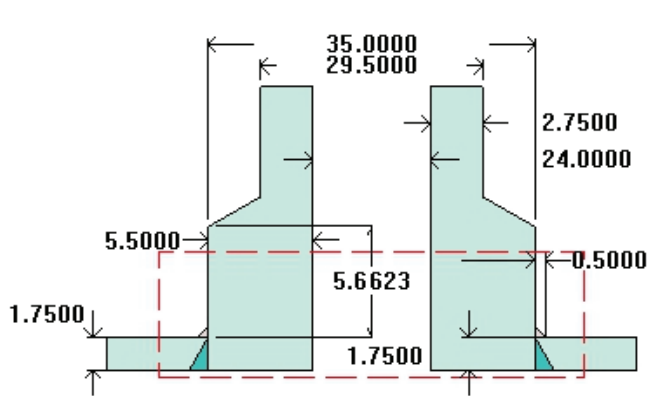
$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 12,976.69 / (3 \cdot (4.12 / 0.1482)) \\ &= 622.51 \text{ psi} \end{aligned}$$

**Design thickness for external pressure  $P_a = 622.51 \text{ psi}$**

$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482 \text{ in}$$

## Manway c/w Blind Flange (MW1)

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$$t_{w(\text{lower})} = 1.75 \text{ in}$$

$$\text{Leg}_{41} = 0.5 \text{ in}$$

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,  $t_n = 2.75 \text{ in}$

The nozzle neck thickness is adequate.

### Check Large Opening per Appendix 1-7(a)

Area required within 75 percent of the limits of reinforcement  
 $= 2 / 3 * A = (2 / 3) * 21 = 14 \text{ in}^2$

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  $P_a = 622.51 \text{ psi}$**

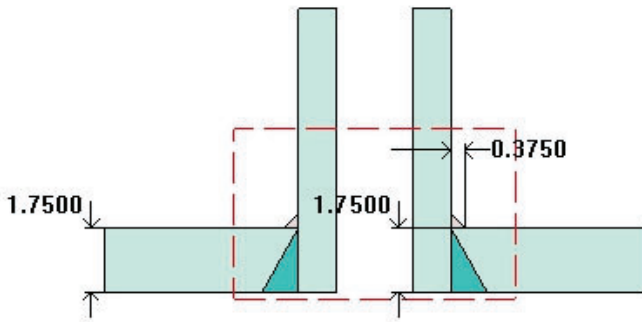
$$t_a = t + \text{Corrosion} = 1.1622 + 0 = 1.1622''$$

PDI High (N7A)

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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, 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)

<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:  $t_{min} =$  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:  $B = 12,976.6933 \text{ psi}$

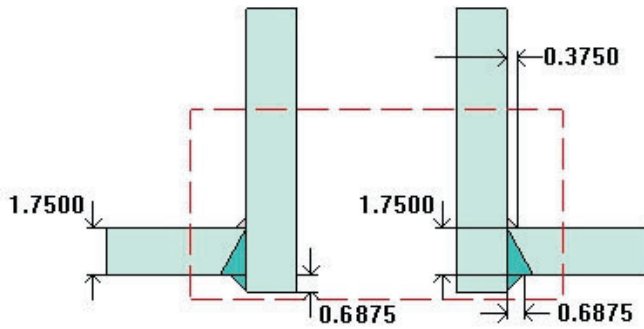
$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 12,976.69 / (3 \cdot (4.12 / 0.1482)) \\ &= 622.51 \text{ psi} \end{aligned}$$

### Design thickness for external pressure $P_a = 622.51 \text{ psi}$

$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

## Inlet (N1)

### 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:	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

$$A_1 = \text{larger of the following} = \underline{1.126} \text{ in}^2$$

$$\begin{aligned} &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 8 \cdot (1 \cdot 1.75 - 1 \cdot 1.6093) - 2 \cdot 1.875 \cdot (1 \cdot 1.75 - 1 \cdot 1.6093) \cdot (1 - 1) \\ &= 1.126 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2 \cdot (1.75 + 1.875) \cdot (1 \cdot 1.75 - 1 \cdot 1.6093) - 2 \cdot 1.875 \cdot (1 \cdot 1.75 - 1 \cdot 1.6093) \cdot (1 - 1) \\ &= 1.0204 \text{ in}^2 \end{aligned}$$

$$A_2 = \text{smaller of the following} = \underline{13.8906} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t \\ &= 5 \cdot (1.875 - 0.2875) \cdot 1 \cdot 1.75 \\ &= 13.8906 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (1.875 - 0.2875) \cdot 1 \cdot 1.875 \\ &= 14.8828 \text{ in}^2 \end{aligned}$$

$$A_3 = \text{smaller of the following} = \underline{2.5781} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot t_i \cdot f_{r2} \\ &= 5 \cdot 1.75 \cdot 1.875 \cdot 1 \\ &= \underline{16.4063} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 5 \cdot t_i \cdot f_{r2} \\ &= 5 \cdot 1.875 \cdot 1.875 \cdot 1 \\ &= \underline{17.5781} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 2 \cdot h \cdot t_i \cdot f_{r2} \\ &= 2 \cdot 0.6875 \cdot 1.875 \cdot 1 \end{aligned}$$

$$= \underline{2.5781} \text{ in}^2$$

$$\begin{aligned} A_{41} &= \text{Leg}^2 * f_{r2} \\ &= 0.375^2 * 1 \\ &= \underline{0.1406} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} A_{43} &= \text{Leg}^2 * f_{r2} \\ &= 0.6875^2 * 1 \\ &= \underline{0.4727} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_3 + A_{41} + A_{43} \\ &= 1.126 + 13.8906 + 2.5781 + 0.1406 + 0.4727 \\ &= \underline{18.208} \text{ in}^2 \end{aligned}$$

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

$$\begin{aligned} P_a &= 4*B / (3*(D_o / t)) \\ &= 4*13,772.85 / (3*(11.75 / 0.3983)) \\ &= 622.51 \text{ psi} \end{aligned}$$

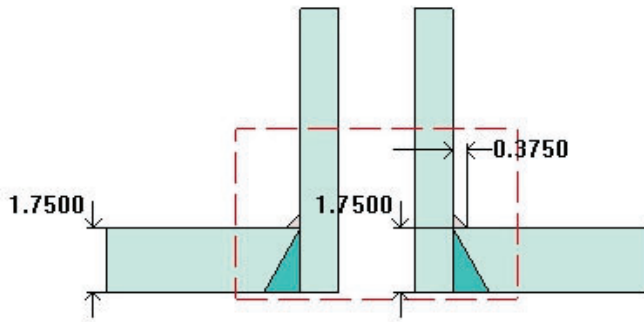
**Design thickness for external pressure  $P_a = 622.51$  psi**

$$t_a = t + \text{Corrosion} = 0.3983 + 0 = 0.3983''$$

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)

<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:  $t_{\min}$  = 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

$$\begin{aligned} t_{a \text{ UG-27}} &= P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion} \\ &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) + 0 \\ &= 0.0719 \text{ in} \end{aligned}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0719, 0 ] \\ &= 0.0719 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378) + 0 \\ &= 1.6092 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6092, 0.0625 ] \\ &= 1.6092 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.2074, 1.6092 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0719, 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06$  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 $P_a = 622.51 \text{ psi}$

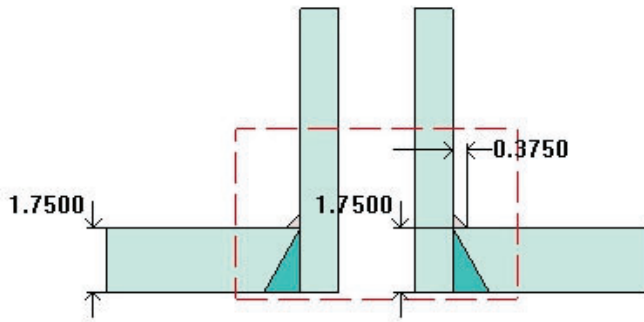
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

## Level Bridle - (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 $\leq 5$ (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)

<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:  $t_{\min}$  = 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

$$\begin{aligned}t_{a \text{ UG-27}} &= P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion} \\ &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) + 0 \\ &= 0.0719 \text{ in}\end{aligned}$$

$$\begin{aligned}t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0719, 0 ] \\ &= 0.0719 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378) + 0 \\ &= 1.6092 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6092, 0.0625 ] \\ &= 1.6092 \text{ in}\end{aligned}$$

$$\begin{aligned}t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.2074, 1.6092 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0719, 0.2074 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06$  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 $P_a = 622.51 \text{ psi}$

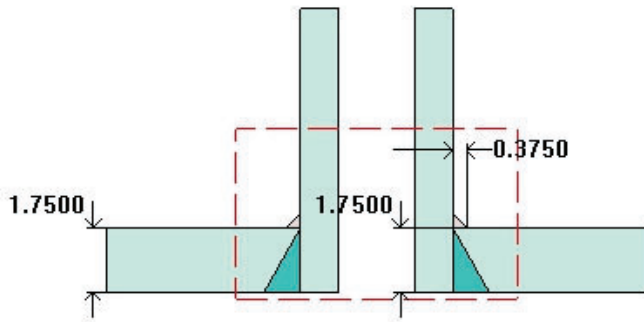
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

## Level Bridle - (Process) Low (N8B)

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:	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 ≤ 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

<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 $P_a = 622.51 \text{ psi}$

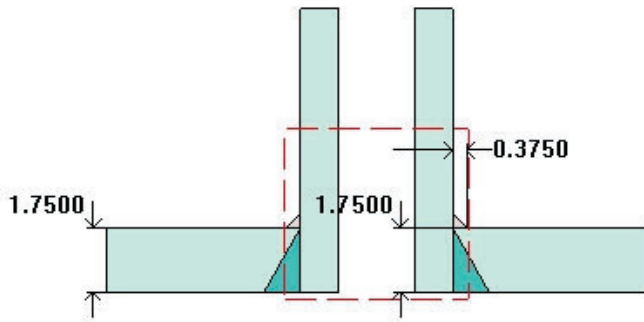
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

## 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  $t_{rn} = 0.1482$  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

$$t_{a \text{ UG-28}} = 0.1482 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.1482, 0 ] \\ &= 0.1482 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 622.5059 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 622.5059) + 0 \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2}, t_{b \text{ UG16}} ] \\ &= \max[ 0.7378, 0.0625 ] \\ &= 0.7378 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b2} ] \\ &= \min[ 0.2074, 0.7378 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.1482, 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

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 $P_a = 622.51 \text{ psi}$

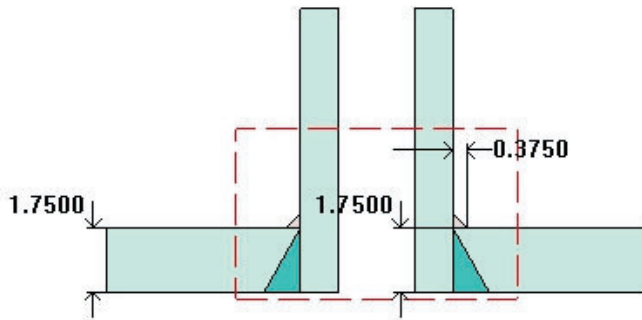
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

## 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

<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:  $B = 12,976.6933 \text{ psi}$

$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 12,976.69 / (3 \cdot (4.12 / 0.1482)) \\ &= 622.51 \text{ psi} \end{aligned}$$

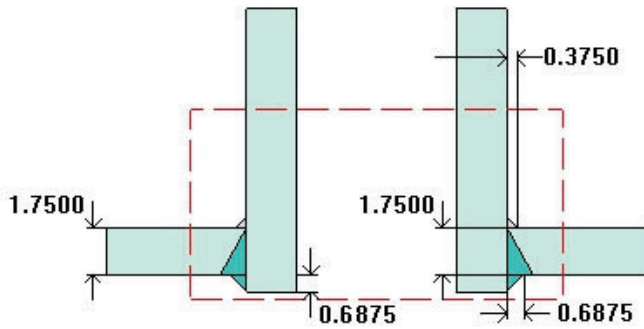
**Design thickness for external pressure  $P_a = 622.51 \text{ psi}$**

$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482 \text{ in}$$



## 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, $L_{pr}$ :	7.25 in
Internal projection, $h_{\text{new}}$ :	0.6875 in
Projection available outside vessel to flange face, $L_f$ :	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)

UW-16 Weld Sizing Summary			
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**

<p align="center"><b>UG-37 Area Calculation Summary (in<sup>2</sup>)</b>                  For <math>P_e = 622.51</math> 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>
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  $t_{rn} = 0.3983$  in**

**From UG-37(d)(1) required thickness  $t_r = 1.75$  in**

**Area required per UG-37(d)(1)**

Allowable stresses:  $S_n = 20,000$ ,  $S_v = 20,000$  psi

$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$\begin{aligned} A &= 0.5 \cdot (d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1})) \\ &= 0.5 \cdot (8 \cdot 1.75 \cdot 1 + 2 \cdot 1.875 \cdot 1.75 \cdot 1 \cdot (1 - 1)) \\ &= \underline{7} \text{ in}^2 \end{aligned}$$

### 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

$$t_{a \text{ UG-28}} = 0.3983 \text{ in}$$

$$t_a = \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ]$$

$$= \max[ 0.3983, 0 ]$$

$$= 0.3983 \text{ in}$$

$$t_{b2} = P * R_o / (S * E + 0.4 * P) + \text{Corrosion}$$

$$= 622.5059 * 24 / (20,000 * 1 + 0.4 * 622.5059) + 0$$

$$= 0.7378 \text{ in}$$

$$t_{b2} = \max[ t_{b2}, t_{b \text{ UG16}} ]$$

$$= \max[ 0.7378, 0.0625 ]$$

$$= 0.7378 \text{ in}$$

$$t_b = \min[ t_{b3}, t_{b2} ]$$

$$= \min[ 0.3281, 0.7378 ]$$

$$= 0.3281 \text{ in}$$

$$t_{\text{UG-45}} = \max[ t_a, t_b ]$$

$$= \max[ 0.3983, 0.3281 ]$$

$$= 0.3983 \text{ in}$$

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)**

$$L / D_o = 107.4233 / 48 = 2.2380$$

$$D_o / t = 48 / 1.77 = 27.1186$$

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 = 1.6101"**

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:  $P = 1,378$  psi @ 140 °F

External design pressure:  $P_e = 15$  psi @ 140 °F

#### Static liquid head:

$P_s = 1.16$  psi (SG=1.1,  $H_s=29.135$ " 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

No impact test performed

Rated MDMT = -320°F

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)**

$$\begin{aligned}
 EFE &= (75 * t / R_f) * (1 - R_f / R_o) \\
 &= (75 * 1.77 / 8.4568) * (1 - 8.4568 / \infty) \\
 &= 15.6974\%
 \end{aligned}$$

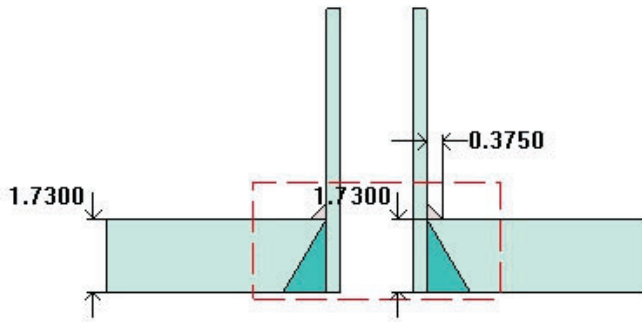


## Bottom Drain (N13)

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 $P_a = 566.01 \text{ psi}$

$$t_a = t + \text{Corrosion} = 0.0949 + 0 = 0.0949 \text{ in}$$

### 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

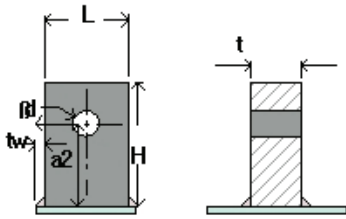
### Required thickness, compressive stress at base:

$$\begin{aligned}t &= (1 + V_{\text{Accel}}) * W / (\pi * D_t * S_c * E_c) + 48 * M / (\pi * D_t^2 * S_c * E_c) \\&= (1 + 1) * 19,538.66 / (\pi * 46.25 * 15,798 * 1) + 48 * 90,303.6 / (\pi * 46.25^2 * 15,798 * 1) \\&= \underline{0.0579} \text{ in}\end{aligned}$$

### 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

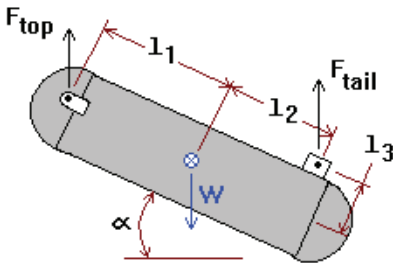
Required Lift Pin Diameter, $d_{reqd}$	<a href="#">0.8351"</a>
Required Lug Thickness, $t_{reqd}$	<a href="#">0.3246"</a>
Lug Stress Ratio, $\sigma_{ratio}$	<a href="#">0.37</a>
Weld Shear Stress Ratio, $\tau_{ratio}$	<a href="#">0.23</a>
Lug Design	Acceptable
Local Stresses	Acceptable
Base ring loading	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

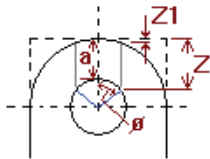
$$\begin{aligned} t_{\text{reqd}} &= [F_v / \sigma_s] / (2 * L_{\text{shear}}) \\ &= (14,592 / 13,320) / (2 * 2.0153) = \underline{0.2718"} \end{aligned}$$

$$t_{\text{reqd}} / t = 0.2718 / 1.5 = 0.18 \quad \text{Acceptable}$$

$$\begin{aligned} \tau &= F_v / A_{\text{shear}} \\ &= F_v / (2 * t * L_{\text{shear}}) \\ &= 14,592 / (2 * 1.5 * 2.0153) = 2,414 \text{ psi} \end{aligned}$$

$$\tau / \sigma_s = 2,414 / 13,320 = 0.18 \quad \text{Acceptable}$$

Shear stress length (per Pressure Vessel and Stacks, A. Keith Escoe)



$$\begin{aligned} \phi &= 55 * D_p / d \\ &= 55 * 1.5 / 1.5625 \\ &= 52.8^\circ \end{aligned}$$

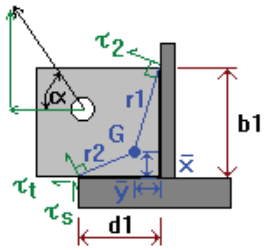
$$\begin{aligned} L_{\text{shear}} &= (H - a_2 - 0.5 * d) + 0.5 * D_p * (1 - \cos(\phi)) \\ &= (7.5 - 5 - 0.5 * 1.5625) + 0.5 * 1.5 * (1 - \cos(52.8)) \\ &= 2.0153" \end{aligned}$$

### 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

$$\begin{aligned} x_1 &= 0" \\ y_1 &= 2.3125" \\ x_2 &= 2.5" \\ y_2 &= 0" \\ X_{\text{bar}} &= \sum (A_i * x_i) / \sum A_i \\ Y_{\text{bar}} &= \sum (A_i * y_i) / \sum A_i \\ X_{\text{bar}} &= (2.0437 * 0 + 2.2094 * 2.5) / 4.253 = 1.2987" \\ Y_{\text{bar}} &= (2.0437 * 2.3125 + 2.2094 * 0) / 4.253 = 1.1112" \end{aligned}$$

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 ( $0.929 \text{ in}^2$ ) 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)

$$\text{Bolt load} = A_b f_s = 0.929 \cdot 521 = 484.47 \text{ lb}_f$$

$$\begin{aligned}t_r &= (3.91 F / (S_y (2b / w + w / (2l) - d_b (2 / w + 1 / (2l))))))^{0.5} \\&= (3.91 \cdot 484.47 / (36,000 (2 \cdot 4.625 / 4 + 4 / (2 \cdot 2.25) - 1.625 (2 / 4 + 1 / (2 \cdot 2.25))))))^{0.5} \\&= 0.1611 \text{ in}\end{aligned}$$

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 (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 in<sup>2</sup>) 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

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

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

$$t_s = (N * A_b) / (\pi * d) \\ = (8 * 0.929) / (\pi * 49) \\ = 0.0483 \text{ in}$$

#### From table 12.4 for $k = 0.264922$ :

$$K_1 = 2.5185, K_2 = 1.4124 \\ L_1 = 11.5204, L_2 = 27.899, L_3 = 10.2954$$

#### 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

$$f_s = T / (t_s * (d / 2) * K_1) \\ = 17,020.84 / (0.0483 * (49 / 2) * 2.5185) \\ = 5,714 \text{ psi}$$

#### Total compressive load on foundation

$$C_c = T + (1 + V_{\text{Accel}}) * W + \text{Bolt Preload} \\ = 17,020.84 + (1 + 1) * 19,872.88 + 0 \\ = 56,766.59 \text{ lb}_f$$

#### Foundation bearing stress

$$f_c = C_c / (((t_c - t_s) + n * t_s) * (d / 2) * K_2) \\ = 56,766.59 / (((7 - 0.0483) + 9.2889 * 0.0483) * (49 / 2) * 1.4124) \\ = 222 \text{ psi}$$

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

$$k = 1 / (1 + f_s / (n * f_c)) \\ = 1 / (1 + 5,714 / (9.2889 * 222)) \\ = 0.264922$$

#### 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)

$$\begin{aligned}
 P &= -W / N + 48 * M / (N * BC) \\
 &= -18,270.39 / 8 + 48 * 86,062.1 / (8 * 51.25) \\
 &= 7,791.77 \text{ lb}_f
 \end{aligned}$$

$$\text{Required area per bolt} = P / S_b = 0.3896 \text{ in}^2$$

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 ( $0.929 \text{ in}^2$ ) 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











