

## HISTORY DOCKET

CUSTOMER : ULTRAFAB INDUSTRIES LTD.,  
WO. NO. : 1173PQ  
A.W.C. SERIAL NO. : 7475  
ITEM : 48" O.D. VERTICAL OUTLET SEPARATOR TAG # 772-VESE-203

### 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 N13-019, N13-021, N13-039, N13-043, N13-046 & N13-  
097, N13-102 & N13-105
- 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:** 7475  
**ITEM:** 48" O D VERTICAL OUTLET SEPARATOR TAG 772-VESE-203

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

NOV 14 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



**(Alternative Form for Single Chamber, Completely Shop or Field Fabricated Vessels Only)  
As Required by the Provisions of the ASME Boiler and Pressure Vessel Code Rules, Section VIII, Division 1**

**COPY**

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

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

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

4. Type VERTICAL 7475 M10135.5 1173-1-IN REV. 5 916 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.

to 2011a N/A 2010  
(Addenda, if applicable (date)) (Code Case numbers) (Year)

LETHAL UW-2(a)  
(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, butt)) (R.T. (spot or full)) (Eff. %) (H.T. temp) (Time, hr) (Girth (welded, dbl., spot, lap, butt)) (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 7 NOV 2013 Co. name ALL-WELD COMPANY LIMITED. Signed [Signature]  
(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 NOV 07, 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 NOV 07, 2013 Signed [Signature] Commissions NB13106A, ONT915  
(Authorized Inspector) (National Board (incl. endorsements), State, Province and number)

COPY

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

2. Manufactured for ULTRA FAB INDUSTRIES LTD., 261088 WAGON WHEEL CRES., ROCKY VIEW, ALBERTA, T4A 0E2 CANADA  
(Name and address of Purchaser)

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

4. Type VERTICAL TANK 7475  
(Horizontal, vertical, or sphere) (Tank, separator, heat exch. etc.) (Manufacturer's serial number)

M10135.5 1173-1-IN REV. 5 916 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	CI.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
PURGE (N11)	1	2" ID	CI.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
LEVEL BRIDAL(SAFE TY)(N8A)	1	2" ID	CI.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
MANWAY C/W BLIND FLANGE	1	24" ID	CI.900 V2/12	SA182 F316	SA182 F316	5.5"	0"	N/A	UW.16 1(e)	N/A	SHELL
PDI LOW (N6B)	1	2" ID	CI.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
LEVEL BRIDAL(PROC ESS)(N7A)	1	2" ID	CI.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
PDI (HIGH) (N6A)	1	2" ID	CI.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
LEVEL BRIDLE (SAFETY) LOW (N8B)	1	2" ID	CI.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
LEVEL GAUGE HIGH (N9A)	1	2" ID	CI.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
INLET (N1)	1	8" ID	CI.900 LWN	SA182 F316	SA182 F316	1.875"	0"	N/A	UW.16 1(e)	N/A	N/A
SPARE (N10)	1	2" ID	CI.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
LEVEL GAUGE LOW (N9B)	1	2" ID	CI.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
PSV (N4)	1	2" ID	CI.900 LWN	SA182 F316	SA182 F316	1.06"	0"	N/A	UW.16 1(e)	N/A	N/A
INSP. C/W BLIND FLANGE (N14)	1	8" ID	CI.900 LWN	SA182 F316	SA182 F316	1.875"	0"	N/A	UW.16 1(e)	N/A	SHELL
BOTTOM DRAIN (N12)	1	NPS 2"	CI.900 WN	SA312 TP 316	SA182 F316	0.344"	0"	N/A	UW.16 1(e)	UW.16.1 (f2)	N/A

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

Date: 7 NOV 2013 Name: ALL-WELD COMPANY LIMITED Signed: [Signature]  
(Manufacturer) (Representative)

Date: NOV 07, 2013 Name: [Signature] Commission: NB13106A, ONT915  
(Authorized Inspector) (National Board (incl. endorsements), State, Province, and number)

# ALL-WELD CO. LTD.

# TRAVELLER

(SUMMARY REPORT) Pg. 1 of 2

DATE 2013-02-06	WORK ORDER 1173Q	CUSTOMER PO 11112	REVIEWED <i>[Signature]</i>	BY A.I. <i>[Signature]</i>
SERIAL NO. 7475	C.R.N. M10135.5	DATE 2013-02-06		SIGN JESSET.13
NATIONAL BOARD NO.				

CUSTOMER <b>ULTRAFAB</b>	ULTIMATE OWNER
FOR DRAWINGS & DOCUMENTS/REV./DATE ISSUED TO Q.C. SEE Q.C. DOCUMENT CONTROL FORM	ASME CODE 2010
VESSEL TYPE/JOB DESCRIPTION 60" ID VERTICAL OUTLET SEPERATOR	SECTION VIII DIV 1
	ADD 2011
	H = HOLD R = REVIEW

**OPERATIONS, INSPECTIONS & TEST POINTS**

REVIEW APPVD DRWGS, CALCS,  
REVIEW TRAVELLER AND REVIEW INSPECTION AND TEST PLAN

REVIEW MATERIAL LIST

REVIEW W.P.S., P.Q.R SAW-3-2, 3-4, 9-4  
+2-1

INCOMING MATERIAL INSPECTION REPORT

CHECK ROUNDNESS OF VESSEL

FIT-UP INSPECTION

AG PARTICLE / LIQUID PEN TEST

APPROVAL OF RADIOGRAPH MAP BY AI

RADIOGRAPHIC TESTS - FULL

ULTRASONIC TEST

HARDNESS TESTS

REVIEW WELDERS QUALIFICATION

WELD MAP REPORT

FINAL INTERNAL INSPECTION

POST WELD HEAT TREATMENT

FINAL (ALL NCR'S HAVE BEEN CLEARED)

FINAL COMPLETED VESSEL INSPECTION

FINAL HYDROSTATIC TEST

FINAL HYDROSTATIC TEST JACKET

FINAL HYDROSTATIC TEST TUBE SIDE

APPLICATION OF CODE STAMP + ATTACH NAMEPLATE

DATA REPORT SIGN OFF

GLASS BEAD BLASTING

DATA PACKAGE SENT TO CUSTOMER

R	H	AWC QC	R	H	CUSTOMER	R	H	AI
	H	E 11/09/13					R	JESSET.13
	H	W 15/03/13					R	SMARIS.13
	H	W 15/03/13					R	ZUL22.13
	H	W 09/01/13					R	FOO29.13
	H	E 23/07/13					R	ZUL23.13
	H	W 10/05/13						
	H	W 10/10/13						
	H	W 15/03/13					R	SMARIS.13
	H	W 28/10/13					R	FOO29.13
	H	W 28/10/13						
	H	W 28/10/13						
	H	W 28/10/13					R	FOO29.13
	H	W 28/10/13					R	FOO29.13
	H	W 29/10/13					H	FOO29.13
	N/A							
	H	W 7/11/13					R	INOV07.13
	H	W 7/11/13					H	INOV07.13
	H	W 7/11/13					H	INOV07.13
	N/A							
	N/A							
	H	W 7/11/13					H	INOV07.13
	H	W 7/11/13					H	INOV07.13
	N/A							
	H	W 16/12/13						

DATE	WORK ORDER	SERIAL NO.	REVIEWED	BY A.I.
2013-02-06	1173Q	7475	<i>[Signature]</i>	<i>[Signature]</i>
			DATE	SIGN
			2013-02-06	FEB 07 13

REMARKS:

NCR 13-019 - accepted on MAR 15 2013 / E



# ALL-WELD HYDROSTATIC TEST REPORT

JOB NUMBER  
1173 PQ

DATE  
NOV 7 / 13

CUSTOMER  
ULTRA FAB INDUSTRIES LTD.

SERIAL NO.  
7475

VESSEL DESCRIPTION  
48" O.D. VERTICAL OUTLET SEPARATOR TAG # 772-VESE-203

TEST PRESSURE	SHELL
	1792 PSIG

TUBE
NA

JACKET
NA

TEST METAL TEMPERATURE	50° F
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HOLDING TIME	1 HOUR MIN
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GAUGE #	LAST CALI. DATE
122 & 123	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 MRS  
 DATU 28/11/13  
 28/11/13  
 28/11/2013

Q.A. SIGNATURE 

DATE: NOV 7 / 13

Exam-24 Hydrostatic Test Report

MIKE KAMYAB	<input type="checkbox"/>
REVIEWED	<input checked="" type="checkbox"/>
WITNESSED	<input checked="" type="checkbox"/>
FOR: ULTRA	DATE: Nov. 7, 13

ACCEPTED/REVIEWED/RELEASED	046
for and on behalf of:	SBAI OFFSHORE
Print Name:	GANESH SAHA
Signature:	
Date:	NOV 7/2013
 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/NCSL 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

3CM  
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)	0.5
Chloride (Cl)	47.4
Bromide (Br)	<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 first test report and then disposed of, unless instructed otherwise in writing.  
\* Cambridge Materials Testing Limited is accredited for tests listed on the scope of accreditation available for review at www.cambridgematerials.com.  
Test Report Template Revision March 2010

**Cambridge Materials Testing Limited**

Per Steve Brown QUALITY ASSURANCE

Per Rupinder Singh TECHNICIAN

35 916



# CERTIFIED BY ALL-WELD

COMPANY LIMITED  
SCARBOROUGH, ONTARIO  
ENGINEERS SINCE 1920

W L  
RTI

SHELL MAWP	137.8	PSI	AT	140	°F
SHELL MAEWP	15	PSI	AT	140	°F
SHELL MDMT	-20	°F	AT	137.8	PSI
CHANNEL MAWP	N/A	PSI	AT	N/A	°F
JACKET MAWP	N/A	PSI	AT	N/A	°F
MAEWP	N/A	PSI	AT	N/A	°F
MDMT	N/A	°F	AT	N/A	PSI

SERIAL NO. 7475 YEAR BUILT 2013

CRN M 10135.5

TAG 772-VIS F-203

CERTIFIED BY  
**ALL-WELD**

COMPANY LIMITED  
SCARBOROUGH, ONTARIO  
ENGINEERS SINCE 1920

W.L.  
RT1

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. 7475 YEAR BUILT 2013

C.R.N. M10/135.5 T0-296008

TAG# 772-VESE-203



**RADIOGRAPH REVIEW FORM**

W.O. NO. 1173 PQ  
SERIAL NO. 7475

- 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: OCT 28 2013



# KV INSPECTION SERVICES LTD

Established 1980

1486 Wallace Road, Oakville, Ontario L6L 2Y2

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

www.kvinspection.com

Email: kvinsp1@aol.com

## EDWIN DUITSCHAEVER



Natural Resources  
Canada

Ressources naturelles  
Canada



Name: Edwin Duitschaever  
 Num: 515  
 Reg. No: 515  
 No matricule: 515  
 Issue Date: 2011/11/28  
 Date d'émission:

This card does not identify the stated individual as 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] pres || distance

Signature: *Edwin Duitschaever*



Natural Resources  
Canada

Ressources naturelles  
Canada

2770 Highway 104, Oakville, ON L6L 2Y2

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 information on certification status, policies and deadlines, visit website  
 http://24hr.nrc.ca/ Can. Prov. la méthode de la certification, les politiques, et les délais,  
 visiter le site web http://24hr.nrc.ca/

For more information on the program  
 Pour plus d'information sur le programme

# 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
	Rec. No. No matricule	6651
	Issue Date Date d'émission	2011/02/14
	Corrective lenses for [X] near [X] far vision Verres correctifs pour la vision de [X] près [X] distance	
	Signature	

	Natural Resources Canada	Ressources naturelles Canada			
Qualified to / Qualifié(e) en	CAN 1050 46 9712	6651			
1050 10621 Quality system					
Method Méthode	Level Niveau	Sector Secteur	Uert Date Date cert	Date recert Date recert	Expires Expiration
MT	2	EMC	1997/05/08		2013/12/31
PT	2	EMC	1997/11/07		2013/12/31
RT	2	EMC	2000/01/06		2013/12/31
UT	2	EMC	2010/06/03		2013/12/31

# KV INSPECTION SERVICES LTD

Established 1980

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

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Email: kvinsp1@aol.com

## FRANK MARUNDE



Natural Resources  
Canada

Ressources naturelles  
Canada



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

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

Signature | 



Natural Resources  
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Registered to Certify selon / ÉAR / RGNB 48 9732

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 certification status, policies and definitions, visit website:  
<http://mbf.prcan.gc.ca/> Pour la vérification de la certification, les politiques, et les définitions,  
 visitez le site web: <http://mbf.prcan.gc.ca/>

Manager / Certifying Agency  
 Gestionnaire / Organisme de certification



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## TODD CAMPBELL



Natural Resources  
Canada

Ressources naturelles  
Canada

Name: **Todd Campbell**  
Nom:  
Reg. No.: **11748**  
No. matricule:  
Issue Date: **2011/12/06**  
Date d'émission:



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Corrective lenses for (N) near (X) far vision.  
Verres correctifs pour la vision de (N) près (X) distance.  
Signature: *Todd Campbell*



Natural Resources  
Canada

Ressources naturelles  
Canada

11748

Method Méthode	Level Niveau	Sector Secteur	Cert. Date Date cert.	Date recert. Date recert.	Expires Expiration
MT	2	EMC	2005/08/11		2014-12-31
PT	2	EMC	2003/12/08		2014-12-31
RT	1	EMC	2011/04/28		2014-12-31

The verification of certification marks, numbers and information, visit website  
N.B. L'information sur la vérification des marques de certification, des numéros et des données,  
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www.kvinspection.com Email: kvinsp1@aol.com

## SHERWIN SUYOM



Natural Resources  
Canada

Ressources naturelles  
Canada



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

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Verres correctifs pour la vision de || près || distance

Signature:



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

For certain types of certification dates, printing, and distribution, visit website  
http://www.nrsc.gc.ca/ Pour les certifications de la certification, les publications, et les distributions,  
visitez le site web: <http://www.nrsc.gc.ca/>  
Minister of the Environment  
Ministère de l'Environnement

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## JOHN MACDONALD



Natural Resources  
Canada

Ressources naturelles  
Canada



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

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

Signature: *[Handwritten Signature]* 8 247 244 51



Natural Resources  
Canada

Ressources naturelles  
Canada

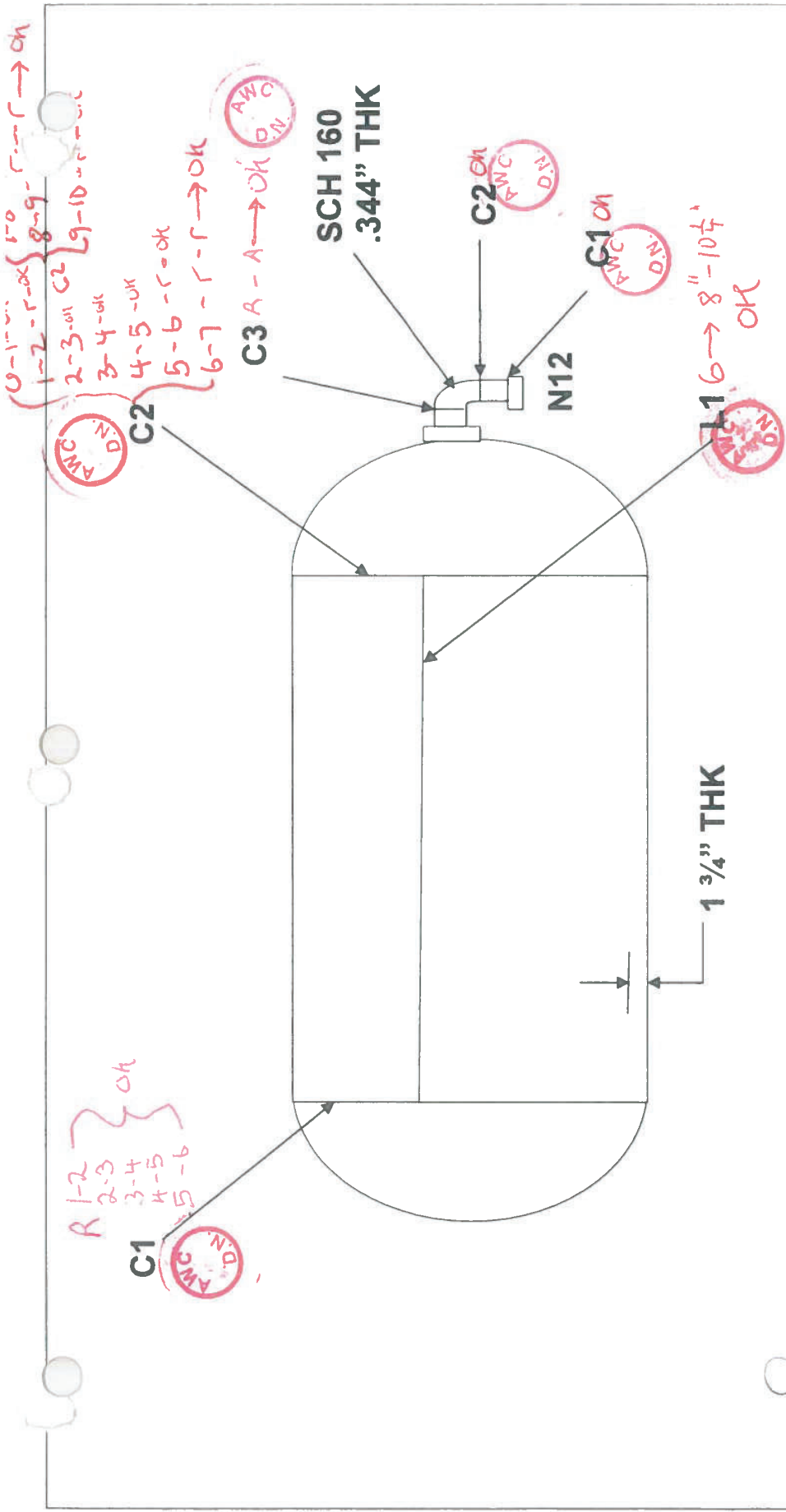
Certified to / Certifié selon: CAN CGSB 48 9712

10375

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

For verification of certifications status, policies and definitions, visit website:  
<http://ndb.nrcan.gc.ca/> Pour la vérification de la certification, les politiques, et les définitions,  
visitez le site web: <http://ndb.nrcan.gc.ca/>

Manager, Certifying Agency  
Gestionnaire, Organisme de certification



AI \_\_\_\_\_ Date MAR 15, 2013

<b>ALL-WELD CO. LTD. - RT MAP</b>	
CLIENT: ULTRAFAB	
WORK ORDER #: 1173PQ	SN 7475
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

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

**Radiographic Examination Report  
RT**

**Specification - Acceptance Criteria**

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

**General Data**

Customer	ALL WELDS CO LTD	Date	March 12/13
Location	SCARBOROUGH ONT	P. O. #	
Project	VERTICAL SEPARATOR	Shop Order #	117372-7475
Procedure	ICW #5 REV 3	Worksheet #	36630
Technician	J McDONALD	CGSB Reg #	10375 ASNT/SNT-TC-1A Level 1

**Technical Data**

Material Type	Carbon	Alloys <input checked="" type="checkbox"/>	Isotope	IR 192	Other <input checked="" type="checkbox"/>	Physical/Focal Size	188
Base Material Thickness	1 3/4		Exposure	Single Wall <input checked="" type="checkbox"/>	Double Wall	Film per Cassette	1
Weld Thickness	1 3/4		View	Single Wall <input checked="" type="checkbox"/>	Double Wall	PWHT	Yes No <input checked="" type="checkbox"/>
Reinforcement	1/8"		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				17/8"

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
L1	0-1								<input checked="" type="checkbox"/>	
	1-2					gas			<input checked="" type="checkbox"/>	
	2-3								<input checked="" type="checkbox"/>	
	3-4								<input checked="" type="checkbox"/>	
	4-5								<input checked="" type="checkbox"/>	
	5-6					gas			<input checked="" type="checkbox"/>	
	6-END) 6+(8"-10 1/4)"							SST TRACING		<input checked="" type="checkbox"/>

ACCEPTED/REVIEWED/RELEASED 046  
for and on behalf of: SBM OFFSHORE  
Print Name: GANESH SAHA  
Signature: [Signature]  
Date: [Date]  
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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]  
AWC  
DN

Date

March 12/13

Customer Representative

Date

MAR 15 2013

**Radiographic Examination Report  
RT**

**Specification - Acceptance Criteria**

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

**General Data**

Customer	ALL WELD	Date	17 APRIL 2013
Location	SCARBOROUGH	P. O. #	
Project	VESSEL	Shop Order #	1173 PQ, SN 7475
Procedure	KU#5 REV03	Worksheet #	36853
Technician	J. MACDONALD	CGSB Reg #	10315 ASNT/SNT-TC-1A Level 1

**Technical Data G60**

Material Type	Carbon	Alloys	Isotope	IR 192	Other	Physical/Focal Size	1188"
Base Material Thickness	1 3/4"		Exposure	Single Wall	Double Wall	Film per Cassette	1
Weld Thickness	1 3/4"		View	Single Wall	Double Wall	PWHT	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>
Reinforcement	1/4"		Number of Exposures	1			
Film Mfg.	KODAK		Minimum Source to Object Distance	18"			
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 7475										
L.R	6-END								✓	

ACCEPTED/REVIEWED/RELEASED 046  
for and on behalf of: SEM OFF SHORE  
Print Name: GANESH SAHAI  
Signature:   
Date: July 13  
Applus VELOSI  
Velosi America LLC

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

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

KV Inspection Technician		Date	17 April 2013
Customer Representative		Date	APR 23 2013





1486 Wallace Road  
Oakville, Ontario L6L 2Y2  
Phone: 905-844-9448  
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# Radiographic Examination Report RT

## Specification - Acceptance Criteria

ASME U1W-51 UW-52 B31.1 B31.3NS CSA Other

### General Data

Customer	ALL-WORLD	Date	OCT. 2 / 13
Location	SCARBOROUGH	P. O. #	
Project	ULTRA-FAB	Shop Order #	1173PQ-7475
Procedure	KV 5 RVZ	Worksheet #	37751
Technician	C. Veeneman	CGSB Reg #	6651
		ASNT/SNT-TC-1A Level	II

### Technical Data C660

Material Type	Carbon	Alloys	Isotope	IR 192	Other	Physical/Focal Size	.13"
Base Material Thickness	1 3/4"		Exposure	Single Wall	Double Wall	Film per Cassette	1
Weld Thickness	"		View	Single Wall	Double Wall	PWHT	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>
Reinforcement	2 1/4"		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"			

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
01	0-1								✓	
	1-2	1+9"-2								✓
	2-3	WT. (SEE TRACON)								✓
	3-4	3+7 1/2"		3+4"						✓
	4-5	4+4+1"								✓
	5-6	5+9"								✓
	6-7									✓
	7-8									✓
	8-9	✓								✓
	9-10									✓
	10-1									✓

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SBM OFFSHORE  
Print Name: GAMBESH SAHA  
Signature: [Signature]  
Date: 10/4/13  
046  
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Velosi America LLC

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

KV Inspection Technician	[Signature]	Date	OCT. 2 / 13
Customer Representative	[Signature]	Date	OCT 11 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	Date	OCT. 9/13
Location	SCARBOROUGH	P. O. #	
Project	ULTRAFAB	Shop Order #	1173 PQ-7475
Procedure	KVS R012	Worksheet #	
Technician	Creeneeman	CGSB Reg #	6651
		ASNT/SNT-TC-1A Level	II

### Technical Data C60

Material Type	Carbon	Alloys	Isotope	IR 192	Other	Physical/Focal Size	.199"
Base Material Thickness	1 3/4"		Exposure	Single Wall	Double Wall	Film per Cassette	1
Weld Thickness	"		View	Single Wall	Double Wall	PWHT	Yes (NO)
Reinforcement	< 1/4"		Number of Exposures	1			
Film Mfg.	KODAK		Minimum Source to Object Distance	PRACTICAL (4'0")			
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
01R	1-2								✓	
	2-3								✓	
	3-4								✓	
	4-5								✓	
	5-6								✓	

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBM OFFSHORE  
 Print Name: ANVESH SAHA  
 Signature: [Signature]  
 Date: OCT 30 2013  
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 Velosi America LLC

KV Inspection Technician	<u>[Signature]</u>	Date	OCT. 9 / 13
Customer Representative		Date	OCT 10 2013

## Radiographic Examination Report RT

### Specification - Acceptance Criteria

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

### General Data

Customer	ALL WELD	Date	19 MARCH 2013
Location	SCARBOROUGH	P. O. #	
Project	VESSEL	Shop Order #	1173PQ SN 7475
Procedure	KV#5 REV 03	Worksheet #	36703
Technician	J. MACDONALD	CGSB Reg #	10375 ASNT/SNT-TC-1A Level 1

### Technical Data Co 60

Material Type	Carbon <u>Alloys</u>	Isotope	IR 192 <u>Other</u>	Physical/Focal Size	.188"	
Base Material Thickness	1 3/4"	Exposure	<u>Single Wall</u>	Double Wall	Film per Cassette	1
Weld Thickness	1 3/4"	View	<u>Single Wall</u>	Double Wall	PWHT	Yes <u>No</u>
Reinforcement	1/2"	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 1/2"			

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
SN 7475										
02	0-1					gus	✓	SEE TRACKING		✓
	1-2	✓					✓	SEE TRACKING		✓
	2-3					✓	✓	"		✓
	3-4	✓						SEE TRACKING		✓
	4-5	✓						"		✓
	5-6	✓					✓	"		✓
	6-7	✓					✓	"		✓
	7-8	✓				✓		"		✓
	8-9	✓				✓		"		✓
	9-10							"		✓
	10-0							WC	✓	

MIKE KAMYAB  
REVIEWED  
WITNESSED  
FOR:

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: CBPI OFFSHORE GIL 046

Print Name: CHRISTOPHER SAH  
Signature: [Signature]  
Date: 19 MAR 2013

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

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KV Inspection Technician

[Signature]  
AWC

Date

19 MARCH 2013

Customer Representative

Date

MAR 29 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	Date	17 APRIL 2013
Location	SCARBOROUGH	P. O. #	
Project	VESSEL	Shop Order #	1173PA, SN7475
Procedure	KU#5 REV 03	Worksheet #	36853
Technician	J. MacDONALD	CGSB Reg #	10375
		ASNT/SNT-TC-1A Level	1

**Technical Data**

Material Type	Carbon	Alloys	Isotope	IR 192	Other	Physical/Focal Size	.188"
Base Material Thickness	1 3/4"		Exposure	Single Wall	Double Wall	Film per Cassette	1
Weld Thickness	1 3/4"		View	Single Wall	Double Wall	PWHT	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>
Reinforcement	1/4"		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"			

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
SN 7475										
CLR	0-1								✓	
	1-2			7/16-7/8"						✓
	2-3	✓							✓	
	3-4								✓	
	4-5								✓	
	5-6	+9/16 → 1/4"						SEE MARKING		✓
	6-7	100%						"		✓
	7-8	+1-2 1/4"						"		✓
	8-9	+9/16-11"						"		✓
	9-10	+1 1/2 → 1 3/4"						"		✓
	10-0							"		✓

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBN OFFSHORE  
 Print Name: GANESH SAHA  
 Signature: [Signature]  
 Date: JUN 5 11 3  
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 Velosi America LLC

MIKE KAMYAD  
 REVIEWED  
 WITNESSED  
 FOR:

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

KV Inspection Technician

Customer Representative

Date 17 APRIL 2013

Date APR 23 2013



**Radiographic Examination Report  
RT**

**Specification - Acceptance Criteria**

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

**General Data**

Customer	ALL WELD	Date	29 APRIL 2013
Location	SCARBOROUGH	P. O. #	
Project	VESSEL	Shop Order #	1173PQ - 7475
Procedure	KU #5 REV #3	Worksheet #	36928
Technician	J. MAC DONALD	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	1188
Base Material Thickness	1 3/4"	Exposure	<u>Single Wall</u> Double Wall	Film per Cassette	1
Weld Thickness	1 3/4"	View	<u>Single Wall</u> Double Wall	PWHT	Yes <u>No</u>
Reinforcement	1/8"	Number of Exposures	1		
Film Mfg.	KODAK	Minimum Source to Object Distance	PANORAMIC		
Film Type	AA	Maximum Distance from Source Side of Object to Film	1 7/8"		

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
CZR										
	1-2								✓	
	5-6								✓	
	6-7	16 1/2 - 7 1/2						SSS TURNING		✓
	7-8								✓	
	8-9	19 1/2 - 10 1/2						SSS TURNING		✓
	9-10								✓	

ACCEPTED/REVIEWED/RELEASED 046  
for and on behalf of: SRM OFFSHORE  
Print Name: CHRISTINA SAH  
Signature: [Signature]  
Date: JULY 5/13  
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Velosi America LLC

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

KV Inspection Technician	<u>[Signature]</u>	Date	29 APRIL 2013
Customer Representative		Date	MAY 06 2013

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

## Radiographic Examination Report RT

### Specification - Acceptance Criteria

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

### General Data

Customer	ALL-WELDS	Date	MAY 7 / 13
Location	SCARBROUGH	P. O. #	
Project	VERTICAL SEPARATOR	Shop Order #	1173 PQ - 7475
Procedure	KV 5 REV 2	Worksheet #	
Technician	P. Beneman	CGSB Reg #	6651
		ASNT/SNT-TC-1A Level	II

### Technical Data 660

Material Type	Carbon	<span style="border: 1px solid black; border-radius: 50%; padding: 2px;">Alloys</span>	Isotope	Other <span style="border: 1px solid black; border-radius: 50%; padding: 2px;">660</span>	Physical/Focal Size	.13"	
Base Material Thickness	1 3/4"		Exposure	<span style="border: 1px solid black; border-radius: 50%; padding: 2px;">Single Wall</span>	Double Wall	Film per Cassette	1
Weld Thickness	"		View	<span style="border: 1px solid black; border-radius: 50%; padding: 2px;">Single Wall</span>	Double Wall	PWHT	Yes <span style="border: 1px solid black; border-radius: 50%; padding: 2px;">No</span>
Reinforcement	2 1/4"		Number of Exposures				1
Film Mfg.	KODAK		Minimum Source to Object Distance	PANORAMIC			(4' dia)
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
02 R1	6-7	✓							✓	
	8-9	✓							✓	

046

ACCEPTED/REVIEWED/RELEASED

for and on behalf of: SBM OFFSHORE

Print Name: CHANESE SAHA

Signature: *(Signature)*

Date: July 5 13

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KV Inspection Technician	 	Date	MAY 7 / 13
Customer Representative		Date	MAY 7 2013



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Fax: 905-844-6697

**Radiographic Examination Report  
RT**

**Specification - Acceptance Criteria**

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

**General Data**

Customer	AM WELD CO LTD.	Date	Aug 13/13
Location	SCARBOROUGH ONT	P. O. #	
Project	ULTRAFAB.	Shop Order #	1173 PR - 7475
Procedure	KW #6 REV 2	Worksheet #	37436
Technician	C VENNEMAN	CGSB Reg #	6651 ASNT/SNT-TC-1A Level II

**Technical Data**

Material Type	Carbon	Alloys <input checked="" type="checkbox"/>	Isotope	IR 192 <input checked="" type="checkbox"/> Other	Physical/Focal Size	.13	
Base Material Thickness	5160		Exposure	Single Wall	Double Wall <input checked="" type="checkbox"/>	Film per Cassette	1
Weld Thickness	5160		View	Single Wall	Double Wall <input checked="" type="checkbox"/>	PWHT	Yes No -
Reinforcement	.125		Number of Exposures				3/weld
Film Mfg.	KODAK		Minimum Source to Object Distance				18"
Film Type	AA		Maximum Distance from Source Side of Object to Film				OP

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
N12	2"φ									
C1	A								✓	
	B								✓	
	C								✓	
C2	2"φ									
	A								✓	
	B								✓	
	C								✓	

046

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SBM OFFSHORE  
Print Name: GARRETT SAHA  
Signature: [Signature]  
Date: July 31/13  
**Applus<sup>®</sup> VELOSI**  
Velosi America LLC

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

KV Inspection Technician

[Signature]

Date

Aug 13/13

Customer Representative



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	Allweld	Date	10/23/13
Location	Toronto	P. O. #	
Project		Shop Order #	1173 PO 7475
Procedure	KV6 Dev J	Worksheet #	37916
Technician	MPenyon	CGSB Reg #	12283
		ASNT/SNT-TC-1A Level	1

**Technical Data**

Material Type		Alloys	Isotope	<u>IR 192</u>	Other	Physical/Focal Size	.13
Base Material Thickness	.344		Exposure	Single Wall	<u>Double Wall</u>	Film per Cassette	1
Weld Thickness	.344		View	Single Wall	<u>Double Wall</u>	PWHT	Yes <u>No</u>
Reinforcement	.125		Number of Exposures	3			
Film Mfg.	Kodak		Minimum Source to Object Distance	16"			
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
112 C3	A					✓		CCR		✓
2" φ	C								✓	
	B								✓	

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SAM OFFSHORE  
 Print Name: GANESH SAHA  
 Signature: [Signature]  
 Date: 10/23/13  
 Applus<sup>®</sup> VELOS  
 Velosi America I

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

KV Inspection Technician		Date	Oct 23/13
Customer Representative		Date	OCT 28 2013

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

## Radiographic Examination Report RT

### Specification – Acceptance Criteria

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

### General Data

Customer	ALL-WORD	Date	OCT. 25 / 13
Location	SCARLETON	P. O. #	
Project	ULTRAFAB	Shop Order #	1173PR-7475
Procedure	KV 6 RV2	Worksheet #	
Technician	B. Veeman	CGSB Reg #	6651
		ASNT/SNT-TC-1A Level	II

### Technical Data

Material Type	Carbon	Alloys	Isotope	IR 192	Other	Physical/Focal Size	.13"
Base Material Thickness	5/16"		Exposure	Single Wall	Double Wal	Film per Cassette	1
Weld Thickness	"		View	Single Wall	Double Wal	PWHT	Yes (NO)
Reinforcement	1/8"		Number of Exposures	1			
Film Mfg.	KODAK		Minimum Source to Object Distance	18"			
Film Type	AA		Maximum Distance from Source Side of Object to Film	2"			

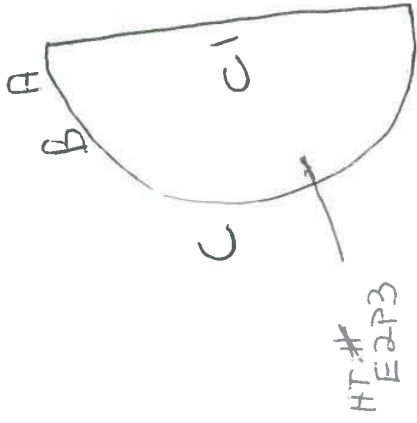
UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
N17-C3R	A'								✓	

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

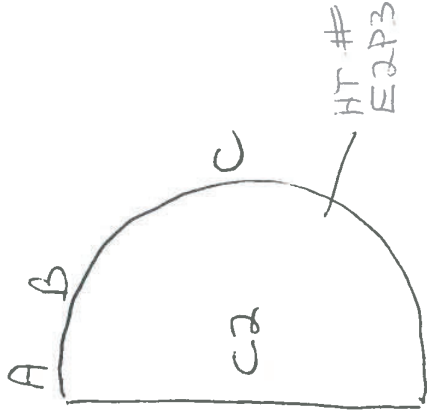
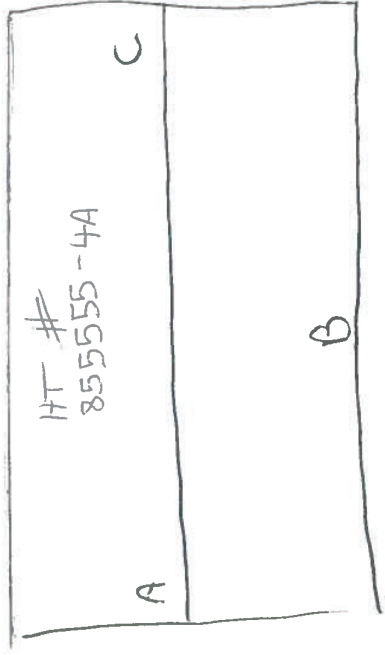
KV Inspection Technician	[Signature]	Date	OCT. 25 / 13
Customer Representative	[Signature]	Date	OCT 28 2013



Thk(A,B,C)



Thk C1(A,B,C)



Thk(A,B,C)

ALL-WELD CO. LTD. -

CLIENT: Ultrafab

WORK ORDER #: 1173 PQ SN7475

JOB DESCRIPTION:

DRAWING #:

PREPARED BY: D.NESCI

DATE: FEB 22 2013

UTMAP - Thk

ASME SECTION VIII. DIV. 1

material SA-240 316/316L

P.O 13-0153-1173PQ



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 # 7475	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="text"/> Temperature
Heat Treated	<input type="radio"/> YES <input type="radio"/> NO	Sensitivity (PRL)	75 dB
Heat Treatment		Surface Conditions	

### Transducers/Calibration Blocks

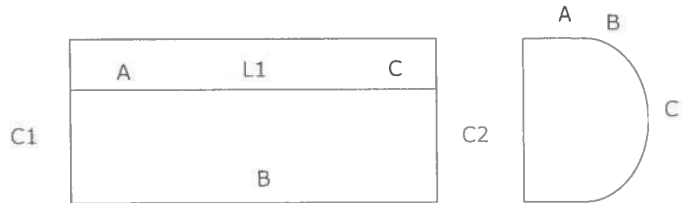
Diameter	Size	Beam Angle	Frequency	Manufacturer	Blocks
<input type="radio"/> 1/4"	<input type="radio"/> 5/8" x 5/8"	<input type="radio"/> 45°	<input type="radio"/> 1.00 MHz	<input type="radio"/> Techsonic	<input type="radio"/> IIW A2
<input type="radio"/> 3/8"	<input type="radio"/> 1/2" x 1"	<input type="radio"/> 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" x 1"	<input type="radio"/> 70°	<input checked="" type="radio"/> 5.00 MHz	<input type="radio"/> Krautkramer	<input type="radio"/> Back Reflection
<input type="radio"/>	<input type="radio"/>	<input 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	1.802	1.776	1.815
B	1.797	1.725	1.737
C	1.786	1.736	1.739

All Dimensions are in inches



FEB 28 2013

### Scanning

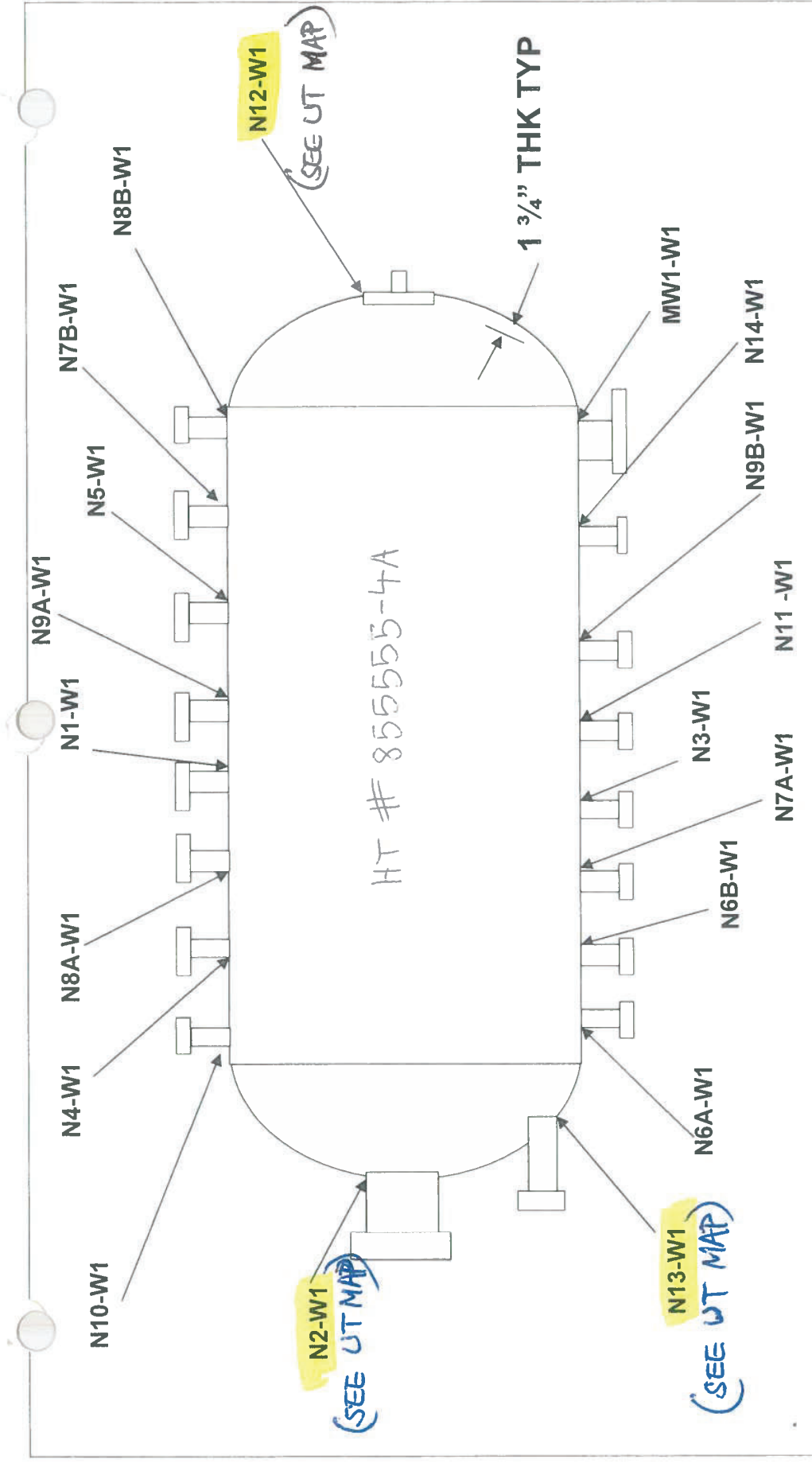
Test Area	Disposition	From	Length	Depth	Amplitude
				SBM	OFFSHORE

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: GRANESH SAHJI  
Print Name: GRANESH SAHJI  
Signature: [Signature]  
Date: 2/24/13  
Applus<sup>®</sup> VELIOSI  
Velosi Amara LLC

### Evaluation - Acceptance

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





<b>ALL-WELD CO. LTD. - RT MAP</b>	
CLIENT: ULTRAFAB	
WORK ORDER #: 1173PQ	SN 7475
JOB DESCRIPTION: 48" O.D. VERTICAL OUTLET	
DRAWING #: 1173-1-OU	
PREPARED BY: D.NESCI	
DATE: March 6, 2013	
<b>RT MAP - 1173PQ</b> <i>Conn's to shell weld</i> <b>ASME SECTION VIII. DIV. 1</b> MATERIAL SA-240 316/316L, SA-182 F316/316L P.O. 13-0225	

# KV Inspection Services Ltd.

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

## Ultrasonic Examination Report UT

### General Data

Customer	All-Weld Company	Date	April 4, 2013		
Shop Order	1173 PQ Serial # 7475	Project			
Component		P.O. #		Worksheet #:	36761
Drawing	Rev.	Technician	Frank Marunde	SNT-TC-1A Level	III
NDT Specification	ASTM 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			

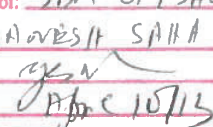
### Transducers/Calibration Blocks

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-7475: Examination of category D nozzle attachment welds  
 N2-W1 & N13-W1



ACCEPTED/REVIEWED/RELEASED 046  
 for and on behalf of: SIM OFFSHORE  
 Print Name: GAVESH SARA  
 Date: APR 04 2013  
  
**Applus<sup>®</sup> VELOSI**  
 Velosi America, LLC

### 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 # 7475	Project	
Component		P.O. #	Worksheet #: 36888
Drawing	Rev.	Technician	Frank Marunde SNT-TC-1A Level III
NDT Specification	ASME Sec. VIII	Appendix	12 NDT Procedure KV-UT# 1 R.02

### Technical Data – Ultrasonic Examination (UT)

Material Type	Stainless Steel	Technique	<input checked="" type="radio"/> Pulse Echo-Contact <input type="radio"/> Immersion <input type="radio"/> Dual
Material Thickness	1 3/4"	Instrument Brand	<input checked="" type="radio"/> Olympus Epoch 1000i <input type="radio"/> 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 <input type="radio"/> 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"/> 60° <input type="radio"/> 70° <input type="radio"/> Normal	<input type="radio"/> 1.00 MHz <input checked="" type="radio"/> 2.25 MHz <input type="radio"/> 5.00 MHz	<input type="radio"/> Techsonic <input checked="" type="radio"/> Panametrics <input type="radio"/> Krautkramer	<input type="radio"/> IIW A2 <input type="radio"/> ASTM E164 MAB <input type="radio"/> Back Reflection <input checked="" type="radio"/> ASME
<input type="radio"/> 3/8"	<input type="radio"/> 1"	<input type="radio"/> 1/2" x 1"				
<input checked="" type="radio"/> 1/2"	<input type="radio"/> 1 1/8"	<input type="radio"/> 1" x 1"				
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>				

### Scope of Testing

1173 PQ-7475: Examination of category D attachment welds N13-W1



NOV 18 2013

Per NCR N13-039

046

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Velosi America LLC

ACCEPTED/REVISED/RELEASED  
for and on behalf of: SBM OFF SITE NF

Print Name: GABRIEL SAHIL

Signature: *[Signature]*

Date: JUN 21 2013

### Scanning

Test Area	Disposition	From	Length	Depth	Amplitude	Date

### Evaluation – Acceptance

<input checked="" type="radio"/> Accepted	KV Inspection Services – Technician	<i>[Signature]</i>	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	October 15, 2013
Shop Order	1173PQ S/N7475	Project	
Component		P.O. #	Worksheet #: 37764
Drawing	Rev.	Technician	Frank Marunde SNT-TC-1A Level III
NDT Specification	ASME Sec VIII	Appendix	12 NDT Procedure KV-UT#1 Rev 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 <input type="radio"/> 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 <input type="radio"/> Temperature
Heat Treated	<input type="radio"/> YES <input type="radio"/> NO	Sensitivity (PRL)	48dB/ 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"/> Normal	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/> ASME

### Scope of Testing

Examination of category 'D' attachment weld

N12-W1



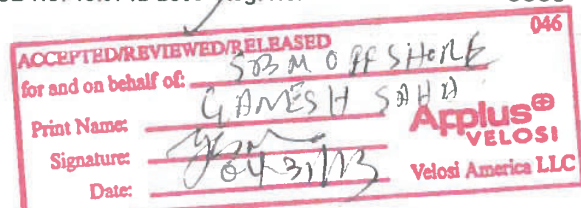
OCT 17 2013

### Scanning

Test Area	Disposition	From	Length	Depth	Amplitude
N12-W1			100% intermit	33mm	

### Evaluation – Acceptance

<input type="radio"/> Accepted	KV Inspection Services – Technician		Date	October 15, 2013
<input type="radio"/> Rejected	CGSB No. 48.9712-2000 Reg. No.	8885	Place	Scarborough, ON





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

## Ultrasonic Examination Report UT

### General Data

Customer	All-Weld Company	Date	October 21, 2013
Shop Order	1173PQ SN: 7475	Project	
Component		P.O. #	Worksheet #: 37867
Drawing	Rev.	Technician	Frank Marunde SNT-TC-1A Level III
NDT Specification	ASME SEC VIII	Appendix	12 NDT Procedure KV-UT#1 Rev 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)	48dB/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"/> Normal	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/> ASME

### Scope of Testing

*Per NCR N13-102*

Examination of nozzle attachment welds  
 Nozzle N12-W1 Repairs

**ACCEPTED/REVIEWED/RELEASED**  
 for and on behalf of: SBM OF IS/IB/IK  
 Print Name: GANESH SAHAI  
 Signature: [Signature]  
 Date: Oct 31/13  
**Applus<sup>®</sup> VELOSI**  
 Velosi America LLC



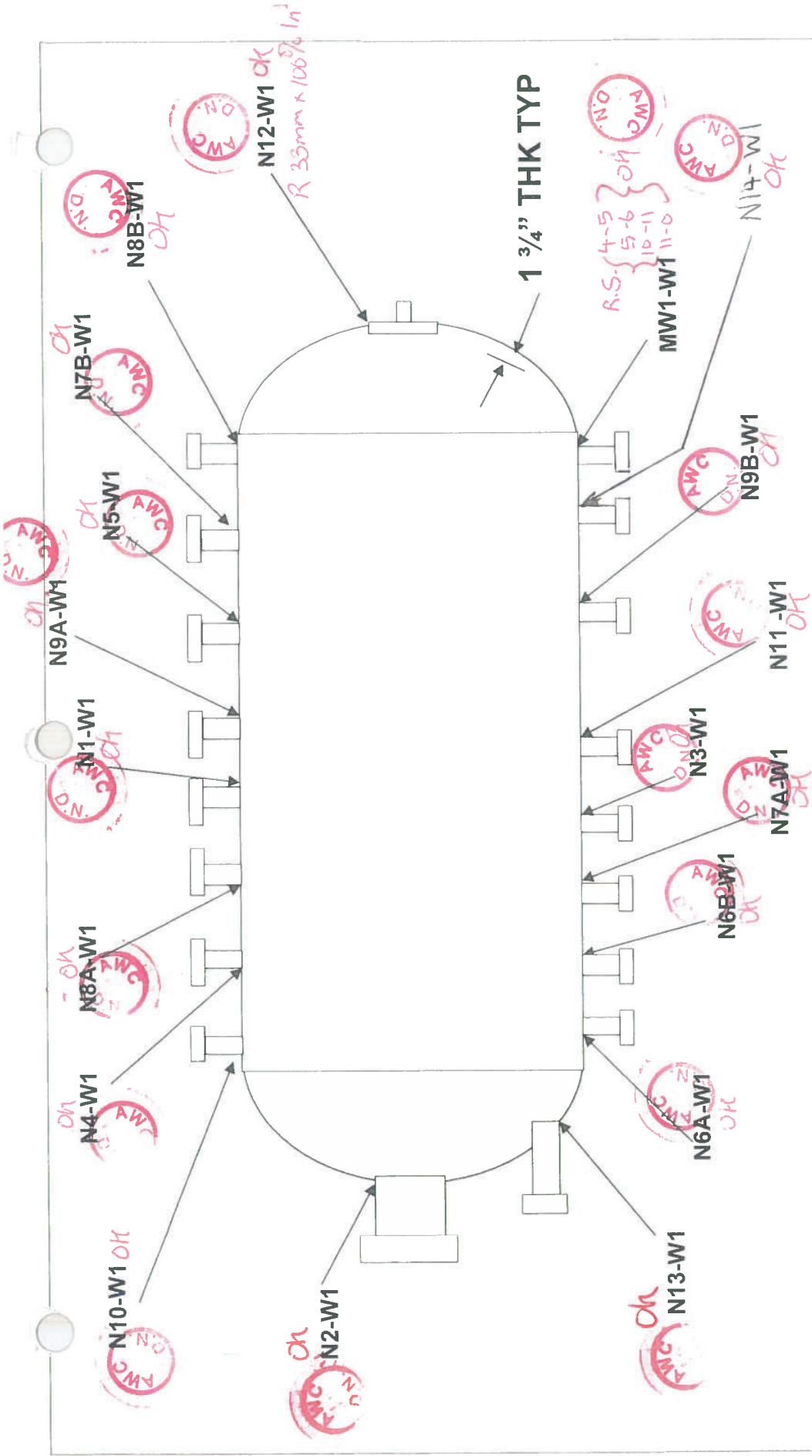
OCT 22 2013

### Scanning

Test Area	Disposition	From	Length	Depth	Amplitude

### Evaluation - Acceptance

<input checked="" type="radio"/> <b>Accepted</b>	KV Inspection Services - Technician	<u>[Signature]</u>	Date	October 21, 2013
<input type="radio"/> <b>Rejected</b>	CGSB No. 48.9712-2000 Reg. No.	8885	Place	Scarborough, ON



<b>ALL-WELD CO. LTD. - UT MAP</b>	
CLIENT: ULTRAFAB	UT MAP - 1173PQ
WORK ORDER #: 1173PQ	ASME SECTION VIII. DIV. 1
JOB DESCRIPTION: 48" O.D. VERTICAL OUTLET	MATERIAL SA-240 316/316L, SA-182 F316/316L
DRAWING #: 1173-1-OU	P.O. 13-0225
PREPARED BY: D.NESCI	
DATE: March 6, 2013	



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

**Radiographic Examination Report  
 RT**

**Specification - Acceptance Criteria**

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

**General Data**

Customer	ALL-WELD	Date	OCT. 2/13
Location	SCARBOROUGH	P. O. #	
Project	ULTRA-FAS	Shop Order #	1173 PQ-7475
Procedure	KV 5 Rev 3	Worksheet #	37751
Technician	C. Veeman	CGSB Reg #	6651
		ASNT/SNT-TC-1A Level	II

**Technical Data 660**

Material Type	Carbon	Alloys	Isotope	IR 192	Other	Physical/Focal Size	.199"
Base Material Thickness	1/4"		Exposure	Single Wall	Double Wall	Film per Cassette	1
Weld Thickness	"		View	Single Wall	Double Wall	PWHT	Yes (No)
Reinforcement	1/4"		Number of Exposures	3/4 pm			
Film Mfg.	KODAK		Minimum Source to Object Distance	21"			
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
N1-W1	1-2								/	
	2-3								/	
	3-4								/	
	4-1								/	
N4-W1	1-2								/	
	2-3								/	
	3-1								/	
N5-W1	1-2								/	
	2-3								/	
	3-1								/	
N6B-W1	1-2								/	
	2-3								/	
	3-1								/	

ACCEPTED/REVIEWED/RELEASED 046  
 for and on behalf of: SBM OFFSHORE  
 Print Name: ANNEST SAHA  
 Signature: [Signature]  
 Date: Oct 31/13  
**Applus**  
 VETOSI  
 Velosi America LLC

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

KV Inspection Technician	[Signature]	Date	OCT. 2/13
Customer Representative	[Signature]	Date	OCT 16 2013



# KV Inspection Services Ltd.

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

## Radiographic Examination Report RT

### Specification - Acceptance Criteria

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

### General Data

Customer	ALL-WORLD	Date	Oct. 5/13
Location	SCARBOROUGH	P. O. #	
Project	ULTRAFAB (CAT. 'B')	Shop Order #	1173 PG - 7475
Procedure	KV 5 PWT	Worksheet #	
Technician	C. Veeneman	CGSB Reg #	6651
		ASNT/SNT-TC-1A Level	II

### Technical Data

Material Type	Carbon <input type="radio"/> Alloys <input checked="" type="radio"/>	Isotope	IR 192 <input type="radio"/> Other <input checked="" type="radio"/>	Physical/Focal Size	.199"
Base Material Thickness	1 3/4"	Exposure	Single Wall <input checked="" type="radio"/> Double Wall <input type="radio"/>	Film per Cassette	1
Weld Thickness	"	View	Single Wall <input checked="" type="radio"/> Double Wall <input type="radio"/>	PWHT	Yes <input type="radio"/> No <input checked="" type="radio"/>
Reinforcement	2 1/4"	Number of Exposures			3 per
Film Mfg.	KODAK	Minimum Source to Object Distance			21"
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
N70-W1	1-2								/	
	2-3								/	
	3-1								/	
N80-W1	1-2								/	
	2-3								/	
	3-1								/	
N3-W1	1-2								/	
	2-3								/	
	3-1								/	
N90-W1	1-2								/	
	2-3								/	
	3-1								/	

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SBM OFFSHORE  
Print Name: GANESH SAHA  
Signature: [Signature]  
Date: Oct 3/13  
Applus® VELOSI  
Velosi America LLC

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

KV Inspection Technician

[Signature]

Date

Oct. 5/13

Customer Representative



Date

OCT 0 8 2013

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

**Radiographic Examination Report  
 RT**

**Specification - Acceptance Criteria**

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

**General Data**

Customer: ALL-WEED Date: OCT. 2/13  
 Location: SCARBOROUGH P. O. #  
 Project: ULTRA-FAB Shop Order # 1173 PQ-7475  
 Procedure: KV 5 ROV 3 Worksheet # 37751  
 Technician: C. Veeneeman CGSB Reg # 6651 ASNT/SNT-TC-1A Level II

**Technical Data**

Material Type: Carbon Alloys Isotope: IR 192 Other Physical/Focal Size: .199"  
 Base Material Thickness: 1 3/4" Exposure: Single Wall Double Wall Film per Cassette: 1  
 Weld Thickness: n View: Single Wall Double Wall PWHT: Yes No  
 Reinforcement: 1/4" Number of Exposures: 3/4 per  
 Film Mfg.: KODAK Minimum Source to Object Distance: 21"  
 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
<u>N7A-W1</u>	<u>1-2</u>								/	
	<u>2-3</u>								/	
	<u>3-1</u>								/	
<u>N8A-W1</u>	<u>1-2</u>								/	
	<u>2-3</u>								/	
	<u>3-1</u>								/	
<u>N9A-W1</u>	<u>1-2</u>								/	
	<u>2-3</u>								/	
	<u>3-1</u>								/	

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SAM OFFSHORE  
 Print Name: GANESH SAHA  
 Signature: [Signature]  
 Date: OCT 3/13  
 046  
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 VELOSI  
 Velosi America LLC

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

KV Inspection Technician

[Signature]

Date: OCT. 2/13

Customer Representative



Date: OCT 04 2013



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

**Radiographic Examination Report  
 RT**

**Specification - Acceptance Criteria**

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

**General Data**

Customer	Allweld	Date	10/15/13
Location	Scarborough	P. O. #	
Project	ULTRAFAB	Shop Order #	7475-1173 P2
Procedure	KV5 Rev 3	Worksheet #	37827
Technician	M Devon	CGSB Reg #	12283 ASNT/SNT-TC-1A Level 1

**Technical Data C660**

Material Type	Carbon <u>Alloys</u>	Isotope	IR 192 <u>Other</u>	Physical/Focal Size	.199
Base Material Thickness	1 3/4	Exposure	<u>Single Wall</u>	Double Wall	Film per Cassette 1
Weld Thickness	1 3/4	View	<u>Single Wall</u>	Double Wall	PWHT Yes <u>No</u>
Reinforcement	< 1/4"	Number of Exposures	3 per 3" Ø 4 per 8" Ø		
Film Mfg.	Kodak	Minimum Source to Object Distance	21"		
Film Type	MA	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
N/A-W1	A-B								✓	
	B-C								✓	
	C-A								✓	
N10-W1	A-B								✓	
	B-C								✓	
	C-A								✓	
N11-W1	A-B								✓	
	B-C								✓	
	C-A								✓	
N14-W1	1-2								✓	
	2-3								✓	
	3-4								✓	
	4-1								✓	

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SAM OFFSHORE  
 Print Name: GAMBESIA SAH A  
 Signature: [Signature]  
 Date: Oct 31/13  
 046  
**Arplus®**  
 VELOSI  
 Velosi America LLC

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

KV Inspection Technician

Date

Oct 15/13

Customer Representative

Date

OCT 17 2013



# KV Inspection Services Ltd.

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

## Radiographic Examination Report RT

### Specification - Acceptance Criteria

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

### General Data

Customer	AA Welds	Date	Oct 23/13
Location	SCARBOROUGH ONT	P. O. #	
Project	ULTRAFAB	Shop Order #	1173 Pd - 7475
Procedure	KW # 5 A. W. 3	Worksheet #	37916
Technician	M. PEARSON	CGSB Reg #	12283 ASNT/SNT-TC-1A Level I

### Technical Data

Material Type	Carbon <input checked="" type="checkbox"/> Alloys <input checked="" type="checkbox"/>	Isotope	IR 192 <input checked="" type="checkbox"/> Other <input checked="" type="checkbox"/>	Physical/Focal Size	13
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	+ FILLER	Number of Exposures	12		
Film Mfg.	KODAK	Minimum Source to Object Distance	22"		
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
MW I										
W1	0-1								-	
	1-2								✓	
	2-3								✓	
	3-4								✓	
	4-5								✓	R/S
	5-6								✓	N/S
	6-7								✓	
	7-8								✓	
	8-9								✓	
	9-10								✓	
	10-11								✓	
	11-12								✓	

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SAM OFFSHORE  
 Print Name: JAMESH SAHA  
 Signature: *[Signature]*  
 Date: Oct 23/13  
 046  
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 VELOSI  
 Velosi America LLC

ED DUTSCHAEVER  
 CGSB LEVEL II, Reg # 515  
 RT/MT/PT  
 SNT-TC-1A LEVEL III  
 RT/MT/PT  
 (NIP/PT)  
 (M/C)

KV Inspection Technician	Date	Oct 23/13
Customer Representative	Date	OCT 28 2013

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

# Radiographic Examination Report RT

## Specification - Acceptance Criteria

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

### General Data

Customer	AM WELD	Date	OCT 25/13
Location	SCARBOROUGH ONT	P. O. #	
Project	ULTRAFAB3	Shop Order #	1173 PQ-7475
Procedure	RTA 5 RW3	Worksheet #	37935
Technician	C VEENEMAN	CGSB Reg #	6651 ASNT/SNT-TC-1A Level II

### Technical Data

Material Type	Carbon <input type="checkbox"/> Alloys <input checked="" type="checkbox"/>	Isotope	IR 192 <input type="checkbox"/> Other <input checked="" type="checkbox"/>	Physical/Focal Size	13
Base Material Thickness	18/4	Exposure	Single Wall <input checked="" type="checkbox"/> Double Wall <input type="checkbox"/>	Film per Cassette	1
Weld Thickness	13/4	View	Single Wall <input checked="" type="checkbox"/> Double Wall <input type="checkbox"/>	PWHT	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>
Reinforcement	+ FILLER	Number of Exposures	4		
Film Mfg.	KODAK	Minimum Source to Object Distance	22"		
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
MW1										
1-1	4-5							LIMITED ACCESS	<input checked="" type="checkbox"/>	
	5-6								<input checked="" type="checkbox"/>	
	10-11								<input checked="" type="checkbox"/>	
	16-0								<input checked="" type="checkbox"/>	

046

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

Print Name: GANESH SAHA  
Signature: *[Signature]*  
Date: OCT 31/13

**Applus**  
VELOSI  
Velosi America LLC

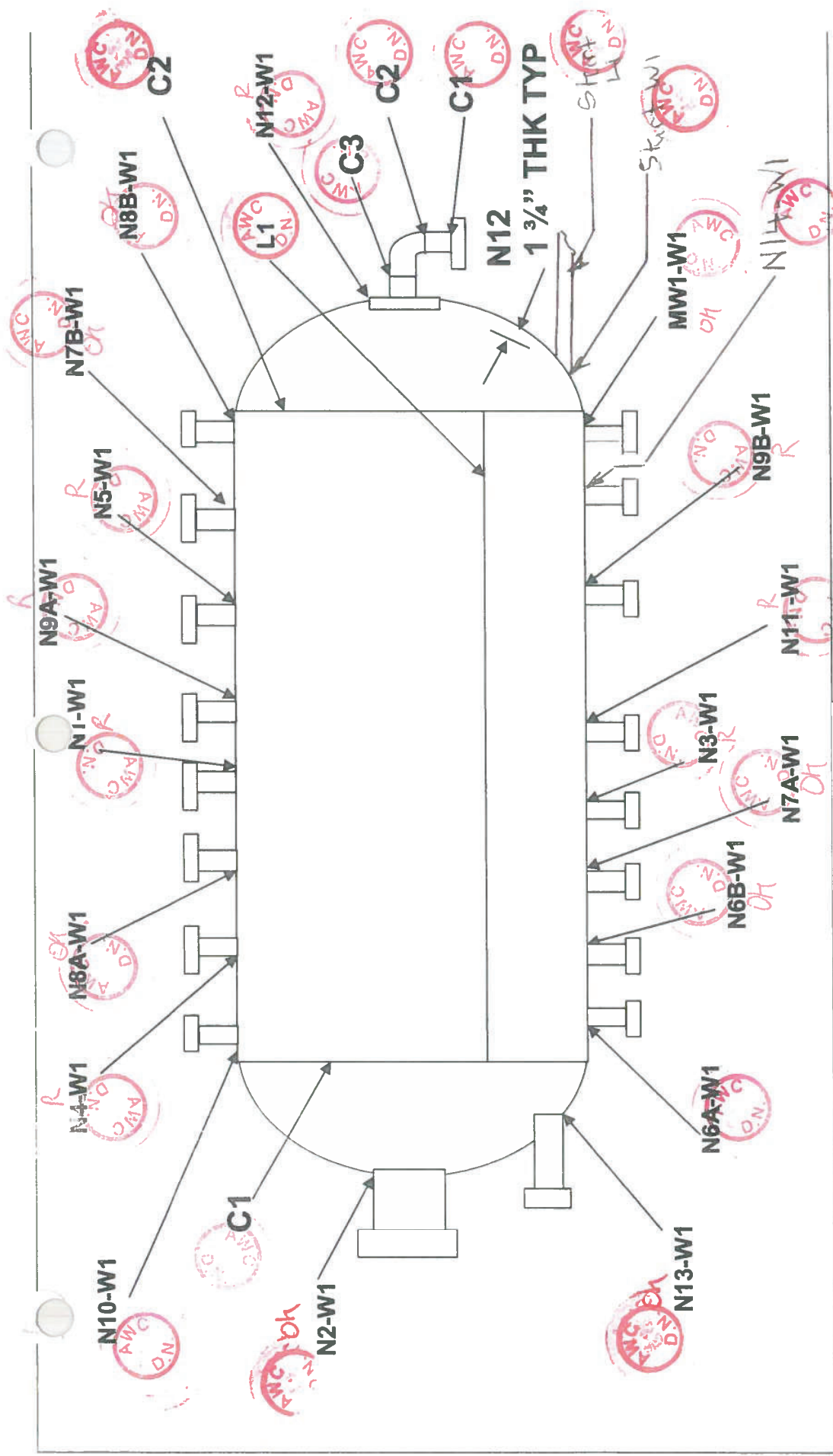
**CHRIS VEENEMAN**  
CGSB LEVEL II, REG.# 6651  
MT/PT/RT/UT  
SNT-TC-1A LEVEL II  
MT/PT/RT/UT

KV Inspection Technician  
Customer Representative

*[Signature]*

Date: OCT 25/13  
Date: OCT 28 2013





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

CLIENT: ULTRAFAB  
 WORK ORDER #: 1173PQ SN 7475  
 JOB DESCRIPTION: 48" O.D. VERTICAL OUTLET  
 DRAWING #: 1173-1-OU  
 PREPARED BY: D.NESCI  
 DATE: March 6, 2013

**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

# KV Inspection Services Ltd.

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

## Liquid Dye Penetrant Inspection Report PT

### Specification – Acceptance Criteria

As per ASME Sec. VIII Div. 1

### General Data

Customer	All-Weld Company	Date	March 12, 2013
Location	Scarborough, ON.	P. O. #	
Project	48" O.D. Vertical Outlet	Shop Order #	1173 PQ
Procedure	KV# 16 Rev. 03	Worksheet #	36630
Technician	Todd Campbell	CGSB Level II, Reg #	11748 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"/> Visible <input type="radio"/> Fluorescent	Light meter	
	<input type="radio"/> Chemetall Oakite 996		Type: EA31	
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 970P25E	<input type="radio"/> Water Washable <input type="radio"/> Solvent Removable	Serial #: 070706809	
	<input checked="" type="radio"/> Chemetall Oakite 9PR50		Intensity: 1200 Lx	
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B			

Lighting Equipment Description: Shop lights, Flashlight

### Inspection

Description: Saw

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

Serial #  
7475

Long seam – L1  
100% inspection  
(internal and external)

No relevant indications noted.  
Acceptable to specification

MIKE KAMYAR  
REVIEWED  
WITNESSED  
FOR:

046

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SBM OFFSHORE CORP

Print Name: GAWRESH SAHAI

Signature: [Signature]

Date: April 10 2013

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

KV Inspection Technician		Date	March 12, 2013
Customer Representative		Date	MAR 16 2013

# KV Inspection Services Ltd.

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

## Liquid Dye Penetrant Inspection Report PT

### Specification - Acceptance Criteria

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

### General Data

Customer	All-Weld Company	Date	April 17, 2013		
Location	Scarborough, ON.	P. O. #			
Project	Vessel	Shop Order #	1173 PQ		
Procedure	KV# 16 Rev. 03	Worksheet #	36853		
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	
---------------	------------------------------------	--	-----------------------------	--------------------	--

### Equipment & Method

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

Lighting Equipment Description: Shoplight and Headlamp

### Inspection

Description: 48" Vertical Separator

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

Ser# 7475	100% internal and external inspection of C2R & L1R		Acceptable to specification.
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MIKE KAMYAB  
REVIEWED  
WITNESSED  
FOR:

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

KV Inspection Technician

Date

April 17, 2013

Customer Representative

Date

APR 22 2013

# KV Inspection Services Ltd.

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

## Liquid Dye Penetrant Inspection Report PT

### Specification - Acceptance Criteria

As per ASME Sec. VIII DIV.1 Appx 8

### General Data

Customer	All-Weld Company	Date	October 2, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7475
Procedure	KV# 16 Rev. 03	Worksheet #	37734
Technician	Frank Marunde	CGSB Level II, Reg #	8885 ASNT/SNT-TC-1A Level II

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

Material Type    Carbon Steel    Stainless Steel    Other   Material Thickness

### Equipment & Method

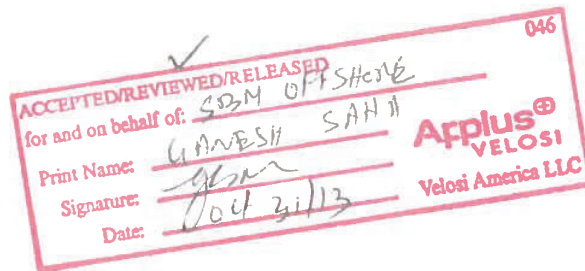
Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906 <input type="radio"/> Chemetall Oakite 996 <input type="radio"/> Chemetall Oakite 970P25E	<input checked="" type="radio"/> Visible <input type="radio"/> Fluorescent	Light meter Type: EA31
Cleaner	<input checked="" type="radio"/> Chemetall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

Lighting Equipment Description: Flashlight

### Inspection

#### Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
Ser#7475	Circ Seam C1 (interior & exterior)		Acceptable to specifications



KV Inspection Technician

*[Handwritten Signature]*

Date      October 2, 2013

Customer Representative

Date      OCT 07 2013



# KV Inspection Services Ltd.

1486 Wallace Road  
Oakville, Ontario L6L 2Y2  
Phone: 905-844-9448  
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## 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	October 9, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173PQ S/N 7475
Procedure	KV# 16 Rev. 03	Worksheet #	37760
Technician	Frank Marunde	CGSB Level II, Reg #	8885 ASNT/SNT-TC-1A Level II

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

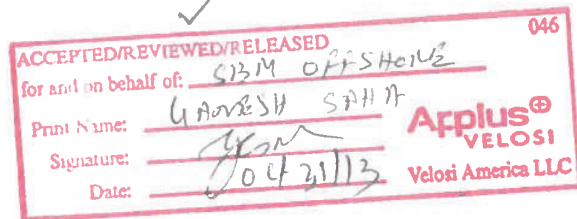
Material Type	<input type="radio"/> Carbon Steel <input checked="" type="radio"/> Stainless Steel <input type="radio"/> Other	Material Thickness	
<b>Equipment &amp; Method</b>			
Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906 <input type="radio"/> Chemetall Oakite 996 <input type="radio"/> Chemetall Oakite 970P25E	<input checked="" type="radio"/> Visible <input type="radio"/> Fluorescent	Light meter
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<input checked="" type="radio"/> Water Washable	Type: EA31
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable	Serial #: 07076803
Lighting Equipment Description: Flashlight			Intensity: 1400 Lx

### Inspection

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
Ser# 7475	C1 repair areas (see RT report)		Acceptable to specifications

Per NCR N13-097



KV Inspection Technician

*[Signature]*

Date

October 9, 2013

Customer Representative

Date

OCT 16 2013



# KV Inspection Services Ltd.

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

## Liquid Dye Penetrant Inspection Report PT

### Specification – Acceptance Criteria

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

#### General Data

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

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

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

#### 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		
	<input type="radio"/> Chemetall Oakite 970P25E		Serial #: 07076863	
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<input checked="" type="radio"/> Water Washable	Intensity: 2000	Lx
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable		

Lighting Equipment Description: Headlamp & Shoplighting

#### Inspection

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
Ser# 7475	Internal and external inspection of C2 R1 repair areas (1-2), (5-10)		Acceptable to specification.

MIKE KAMYAB  
 REVIEWED  
 WITNESSED  
 FOR:

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

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

# KV Inspection Services Ltd.

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

## Liquid Dye Penetrant Inspection Report PT

### Specification – Acceptance Criteria

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

### General Data

Customer	All-Weld Company	Date	May 7, 2013		
Location	Scarborough, ON.	P. O. #			
Project	Vertical Separator	Shop Order #	1173 PQ -7475		
Procedure	KV# 16 Rev. 03	Worksheet #	36980		
Technician	Chris Veeneman	CGSB Level II, Reg #	6651	ASNT/SNT-TC-1A Level	II

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

Material Type     Carbon Steel     Stainless Steel     Other    Material Thickness    1 3/4"

### Equipment & Method

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter	
	<input type="radio"/> Chemetall Oakite 996			
	<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 #: 07076863	
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable	Intensity: 1400	Lx

Lighting Equipment Description: Trouble Light

### Inspection

Description: Repair Areas Inside and Out

Item #	Description of Weld/Test Area	Defect Location	Interpretation
C2R1	6-7		Acceptable to specification
	8-9		Acceptable to specification

MIKE KAMYAN  
REVIEWED  
WITNESSED  
FOR:

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

KV Inspection Technician		Date	May 7, 2013
Customer Representative		Date	MAY 08 2013

# KV Inspection Services Ltd.

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 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	October 15, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173PQ S/N 7475
Procedure	KV# 16 Rev. 03	Worksheet #	37764
Technician	Frank Marunde	CGSB Level II, Reg #	8885 ASNT/SNT-TC-1A Level II

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

Material Type  Carbon Steel  Stainless Steel  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		
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<input checked="" type="radio"/> Water Washable	Type: EA31
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable	Serial #: 07076803
Lighting Equipment Description: Flashlight			Intensity: 1400 Lx

### Inspection

#### Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
Ser# 7475	Circumferential seam C2 (interior and exterior)		Acceptable to specifications

046
**ACCEPTED/REVIEWED/RELEASED**  
 for and on behalf of: SBM OFFSHORE  
 Print Name: WANESH SAHA  
 Signature: [Signature]  
 Date: 10/13/13  
**Applus®**  
VELOSI  
Velosi America LLC

KV Inspection Technician

*[Signature]*

Date

October 15, 2013

Customer Representative



Date

OCT 17 2013

# KV Inspection Services Ltd.

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

## Liquid Dye Penetrant Inspection Report PT

### Specification – Acceptance Criteria

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

#### General Data

Customer	All-Weld Company	Date	April 11, 2013		
Location	Scarborough, ON.	P. O. #			
Project	Vessel	Shop Order #	1173 PQ		
Procedure	KV# 16 Rev. 03	Worksheet #	36766		
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	Serial #: 07076863
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<input checked="" type="radio"/> Water Washable	Intensity: 1400 Lx	
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable		

Lighting Equipment Description: Flashlight

#### Inspection

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
Ser# 7475	Skirt W1 weld -interior and exterior		9 areas of bleed out indications on interior weld. Areas were repaired and re-tested and found acceptable to specification.
	Skirt L1 weld -interior and exterior		Acceptable to specification.

MIKE KAMYAB  
REVIEWED  
WITNESSED  
FOR:

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SBM OFF SHORE 046  
Print Name: GRANESH SAHA  
Signature: [Signature] **Applus<sup>®</sup> VELOSI**  
Date: July 5 13 **Velosi America LLC**

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



# KV Inspection Services Ltd.

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

## Liquid Dye Penetrant Inspection Report PT

### Specification - Acceptance Criteria

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

#### General Data

Customer	All-Weld Company	Date	April 04, 2013		
Location	Scarborough, ON.	P. O. #			
Project	Vessel	Shop Order #	1173 PQ		
Procedure	KV# 16 Rev. 03	Worksheet #	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	
---------------	------------------------------------	--	-----------------------------	--------------------	--

#### Equipment & Method

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter	
	<input type="radio"/> Chemetall Oakite 996		<input type="radio"/> Fluorescent	Type: EA31
	<input type="radio"/> Chemetall Oakite 970P25E			Serial #: 80613518
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<input checked="" type="radio"/> Water Washable	Intensity: 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
Ser# 7475	N2-W1 -nozzle attachment weld (exterior and interior)		Acceptable to specification.
	N13-W1 -nozzle attachment weld (exterior and interior)		Acceptable to specification.

MIKE KAMYAR  
 REVIEWED  
 WITNESSED  
 FOR:

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBM OFFSHORE GULF 046  
 Print Name: CHAVESH SAHA  
 Signature: [Signature]  
 Date: APR 11 2013  
**Applus®**  
 VELOSI  
 Velosi America LLC

KV Inspection Technician

Date

April 04, 2013

Customer Representative

Date

APR 09 2013



# KV Inspection Services Ltd.

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

## Liquid Dye Penetrant Inspection Report PT

### Specification - Acceptance Criteria

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

#### General Data

Customer	All-Weld Company	Date	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	
---------------	------------------------------------	--	-----------------------------	--------------------	--

#### 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	
	<input type="radio"/> Chemetall Oakite 970P25E		
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# 7475	N13-W1 attachment weld (interior and exterior)		Acceptable to specification.
-----------	--	--	------------------------------

Per NCR N13-039

MIKE KAMYAR  
REVIEWED  
WITNESSED  
FOR:

ACCEPTED/REVIEWED/RELEASED 046  
for and on behalf of: SBM OFF SITE  
Print Name: GRANESH SAHAI  
Signature: [Signature]  
Date: JUN 13 2013  
Applus® VELOSI  
Velosi America LLC

KV Inspection Technician

*[Signature]*

Date

April 30, 2013

Customer Representative



Date

MAY 07 2013

# KV Inspection Services Ltd.

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

## Liquid Dye Penetrant Inspection Report PT

### Specification - Acceptance Criteria

As per ASME Sec. VIII DIV.1 Appx 8

### General Data

Customer	All-Weld Company	Date	September 26, 2013		
Location	Scarborough, ON	P. O. #			
Project		Shop Order #	1173 PQ S/N 7475		
Procedure	KV# 16 Rev. 03	Worksheet #			
Technician	Frank Marunde	CGSB Level II, Reg #	8885	ASNT/SNT-TC-1A Level	II

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

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

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter	
	<input type="radio"/> Chemetall Oakite 996	<input type="radio"/> Fluorescent	Type: EA31	
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 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

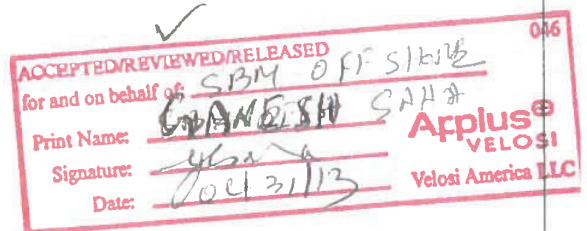
Lighting Equipment Description: Flashlight

### Inspection

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
1)	Nozzle attachment welds N3-W1 and N11-W1 (interior and exterior)	As Marked	Unacceptable, indications detected (interior and exterior)
2)	Nozzle attachment welds N5-W1 (interior and exterior)	As marked	Unacceptable undercut detected (interior)
3)	Nozzle attachment welds N4-W1, N1-W1, N9A-W1, N9B-W1, N12-W1 (interior and exterior)	As Marked	Unacceptable indications detected (exterior)
4)	Nozzle attachment welds N6B-W1, N7A-W1, N7B-W1, N8A-W1, N8B-W1 (interior and exterior)		Acceptable to specifications

MIKE KAMYAB  
REVIEWED  
WITNESSED  
FOR.



KV Inspection Technician		Date	September 26, 2013
Customer Representative		Date	OCT 01 2013

# KV Inspection Services Ltd.

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

## Liquid Dye Penetrant Inspection Report PT

### Specification - Acceptance Criteria

As per ASME Sec. VIII DIV.1 Appx 8

#### General Data

Customer	All-Weld Company	Date	September 30, 2013		
Location	Scarborough, ON	P. O. #			
Project		Shop Order #	1173 PQ S/N 7475		
Procedure	KV# 16 Rev. 03	Worksheet #	37595		
Technician	Frank Marunde	CGSB Level II, Reg #	8885	ASNT/SNT-TC-1A Level	II

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

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

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter	
	<input type="radio"/> Chemetall Oakite 996			
	<input type="radio"/> Chemetall Oakite 970P25E		<input type="radio"/> Fluorescent	
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 #7475	Nozzle attachment welds N3-W1, N11-W1, N5-W1, N4-W1, N1-W1, N9A-W1, N9B-W1, N12-W1 (repair areas)		Acceptable to specifications

MIKE KAMYAB  
 REVIEWED  
 WITNESSED  
 FOR

046

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBM OFFSHORE  
 Print Name: DANESH SAHA  
 Signature: [Signature]  
 Date: OCT 31 2013  
**Applus®**  
 VELOSI  
 Velosi America LLC

KV Inspection Technician		Date	September 30, 2013
Customer Representative		Date	OCT 02 2013

# KV Inspection Services Ltd.

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

## Liquid Dye Penetrant Inspection Report PT

### Specification - Acceptance Criteria

As per ASME Sec. VIII DIV.1 Appx 8

### General Data

Customer	All-Weld Company	Date	October 21, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173PQ S/N 7475
Procedure	KV# 16 Rev. 03	Worksheet #	37765
Technician	Frank Marunde	CGSB Level II, Reg #	8885 ASNT/SNT-TC-1A Level II

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

Material Type  Carbon Steel  Stainless Steel  Other Material Thickness

### 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 checked="" type="radio"/> Water Washable	Type: EA31
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable	Serial #: 07076803
Lighting Equipment Description: Flashlight			Intensity: 1400 Lx

### Inspection

Description: *Per NCR N13-102*

Item #	Description of Weld/Test Area	Defect Location	Interpretation
Ser# 7475	Nozzle attachment weld N12-W1 (interior & exterior)		Acceptable to specifications
	Item 6/4 - manway cover welds		Acceptable to specifications

ACCEPTED/REVIEWED/RELEASED 046  
 for and on behalf of: *SBM OFFSHORE*  
 Print Name: *GARRETH SAHAR*  
 Signature: *[Signature]*  
 Date: *Oct 31 2013*  
**Applus<sup>®</sup> VELOSI**  
 Velosi America LLC

KV Inspection Technician *[Signature]* Date October 21, 2013

Customer Representative *[Signature]* Date *Oct 23 2013*



# KV Inspection Services Ltd.

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

## Liquid Dye Penetrant Inspection Report PT

### Specification - Acceptance Criteria

As per ASME Sec. VIII DIV.1 Appx 8

### General Data

Customer	All-Weld Company	Date	October 15, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173PQ S/N 7475
Procedure	KV# 16 Rev. 03	Worksheet #	37764
Technician	Frank Marunde	CGSB Level II, Reg #	8885 ASNT/SNT-TC-1A Level II

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

Material Type  Carbon Steel  Stainless Steel  Other Material Thickness

### Equipment & Method

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

Lighting Equipment Description: Flashlight

### Inspection

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
Ser# 7475	Nozzle attachment welds N6A-W1, N10-W1, N14-W1 (interior and exterior)		Acceptable to specifications

✓

ACCEPTED/REVIEWED/RELEASED 046

for and on behalf of: SSM OFFSHORE

Print Name: GARRETH SAHFF

Signature: [Signature]

Date: OCT 21/13

**Applus®**  
VELOSI  
Velosi America LLC

KV Inspection Technician

[Signature]

Date

October 15, 2013

Customer Representative



Date

OCT 17 2013



# KV Inspection Services Ltd.

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

## Liquid Dye Penetrant Inspection Report PT

### Specification - Acceptance Criteria

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

### General Data

Customer	All-Weld Company	Date	August 13, 2013		
Location	@ KV Inspection, Oakville, ON	P. O. #			
Project	Ultrafab	Shop Order #	1173 PQ 7475		
Procedure	KV# 16 Rev. 03	Worksheet #	37436		
Technician	Ed Duitschaever	CGSB Level II, Reg #	515	ASNT/SNT-TC-1A Level	III

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

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

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter
	<input type="radio"/> Chemetall Oakite 996		
	<input type="radio"/> Chemetall Oakite 970P25E		
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<input checked="" type="radio"/> Water Washable	Serial #: 80613518
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable	Intensity: 1300 Lx

Lighting Equipment Description: Shop & Exterior Lighting

### Inspection

Description: Nozzle 12

Item #	Description of Weld/Test Area	Defect Location	Interpretation
SN# 7475	C1 - 2"Ø Butt weld		Acceptable to specification
	C2 - 2"Ø Butt weld		Acceptable to specification

MIKE KAMYAB  
REVIEWED  
WITNESSED  
FOR:

ACCEPTED/REVIEWED/RELEASED 046  
for and on behalf of: CBM OFFSHORE  
Print Name: HARESH SAHJI  
Signature: [Signature]  
Date: 10/13/13  
**Applus<sup>®</sup> VELOSI**  
Velosi America LLC

KV Inspection Technician	<u>[Signature]</u>	Date	August 13, 2013
Customer Representative	<u>[Signature]</u> <b>AWC D.N.</b>	Date	AUG 14 2013

# KV Inspection Services Ltd.

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

## Liquid Dye Penetrant Inspection Report PT

### Specification - Acceptance Criteria

As per ASME Sec. VIII DIV.1 Appx 8

### General Data

Customer	All-Weld Company	Date	October 23, 2013
Location	Scarborough, ON	P. O. #	
Project	Ultrafab	Shop Order #	1173PQ S/N 7475
Procedure	KV# 16 Rev. 03	Worksheet #	37924
Technician	Chris Veeneman	CGSB Level II, Reg #	6651 ASNT/SNT-TC-1A Level II

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

Material Type  Carbon Steel  Stainless Steel  Other Material Thickness

### 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"/> Chemetall Oakite 9D1B	<input checked="" type="radio"/> Water Washable <input type="radio"/> Solvent Removable	Type: EA31
Developer			Serial #: 07076803
Lighting Equipment Description: Trouble light			Intensity: 1400 Lx

### Inspection

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
N12 C3	Nozzle Weld		Acceptable to specifications
MW1-W1	CAT 'D' Manway		Acceptable to specifications
19/2 to N1	Elbow Weld		Acceptable to specifications
26/2	Internal Clip to Shell		Acceptable to specifications
1/7	Internal Ring Welds		Acceptable to specifications
6/7	Internal Ring Welds		Acceptable to specifications

ACCEPTED/REVIEWED/RELEASED 046  
 for and on behalf of: SBM OFFSHORE  
 Print Name: GANESH SAHA  
 Signature: [Signature]  
 Date: 2013/10/23  
**Applus<sup>®</sup> VELOSI**  
 Velosi America LLC

KV Inspection Technician		Date	October 23, 2013
Customer Representative		Date	OCT 28 2013

# KV Inspection Services Ltd.

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

## Liquid Dye Penetrant Inspection Report PT

### Specification - Acceptance Criteria

As per ASME Sec. VIII DIV.1 Appx 8

### General Data

Customer	All-Weld Company	Date	October 29, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173PQ S/N 7475
Procedure	KV# 16 Rev. 03	Worksheet #	37874
Technician	Frank Marunde	CGSB Level II, Reg #	8885 ASNT/SNT-TC-1A Level II

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

Material Type     Carbon Steel     Stainless Steel     Other    Material Thickness

### Equipment & Method

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

Lighting Equipment Description: Flashlight

### Inspection

Description: *Per NCR N13-105*

Item #	Description of Weld/Test Area	Defect Location	Interpretation
	N12-C3 Weld		Acceptable to specification

046

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: *SIBM OFFSHORE*  
 Print Name: *WONESH SAHA*  
 Signature: *[Signature]*  
 Date: *Oct 31 2013*  
**Applus<sup>®</sup>**  
**VELOSI**  
 Velosi America LLC

KV Inspection Technician

*[Signature]*

Date

October 29, 2013

Customer Representative

Date

# KV Inspection Services Ltd.

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

## Liquid Dye Penetrant Inspection Report PT

### Specification - Acceptance Criteria

As per ASME Sec. VIII DIV.1 Appx 8

#### General Data

Customer	All-Weld Company	Date	October 22, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173PQ S/N 7475
Procedure	KV# 16 Rev. 03	Worksheet #	37869
Technician	Frank Marunde	CGSB Level II, Reg #	8885 ASNT/SNT-TC-1A Level II

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

Material Type  Carbon Steel  Stainless Steel  Other Material Thickness

#### Equipment & Method

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter	
	<input type="radio"/> Chemetall Oakite 996			<input type="radio"/> Fluorescent
	<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
Ser# 7475	Manway attachment weld MW1-W1 (Interior & Exterior)		Acceptable to specifications

ACCEPTED/REVIEWED/RELEASED 046

for and on behalf of: SIBM OFFSHORE

Print Name: GRANBISH SAH

Signature: [Signature]

Date: Oct 21/13

**Applus®**  
VELOSI  
Velosi America LLC

KV Inspection Technician

*[Signature]*

Date

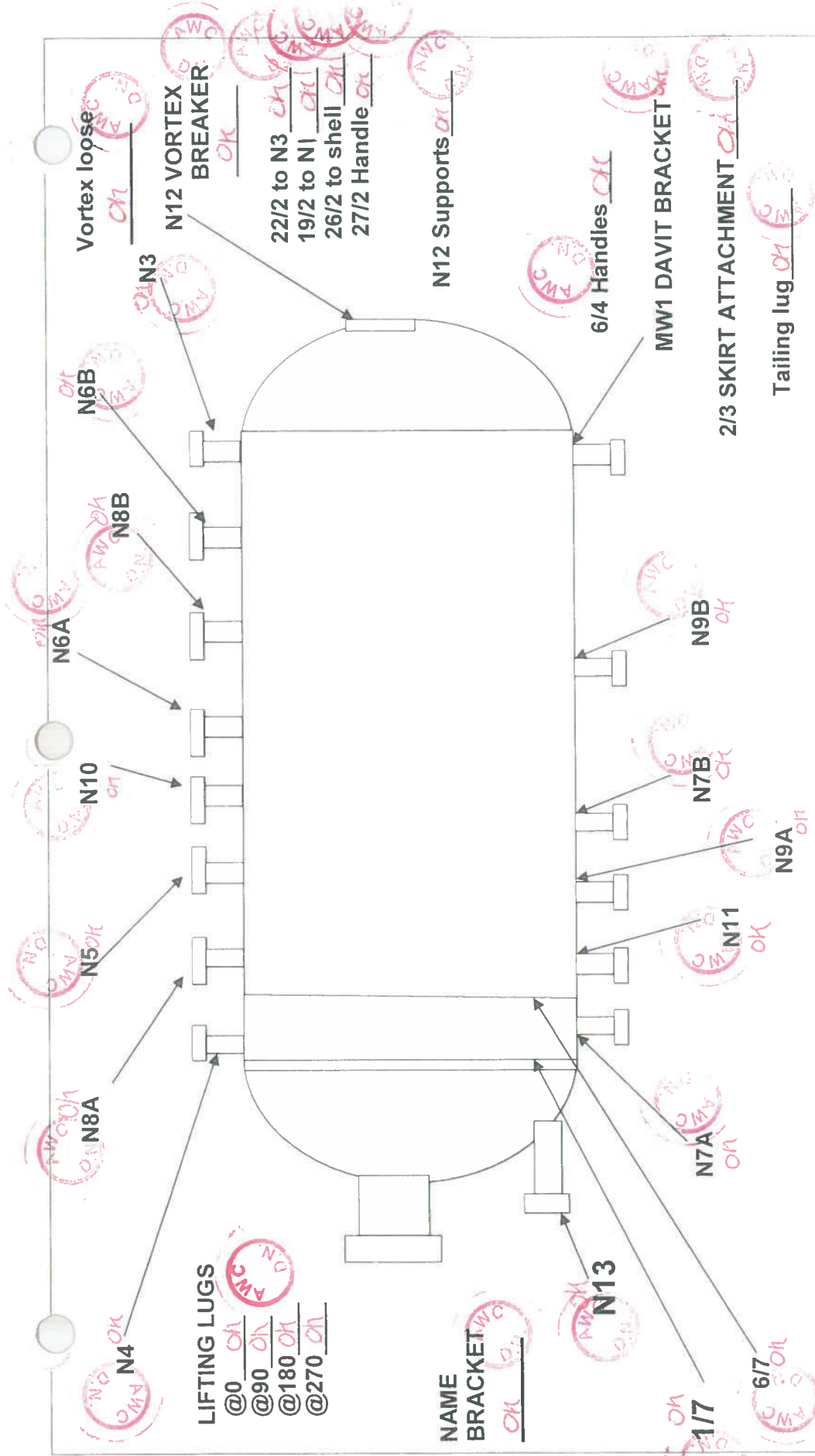
October 22, 2013

Customer Representative



Date

OCT 28 2013



PT MAP - 1173PQ  
 ASME SECTION VIII. DIV. 1  
 ATTACHMENTS / BRACKETS  
 MATERIAL SA-240 316/316L  
 P.O.

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

CLIENT: ULTRAFAB  
 WORK ORDER #: 1173PQ SN 7475  
 JOB DESCRIPTION: 48" O.D. VERTICAL OUTLET  
 DRAWING #: 1173-1-IN  
 PREPARED BY: D.NESCI  
 DATE: March 6, 2013



# KV Inspection Services Ltd.

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

## Liquid Dye Penetrant Inspection Report PT

Specification - Acceptance Criteria

As per ASME Sec. VIII DIV.1 Appx 8

### General Data

Customer	All-Weld Company	Date	October 31, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173PQ S/N7475
Procedure	KV# 16 Rev. 03	Worksheet #	37959
Technician	John MacDonald	CGSB Level II, Reg #	10375 ASNT/SNT-TC-1A Level II

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

Material Type  Carbon Steel  Stainless Steel  Other Material Thickness Various

### 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"/> Chemetall Oakite 9D1B	<input checked="" type="radio"/> Water Washable <input type="radio"/> Solvent Removable	Type: EA31
Developer			Serial #: 07076803
			Intensity: 1400

Lighting Equipment Description: Flashlight

### Inspection

Description: Nozzle attachment bracket

Item #	Description of Weld/Test Area	Defect Location	Interpretation
N3	Attachment bracket welds		Acceptable to specifications
N6A	Attachment bracket welds		Acceptable to specifications
N6B	Attachment bracket welds		Acceptable to specifications
N7A	Attachment bracket welds		Acceptable to specifications
N7B	Attachment bracket welds		Acceptable to specifications
N11	Attachment bracket welds		Acceptable to specifications
Tailing Lug	100% attachment welds		Acceptable to specifications
Davit Bracket MW1	100% attachment welds		Acceptable to specifications
27/2 Handle	100% attachment welds		Acceptable to specifications

046  
 ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SAH  
 Print Name: SAH  
 Signature: [Signature]  
 Date: NOV 12/13  
**Applus®**  
**VELOSI**  
 Velosi America LLC

KV Inspection Technician

Date October 31, 2013

Customer Representative

Date NOV 04 2013



# KV Inspection Services Ltd.

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

## Liquid Dye Penetrant Inspection Report PT

### Specification – Acceptance Criteria

As per ASME Sec. VIII DIV.1 Appx 8

### General Data

Customer	All-Weld Company	Date	October 29, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173PQ S/N 7475
Procedure	KV# 16 Rev. 03	Worksheet #	37874
Technician	Frank Marunde	CGSB Level II, Reg #	8885 ASNT/SNT-TC-1A Level II

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

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

### Equipment & Method

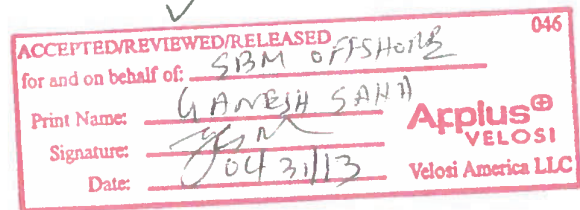
Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter
	<input type="radio"/> Chemetall Oakite 996	<input type="radio"/> Fluorescent	Type: EA31
	<input type="radio"/> Chemetall Oakite 970P25E	<input checked="" type="radio"/> Water Washable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

Lighting Equipment Description: Flashlight

### Inspection

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
1)	Nozzle support welds; N4, N5, N8A, N8B, N9A, N9B, N10, N12, N13		Acceptable to specifications
2)	Name plate bracket attachment weld		Acceptable to specifications
3)	Vortex breaker to shell weld		Acceptable to specifications
4)	Item 22/2-N3 weld		Acceptable to specifications



KV Inspection Technician

Date

October 29, 2013

Customer Representative

Date



# KV Inspection Services Ltd.

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

## Liquid Dye Penetrant Inspection Report PT

### Specification - Acceptance Criteria

As per ASME Sec. VIII DIV.1 Appx 8

### General Data

Customer	All-Weld Company	Date	October 1, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7475
Procedure	KV# 16 Rev. 03	Worksheet #	37733
Technician	Frank Marunde	CGSB Level II, Reg #	8885 ASNT/SNT-TC-1A Level II

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

Material Type  Carbon Steel  Stainless Steel  Other Material Thickness

### Equipment & Method

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter Type: EA31 Serial #: 07076802 Intensity: 1400 Lx
	<input type="radio"/> Chemetall Oakite 996	<input type="radio"/> Fluorescent	
	<input type="radio"/> Chemetall Oakite 970P25E		
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<input checked="" type="radio"/> Water Washable	
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
Ser#7475	Vortex breaker welds (loose)		Acceptable to specifications

046

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SBM OFFSHORE  
Print Name: GANESH SANA  
Signature: [Signature]  
Date: NOV 12 2013  
**Applus<sup>®</sup> VELOSI**  
Velosi America LLC

KV Inspection Technician

*[Signature]*

Date

October 1, 2013

Customer Representative



Date

NOV 08 2013

# KV Inspection Services Ltd.

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

## Liquid Dye Penetrant Inspection Report PT

Specification - Acceptance Criteria

As per ASME Sec. VIII DIV.1 Appx 8

### General Data

Customer	All-Weld Company	Date	October 7, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7475
Procedure	KV# 16 Rev. 03	Worksheet #	37758
Technician	Frank Marunde	CGSB Level II, Reg #	8885 ASNT/SNT-TC-1A Level II

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

Material Type  Carbon Steel  Stainless Steel  Other Material Thickness

### 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 checked="" type="radio"/> Water Washable	Type: EA31
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable	Serial #: 07076803
Lighting Equipment Description: Flashlight			Intensity: 1400 Lx

### Inspection

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
Ser#7475	Lifting lug attachment welds (x4)		Acceptable to specifications

✓

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBM OFFSHORE  
 Print Name: VIJAYESH SAHA  
 Signature: [Signature]  
 Date: Oct 31/13

046

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


KV Inspection Technician

Date October 7, 2013

Customer Representative

Date Oct 8 2013

*[Signature]*



# KV Inspection Services Ltd.

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

## Liquid Dye Penetrant Inspection Report PT

### Specification – Acceptance Criteria

As per ASME Sec. VIII DIV.1 Appx 8

### General Data

Customer	All-Weld Company	Date	November 8, 2013		
Location	Scarborough, ON	P. O. #			
Project		Shop Order #	1173PQ S/N 7475		
Procedure	KV# 16 Rev. 03	Worksheet #	37879		
Technician	Frank Marunde	CGSB Level II, Reg #	8885	ASNT/SNT-TC-1A Level	II

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

Material Type     Carbon Steel     Stainless Steel     Other    Material Thickness

### Equipment & Method

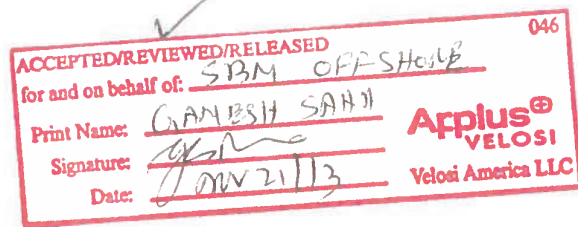
Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter	
	<input type="radio"/> Chemetall Oakite 996			<input type="radio"/> Fluorescent
	<input type="radio"/> Chemetall Oakite 970P25E			Type: EA31
Cleaner	<input checked="" type="radio"/> Chemetall 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
Ser# 7475	Item 2 /3 skirt attachment weld (Interior and Exterior)		Acceptable to specifications



KV Inspection Technician

*[Handwritten Signature]*

Date

November 8, 2013

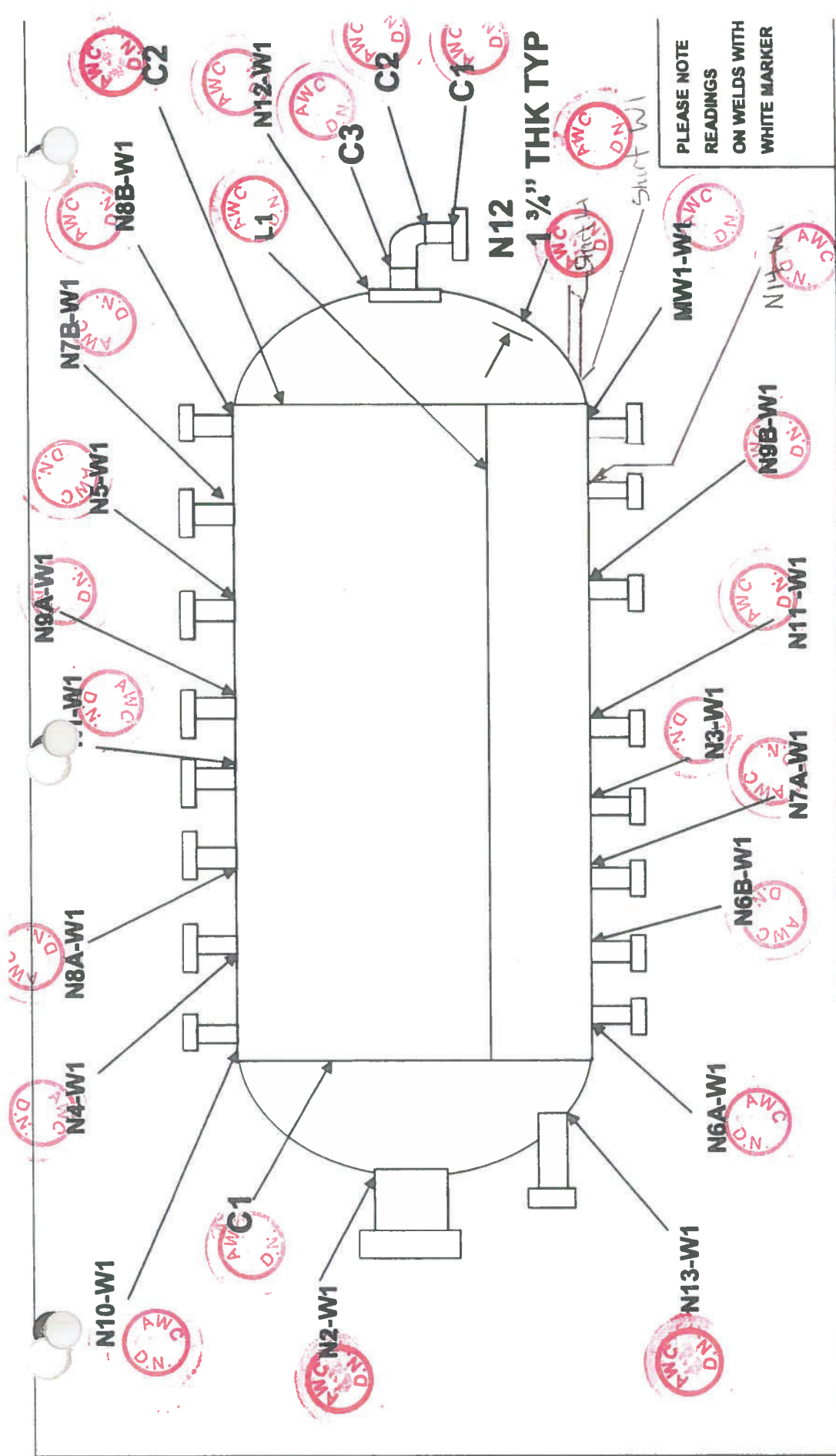
Customer Representative



Date

NOV 18 2013





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

CLIENT: ULTRAFAB

WORK ORDER #: 1173PQ

JOB DESCRIPTION: 48" O.D. VERTICAL OUTLET

DRAWING #: 1173-1-OU

PREPARED BY: D.NESCI

DATE: March 6, 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)  
240 HV10 MAX.

P.O. 13-0228

# KV Inspection Services Ltd.

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

## Hardness Testing Report HT

### Specification – Acceptance Criteria

248 HV

### General Data

Customer	All-Weld Company	Date	March 12, 2013
Location	Scarborough, Ontario	P. O. #	
Project	Vertical Separator	Shop Order #	1173 PQ
Procedure	KV HT# 50	Worksheet #	36630
Technician	John MacDonald	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 10375

### Technical Data – Hardness Testing (HT)

Material

### 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 # 7475 – L1	Parent Material	222
	H.A.Z	229
	Weld	244
	H.A.Z	224
	Parent Material	227

046

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBM OFFSHORE  
 Print Name: CHRISTOPHER SAH  
 Signature: [Signature] **Applus®**  
 Date: APR 10 2013 **VELOSI**  
 Velosi America LLC

KV Inspection Technician

Date

March 12, 2013

Customer Representative

Date

MAR 14 2013



# KV Inspection Services Ltd.

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

## Hardness Testing Report HT

### Specification – Acceptance Criteria

248 HV Max

### General Data

Customer	All-Weld Company	Date	April 17, 2013
Location	Scarborough, Ontario	P. O. #	
Project	Vessel	Shop Order #	1173 PQ
Procedure	KV HT# 35 Rev. 00	Worksheet #	36853
Technician	John MacDonald	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 10375

### Technical Data – Hardness Testing (HT)

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

### Test Method & Equipment

Technique	<input checked="" type="radio"/> Impact Load – Digital Readout
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# 7475	C2R	234	200	163	158	192
	L1R	209	203	149	189	193

046

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBM OFFSHORE  
 Print Name: GANESH SATHI  
 Signature: [Signature]  
 Date: July 5 2013  
**Applus®**  
**VELOSI**  
 Velosi America LLC

KV Inspection Technician		Date	April 17, 2013
Customer Representative		Date	APR 22 2013

# KV Inspection Services Ltd.

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	October 2, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7475
Procedure	KV HT# 35 Rev.00	Worksheet #	37734
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# 7475	C1	212	210	191	150	144

046

ACCEPTED/REVIEWED/RELEASED

for and on behalf of: SBM OFFSHORE

Print Name: GAVESH SAHJ

Signature: [Signature]

Date: OCT 31/13

Applus<sup>®</sup>  
VELOSI

Velosi America LLC

KV Inspection Technician		120	October 2, 2013
Customer Representative		Date	OCT 07 2013



# KV Inspection Services Ltd.

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	October 9, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7475
Procedure	KV HT# 35 Rev.00	Worksheet #	37760
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# 7475	C1	221	218	178	165	148

Per NCR N13-097

046

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBM OFFSHORE  
 Print Name: GABRIEL SAHJ  
 Signature: [Signature]  
 Date: Oct 31/13

**Applus®**  
 VELOSI  
 Velosi America LLC

KV Inspection Technician

*[Signature]*

Date: October 9, 2013

Customer Representative



Date: OCT 16 2013

**Hardness Testing Report  
 HT**

**Specification – Acceptance Criteria**

**General Data**

<b>Customer</b>	All-Weld Company	<b>Date</b>	October 15, 2013
<b>Location</b>	Scarborough, ON	<b>P. O. #</b>	
<b>Project</b>		<b>Shop Order #</b>	1173 PQ S/N 7475
<b>Procedure</b>	KV HT# 35 Rev.00	<b>Worksheet #</b>	37764
<b>Technician</b>	Frank Marunde	<b>HT Certified</b>	<input checked="" type="checkbox"/> CGSB Reg # 8885

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

**Material** 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# 7475	C2	197	200	176	175	157

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: S&W OFF SITE  
 Print Name: GARY BISH SAHJ  
 Signature: [Signature]  
 Date: OCT 31 13  
**Applus®**  
**VELOSI**  
 Velos America LLC

<b>KV Inspection Technician</b>		<b>Date</b>	October 15, 2013
<b>Customer Representative</b>		<b>Date</b>	OCT 17 2013

# KV Inspection Services Ltd.

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 19, 2013
Location	Scarborough, Ontario	P. O. #	
Project	Vessel	Shop Order #	1173 PQ
Procedure	KV HT# 50	Worksheet #	36645
Technician	John MacDonald	HT Certified	✓ 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: Skirt to Head Weld

Item #	Description of Test Area	Readings
Serial # 7475	Parent Material	221
Skirt to Head Weld	H.A.Z	224
	Weld	241
	H.A.Z	243
	Parent Material	238
<div style="border: 2px solid red; padding: 5px; display: inline-block;"> <p>ACCEPTED/REVIEWED/RELEASED <span style="float: right;">046</span>                      for and on behalf of: <u>SPM OFFSHORE INC</u>                      Print Name: <u>CANDICE SAH</u>                      Signature: <u>[Signature]</u> <b>Applus®</b>                      Date: <u>April 10 13</u> <b>VELOSI</b>                      Velosi America LLC</p> </div>		

KV Inspection Technician	<u>[Signature]</u>	Date	March 19, 2013
Customer Representative	<u>[Signature]</u> 	Date	MAR 21 2013

# KV Inspection Services Ltd.

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 30, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7475
Procedure	KV HT# 35 Rev.00	Worksheet #	37595
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

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

Material	Stainless Steel		
<b>Test Method &amp; Equipment</b>			
Technique	<input checked="" type="radio"/> Impact Load - Digital Readout <input type="radio"/> Impact Load - Ocular Viewing		046 <b>ACCEPTED/REVIEWED/RELEASED</b> for and on behalf of: SBM OFF SITE Print Name: YAMBSH SAHAI Signature: [Signature] Date: 10/1/13 <b>Applus®</b> <b>VELOSIT</b> Velos America LLC
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: W1

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7475	N1	207	190	140	152	153
	N3	209	225	151	159	179
	N4	215	176	166	203	220
	N5	229	193	164	175	166
	N6B	192	182	157	178	175
	N7A	186	200	152	176	171
	N7B	221	194	143	181	198
	N8A	178	175	164	185	190
	N8B	217	182	158	175	220
	N9A	226	196	154	159	155
	N9B	235	214	157	179	194

KV Inspection Technician

[Signature]  
[Red Stamp]

120

September 30, 2013

Customer Representative

Date

OCT 02 2013



# KV Inspection Services Ltd.

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
<b>Test Method &amp; Equipment</b>	
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# 7475	N2-W1	177	167	142	183	174
	N13-W1	182	204	144	179	168
	Skirt-L1	175	173	141	172	154

046

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

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

# KV Inspection Services Ltd.

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

## Hardness Testing Report HT

Specification - Acceptance Criteria

248 HV Max

### General Data

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

### Technical Data - Hardness Testing (HT)

Material	Stainless Steel		
<b>Test Method &amp; Equipment</b>			
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# 7475	N13-W1	195	213	153	177	159

Per NCR N13-039

ACCURATELY REVIEWED/RELEASED  
 for use on behalf of: SCH OFF SHORE 046  
 Print Name: GANESH SAHA  
 Signature: [Signature]  
 Date: July 8 2013  
**Applus<sup>®</sup>**  
**VELOSI**  
 Velosi America LLC

KV Inspection Technician	<u>[Signature]</u>	Date	April 30, 2013
Customer Representative	<u>[Signature]</u>	Date	MAY 07 2013



# KV Inspection Services Ltd.

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	October 15, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7475
Procedure	KV HT# 35 Rev.00	Worksheet #	37764
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# 7475	N6A	218	186	144	161	198
	N10	225	190	184	169	168
	N14	210	209	169	185	192

046

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBM OFFSHORE  
 Print Name: GARVEST SAHA  
 Signature: [Signature]  
 Date: OCT 31/13  
**Applus®**  
**VELOSI**  
 Velosi America LLC

KV Inspection Technician [Signature] Date: October 15, 2013  
 Customer Representative [Signature] Date: OCT 17 2013

# KV Inspection Services Ltd.

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 30, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7475
Procedure	KV HT# 35 Rev.00	Worksheet #	37595
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

Technical Data - Hardness Testing (HT)			
Material	Stainless Steel		
Test Method & Equipment			
Technique	<input checked="" type="radio"/> Impact Load - Digital Readout <span style="margin-left: 100px;"><input type="radio"/> Impact Load - Ocular Viewing</span>		
Equipment	<input checked="" type="radio"/> Equotip D Impact Device		
Readings Taken	<input type="radio"/> Average of 5 readings <span style="margin-left: 20px;"><input checked="" type="radio"/> Average of 3 readings</span> <span style="margin-left: 20px;"><input type="radio"/> Other</span>		
Scale	<input type="radio"/> Brinell Hardness <span style="margin-left: 50px;"><input checked="" type="radio"/> HV</span>	Unit Setting:	

Inspection						
Description: $\sqrt{1}$						
Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7475	N11	221	193	148	191	183
	N12	179	169	160	179	167

046

ACCEPTED/REVIEWED/RELEASED



for and on behalf of: SBM OF SHOCK

Print Name: G. W. B. SH S. H. H.

Signature: [Signature]

Date: Oct 31 2013

**Applus®**  
VELOSI  
Velosi America LLC

KV Inspection Technician		120	September 30, 2013
Customer Representative		Date	OCT 02 2013



# KV Inspection Services Ltd.

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	October 21, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7475
Procedure	KV HT# 35 Rev.00	Worksheet #	37867
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

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

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

#### Inspection

Description:

*Per NCR N13-102*

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7475	N12-W1	194	190	127	211	190
	Item 6/4 Manway #1	166	180	134	215	207
	Item 6/4 Manway #2	174	184	132	188	204
	Item 6/4 Manway #3	187	171	164	180	191
	Item 6/4 Manway #4	166	164	143	186	200

046

**ACCEPTED/REVIEWED/RELEASED**  
 for and on behalf of: *SBM OAFS Heil*  
 Print Name: *GANESH SAHAI*  
 Signature: *[Signature]*  
 Date: *Oct 31 13*

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

KV Inspection Technician

*[Signature]*

Date October 21, 2013

Customer Representative



Date OCT 22 2013

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 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#7475
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		
<b>Test Method &amp; Equipment</b>			
Technique	<input checked="" type="radio"/> Impact Load – Digital Readout <input type="radio"/> Impact Load – Ocular Viewing		
Equipment	<input checked="" type="radio"/> Equotip D Impact Device		
Readings Taken	<input type="radio"/> Average of 5 readings <input checked="" type="radio"/> Average of 3 readings <input type="radio"/> Other		
Scale	<input checked="" type="radio"/> Brinell Hardness <input type="radio"/> Other		

### Inspection

Description:

Item #	Description of Test Area	Parent Material Flange	HAZ	Weld	HAZ	Parent Material
Ser# 7475	N12 – C1	156	148	158	162	154
	N12 – C2	145	142	148	151	187

ACCEPTED/REVIEWED/RELEASED


for and on behalf of: SBM OFF SHORE

Print Name: GARRETT SAHA

Signature: [Signature]

Date: 04/31/13

**Applus**  
VELO  
Velos America

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

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

## Hardness Testing Report HT

### Specification – Acceptance Criteria

### General Data

Customer	All-Weld Company	Date	October 23, 2013
Location	Scarborough, ON	P. O. #	
Project	Ultrafab	Shop Order #	1173 PQ S/N 7475
Procedure	KV HT# 35 Rev.00	Worksheet #	37924
Technician	Chris Veeneman	HT Certified	✓ CGSB Reg # 6651

### 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
Scale	<input type="radio"/> Brinell Hardness	<input checked="" type="radio"/> HV
	Unit Setting:	248 VIC Max

### Inspection

#### Description:

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
N12 C3	2" Nozzle weld	145	153	134	163	170
MW1-W1	Manway CAT 'D'	194	211	184	203	189
19-2 to N1	Elbow Weld	154	163	160	159	149
26/2 to Shell	Internal Clip	193	189	160	162	149
1/7	Internal Ring	192	193	170	168	153
6/7	Internal Ring	190	186	162	160	160

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SOM off SHORE  
Print Name: C. AWESH SAH  
Signature: [Signature]  
Date: 04/31/13  
Applus VELOS  
Velosi America L

KV Inspection Technician

[Signature]

Date: October 23, 2013

Customer Representative



Date: OCT 28 2013

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

### Specification – Acceptance Criteria

#### General Data

Customer	All-Weld Company	Date	October 29, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7475
Procedure	KV HT# 35 Rev.00	Worksheet #	37874
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

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

Material: Stainless Steel

#### Test Method & Equipment

Technique:  Impact Load – Digital Readout       Impact Load – Ocular Viewing  
 Equipment:  Equotip D Impact Device  
 Readings Taken:  Average of 5 readings       Average of 3 readings       Other  
 Scale:  Brinell Hardness       HV      Unit Setting: \_\_\_\_\_

#### Inspection

Description:

*Per NCR N13-105*

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
	N12-C3	142	132	183	161	143
	Vortex Breaker-Shell	158	174	171	173	155
	Item 22/2-N3	146	150	134	132	145
	N12 Support Welds					
	#1	128	135	140	165	156
	#2	133	121	176	137	163
	#3	160	184	145	129	147
	#4	165	<input checked="" type="checkbox"/> 149	151	139	125

ACCEPTED/REVIEWED/RELEASED 046  
 for and on behalf of: SIBON OFF SHELF  
 Print Name: GRANESH SAHJI  
 Signature: [Signature]  
 Date: Oct 31 2013  
**Applus®**  
**VELOSI**  
 Velosi America LLC

KV Inspection Technician

*[Signature]*

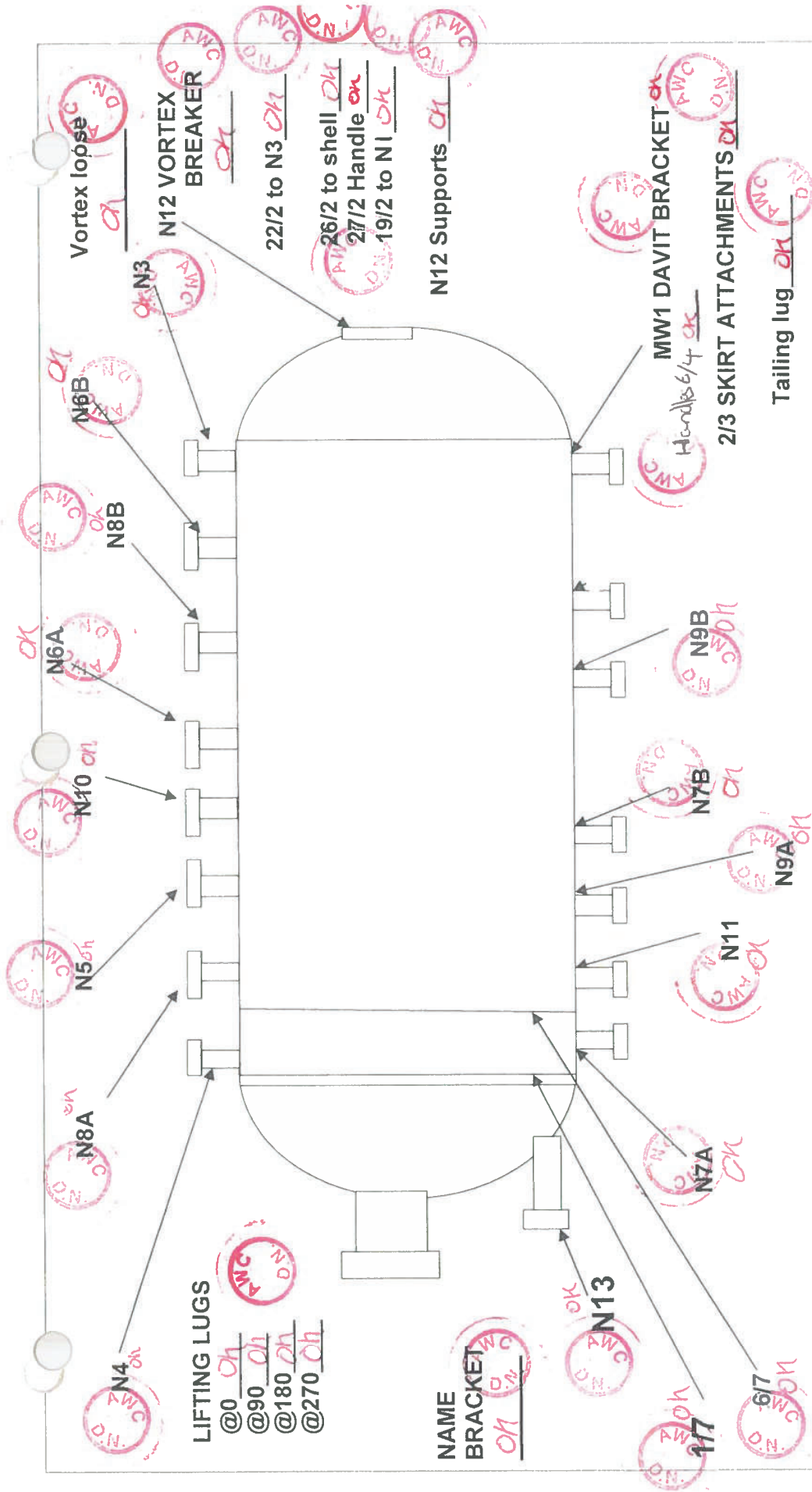
Date: October 29, 2013

Customer Representative



Date: Oct 31 2013





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

CLIENT: ULTRAFAB

WORK ORDER #: 1173PQ SN 7475

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.



# KV Inspection Services Ltd.

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

## Hardness Testing Report HT

### Specification – Acceptance Criteria

Max 248V

#### General Data

Customer	All-Weld Company	Date	October 31, 2013
Location	Scarborough, ON	P. O. #	
Project	Vessel	Shop Order #	1173 PQ S/N 7475
Procedure	KV HT# 35 Rev.00	Worksheet #	37959
Technician	John MacDonald	HT Certified	✓ CGSB Reg # 10375

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

Material 316

#### 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:

046  
 ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SORM OFFSHORE  
 Print Name: GUYBETH SAHJI  
 Signature: [Signature]  
 Date: NOV 21/13  
**Applus®**  
**VELOS**  
 Velori America LLC

#### Inspection

Description: Nozzle N3

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7475	N3					
	0° Bracket/Shell-#1	239	181	147	159	100
	0° Bracket/Shell -#2	239	190	186	201	224
	0° Bracket/Nozzle-#1	197	189	148	162	194
	0° Bracket/Nozzle-#2	206	190	170	178	215
	90° Bracket/Shell-#1	236	185	156	172	214
	90° Bracket/Shell-#2	221	173	168	179	194
	90° Bracket/Nozzle-#1	201	184	143	188	217
	90° Bracket/Nozzle-#2	211	178	189	102	197

KV Inspection Technician

Date October 31, 2013

Customer Representative

Date NOV 04 2013



# KV Inspection Services Ltd.

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	October 29, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7475
Procedure	KV HT# 35 Rev.00	Worksheet #	37874
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:

046  
 ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SIBAL OFF SHORE  
 Print Name: CHAMEL SAHJI  
 Signature: [Signature]  
 Date: Oct 31 2013  
**Applus**  
**VELOSI**  
 Veloci America LLC

#### Inspection

Description:

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
	N4 Support weld					
#1		189	175	177	169	142
#2		185	161	165	129	118
#3		179	163	173	151	124
#4		170	152	192	157	121
	N5 Support weld					
#1		210	173	190	167	172
#2		202	185	184	147	144
#3		146	176	145	151	156
#4		157	185	152	150	147

KV Inspection Technician

Date: October 29, 2013

Customer Representative

Date: OCT 31 2013



# KV Inspection Services Ltd.

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

## Hardness Testing Report HT

### Specification – Acceptance Criteria

Max 248V

### General Data

Customer	All-Weld Company	Date	October 31, 2013
Location	Scarborough, ON	P. O. #	
Project	Vessel	Shop Order #	1173 PQ S/N 7475
Procedure	KV HT# 35 Rev.00	Worksheet #	37959
Technician	John MacDonald	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 10375

### Technical Data – Hardness Testing (HT)

Material 316

### 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:

046  
 ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SIMM OFFSHORE  
 Print Name: JAMES H. SMITH  
 Signature: *[Signature]*  
 Date: 30/11/13  
**Applus**  
**VELOSI**  
 Veloci America LLC

### Inspection

Description: Nozzle N6A

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7475	N6A					
	0° Bracket/Shell-#1	213	186	142	159	196
	0° Bracket/Shell-#2	210	170	160	138	203
	0° Bracket/Nozzle-#1	201	173	178	161	215
	0° Bracket/Nozzle-#2	221	188	156	170	209
	90° Bracket/Shell-#1	231	177	148	163	210
	90° Bracket/Shell-#2	211	109	144	138	217
	90° Bracket/Nozzle-#1	198	156	136	130	176
	90° Bracket/Nozzle-#2	98	161	182	189	184

KV Inspection Technician

Date October 31, 2013

Customer Representative

Date





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

## Hardness Testing Report HT

### Specification – Acceptance Criteria

Max 248V

### General Data

Customer	All-Weld Company	Date	October 31, 2013
Location	Scarborough, ON	P. O. #	
Project	Vessel	Shop Order #	1173 PQ S/N 7475
Procedure	KV HT# 35 Rev.00	Worksheet #	37959
Technician	John MacDonald	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 10375

### Technical Data – Hardness Testing (HT)

Material 316

### 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:	

046  
 ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SAW OFF SHORE  
 Print Name: John MacDonald  
 Signature: [Signature]  
 Date: Nov 21 13  
**APOLUS®**  
**VELOSI**  
 Veloci America LLC

### Inspection

Description: Nozzle N6B

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7475	N6B					
	0° Bracket/Shell-#1	215	211	145	143	84
	0° Bracket/Shell -#2	96	142	136	171	183
	0° Bracket/Nozzle-#1	216	127	148	182	184
	0° Bracket/Nozzle-#2	220	178	153	196	175
	90° Bracket/Shell-#1	228	201	167	149	84
	90° Bracket/Shell-#2	83	148	186	158	235
	90° Bracket/Nozzle-#1	201	173	173	167	173
	90° Bracket/Nozzle-#2	210	190	181	186	186

KV Inspection Technician

Date October 31, 2013

Customer Representative

Date



# KV Inspection Services Ltd.

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

## Hardness Testing Report HT

### Specification – Acceptance Criteria

Max 248V

### General Data

Customer	All-Weld Company	Date	October 31, 2013
Location	Scarborough, ON	P. O. #	
Project	Vessel	Shop Order #	1173 PQ S/N 7475
Procedure	KV HT# 35 Rev.00	Worksheet #	37959
Technician	John MacDonald	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 10375

### Technical Data – Hardness Testing (HT)

Material 316

### 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:	

046  
 ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBM O.P.S. H&ME  
 Print Name: GANESH SAHA  
 Signature: *[Signature]*  
 Date: Nov 12/13  
**Applus®**  
**VELOS!**  
 Velos America LLC

### Inspection

Description: Nozzle N7A

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7475	N7A					
	0° Bracket/Shell-#1	210	170	84	194	96
	0° Bracket/Shell -#2	98	186	136	172	214
	0° Bracket/Nozzle-#1	200	201	148	210	186
	0° Bracket/Nozzle-#2	172	186	171	170	198
	90° Bracket/Shell-#1	201	180	148	191	186
	90° Bracket/Shell-#2	172	156	163	178	198
	90° Bracket/Nozzle-#1	211	193	185	180	201
	90° Bracket/Nozzle-#2	189	172	187	163	210

KV Inspection Technician

Date October 31, 2013

Customer Representative

Date NOV 04 2013



**Hardness Testing Report  
HT**

**Specification – Acceptance Criteria**

**Max 248V**

**General Data**

<b>Customer</b>	All-Weld Company	<b>Date</b>	October 31, 2013
<b>Location</b>	Scarborough, ON	<b>P. O. #</b>	
<b>Project</b>	Vessel	<b>Shop Order #</b>	1173 PQ S/N 7475
<b>Procedure</b>	KV HT# 35 Rev.00	<b>Worksheet #</b>	37959
<b>Technician</b>	John MacDonald	<b>HT Certified</b>	✓ CGSB Reg # 10375

046  
 ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SABM OFFSHORE  
 Print Name: LAURENCE S. H. H.  
 Signature: [Signature]  
 Date: NOV 12 2013  
**Applus**  
**VELOSI**  
 Velocity America LLC

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

**Material** 316

**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              Unit Setting:

**Inspection**

**Description:** Nozzle N7B

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7475	N7B					
	0° Bracket/Shell-#1	230	136	156	180	176
	0° Bracket/Shell -#2	86	196	148	173	190
	0° Bracket/Nozzle-#1	200	173	160	138	182
	0° Bracket/Nozzle-#2	196	184	178	142	180
	90° Bracket/Shell-#1	215	186	170	173	201
	90° Bracket/Shell-#2	199	149	136	152	197
	90° Bracket/Nozzle-#1	188	190	186	195	172
	90° Bracket/Nozzle-#2	190	181	170	173	186

KV Inspection Technician

**Date** October 31, 2013

Customer Representative

**Date** NOV 04 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	October 29, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7475
Procedure	KV HT# 35 Rev.00	Worksheet #	37874
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:

046  
 ACCEPTED FOR RELEASE  
 for and on behalf of: SOBAM OFFSHORE  
 Print Name: G MARUNDE SA (H.A.)  
 Signature: [Signature]  
 Date: OCT 31 2013  
**APPLUS**  
 VELOSI  
 Weld America LLC

#### Inspection

Description:

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
	N8A Support Weld					
#1		209	165	191	158	132
#2		204	167	198	157	145
#3		167	152	201	127	125
#4		166	143	203	154	129
	N8B Support Weld					
#1		214	183	154	158	137
#2		210	196	179	141	155
#3		161	137	144	123	148
#4		167	154	146	161	180

KV Inspection Technician

*[Signature]*

Date: October 29, 2013

Customer Representative



Date

OCT 31 2013



# KV Inspection Services Ltd.

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	October 29, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7475
Procedure	KV HT# 35 Rev.00	Worksheet #	37874
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:

046  
 ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SOBAM ONTARIO  
 Print Name: GAVESHI SORANI  
 Signature: *[Signature]*  
 Date: Oct 31 2013  
**APPLUS®**  
**VELOSI**  
 Velosi America LLC

#### Inspection

Description:

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
	N9A Support Weld					
#1		201	163	189	135	132
#2		211	179	163	143	151
#3		146	137	167	162	174
#4		158	149	142	154	143
	N9B Support Weld					
#1		200	203	154	161	143
#2		206	195	146	167	157
#3		209	190	162	153	128
#4		199	154	145	164	136

KV Inspection Technician

*[Signature]*

Date

October 29, 2013

Customer Representative



Date

Oct 31 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	October 29, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7475
Procedure	KV HT# 35 Rev.00	Worksheet #	37874
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:	

046  
 ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBM OFF SAHORE  
 Print Name: G. JAMES H. SAHORE  
 Signature: *[Signature]*  
 Date: 10/29/13  
**Applus®**  
**VELOSI**  
 Velocity America LLC

#### Inspection

Description:

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
	N10 Support Weld					
	#1	205	148	186	183	136
	#2	201	168	184	176	137
	#3	194	155	176	130	138
	#4	173	155	148	164	129
	N13 Support Weld					
	#1	149	140	180	139	160
	#2	154	150	152	137	132
	#3	175	150	179	141	128
	#4	155	141	146	139	151
	Name plate Bracket	181	N/A	149	137	132

KV Inspection Technician

*[Signature]*

Date: October 29, 2013

Customer Representative



Date: OCT 31 2013

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

**Hardness Testing Report  
 HT**

**Specification – Acceptance Criteria**

**Max 248V**

**General Data**

<b>Customer</b>	All-Weld Company	<b>Date</b>	October 31, 2013
<b>Location</b>	Scarborough, ON	<b>P. O. #</b>	
<b>Project</b>	Vessel	<b>Shop Order #</b>	1173 PQ S/N 7475
<b>Procedure</b>	KV HT# 35 Rev.00	<b>Worksheet #</b>	37959
<b>Technician</b>	John MacDonald	<b>HT Certified</b>	✓ CGSB Reg # 10375

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

**Material** 316

**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
<b>Scale</b>	<input type="radio"/> Brinell Hardness	<input checked="" type="radio"/> HV
		<b>Unit Setting:</b>

046  
 ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SPSM OFFSHORE  
 Print Name: GANESH SAHOO  
 Signature: *[Signature]*  
 Date: 10/31/13  
**Applus**  
**VELOSI**  
 Veloci America LLC

**Inspection**

**Description:** Nozzle N11

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7475	N11					
	0° Bracket/Shell-#1	210	186	129	172	191
	0° Bracket/Shell -#2	217	200	108	184	209
	0° Bracket/Nozzle-#1	196	194	172	187	205
	0° Bracket/Nozzle-#2	173	163	156	193	199
	90° Bracket/Shell-#1	197	183	170	194	193
	90° Bracket/Shell-#2	186	169	143	172	172
	90° Bracket/Nozzle-#1	210	186	182	174	212
	90° Bracket/Nozzle-#2	199	147	200	198	203

**KV Inspection Technician**

**Date**

October 31, 2013

**Customer Representative**

**Date**

NOV 04 2013



# KV Inspection Services Ltd.

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	October 1, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7475
Procedure	KV HT# 35 Rev.00	Worksheet #	37733
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# 7475	Vortex breaker loose	109	144	105	163	147

✓

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SOM OFF STORE 046  
 Print Name: GANESH SAH  
 Signature: [Signature]  
 Date: OCT 2 2013  
**Applus®**  
**VELOSI**  
 Velosi America LLC

KV Inspection Technician	<i>[Signature]</i>	120	October 1, 2013
Customer Representative		Date	OCT 02 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	October 7, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7475
Procedure	KV HT# 35 Rev.00	Worksheet #	37758
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
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# 7475	Lifting lug					
	0°	140	144	152	164	151
	90°	152	137	180	159	132
	180°	136	160	130	140	130
	270°	155	155	133	161	170

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SAM OFF SHORE  
 Print Name: CAWESHA SAHA  
 Signature: [Signature]  
 Date: 10/4/2013  
046  
**Applus®**  
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 Velosi America LLC

KV Inspection Technician

120

October 7, 2013

Customer Representative

Date

OCT 09 2013



**Hardness Testing Report  
HT**

**Specification – Acceptance Criteria**

**Max 248V**

**General Data**

Customer	All-Weld Company	Date	October 31, 2013
Location	Scarborough, ON	P. O. #	
Project	Vessel	Shop Order #	1173 PQ S/N 7475
Procedure	KV HT# 35 Rev.00	Worksheet #	37959
Technician	John MacDonald	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 10375

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

Material 316

**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: **Davit Bracket**

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7475	0° Top Weld	193	173	145	197	192
	90° Front Weld	213	184	165	176	205
	180° Bottom Weld	166	210	127	178	177
	360° Back Weld	177	167	114	159	171

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBM OFFSHORE  
 Print Name: CHAVESH SAHA  
 Signature: [Signature]  
 Date: NOV 14 2013  
046  
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 Velosi America LLC

KV Inspection Technician	Date	October 31, 2013
Customer Representative	Date	NOV 04 2013



# KV Inspection Services Ltd.

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

## Hardness Testing Report HT

### Specification – Acceptance Criteria

Max 248V

### General Data

Customer	All-Weld Company	Date	October 31, 2013
Location	Scarborough, ON	P. O. #	
Project	Vessel	Shop Order #	1173 PQ S/N 7475
Procedure	KV HT# 35 Rev.00	Worksheet #	37959
Technician	John MacDonald	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 10375

### Technical Data – Hardness Testing (HT)

Material	316
----------	-----

### 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: Tailing Lug

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7475	Tailing Lug #1	147	156	179	163	148
	Tailing Lug #1	155	154	168	163	170

✓

ACCEPTED/REVIEWED/RELEASED

for and on behalf of: SBM OFFSHORE

Print Name: GABRIEL SANA

Signature: [Signature]

Date: NOV 12 2013

046

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

KV Inspection Technician	Date	October 31, 2013
Customer Representative	Date	NOV 04 2013



# KV Inspection Services Ltd.

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

## Hardness Testing Report HT

### Specification - Acceptance Criteria

Max 248V

### General Data

Customer	All-Weld Company	Date	October 31, 2013
Location	Scarborough, ON	P. O. #	
Project	Vessel	Shop Order #	1173 PQ S/N 7475
Procedure	KV HT# 35 Rev.00	Worksheet #	37959
Technician	John MacDonald	HT Certified	✓ CGSB Reg # 10375

### Technical Data - Hardness Testing (HT)

#### Material

### 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 <span style="float: right;">Unit Setting:</span>

### Inspection

Description: Skirt Attachment <sup>2/3</sup>

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7475	0°	183	131	137	126	135
	90°	196	148	142	133	170
	180°	201	173	158	162	169
	360°	189	190	134	148	203

046

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SBM OFFSHORE  
Print Name: CAVESH SANA  
Signature: [Signature]  
Date: NOV 14 2013

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

KV Inspection Technician	Date	October 31, 2013
Customer Representative	Date	NOV 04 2013





# KV Inspection Services Ltd.

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

## Hardness Testing Report HT

### Specification – Acceptance Criteria

Max 248V

### General Data

Customer	All-Weld Company	Date	October 31, 2013
Location	Scarborough, ON	P. O. #	
Project	Vessel	Shop Order #	1173 PQ S/N 7475
Procedure	KV HT# 35 Rev.00	Worksheet #	37959
Technician	John MacDonald	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 10375

### Technical Data – Hardness Testing (HT)

Material	316
----------	-----

### 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: 27/2 Handle

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7475	Left	201	176	148	187	198
	Right	193	173	159	148	187

✓

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: B3M OFFSHORE 046  
 Print Name: GAURESH SAHA  
 Signature: [Signature] **Applus®**  
 Date: 30/10/13 **VELOSI**  
 Velosi America LLC

KV Inspection Technician	Date	October 31, 2013
Customer Representative	Date	NOV 04 2013



**QA COPY**

<b>NON-CONFORMANCE REPORT</b>				NCR No. N13-019
Work Order 1173PQ	Serial Number 7472 & 7475	Customer Ultrafab	NCR Author DN	NCR Date 13-Mar-13

NCR Background					
Discovered By	Customer	AWC		Other	
		DN		KVI	
Nature of NCR	Product	System	Document	Vendor	Other
	X				

Description	
SN 7472 x-ray weld repair in L1 @3 (3" to 4") slag, lack of fusion. Welders # 25 & 109	
SN 7475 x-ray weld repair in L1 @6 (8" to 10 1/4") slag. Welders # 25 & 109	
Immediate Action	

NCR Disposition								
Decision	Scrap	Rework	Repair	X	Return to Supplier	Use As Is	Other -	Assigned to
Description								

Grind out repair areas.							
2) PT repair areas. QA Inspect							
3) Weld with WPS 3-4							
4) PT repaired weld							
5) X-ray repair							
See supplementary file for further Disposition				File Name			

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

NCR Approvals					
<input checked="" type="checkbox"/>	Approvals Required - (Sign and Date)				
Customer		Engineer		ISO	
Sales		X QA	DN MAR 13/13	Other -	
X Proj. Mgr		X AI	FA MAR 15.13	Other -	

Disposition Verification					
(Sign and Date)		Prod-CPS		ISO	
Dwgs/Calcs					
Purchasing		X QA	DN May 29/13	Other -	
Prod-AWC		X AI	FA MAR 29.13	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 -

<b>NON-CONFORMANCE REPORT</b>				NCR No. N13-021
Work Order 1173PQ	Serial Number 7475	Customer Ultrafab	NCR Author BB	NCR Date 21-Mar-13

**NCR Background**

Discovered By	Customer	AWC		BB	Other	KVI
Nature of NCR	Product <b>X</b>	System	Document	Vendor	Other	
Description						
Circ 2 was x-rayed and found to have 11 out of 12 films rejected						
Immediate Action						

**NCR Disposition**

Decision	Scrap	Rework <b>X</b>	Repair	Return to Supplier	Use As Is	Other -	Assigned to
Description							
Machine out Circ down so as to remove the repairs							
2) X-Ray the remaining weld to make sure all repairs are out.							
3) PT Machined out area after X-Ray							
4) Weld up grooved out area using WPS SAW-W-2-4							
5) Complete C2 , Visual , PT in and out & then 100% RT weld and Hardness on External Weld							
See suplimentary file for further Disposition				File Name			
Contract Adjustment (ECN Only)	Quote	Extra Amount	AWC Rep	Notes			Dates
							Submitted
							Approved

**NCR Approvals**

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

**Disposition Verification**

(Sign and Date)	<input checked="" type="checkbox"/>	Dwgs/Calcs		Prod-CPS		ISO
Purchasing				QA <i>[Signature]</i>		Other -
Prod-AWC				AI <i>[Signature]</i>		Other -

**Follow-Up Required**

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

<b>NON-CONFORMANCE REPORT</b>				NCR No. N13-039
Work Order 1173PQ	Serial Number 7475	Customer Utrafab	NCR Author DN	NCR Date 12-Apr-13

### NCR Background

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

### Description

N13 conn out of level 0.6 degrees max per ASME & SBM spec is 0.5

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

### NCR Disposition

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

### Description

• Apply slight heat & JACK INTO POSITION  
 • REMOVE PT & UT NDE + HT  
 Repair if required

See supplementary file for further Disposition File Name

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

Approvals Required - (Sign and Date)

### NCR Approvals

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

(Sign and Date)

### Disposition Verification

<input type="checkbox"/> Dwgs/Calcs	<input type="checkbox"/> Prod-CPS	<input type="checkbox"/> ISO
<input type="checkbox"/> Purchasing	QA <i>DNese</i> 1/05/13	Other -
<input type="checkbox"/> 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 -
--	--	--	----------------------------------



QA COPY

<b>NON-CONFORMANCE REPORT</b>				NCR No. N13-043
Work Order 1173PQ	Serial Number 7475	Customer Ultrafab	NCR Author DN	NCR Date 18-Apr-13

**NCR Background**

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

**Description**

X-ray repair in C2 @ 1-2, 5-6, 6-7, 7-8, 8-9, & 9-10 film segments (slag inclusion) welder 109

Immediate Action

**NCR Disposition**

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

**Description**

Gouge out repair.

- 2) PT repair area.
- 3) Weld with WPS 3-4
- 4) QA Inspect
- 5) PT, HT, & RT repairs

See suplimentary file for further Disposition File Name

<b>Contract Adjustment (ECN Only)</b>	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>18/04/13</i>	Other -	
<input checked="" type="checkbox"/>	Proj. Mgr <i>Alan</i>	<i>Apr 18</i>	AI <i>DN</i>	<i>MAY 29.13</i>	Other -	

**Disposition Verification**

<input type="checkbox"/>	Dwgs/Calcs		Prod-CPS		ISO	
<input type="checkbox"/>	Purchasing		QA <i>DN</i>	<i>May 29/13</i>	Other -	
<input type="checkbox"/>	Prod-AWC		AI <i>DN</i>	<i>MAY 29.13</i>	Other -	

**Follow-Up Required**

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

<b>NON-CONFORMANCE REPORT</b>				NCR No. N13-046
Work Order 1173PQ	Serial Number 7475	Customer Ultrafab	NCR Author DN	NCR Date 30-Apr-13

**NCR Background**

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

**Description**

RT repair in C2 slag indications @ films 6 -7 & 8-9

Immediate Action

**NCR Disposition**

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

**Description**

Grind out repair areas

2) PT repair areas

3) Weld with WPS 3-4

4) VT inspect

5) RT

See suplimentary file for further Disposition File Name

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

Approvals Required - (Sign and Date)

**NCR Approvals**

Customer	Engineer	ISO
Sales	QA <i>DN May 1/13</i>	Other -
<input checked="" type="checkbox"/> Proj. Mgr <i>John May 1</i>	AI <i>May 29, 13</i>	Other -

(Sign and Date)

**Disposition Verification**

Dwgs/Calcs	Prod-CPS	ISO
Purchasing	QA <i>DN May 29/13</i>	Other -
Prod-AWC	AI <i>May 29, 13</i>	Other -

**Follow-Up Required**

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

# ALL-WELD

C O M P A N Y L I M I T E D  
Engineers Since 1920

<b>NON-CONFORMANCE REPORT</b>				NCR No. N13-097
Work Order 1173PQ	Serial Number 7475	Customer Ultrafab	NCR Author DN	NCR Date 3-Oct-13

### NCR Background

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

### Description

RT repairs in C1 (slag inclusion) in films 1 to 2, 2 to 3, 3 to 4, 4 to 5, & film 5 to 6.

Welders #53, #109 & #110

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

### NCR Disposition

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

### Description

1) Grind out repair area's

2) PT repair area's

3) Weld with WPS 3-4

4) QA Inspect weld.

5) PT / HT weld repairs

6) RT repair area's

See supplementary file for further Disposition File Name

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

### NCR Approvals

<input checked="" type="checkbox"/> Approvals Required - (Sign and Date)						
Customer		Engineer		ISO		
Sales		<input checked="" type="checkbox"/> QA <i>EMedon Oct 3/13</i>		Other -		
<input checked="" type="checkbox"/> Proj. Mgr <i>(LMA) Oct 3/13</i>		<input checked="" type="checkbox"/> AI <i>2 Oct 04.13</i>		Other -		

### Disposition Verification

<input type="checkbox"/> Dwg/Calcs		Prod-CPS		ISO		
Purchasing		<input checked="" type="checkbox"/> QA <i>PLA Oct 4/13</i>		Other -		
Prod-AWC		<input checked="" type="checkbox"/> AI <i>2 Oct 04.13</i>		Other -		

### Follow-Up Required

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

C O M P A N Y L I M I T E D  
Engineers Since 1920

<b>NON-CONFORMANCE REPORT</b>				NCR No. N13-102
Work Order 1173PQ	Serial Number 7475	Customer Ultrafab	NCR Author DN	NCR Date 16-Oct-13

### NCR Background

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

### Description

UT repair in N12-W1 @ 33mm x 100% intermittent slag (welders # 109 # 110)

Immediate Action

### NCR Disposition

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

1) Grind out repair

2) PT repair area

3) Weld with WPS 3-4

4) QA Inspect

5) PT, UT, HT repair

See supplementary file for further Disposition File Name

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

### NCR Approvals

<input checked="" type="checkbox"/>	Approvals Required - (Sign and Date)			Engineer		ISO
	Customer					
	Sales		<input checked="" type="checkbox"/>	QA DP <i>Perce Oct 16/13</i>		Other -
<input checked="" type="checkbox"/>	Proj. Mgr <i>Justin Oct 16/13</i>			AI		Other -

### Disposition Verification

(Sign and Date)		Prod-CPS		ISO
Dwgs/Calcs				
Purchasing		<input checked="" type="checkbox"/>	QA DP <i>Perce Oct 21/13</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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# ALL-WELD

COMPANY LIMITED  
Engineers Since 1920

<b>NON-CONFORMANCE REPORT</b>				NCR No. N13-105
Work Order 1173PQ	Serial Number 7475	Customer Ultrafab	NCR Author DN	NCR Date 24-Oct-13

NCR Background				
Discovered By	Customer	AWC DN		Other KVI
Nature of NCR	Product <b>X</b>	System	Document	Vendor Other
Description				
1) RT repair found in N12 C3 film 'A' porosity welder # 53				
2) MW1-W1 reshoots in films 4-5, 5-6, 10-11, & 11-0				
Immediate Action				

NCR Disposition							
Decision	Scrap	Rework <b>X</b>	Repair	Return to Supplier	Use As Is	Other -	Assigned to
Description							
1) N12-C3:							
Grind out repair							
PT repair area							
Weld with wps 9-4							
PT, HT, RT							
2) MW1-W1 reshoot films 4-5, 5-6, 10-11, & 11-0							
See suplimentary file for further Disposition				File Name			
Contract Adjustment (ECN Only)	Quote	Extra Amount	AWC Rep	Notes	Submitted	Dates	
					Approved		

NCR Approvals				
Approvals Required - (Sign and Date)				
Customer		Engineer		ISO
Sales		QA <i>[Signature]</i> Oct 24/13		Other -
	<i>[Signature]</i> 01/24/13	AI <i>[Signature]</i> Oct 30, 13		Other -
(Sign and Date)				
Disposition Verification				
Dwgs/Calcs		Prod-CPS		ISO
Purchasing		QA <i>[Signature]</i> Oct 30/13		Other -
Prod-AWC		AI <i>[Signature]</i> Oct 30, 13		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 -

# Welding Procedure Specification (WPS)

CARBON STEEL

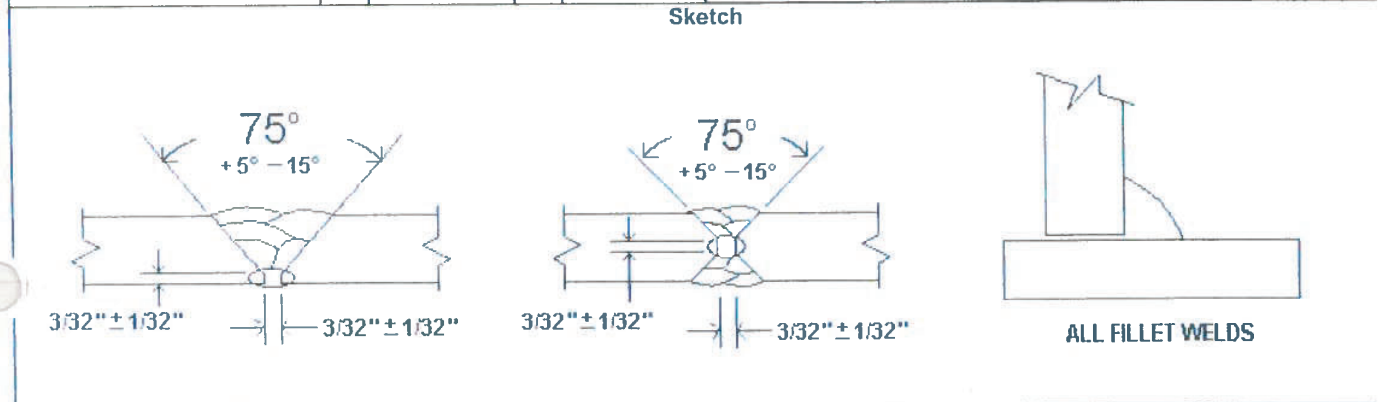
<b>1</b>	<b>Company</b>
Name: ALL-WELD COMPANY LIMITED	
Address: 49 PASSMORE AVE. PLANT 1      14 PASSMORE AVE. PLANT 2	
SCARBOROUGH, ONTARIO	
Postal Code ( PLANT 1 )      Postal Code ( PLANT 2 )	
M1V-4T1      M1V-2R6	

<b>2</b>	<b>Provincial Registration</b>	WP D700.5 R2363.5 / R2060.5
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<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>4</b>	<b>Welding Process(es)</b>	1	<b>SMAW</b>	Manual	<input checked="" type="checkbox"/>	Semi-auto.	<input type="checkbox"/>	Auto.	<input type="checkbox"/>
		2		Manual	<input type="checkbox"/>	Semi-auto.	<input type="checkbox"/>	Auto.	<input type="checkbox"/>
		3		Manual	<input type="checkbox"/>	Semi-auto.	<input type="checkbox"/>	Auto.	<input type="checkbox"/>

<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"/>	NOTE	SMAW SHALL BE USED WITH BACKING ONLY



<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	
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	
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	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 to 200° F		

1	<b>Supplementary Comments</b>	
	NONE	

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

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



Ministry of  
Consumer and  
Commercial  
Relations

Boilers and  
Pressure Vessels  
Branch  
Technical Standards Division

Tel. (416) 965-4121

400 University Avenue  
Toronto, Ontario  
M5G 1S5

**COPY**

**PROCEDURE QUALIFICATION RECORD**

**PQR - 1**

Date **APR 23, 1979**

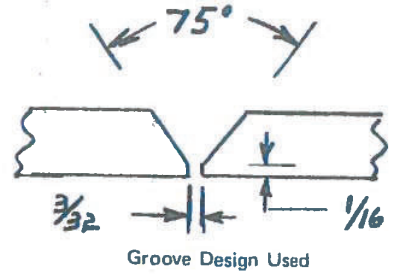
**ALL-WELD COMPANY LIMITED**  
(Manufacturer)

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

Weld Proc. Spec. No. **WPSI-1**

Weld Process(es) **SMAW**

Types **MANUAL**  
(Manual, Automatic)

<p>JOINTS (QW-402)</p>  <p>Groove Design Used</p>	<p>BASE METALS (QW-403)</p> <p>Material Spec. <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" FLICK VOID</i> <i>10/4 3/3/85 (PW) 3/2/85 @ 14/3/85</i></p>
<p>FILLER METALS (QW-404)</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>POSITION (QW-405)</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>PREHEAT (QW-406)</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>POSTWELD HEAT TREATMENT (QW-407)</p> <p>Temperature <b>None</b></p> <p>Time <b>N/A</b></p> <p>Other <b>N/A</b></p>	<p>GAS (QW-408)</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>ELECTRICAL CHARACTERISTICS (QW-409)</p> <p>Current <b>DC</b></p> <p>Polarity <b>Reverse</b></p> <p>Amps. <b>120-150</b> Volts <b>22-24</b></p> <p>Travel Speed <b>N/A</b></p> <p>Other <b>N/A</b></p>	<p>TECHNIQUE (QW-410)</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 Meta
13-47-T2	0.773	0.359	0.278	18,600	66,900	Parent Meta

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 Authorized Inspector

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

Laboratory Test No. 282-0170

**Warnock Hersey Professional Service**

BOILERS AND PRESSURE VESSELS BRANCH

**ACCEPTED**

W.P. No. D.700-5 P1XF4-01

Date 12-7-79

Examiner [Signature]

MINISTRY OF CONSUMER & COMMERCIAL RELATIONS  
 PROVINCE OF ONTARIO

We certify that the Statements in this record are correct an the test welds were prepared, welded and tested in accordanc 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 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	Mills Millimètres	Break Cassé	No Brk Non cassé

17 Fillet Weld Test/Essai de soudure d'angle				Reference: Référence:	
Result - Satisfactory Résultat satisfaisant	Yes <input checked="" type="checkbox"/> Oui	No <input type="checkbox"/> Non	Penetration Into Parent Metal Pénétration dans métal de base	Yes <input type="checkbox"/> Oui	No <input type="checkbox"/> Non
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°: 125124-19

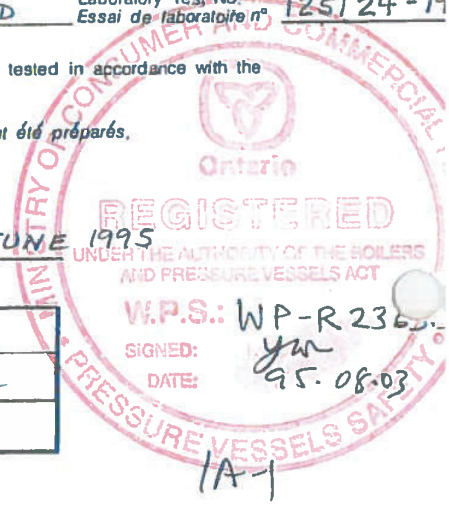
We certify that the statements in this record are correct and that the test welds were prepared, welded and tested in accordance with the requirements of section IX of the ASME Code.

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: Robert C Bentley Date: 27 JUNE 1995

21 Department Use Only / Réservé au ministère

Samples Welded on / Pièces soudées le: <u>JUNE 27/95</u>	Inspector / Inspecteur: <u>R. C. Bentley</u>
Record verified on / Résultats vérifiés le: <u>JULY 17/95</u>	Inspector / Inspecteur: <u>R. C. Bentley</u>







14 Tensile Tests/Essais à la traction					Reference: Référence:	Character and Location of Failure Nature et endroit de la rupture
Specimen Éprouvette	Dimensions Dimensions		Area Surface	Ultimate Total Load Charge limite	Ultimate Unit Stress Contrainte limite	
	Width Largeur	Thickness Épaisseur				
T1	0.715	1.487	1.0632	84700	79669	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:	Result Résultat			
Specimen Éprouvette	Face Face	Root Racine	Side Côté	Result Résultat	Specimen Éprouvette		Face Face	Root Racine	Side Côté
S1			✓	ACCEPTABLE	S3			✓	ACCEPTABLE
S2			✓	ACCEPTABLE	S4			✓	ACCEPTABLE

16 Toughness Tests/Essais de résilience					Reference: Référence:	Drop Weight Essai en chute libre		
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		Break Cassé	No Br Non c.
					Shear % cisaillement	Mills Millimètres		

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
Macro - Results Résultats macroscopiques	Yes <input type="checkbox"/>	No <input type="checkbox"/>	

18 Other Tests/Autres essais		Reference: Référence:

19 Welder's Name  
Nom du soudeur KELVIN RAMNATH

Tests conducted by  
Essais effectués par CAMBRIDGE MATERIALS TESTING LTD

Stamp No.  
N° de symbole 34

Laboratory Test No.  
Essai de laboratoire n° 157871-15

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.

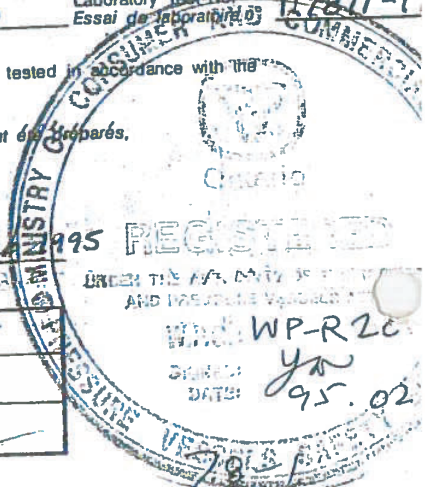
20 Company Representative's  
Signature Robert C Bentley Date 1 Feb 1995

Signature du représentant de l'entreprise

21 Department Used Only/Réservé au ministère

Samples Welded on  
Pièces soudées le JAN 26/95 Inspector R E Kelly

Record verified on  
Résultats vérifiés le Feb 1/95 Inspector R E Kelly



# Welding Procedure Specification (WPS)

STAINLESS TO  
CARBON STEEL

**Customer  
Work Order #**

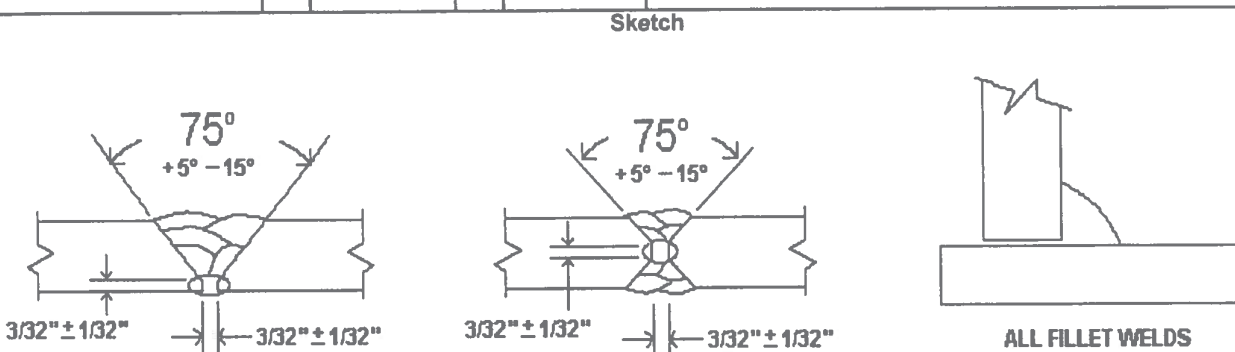
<b>1</b>	<b>Company</b>
Name/	ALL-WELD COMPANY LIMITED
Address /	49 PASSMORE AVE. , 14 PASSMORE AVE. PLANT 1 PLANT 2
	SCARBOROUGH, ONTARIO
Postal Code ( PLANT 1 )	Postal Code ( PLANT 2 )
M1V-4T1	M1V-2R6

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

<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"/> X	Other NONE



<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
2. AWS No. E309-16		SFA 5.4 F-No 5 A-No. 8 Dia. 5/32" & 3
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

<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	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.

<b>13 Supplementary Comments</b>	
NONE	

<b>14</b>	Company Representative Signature _____ <i>Stephen White</i> _____	Date <u>14 April, 07</u>
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

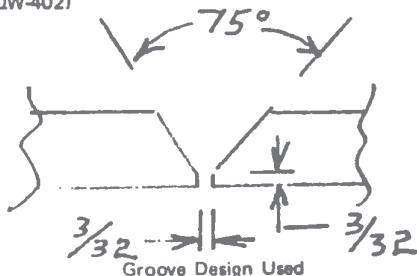
## PROCEDURE QUALIFICATION RECORD

### 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>VOID @ 14/3/9.</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>



**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. L.  
 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

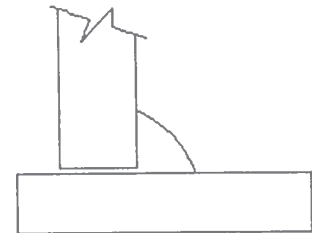
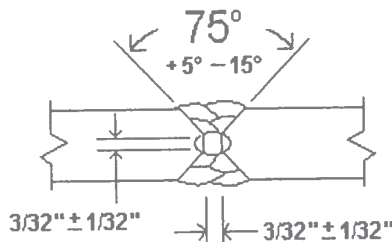
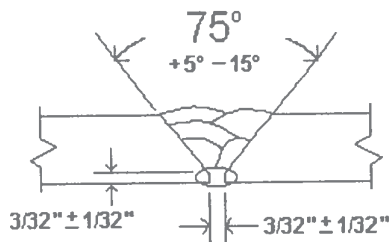
<b>2</b>	<b>Provincial Registration</b>	WP T4628.5
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<b>3</b>	<b>Procedure Identification</b>	
WPS NO.	3-4	Revision No. 1
Code Section	IX	Date 27 March, 2013
PQR No.	3-3X	

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

<b>5</b>	<b>Joints (QW-402)</b>			
Design	SINGLE & DOUBLE V GROOVE			Backing Material WELD METAL
Backing	Yes	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	

(10) <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	NONE
Gas Flow Rate	NONE
Backing Gas Composition	NONE
Trailing Shield Gas Composition	NONE
Other	NONE

(12) <b>Electrical Characteristics and Technique (QW-409)-(QW-410)</b>								
Weld Layer(s)	Process	Filler Metal		Current				Travel Speed Range
		Classification	Diameter	Type	Polarity	Amp. Range	Volt Range	
ROOT	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</b>		<b>Maximum</b>				
<b>Per QW 409.1 only 3/32 ' and 1/8 " Electrode used for Impact welding</b>								
Tungsten Electrode Size and Type		NONE						
Mode of Metal Transfer for GMAW		NONE						
String or Weave Bead		STRING						
Method of Back Gouging		GRINDING OR ARC AIR GOUGING AND GRINDING TO SOUND METAL						
Initial and Interpass Cleaning (Brushing, Grinding, etc.)		WIRE BRUSH OR GRINDING						
Orifice or Gas Cup Size		NONE						
Oscillation	NONE	Width	NONE	Frequency	NONE			
Contact Tube to Work Distance		NONE						
Multiple or Single Pass (per side)		MULTIPLE						
Multiple or Single Electrode		SINGLE						
Electrode Wire feed speed range		NONE						
Other								

(13) <b>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 C. Bentley Date 27 March, 2013  
 Robert C. Bentley C.E.T.

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

# 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	SMAW	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 240 316		75000	
Thickness		Diameter	
1 3/4 "			
Other			
NONE			
<b>7 Filler Metals (QW-405)</b>			
Classification (AWS)	SFA-No.	F - No.	A - No.
E316-16	5.4	5	8
Other			
NONE			
<b>8 Positions QW-405</b>			
Position(s) of Groove			
2G			
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			
No single pass greater than 1/2 "			

<b>2 Provincial Registration</b>		WP
<b>3 Record Identification</b>		
PQR No.	3-3X	
WPS No.	3-3B	
<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	NONE	
Gas Flow Rate	NONE	
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	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	SMAW	E316-16	3/32"	DC	RP	65 - 95	20 - 25	4" TO 8 "	
FILL	SMAW	E316-16	1/8"	DC	RP	90 - 120	20 - 25	4" TO 8 "	



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 LIEW	Stamp No.	90
Tests conducted by		CAMBRIDGE MATERIAL TESTING LTD.	
		Laboratory Test No.	634805-13 ( REVISED )

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

20 Company Representative's Signature		Technical Standards and Safety Authority	Date	18 MARCH 2013
	ROBERT C. BENTLEY, C.E.T.			Boilers and Pressure Vessel Safety Program

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

P&R: 3-3X  
WPS: 3-3B

REGISTERED

WP-T4628.5

W.P.S.: .....

Signed: S. Lee

Date: MAR 26, 2013

# Welding Procedure Specification (WPS)

STAINLESS  
STEEL

**Customer  
Work Order #**

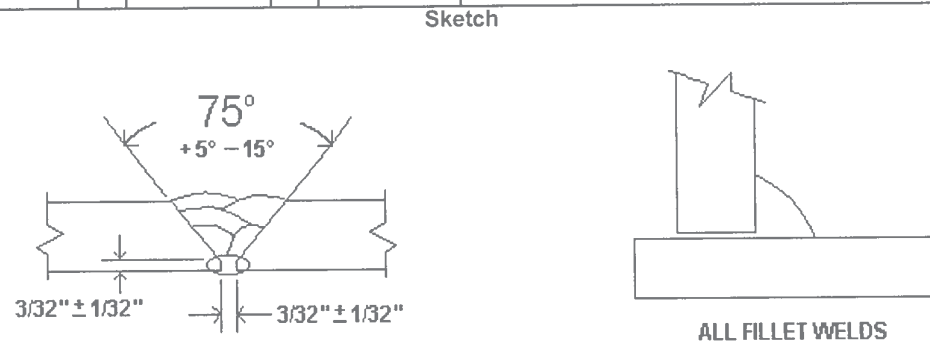
<b>1</b>	<b>Company</b>
Name/	ALL-WELD COMPANY LIMITED
Address /	49 PASSMORE AVE. , 14 PASSMORE AVE. PLANT 1 PLANT 2
	SCARBOROUGH, ONTARIO
Postal Code ( PLANT 1 )	Postal Code ( PLANT 2 )
M1V-4T1	M1V-2R6

<b>2</b>	<b>Provincial Registration</b>	<b>WP</b> 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>	1 <b>GTAW</b>	Manual	<input checked="" type="checkbox"/>	Semi-auto.	<input type="checkbox"/>	Auto.	<input type="checkbox"/>
		2	Manual	<input type="checkbox"/>	Semi-auto.	<input type="checkbox"/>	Auto.	<input type="checkbox"/>
		3	Manual	<input type="checkbox"/>	Semi-auto.	<input type="checkbox"/>	Auto.	<input type="checkbox"/>

<b>5</b>	<b>Joints (QW-402)</b>	
Design	SINGLE V GROOVE	Backing Material WELD METAL
Backing	Yes <input type="checkbox"/> 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" Impac

<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

11 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) 965-4121  
400 University Avenue  
Toronto, Ontario  
M5G 1S5

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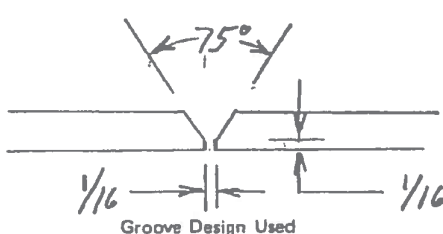
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**PROCEDURE QUALIFICATION RECORD**

**PQR 9**

Date October 10, 1979

All-Weld Company Limited <sup>2/15/90</sup> 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><b>JOINTS (QW-402)</b></p>  <p>Groove Design Used</p>	<p><b>BASE METALS (QW-403)</b></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><b>FILLER METALS (QW-404)</b></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><b>POSITION (QW-405)</b></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><b>PREHEAT (QW-406)</b></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><b>POSTWELD HEAT TREATMENT (QW-407)</b></p> <p>Temperature <u>N/A</u></p> <p>Time <u>N/A</u></p> <p>Other <u>N/A</u></p>	<p><b>GAS (QW-408)</b></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><b>ELECTRICAL CHARACTERISTICS (QW-409)</b></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><b>TECHNIQUE (QW-410)</b></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. DASA:5.....PAXT-02

Date.....17.10.79.....

Examiner.....G. Ewing.....  
 MINISTRY OF CONSUMER & COMMERCIAL RELATIONS  
 PROVINCE OF ONTARIO

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

Signed ALL-WELD COMPANY LIMITED  
 (Manufacturer)

By R. J. McIntyre  
**R. J. MCINTYRE**  
 Q. A. SUPERVISOR



14 Tensile Tests/Essais à la traction						Reference: Référence:
Specimen Eprouvette	Dimensions Dimensions		Area Surface	Ultimate Total Load Charge finale	Ultimate Unit Stress Contrainte finale	Character and Location of Failure Nature et endroit de la rupture
	Width Largeur	Thickness Épaisseur				
T1	0.250	0.0350"	0.0236	1987 lbf	84000 PSI	BOTH FRACTURE BASE METAL
T2	0.249"	0.0350"	0.0235"	1975 lbf	84000 PSI	" "

15 Guided Bend Tests/Essais de pliage guidé						Reference: Référence:			
Specimen Eprouvette	Face Face	Root Racine	Side Côté	Result Résultat	Specimen Eprouvette	Face Face	Root Racine	Side Côté	Result Résultat
B1	X			ACCEPTED	B3	X			ACCEPTED
B2		X		ACCEPTED	B4		X		ACCEPTED

16 Toughness Tests/Essais de résilience						Reference: Référence:		
Specimen Eprouvette	Notch Location Endroit de l'entaille	Notch Type Forme de l'entaille	Specimen Temperature Température de l'éprouvette	Impact Value Énergie de rupture	Lateral Expansion Expansion latérale		Drop Weight Essai en chute libre	
					Shear % cisaillement	Mills Milles	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

Tests conducted by  
Essais effectués par CAMBRIDGE MATERIALS TESTING LTD.

Stamp No.  
N° de symbole 9

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 du représentant de l'entreprise

Robert C. Bentley Date 18, APRIL 2002

W.P.S.: WR R 76 74 5

Signed: [Signature]

Date: 2002.04.18

Department Use Only/Réservé au ministère

Samples Welded on  
Pièces soudées le

Inspector  
Inspecteur

Record verified on  
Résultats vérifiés le

Inspector  
Inspecteur

9-A





Tensile Tests/Essais à la traction					Reference: Référence:	SECT IX ASME CODE
Specimen Epruvette	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 WEI
T3	0.751	0.751	0.5640	49630	87990	FRACTURED IN WEI

Guided Bend Tests/Essais de pliage guidé					Reference: Référence:	SECT IX Q.W. 462:2			
Specimen Epruvette	Face Face	Root Racine	Side Côté	Result Résultat	Specimen Epruvette	Face Face	Root Racine	Side Côté	Result Résultat
S1			✓	ACCEPTED	S3			✓	ACCEPTED
S2			✓	— V —	S4			✓	— " —

Toughness Tests/Essais de résilience						Reference: Référence:		
Specimen Epruvette	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

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
Macro - Results Résultats macroscopiques			Yes <input type="checkbox"/> No <input type="checkbox"/>

Other Tests/Autres essais		Reference: Référence:

19) Welder's Name ROBIN GREER Stamp No. 9  
 Nom du soudeur  
 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

WP-R35  
 ya  
 26.10.17  
 54-1

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



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 (A) BASE METAL
16	0.754	0.247	0.1862	16840	90440	FRACTURED (A) 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	Mills Millimètres	Break Cassé	No Br Non ca:
1	WELD	CHARPY V-NOTCH	-200°F	94	100	80		
2	WELD			96		86		
3	WELD			94		78		
4	HAZ			89		78		
5	HAZ			70		70		
6	HAZ			82		72		
7	BASE			89		74		
8	BASE			100		75		
	BASE			96		75		

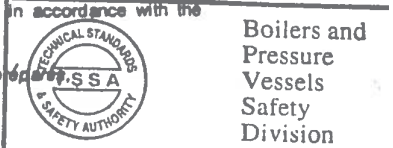
17 Fillet Weld Test/Essai de soudure d'angle				Reference: Référence:
Result - Satisfactory Résultat satisfaisant	Yes Oui <input type="checkbox"/>	No Non <input type="checkbox"/>	Penetration into Parent Metal Pénétration dans métal de base	Yes Oui <input type="checkbox"/>
Macro - Results Résultats macroscopiques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

18 Other Tests/Autres essais		Reference: Référence:

19 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>169712-19</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.



20 Company Representative's Signature	<u>Robert Bentley</u>	Date	<u>13 JUNE 1997</u>
Signature du représentant de l'entreprise		Date	

21 Department Use Only/Réservé au ministère	
Welds inspected on Yécés soudées le	Inspector Inspecteur
Record verified on Résultats vérifiés le	Inspector Inspecteur

REGISTERED

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

Signed: ya

Date: 97.06.17

105-1



# 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

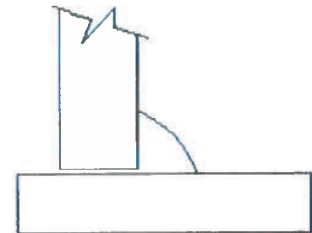
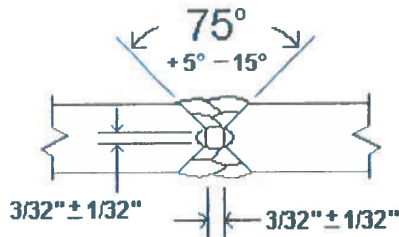
<b>2</b>	<b>Provincial Registration</b>	WP T4646.5
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<b>3</b>	<b>Procedure Identification</b>	
WPS NO.	50-3A	Revision No. 0
Code Section	IX	Date 23 March, 13
PQR No.	50X	

<b>4</b>	<b>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</b>	<b>Joints (QW-402)</b>	
Design	DOUBLE V GROOVE & FILLETS	
Backing Material	WELD METAL	
Backing	Yes	No <input checked="" type="checkbox"/>
Other	NONE	

Sketch



ALL FILLET WELDS

<b>6</b>	<b>Base Metals (QW-403)</b>	P. No. <u>8</u> Gr. No. <u>1</u> to P. No. <u>8</u> Gr. No. <u>1</u>
	or Specifications type and grade	SA-240, 316L to SA-240, 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</b>	<b>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</b>	<b>Positions (QW-405)</b>
Position(s) of Groove	1G TO 6G
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.	50° F
Interpass Temperature	Max.	350° F
Preheat Maintenance		50° F
Other		NONE

11	<b>Gas (QW-408)</b>	
Shielding Gas Composition		CO2
Gas Flow Rate		45 CFH
Backing Gas Composition		NONE
Trailing Shield Gas Composition		NONE
Other		NONE

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

Weld Layer(s)	Process	Filler Metal		Current				Travel Speed Range
		Classification	Diameter	Type	Polarity	Amp. Range	Volt Range	
ROOT	FCAW	E316TO-1	0.045"	DC	RP	290 - 330	27-30	10-15 IPM
FILL	FCAW	E316TO-1	0.045"	DC	RP	290 - 330	27-30	10-15 IPM
<b>Heat Input ( Per QW-409.1 ) = 59,400 j / in</b>								

Tungsten Electrode Size and Type	NONE	
Mode of Metal Transfer for GMAW	SPRAY	
String or Weave Bead	STRING	
Method of Back Gouging	GRINDING OR ARC AIR GOUGING AND GRINDING	
Initial and interpass Cleaning (Brushing, Grinding, etc.)	WIRE BRUSH OR GRINDING	
Orifice or Gas Cup Size	1/2"	
Oscillation	NONE	Width NONE Frequency NONE
Contact Tube to Work Distance	3/4"	
Multiple or Single Pass (per side)	MULTIPLE	
Multiple or Single Electrode	SINGLE	
Electrode Wire feed speed range	400 IPM	
Other	NONE	

1 **Supplementary Comments**

NONE

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</b>	<b>Company</b>
Name / <b>ALL-WELD COMPANY LIMITED</b>	
Address / <b>49 PASSMORE AVENUE</b>	
<b>SCARBOROUGH, ONTARIO</b>	
Postal Code	
M   1   V   4   T   1	

<b>4</b>	<b>Welding Process(es)</b>	
1	FCAW	Type MANUAL
2		Type
3		Type

<b>6</b>	<b>Base Metals</b>		(QW-403)
P No.	8	Gr No.	1
Specification		Tensile	
SA-240-316L		70,000 psi	
Thickness		Diameter	
1 3/4 "		N/A	
Other <b>NONE</b>			

<b>7</b>	<b>Filler Metals</b>			(QW-405)
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 <b>No Single Pass Greater than 1/2 "</b>				

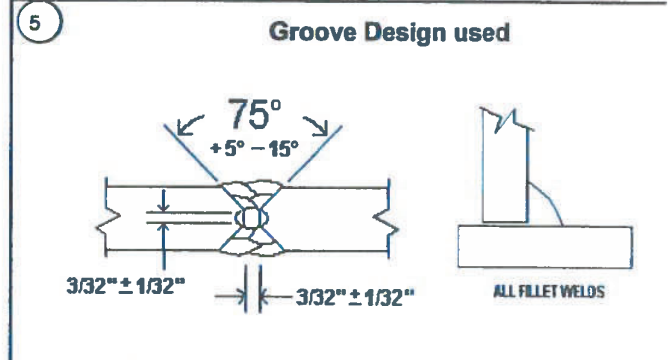
<b>8</b>	<b>Positions</b>		QW-405
Position(s) of Groove <b>3G</b>			
Welding Progression		Up <input type="checkbox"/>	Down <input type="checkbox"/>
Other <b>NONE</b>			

<b>9</b>	<b>Preheat</b>		(QW-406)
Preheat Temperature		50°F	
Interpass Temperature		350°F	
Other <b>NONE</b>			

<b>13</b>	<b>Electrical Characteristics and Technique</b> (QW-409) + (QW-410)							
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</b>	<b>Provincial Registration</b>	WP <b>T4646.5</b>
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<b>3</b>	<b>Record Identification</b>	
PQR No.		50-X
WPS No.		50-3A



<b>10</b>	<b>Postweld Heat Treatment /</b>	
Temperature		NONE
Time		NONE
Other		NONE

<b>11</b>	<b>Gas</b> (QW-408)	
Shielding Gas Composition		CO2
Gas Flow Rate		45 CFH
Backing Gas composition		NONE
Gas Flow Rate		NONE
Other		NONE

<b>12</b>	<b>Technique</b>		(QW-410)
String or Weave Bead		STRING	
Oscillation		NONE	
Multipass or Single Pass (per side)		MULTIPLE	
Single or Multiple Electrode		SINGLE	
Other <b>Transfer : Spray</b>			

14 Tensile Tests				Reference:		
Specimen	Dimensions in Inches		Area in Inches <sup>2</sup>	Ultimate Total Load in Foot Pounds	Ultimate Unit Stress in PSI	Character and Location of Failure
	Width	Thickness				
T2A	0.754"	0.810"	0.611"	49,863	81,500	All coupons failed ductile manner in base metal
T2B	0.756"	0.820"	0.620"	51,094	82,500	
T5A	0.754"	0.885"	0.667"	57,278	86,000	
T5B	0.756"	0.908"	0.686"	56,013	81500	

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

16 Toughness Tests					Reference:			
Specimen	Notch Location	Notch Type	Specimen Temperature	Impact Value	Lateral Expansion		Drop Weight	
					Shear	Mills	Break	No Break
1	Weld ( 1/16" below )	V NOTCH	- 50 F	26 ft-lbf	100	22		
2	Weld ( 1/16" below )	V NOTCH	- 50 F	26 ft-lbf	100	24		
3	Weld ( 1/16" below )	V NOTCH	- 50 F	26 ft-lbf	100	20		
1	HAZ	V NOTCH	- 50 F	85 ft-lbf	100	37		
2	HAZ	V NOTCH	- 50 F	43 ft-lbf	100	28		
3	HAZ	V NOTCH	- 50 F	63 ft-lbf	100	30		
1	Weld ( 1/4 t opposite )	V NOTCH	- 50 F	25 ft-lbf	100	20		
2	Weld ( 1/4 t opposite )	V NOTCH	- 50 F	25 ft-lbf	100	19		
3	Weld ( 1/4 t opposite )	V NOTCH	- 50 F	27 ft-lbf	100	23		

17 Fillet Weld Test			Reference:	
Result - Satisfactory	Yes <input type="checkbox"/>	No <input type="checkbox"/>	Penetration Into Parent Metal	Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>
HEAT INPUT = 59,400 j / in Maximum			W.P.S.: WP-14645	
			Signed: [Signature]	
			Date: April 11, 2013	

18 Other Tests		Reference:	
1) MACROETCH EXAMINATION PER LAB REPORT 636455-13 ( Report A )			
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. 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	[Signature]	Date	23 March, 2013
		ROBERT C. BENTLEY, C.E.T.	

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



# Welding Procedure Specification (WPS)

STAINLESS  
STEEL

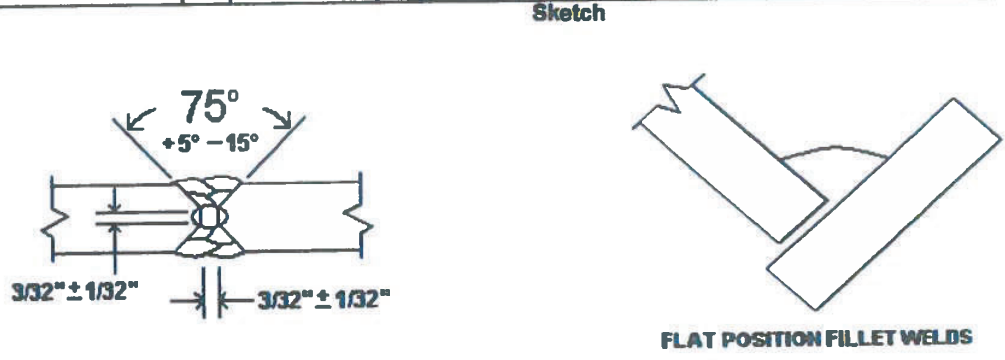
**Customer  
Work Order #**

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

<b>2</b>	<b>Provincial Registration</b>	WP R4428.5
<b>3</b>	<b>Procedure Identification</b>	
WPS NO.	SAW-W-2-4	Revision No. 0
Code Section	IX	Date 21-Mar-13
PQR No.	SAW-2A1	

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

<b>5</b>	<b>Joints (QW-402)</b>			
Design	DOUBLE 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-240, 316L to SA-240, 304, 304L, 316 & 316L			
	or Chemical Analysis and Mech. Prop.	NONE			
	Thickness Range Qualified	Total 5/8" TO 8" for Impact Test and 3/16" to 8" for Non Impact test			
	Other	1) NO SINGLE PASS TO BE GREATER THAN 1/2"			

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

<b>8</b>	<b>Positions (QW-405)</b>
Position(s) of Groove	1G
Welding Progression	UP
Position(s) of Fillet	1F
Other	NONE

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




<b>9 Preheat (QW-406)</b>		
Preheat Temperature	Min.	60° F
Interpass Temperature	Max.	350 ° F
Preheat Maintenance		350 ° 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	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	
Heat Input ( Per QW-409.1 ) = 60;000 ; / in								Maximum	
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 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, 1
		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.



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				
	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: Référence:				
Specimen Éprouvette	Face	Root Racine	Side Côté	Result Résultat	Specimen Éprouvette	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. of Non c

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"/> No <input type="checkbox"/>
Macro - Results Résultats macroscopiques				

18 Other Tests/Autres essais		Reference: Référence:

19 Welder's Name / Nom du soudeur: VITTORIO VITRANO Stamp No. / N° de symbole: 38

Tests conducted by / Essais effectués par: CAMBRIDGE MATERIALS TESTING LTD. Laboratory Test No. / Essai de laboratoire n°: 183506-1998

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. Boilers and Pressure Vessels Safety Division

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: Robert C. Bentley Date: 7 JAN. 1998 REGISTERED

W.P.S.: WR-R4428.F

21 Department Use Only/Réserve au ministère	
Samples Welded on / Pièces soudées le	Inspector / Inspecteur
Records verified on / Résultats vérifiés le	Inspector / Inspecteur

Signed:   M    
Date: 98.01.15.



WPS 2-1  
W-0-1173 PQ

PO# 13-0765

5

**HOBART BROTHERS**

McKay

**CERTIFICATE OF ANALYSIS**

CUSTOMER: MARKED FOR: PACK SLIP/ORDER #: LBS SHIPPED:	EXOCOR C/O USF HOLLAND BUFFALO A503500 60	P.O. #: DATE: WORK ORDER:	021702 5/7/2013 2:14:09 PM
PRODUCT TYPE: LOT NO: SPECIFICATION:	STERL AP 309/309L 1/8 10 CAN 23R056 AWS A5.4, ASME SFA 5.4	STOCK NUMBER: HEAT NO: CLASS:	S483944-033 743678 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. 1173 PG  
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:	24R046 ✓	HEAT NO:	744973 ✓
SPECIFICATION:	AWS A5.4, /ASME SFA 5.4 ✓	CLASS:	E309/309L-16 ✓

### ACTUAL CHEMICAL ANALYSIS (%)

C	0.032 ✓
Mn	1.068 ✓
P	0.020 ✓
S	0.008 ✓
Si	0.574 ✓
Cu	0.070 ✓
Cr	22.722 ✓
Ni	12.735 ✓
Mo	0.147 ✓

This material has not come in contact with mercury or mercury containing compounds.

Measured FN : 10  
 Delong FN : 13  
 Schaeffler : 9

### TYPICAL MECHANICAL PROPERTIES

Tensile 83,000 psi ( 575 Mpa)  
 Yield 66,000 psi ( 455 Mpa)  
 Elongation 46

Filler Metals Quality Assurance  
 Hobart Brothers  
 400 Trade Square  
 Troy, Ohio 43373

Authorized Signature :

Tim Wagner, Q.A. Technician

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



**CERTIFICATE OF ANALYSIS**

CUSTOMER:	CPG	P.O #:	59751
MARKED FOR:		DATE:	7/24/2012 8:42:12 AM
PACK SLIP/ORDER #:	44941/01	WORK ORDER:	
LBS SHIPPED:	180		
PRODUCT TYPE:	STERL AP 309/309L 5/32 10 CAN	STOCK NUMBER:	S483951-033
LOT NO:	26P006	HEAT NO:	740749
SPECIFICATION:	AWS A5.4,/ASME SFA 5.4	CLASS:	E309/309L-16

**ACTUAL CHEMICAL ANALYSIS (%)**

C	0.028
Mn	1.102
P	0.021
S	0.005
Si	0.647
Cu	0.048
Cr	22.454
Ni	12.309
Mo	0.070

This material has not come in contact with mercury or mercury containing compounds .

Measured FN : 9  
 Delong FN : 14  
 Schaeffler : 10

**TYPICAL MECHANICAL PROPERTIES**

Tensile 83,000 psi ( 575 Mpa)  
 Yield 66,000 psi ( 455 Mpa)  
 Elongation 46

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



Authorized Signature :

Brian Simpson, Q.A. Technician

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

**HOBART BROTHERS**

McKay

W.O.N. 1  
1173 P&Q

SMAW  
WPS 3-4

6

**CERTIFICATE OF ANALYSIS**

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

P.O. #:  
DATE: 1/19/2013 5:26:19 AM  
WORK ORDER:

PRODUCT TYPE,  
LOT NO.  
SPECIFICATION

STERL AP 316/316L 1/8 10 CAN  
21R006  
AWS A5.4, ASME SFA 5.4 EN10204 3.1 CLASS:

STOCK NUMBER: S482944-033  
HEAT NO: 741891  
E316L-16 E316-16

**ACTUAL CHEMICAL ANALYSIS (%)**

C 0.04  
Mn 1.08  
P 0.028  
S 0.009  
Si 0.65  
Cu 0.28  
Cr 17.30  
Ni 13.41  
Mo 2.27

This material has not come in contact with mercury or mercury containing compounds .

Measured FN : 1  
Schaeffler : 2

**TYPICAL MECHANICAL PROPERTIES**

Tensile 81,000 psi ( 559 Mpa)  
Yield 58,000 psi ( 398 Mpa)  
Elongation 39

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



Authorized Signature :

Brian Simpson, Q.A. Technician

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

**HOBART BROTHERS**

McKay

SMAW  
WPS. 3-4

(6)

**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").



CTAW 9.9

**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**



**Bohler Welding**  
**GROUP**

Test Object: welding wire for GTAW ✓  
 Dimensions: 3.2mm(1/8") x 914mm (36") x 4.5kg (10 lb)  
 Trade Designation: AVESTA ER318/316L ✓  
 Lot No : E48111 ✓  
 Marking of Product  
 Delivery Qty:  
 Standard Designation: AWS A5.9/ASME SFA5.9 ER316L

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.
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 %	Authorized inspection representative:
						Russel Fuchs Loc: Houston, TX Date:



P0#13-0511

4

CW.O.NI 1173P8  
50-3A

**NOBELCO**

INSPECTION CERTIFICATE													
PURCHASER		DIMENSION		MFG. No		APPLICABLE SPECIFICATION AND CLASSIFICATION							
		0.045 inch		F2G2315		ANS A5.22 E316LTO-1 AWS 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	N	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	F <sub>MN</sub>												
DEPOSITED METAL	7												
MECHANICAL PROPERTY ACCORDING TO EN10204 TYPE 3.1													
TENSILE TEST OF DEPOSITED METAL													
YIELD POINT	YIELD STRENGTH AT 0.2% OFFSET	TENSILE STRENGTH	ELONGATION		TEST TEMP.		IMPACT TEST OF DEPOSITED METAL			HARDNESS TEST			
- ksi	- ksi	81 ksi	28 %	- F	AVG.			ABSORBED ENERGY					
WELDING CONDITIONS													
TYPE OF CURRENT	DCEP	SHIELDING GAS	CO2 100%		POSTWELD HEAT TREATMENT			DISMUTING(B1) CONTENT IN DEPOSIT METAL IS NO LESS THAN 0.002%.					
AMPLITUDE	200 A				- F X - A			<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.													
<b>H. Sugawara</b> APPROVED BY CHIEF INSPECTOR													
◆KOBEL STEEL, LTD. WELDING BUSINESS FUJISAWA PLANT													

1281189-01/043181612000010-02104

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

W.O.N 11/27/12  
 2110 11 27  
 (9)

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



Product: Lincolnweld® 316/316L  
 Classification: ER316, ER316L  
 Specification: AWS A5.9:2008, ASME SFA-6.9  
 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 VJTUV.

Electrode composition (weight %)	ER316 Requirements	ER316L Requirements	3/32 Electrode RESULTS
C	0.08 max.	0.03 max.	0.02
Mn	1.0 - 2.5	1.0 - 2.5	1.4
Si	0.30 - 0.65	0.30 - 0.65	0.39
S	0.03 max.	0.03 max.	0.00
P	0.03 max.	0.03 max.	0.02
Cr	18.0 - 20.0	18.0 - 20.0	19.1
Ni	11.0 - 14.0	11.0 - 14.0	12.3
Mo	2.0 - 3.0	2.0 - 3.0	2.4
Cu	0.75 max.	0.75 max.	0.08
N	Not Required	Not Required	0.04
Nb	Not Required	Not Required	0.01
WRC-1992 (C)	Not Required	Not Required	8.10
WRC-Delong (C)	Not Required	Not Required	9.80

1. This certificate complies with the requirements of EN 10204, Type 2.2.
2. All other diameters manufactured will also meet these requirements
3. Results below the detection limits of the instrument or lower than the precision required by the specification are reported as zero.

Toronto Cunningham March 06, 2012  
 Toronto Cunningham, Certification Supervisor Date

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

WPS SAW-W-2-Y 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





Technical Standards and Safety Authority

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

# Welder/Welding Operator Certificate

Technical Standards and Safety Act  
Boilers and Pressure Vessels Regulation

No. 258822

Welder's Last Name <b>GREER</b>		Initial <b>R</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; R764.5</b>
Employer Name <b>ALL - WELD COMPANY LIMITED</b>				Company PCR 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		
Backing material (with/without)			WITHOUT		
Base Metal P-Number to P-Number			8 to 8		
( ) 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		
Manual or Semi-automatic Variables (QW-350)			Actual Values		
Filler Metal F-No. (QW-404)			F6		
Filler Metal Product Form for GTAW, PAW (QW-404)			SOLID		
Weld deposit thickness for each welding process (QW-404)			0.188"		
Process 1: _____ 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No			3		
Process 2: _____ 3 layers minimum <input type="checkbox"/> Yes <input type="checkbox"/> No			NONE		
Vertical progression (uphill/downhill) (QW-405)			UPHILL		
GTAW, PAW or GMAW backing gas; or OFW fuel gas (QW-408)			ARGON 99.9%		
GMAW transfer mode (spray/globular or pulse to short circuit)(QW-409)			NONE		
GTAW welding current type & polarity (AC, DCEP, DCEN)(QW-409)			DC / SP		
Machine Welding Variables (QW-361.2)			Actual Values		
Direct or remote visual control			NONE		
Automatic arc voltage control (GTAW)			NONE		
Automatic joint tracking			NONE		
Multiple or single pass per side			NONE		
Automatic Welding Variables (QW-361.1)			Actual Values		
Filler Metal (EBW or LBW)			NONE		
Laser type for LBW (CO <sub>2</sub> to YAG etc.)			NONE		
Continuous drive or inertia welding (FW)			NONE		
Vacuum or out of vacuum (EBW)			NONE		

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

### RESULTS

Visual Examination of Completed Weld (QW-302.4) ACCEPTED

Transverse root and face [QW-462.3(a)];  Longitudinal root and face [QW-462.3(b)];  Side (QW-462.2);

Pipe bend specimen, corrosion-resistant overlay (QW-462.5(c));  Plate bend specimen, corrosion-resistant overlay (QW-462.5(d));

Pipe specimen, macro test for fusion [QW-462.5(b)];  Plate specimen, macro test for fusion [QW-462.5(e)]

Type	Result	Type	Result	Type	Result	Type	Result
QW-462.3 (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)

COSTICA ROSU OUT 915 MAR 07, 2012  
Inspector Name and Number (Print) Inspector Signature and Date



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. 12707

Welder's Last Name/Nom du soudeur <b>ALPHONSO</b>		Initial/Nom du (de la) <b>GABBIDON</b>		First Name/Soudeur(euse) <b>GABBIDON</b>		Signature/Signature 		Stamp No./N° de symbole <b>25</b>	
Address/Adresse <b>49 NAVAGAL CRES</b>				Postal Code/Code postal <b>L3P 7G6</b>		Provincial Registration No. N° d'enregistrement provincial <b>QW 21425R</b>			
Company Name Nom de l'entreprise <b>ALL-WELD CO. LTD</b>				Address/Adresse <b>49 PASSMORE AVE</b>		Company POR No. N° RMS de l'entreprise <b>3</b>			
Address/Adresse <b>SCARBOROUGH ONT</b>				Postal Code/Code postal <b>M1V 4T1</b>		Company WPS No. N° DMS de l'entreprise <b>3-1</b>			
Process(es)/Procédé(s) <b>SMAW</b>				Type(s)/Type(s) <b>MANUAL</b>		Base Material(s) <b>SA-106-B/SA-106-B</b>			
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	
Backing & Type/Soutien et type						<b>NONE</b>		<b>WITH OR WITHOUT</b>	
ASME P-No./Du nr P- <b>1</b> (ASME) au nr P- <b>1</b> (ASME) & Thickness <b>0.218"</b>						<b>PER TO PT</b>		<b>PI THRU PII + PII</b>	
( ) Plate/Plaque ( <b>X</b> ) Pipe Dia./Diamètre du tuyau <b>2" Sch 80</b>						<b>0.218"</b>		<b>PIPE &gt; 24"</b>	
Filler Metal Specification (SFA)/Métal d'apport - spécification (SFA)						<b>E308</b>		<b>1" OD TO 24" OD</b>	
Filler Metal F- No./Métal d'apport - nr F-						<b>FS</b>		<b>FS</b>	
Consumable Insert (GTAW or PAW)/Pièce insérée consommable (TIG ou plasma)						<b>NONE</b>		<b>0. -</b>	
Weld deposit thickness for each process/Épaisseur du dépôt de soudure pour chaque procédé						<b>0.218</b>		<b>0.436" MAX</b>	
Welding Position (1G, 5G etc.)/Position du soudeur (1G, 5G etc.)						<b>6G</b>		<b>ALL GROOVE</b>	
Progression (uphill/downhill)/Progression (montant/descendant)						<b>NONE</b>		<b>ALL PIPE 1" OD AND</b>	
GTAW, PAW or GMAW or GMAW backing gas or OFW fuel gas/Gaz de soutien TIG, plasma ou SAGFE, ou gaz combustible pour soudage aux gaz						<b>NONE</b>		<b>UP TO 24" A</b>	
GMAW transfer mode/Mode de transfert SAGFE						<b>NONE</b>		<b>FILLETS.</b>	
GTAW welding current type & polarity/Type et polarité du courant de soudage TIG						<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	
Direct/remote visual control/Contrôle visuel direct ou à distance						<b>NONE</b>			
Automatic voltage control (GTAW)/Régulation de tension automatique (TIG)									
Automatic joint tracking/Suivi de joint automatique									
Welding position (1G, 5G etc.)/Position du soudeur (1G, 5G, etc.)									
Consumable insert/Pièce insérée consommable									
Backing & Type/Soutien et type									

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>-U-</b>	<b>ACCEPTABLE</b>
<b>S3</b>	<b>FACE</b>		<b>-U-</b>	<b>ACCEPTABLE</b>
<b>S4</b>	<b>ROOT</b>		<b>-U-</b>	<b>ACCEPTABLE</b>

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

Fillet Weld Fracture Test Essai de rupture	<b>NONE</b>	Length and percentage of defects Longueur et pourcentage de défauts	<b>-</b>	in. po.
Macro Test Fusion Macroscopie-fusion	<b>NONE</b>	Fillet Leg Size Dimension du côté	<b>-</b>	in. x po sur
Welding Test conducted by Essai effectué par	<b>ALL-WELD CO. LTD</b>	Date	<b>1 MARCH 94</b>	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 **ALL-WELD CO. LTD** Signature **Robert Bentley** Date **1 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**

**ALPHONSO GABBIDON** **25**  
Welder/Soudeur(euse) Symbol/Scéau

passed the welding test required under section 36 of the Boilers and Pressure Vessels Act, and is authorized to weld for:  
a passé l'examen de soudage exigé aux termes de l'article 36 de la Loi sur les chaudières et appareils sous pression, et est autorisé(e) par la présente 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 P. Eng. Chief Inspector

Ministry Use/Réservé au ministère

Test Requested By **Robert Bentley**  
Essai demandé (Print Name) (Nom en lettres moulées)

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

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



Technical Standards and Safety Authority

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

# Welder/Welding Operator Certificate

Technical Standards and Safety Act  
Boilers and Pressure Vessels Regulation

No. 262465

Welder's Last Name <b>GABBDON</b>	Initial	First Name <b>ALPHONSO</b>	Signature 	Stamp No. <b>25</b>
Res. Address <b>49 HAVAGAL CRES MARKHAM, ONT</b>		Postal Code <b>L 3 P 7 G 6</b>	Provincial Registration No. <b>R4428.5</b>	
Employer Name <b>ALL - WELD COMPANY LIMITED</b>		Company PQR No. <b>SAW - W-2-A1</b>		Company WPS No. used <b>SAW - W - 2 - 4</b>
Street Address <b>49 PASSMORE AVE</b>		Postal Code <b>M 1 V 4 T 1</b>	SCARBOROUGH, ONT	
Welding Process(es) Used <b>SAW</b>		Type(s)	<input type="checkbox"/> manual <input type="checkbox"/> machine <input type="checkbox"/> semi-automatic <input checked="" type="checkbox"/> automatic	
Base Material(s) <b>SA - 240 - 316L</b>		Thickness(es) <b>1 3/4"</b>	<input checked="" type="checkbox"/> Test Coupon <input type="checkbox"/> Production Weld	
Variables for All Processes		Actual Values	Range Qualified	
Backing material (with/without)		<b>BASE &amp; WELD METAL</b>	<b>BASE &amp; WELD METAL</b>	
Base Metal P-Number to P-Number		<b>P8 to P8</b>	<b>P1 THRU P15F, P34 &amp; P4X PLATE AND PIPE 2 7/8" OD AND UP</b>	
( X ) Plate ( ) Pipe (enter diameter if pipe)		<b>1 3/4"</b>		
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)		<b>5.9 ER316L</b>		
Consumable insert for GTAW or PAW (QW-404)		<b>NONE</b>		
Welding Position (1G, 5G, etc.) (QW-405)		<b>1G</b>	<b>1G</b>	
Manual or Semi-automatic Variables (QW-350)		Actual Values	Range Qualified	
Filler Metal F-No. (QW-404)		<b>6</b>	<b>6</b>	
Filler Metal Product Form for GTAW, PAW (QW-404)		<b>NONE</b>		
Weld deposit thickness for each welding process (QW-404)		<b>1 3/4"</b>	<b>MAX TO BE WELDED</b>	
Process 1: _____ 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No		<b>14</b>		
Process 2: _____ 3 layers minimum <input type="checkbox"/> Yes <input type="checkbox"/> No		<b>NONE</b>		
Vertical progression (uphill/downhill) (QW-405)		<b>NONE</b>		
GTAW, PAW or GMAW backing gas; or OFW fuel gas (QW-408)		<b>NONE</b>		
GMAW transfer mode (spray/globular or pulse to short circuit) (QW-409)		<b>NONE</b>		
GTAW welding current type & polarity (AC, DCEP, DCEN) (QW-409)		<b>NONE</b>		
Machine Welding Variables (QW-361.2)		Actual Values	Range Qualified	
Direct or remote visual control		<b>NONE</b>		
Automatic arc voltage control (GTAW)		<b>NONE</b>		
Automatic joint tracking		<b>NONE</b>		
Multiple or single pass per side		<b>NONE</b>		
Automatic Welding Variables (QW-361.1)		Actual Values	Range Qualified	
Filler Metal (EBW or LBW)		<b>NONE</b>		
Laser type for LBW (CO <sub>2</sub> to YAG etc.)		<b>NONE</b>		
Continuous drive or inertia welding (FW)		<b>NONE</b>		
Vacuum or out of vacuum (EBW)		<b>NONE</b>		

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

## RESULTS

Visual Examination of Completed Weld (QW-302.4) ACCEPTED

- Transverse root and face (QW-462.3(a));  Longitudinal root and face (QW-462.3(b));  Side (QW-462.2);  
 Pipe bend specimen, corrosion-resistant overlay (QW-462.5(c));  Plate bend specimen, corrosion-resistant overlay (QW-462.5(d));  
 Pipe specimen, macro test for fusion (QW-462.5(b));  Plate specimen, macro test for fusion (QW-462.5(e))

Type	Result	Type	Result	Type	Result	Type	Result
QW-462.2.2	ACCEPTED	QW-462.2.2	ACCEPTED				

Alternative radiographic examination results (QW-191) NONE

Fillet weld -- fracture test (QW-181.2) NONE Length and percent of defects NONE

- Fillet welds in plate (QW-462.4(b))  Fillet welds in pipe (QW-462.4(c))

Macro examination (QW-184) NONE Fillet size (in.) NONE x NONE Concavity/convexity (in.) NONE

Other tests NONE

Film or specimens evaluated by NONE Company NONE

Mechanical tests conducted by ALL - WELD COMPANY LIMITED Laboratory test no. NONE

Welding supervised by (Print name) ANDREW LEWIS

Test requested by (Print name) ROBERT BENTLEY Tested at (Print address) 49 PASSMORE AVE, SCARBOROUGH, ONT

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

Organization ALL - WELD COMPANY LIMITED Signature Date 03 - 04 - 2013  
(mm-dd-yyyy)

### FOR TSSA INSPECTOR USE ONLY

The Welder named above has passed the welding test required under Ontario's *Technical Standards and Safety Act*, Boilers and Pressure Vessels Regulation and is hereby authorized, subject to the limitations of this certificate.

Check (✓) applicable box below:

- To weld for the Employer named above only.  
 For seeking employment only.

This Certificate expires: PER ASME SECTION IX  
(mm-dd-yyyy)

COSICA DOW ONT 915  
Inspector Name and Number (Print)

Inspector Signature and Date MAR 04 19. 2013



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. 262459

Welder's Last Name MIRZA	Initial HAFEEZ (ABDUL)	First Name HAFEEZ (ABDUL)	Signature 	Stamp No. 53
Res. Address 2050 BRIDLE TOWN CRICLE, #607, SCARBOROUGH ONTARIO		Postal Code M 1 W 2 V 5	Provincial Registration No. 1 4628 5	
Employer Name ALL - WELD COMPANY LIMITED		Company PQR No. 3 - 3X		Company WPS No used
Street Address 49 PASSMORE AVE		Postal Code M 1 V 4 T 1	J-3D	
SCARBOROUGH, ONT		Welding Process(es) Used SMAW		
Base Material(s) SA-240-316 TO SA-240-316		Thickness(es) 1 3/4"	<input checked="" type="checkbox"/> Test Coupon <input type="checkbox"/> 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"		
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)		(5.4) E316-16		
Consumable insert for GTAW or PAW (QW-404)		NONE		
Welding Position (1G, 5G, etc.) (QW-405)		2G	2G	
Manual or Semi-automatic Variables (QW-360)		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: SMAW 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No		-	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-408)		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-462.2 (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 NONE

Fillet welds in plate [QW-462.4(b)]  Fillet welds in pipe [QW-462.4(c)]

Macro examination (QW-194) 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 03-28-2013  
(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)

ROBERT BOSCH 03/28/13  
Inspector Name and Number (Print)

Inspector Signature and Date



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**

City: **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;</b>
( <input checked="" type="checkbox"/> ) Plate ( ) Pipe (enter diameter if pipe)	<b>5/16"</b>	<b>PIPE 2 7/8" O.D. &amp; UP</b>
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)	<b>(5.4) E308-16</b>	
Consumable Insert for GTAW or PAW (QW-404)	<b>--</b>	
Welding Position (1G, 5G, etc.) (QW-405)	<b>2G</b>	<b>2G</b>
Manual or Semi-automatic Variables (QW-350)	Actual Values	Range Qualified
Filler Metal F. No. (QW-404)	<b>F5</b>	<b>F5</b>
Filler Metal Product Form for GTAW PAW (QW-404)	<b>--</b>	<b>--</b>
Weld deposit thickness for each welding process (QW-404)	<b>5/16"</b>	<b>5/8" MAX.</b>
Progression (uphill/downhill) (QW-405)	<b>--</b>	<b>--</b>
GTAW PAW or GMAW backing gas, or OFW fuel gas (QW-408)	<b>--</b>	<b>--</b>
GMAW transfer mode (QW-409)	<b>--</b>	<b>--</b>
GTAW welding current type & polarity (QW-409)	<b>--</b>	<b>--</b>
Machine Welding Variables (QW-361-2)	Actual Values	Range Qualified
Direct or remote visual control	<b>--</b>	<b>--</b>
Automatic voltage control (GTAW)	<b>--</b>	<b>--</b>
Automatic joint tracking	<b>--</b>	<b>--</b>
Multiple or single pass per side	<b>--</b>	<b>--</b>
Automatic Welding Variables (QW-361-1)	Actual Values	Range Qualified
Filler metal (EBW or LBW)	<b>--</b>	<b>--</b>
Laser type for LBW (CO <sub>2</sub> to YAG etc.)	<b>--</b>	<b>--</b>
Continuous drive or inertia welding (FW)	<b>--</b>	<b>--</b>
Vacuum or out of vacuum (EBW)	<b>--</b>	<b>--</b>

Manufacturer's Copy

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

**RESULTS**

Visual Examination of Completed Weld (QW-302.4) **ACCEPTED**

Bend test,  Transverse root and face [QW-462.3(a)];  Longitudinal root and face [QW-462.3(b)];  Side [QW-462.2];

Pipe bend specimen, corrosion-resistant overlay [QW-462.5(c)];  Plate bend specimen, corrosion-resistant overlay [QW-462.5(d)];

Macro test for fusion [QW-462.5(b)];  Macro test for fusion [QW-462.5(e)]

Type	Result	Type	Result	Type	Result
<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**

Symbol

**FAN YANG**  
 Welder

Has passed the welding test required under Ontario's **Technical Standards and Safety Act**, Boilers and Pressure Vessels Regulation and is hereby authorized to weld for

**ALL-WELD COMPANY LIMITED**

Subject to the limitations of this certificate

Authorized Examiner *[Signature]*

Director

**Office Use Only**

Test Requested By **ROBERT BENTLEY**

(Print Person's Name)

**ALL-WELD COMPANY LIMITED**

Tested At **49 PASSMORE AVE., SCARBOROUGH, ONT.**

(Print Address)

District # **13**

Inspector # **OWI-037**

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</b> to <b>P 8</b>	<b>P1 THRU P11 &amp; P4X PLATE &amp; ALL PIPE 1" O.D. &amp; UP</b>
( ) Plate ( <input checked="" type="checkbox"/> ) Pipe (enter diameter if pipe)	<b>2 3/8" O.D.</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>
G transfer mode (QW-409)	<b>N/A</b>	<b>N/A</b>
GTAW welding current type & polarity (QW-409)	<b>DC/SP</b>	<b>DC/SP</b>
Machine Welding Variables (QW-361-2)	Actual Values	Range Qualified
Direct or remote visual control	<b>---</b>	<b>---</b>
Automatic voltage control (GTAW)	<b>---</b>	<b>---</b>
Automatic joint tracking	<b>---</b>	<b>---</b>
Multiple or single pass per side	<b>---</b>	<b>---</b>
Automatic Welding Variables (QW-361-1)	Actual Values	Range Qualified
Filler metal (EBW or LBW)	<b>---</b>	<b>---</b>
Laser type for LBW (CO <sub>2</sub> to YAG etc.)	<b>---</b>	<b>---</b>
Continuous drive or inertia welding (FW)	<b>---</b>	<b>---</b>
Vacuum or out of vacuum (EBW)	<b>---</b>	<b>---</b>

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

## RESULTS

Visual Examination of Completed Weld (QW-302.4) **ACCEPTED**

- Bend test;  Transverse root and face [QW-462.3(a)];  Longitudinal root and face [QW-462.3(b)];  Side [QW-462.2];  
 Pipe bend specimen, corrosion-resistant overlay [QW-462.5(c)];  Plate bend specimen, corrosion-resistant overlay [QW-462.5(d)];  
 Macro test for fusion [QW-462.5(b)];  Macro test for fusion [QW-462.5(e)]

Type	Result	Type	Result	Type	Result
(ROOT)	ACCEPTED	(FACE)	ACCEPTED		
(ROOT)	ACCEPTED	(FACE)	ACCEPTED		

Alternative radiographic examination results (QW-191) **---**

Fillet weld — fracture test (QW-180) **---** Length and percent of defects **---**

Macro examination (QW-184) **---** Fillet size (in.) **---** x **---** Concavity/convexity (in.) **---**

Other tests **---**

Film or specimens evaluated by **---** Company **---**

Mechanical tests conducted by **ALL-WELD COMPANY LIMITED** Laboratory test no **---**

Welding supervised by **ANDREW LEWIS**

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

Organization **ALL-WELD COMPANY LIMITED** Signature *R.B. Bentley* Date **JANUARY 26, 2006**



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

PER ASME  
Expiry Date **SECT. IX**  
**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)

District # **5**

Inspector # **20005**

Fee **0.5**



Technical Standards and Safety Authority

14th Floor - Centre Tower  
3300 Bloor Street West  
Toronto, Ontario MBX 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 <i>[Signature]</i>	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 PQR 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>	Type(s) <input checked="" type="checkbox"/> manual <input type="checkbox"/> machine <input type="checkbox"/> semi-automatic <input type="checkbox"/> automatic	
City <b>Scarborough, Ontario</b>		Thickness(es) <b>3/8"</b>		
Welding Process(es) Used <b>SMAW</b>		Base Material(s) <b>SA 516-GR 70 / SA 516-GR 70</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
( ) 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-350)	Actual Values	Range Qualified
Filler Metal F- No. (QW-404)	F4	F4
Filler Metal Product Form for GTAW, PAW (QW-404)	--	--
Weld deposit thickness for each welding process (QW-404)	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-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 (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 *[Signature]* Date July 11, 2011

### 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

Michael Scott Ont00952  
Inspector Name and Number (Print)

*[Signature]*  
Inspector Signature



Technical Standards and Safety Authority

11th Floor - Centre Tower  
1100 Bloor Street West  
Toronto, Ontario M6K 2X4  
Web site: www.tssa.org

# Welder/Welding Operator Certificate

Technical Standards and Safety Act  
Boilers and Pressure Vessels Regulation

No. 002100

Welder's Last Name: STEVE Initial: STEVE First Name: STEVE Signature: [Signature] Stamp No.: 00  
 Postal Code: M1H1W2 Provincial Registration No.: WP-746285  
 Employer Name: ALL-WELD COMPANY LIMITED Company PQR No.: 3-3X  
 Street Address: 48 PASSMORE AVE Postal Code: M1V4T1 Company WPS No. used: 3-3B  
 Welding Process(es) Used: SMAW Type(s):  manual  machine  semi-automatic  automatic

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

Variables for All Processes	Actual Values	Range Qualified
Backing material (with/without)	WITH	WITH
Base Metal P-Number to P-Number	8 to 8	P1 THRU P15F, P34 & P4X PLATE AND PIPE 2 7/8" OD AND UP AND ALL FILLETS
(X) Plate ( ) Pipe (enter diameter if pipe)	1 3/4"	
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)	5.4 E318-16	
Consumable treat for GTAW or PAW (QW-404)	NONE	
Welding Position (1G, 5G, etc.) (QW-405)	2G	1G & 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)	1 3/4"	MAX TO BE WELDED
Process 1: _____ 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	NONE	
Process 2: _____ 3 layers minimum <input type="checkbox"/> Yes <input type="checkbox"/> No	NONE	
Vertical progression (uphill/downhill) (QW-405)	NONE	
GTAW, PAW or GMAW backing gas; or OPW fuel gas (QW-406)	NONE	
GMAW transfer mode (spray/globular or pulse to short circuit) (QW-406)	NONE	
GTAW welding current type & polarity (AC, DCEP, DCEN) (QW-406)	NONE	
Machine Welding Variables (QW-391.2)	Actual Values	Range Qualified
Direct or remote visual control	NONE	
Automatic arc voltage control (GTAW)	NONE	
Automatic joint tracking	NONE	
Multiple or single pass per side	NONE	
Automatic Welding Variables (QW-391.1)	Actual Values	Range Qualified
Filler Metal (EBW or 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	ACCEPTED	QW-462.2	ACCEPTED	QW-462.2	ACCEPTED	QW-462.2	ACCEPTED
(Side)		(Side)		(Side)		(Side)	

Alternative radiographic examination results (QW-191) NONE  
 Fillet weld - fracture test (QW-181.2) NONE Length and percent of defects \_\_\_\_\_  
 Fillet welds in plate [QW-462.4(b)]  Fillet welds in pipe [QW-462.4(c)]  
 Macro examination (QW-184) NONE Fillet size (in.) NONE x NONE Concavity/convexity (in.) NONE  
 Other tests NONE  
 Film or specimens evaluated by NONE Company NONE  
 Mechanical tests conducted by CAMBRIDGE MATERIAL TESTING LIMITED Laboratory test no. 634882-2813 & 634881-2813  
 Welding supervised by (Print name) ANDREW LEWIS  
 Test requested by (Print name) ROBERT BENTLEY Tested at (Print address) 48 PASSMORE AVE, SCARBOROUGH, ONT

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Boiler and Pressure Vessel Code.  
 Organization ALL-WELD COMPANY LIMITED Signature [Signature] Date 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.  
 Inspector Name and Number (Print) OUT915  
 Inspector Signature and Date [Signature] MAR 15, 2013  
(mm-dd-yyyy)





Technical Standards and Safety Authority

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

# Welder/Welding Operator Certificate

Technical Standards and Safety Act  
Boilers and Pressure Vessels Regulation

No. 258828

Welder's Last Name <b>ALROUBAYI</b>		Initial <b>A</b>	First Name <b>RAZZAK</b>	Signature 	Stamp No <b>109</b>
Res. Address <b>140 QUANTRELL TRIAL SCARBOROUGH, ONT</b>				Postal Code <b>M 1 B 1 L B</b>	Provincial Registration No. <b>R4428.5</b>
Employer Name <b>ALL - WELD COMPANY LIMITED</b>				Company POR No. <b>SAW - 2A1</b>	
Street Address <b>49 PASSMORE AVE</b>				Company WPS No used <b>SAW - W - 2 - 1</b>	
SCARBOROUGH, ONT				Postal Code <b>M 1 V 4 T 1</b>	
Welding Process(es) Used <b>SAW</b>				Type(s) <input type="checkbox"/> manual <input type="checkbox"/> machine <input type="checkbox"/> semi-automatic <input checked="" type="checkbox"/> automatic	
Base Material(s) <b>SA - 240 - 304</b>			Thickness(es) <b>1"</b>	<input checked="" type="checkbox"/> Test Coupon <input type="checkbox"/> Production Weld	
Variables for All Processes		Actual Values		Range Qualified	
Backing material (with/without)		<b>BASE &amp; WELD METAL</b>		<b>BASE &amp; WELD METAL</b>	
Base Metal P-Number to P-Number		P8 to P8		P1 THRU P15F, P34 & P4X PLATE AND PIPE 2 7/8" OD AND UP	
( <input checked="" type="checkbox"/> ) Plate ( ) Pipe (enter diameter if pipe)		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-406)		NONE			
GMAW transfer mode (spray/globular or pulse to short circuit) (QW-409)		NONE			
GTAW welding current type & polarity (AC, DCEP, DCEN)(QW-409)		NONE			
Machine Welding Variables (QW-361.2)		Actual Values		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-462.2.2	ACCEPTED	QW-462.2.2	ACCEPTED				

Alternative radiographic examination results (QW-191) **NONE**

Fillet weld — fracture test (QW-181.2) **NONE** Length and percent of defects **NONE**  
 Fillet welds in plate [QW-462.4(b)]  Fillet welds in pipe [QW-462.4(c)]  
 Macro examination (QW-184) **NONE** Fillet size (in.) **NONE** x **NONE** Concavity/convexity (in.) **NONE**  
 Other tests **NONE**

Film or specimens evaluated by **NONE** Company **NONE**  
 Mechanical tests conducted by **ALL - WELD COMPANY LIMITED** Laboratory test no. **NONE**

Welding supervised by (Print name) **ANDREW LEWIS**  
 Test requested by (Print name) **ROBERT BENTLEY** Tested at (Print address) **49 PASSMORE AVE, SCARBOROUGH, ONT**

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

Organization **ALL - WELD COMPANY LIMITED** Signature Date **03-06-2012**  
(mm-dd-yyyy)

### FOR TSSA INSPECTOR USE ONLY

The Welder named above has passed the welding test required under Ontario's *Technical Standards and Safety Act*, Boilers and Pressure Vessels Regulation and is hereby authorized, subject to the limitations of this certificate.

Check (✓) applicable box below:

- To weld for the Employer named above only.  
 For seeking employment only.

This Certificate expires: **PER ASME SECTION IX**  
(mm-dd-yyyy)

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

**ONT915**

**MAR 09, 2012**  
 Inspector Signature and Date



Technical Standards and Safety Authority

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. 257501

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

Res. Address: 21 BORNHOLM DRIVE TORONTO, ONTARIO Postal Code: M1C4P6G Provincial Registration No.: QW2142.5R & R2180.5  
Company PQR No.: 3 & 3A  
Company WPS No. used:

Employer Name: ALL - WELD COMPANY LIMITED Street Address: 49 PASSMORE AVE  
Postal Code: M1V4T1 3-1

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

Base Material(s): SA-240-304 TO SA-240-304 Thickness(es): 3/8"  Test Coupon  Production Weld

Variables for All Processes	Actual Values	Range Qualified
Backing material (with/without)	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)

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. 257507

Welder's Last Name <b>INNIS</b>	Initial <b>AI</b>	First Name <b>ANDREW</b>	Signature <i>Andrew Innis</i>	Stamp No. <b>110</b>
Res Address <b>21 BORNHOLM DRIVE TORONTO, ONTARIO</b>		Postal Code <b>M 1 C 4 P G</b>	Provincial Registration No. <b>R3578 5, D852 5 &amp; R764 5</b>	
Employer Name <b>ALL - WELD COMPANY LIMITED</b>		Company PQR No. <b>54 9 9AB</b>		
Street Address <b>49 PASSMORE AVE</b>		Company WPS No used		
SCARBOROUGH, ONT		Postal Code <b>M 1 V 4 T 1</b>	9-1	
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		
Base Metal P-Number to P-Number		WITH OR WITHOUT		
( ) Plate ( X ) Pipe (enter diameter if pipe)		P1 THRU P15F, P34, & P4X PLATE AND PIPE 1" OD AND UP		
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)		2.3/8"		
Consumable Insert for GTAW or PAW (QW-404)		5.9 ER 308		
Welding Position (1G, 5G, etc.) (QW-405)		NONE		
Manual or Semi-automatic Variables (QW-350)		Actual Values	Range Qualified	
Filler Metal F-No (QW-404)		6G		
Filler Metal Product Form for GTAW, PAW (QW-404)		F6		
Weld deposit thickness for each welding process (QW-404)		SOLID		
Process 1 _____ 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No		0.218"		
Process 2 _____ 3 layers minimum <input type="checkbox"/> Yes <input type="checkbox"/> No		0.436" MAX PLATE GROOVE + PIPE 1" OD + UP		
Vertical progression (uphill/downhill) (QW-405)		3		
GTAW, PAW or GMAW backing gas, or OFW fuel gas (QW-408)		+ ALL FILLETS		
GMAW transfer mode (spray/globular or pulse to short circuit) (QW-409)		NONE		
GMAW 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		UPHILL		
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)		ARGON 99%		
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	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 *Robert Bentley* Date **01-09-2012**  
(mm-dd-yyyy)

### FOR TSSA INSPECTOR USE ONLY

The Welder named above has passed the welding test required under Ontario's Technical Standards and Safety Act, Boilers and Pressure Vessels Regulation and is hereby authorized, subject to the limitations of this certificate

Check (✓) applicable box below:

- To weld for the Employer named above only  
 For seeking employment only

This Certificate expires **PER ASME SECTION IX**  
(mm-dd-yyyy)

**WOSTICA ROW ONT915**  
Inspector Name and Number (Print)

*[Signature]* **21/09/2012**  
Inspector Signature and Date



Technical Standards and Safety Authority

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

Welder/Welding Operator Certificate

Technical Standards and Safety Act  
Boilers and Pressure Vessels Regulation

No. 262463

Welder's Last Name: INNISS Initial: ANDREW First Name: ANDREW Signature: [Signature] Stamp No: 110  
 Res. Address: 21 BORNHOLM DRIVE TORONTO, ONTARIO Postal Code: M1B 1L8 Provincial Registration No: WP T-3646 5  
 Employer Name: ALL - WELD COMPANY LIMITED Company PQR No: 50-X  
 Street Address: 49 PASSMORE AVE Postal Code: M1V 4T1 Company WPS No used: 50-3A  
 Welding Process(es) Used: FCAW Type(s):  manual  machine  semi-automatic  automatic  
 Base Material(s): SA-240-316 TO SA-240-316 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	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"	
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)	(5.22) E316LTO-1	
Consumable Insert for GTAW or PAW (QW-404)	NONE	
Welding Position (1G, 5G, etc.) (QW-405)	2G	2G
<b>Manual or Semi-automatic Variables (QW-350)</b>		
Filler Metal F-No. (QW-404)	F6	F6
Filler Metal Product Form for GTAW, PAW (QW-404)	NONE	NONE
Weld deposit thickness for each welding process (QW-404)	3/8"	MAX TO BE WELDED
Process 1, FCAW 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	--	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)	CO2	CO2
GMAW transfer mode (spray/globular or pulse to short circuit) (QW-409)	SPRAY	SPRAY, GLOBULAR & PULSE
GTAW welding current type & polarity (AC, DCEP, DCEN) (QW-409)	NONE	
<b>Machine Welding Variables (QW-381.2)</b>		
Direct or remote visual control	NONE	
Automatic arc voltage control (GTAW)	NONE	
Automatic joint tracking	NONE	
Multiple or single pass per side	NONE	
<b>Automatic Welding Variables (QW-381.1)</b>		
Filler Metal (EBW or LBW)	NONE	
Laser type for LBW (CO <sub>2</sub> to YAG etc.)	NONE	
Continuous drive or inertia welding (FW)	NONE	
Vacuum or out of vacuum (EBW)	NONE	

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

RESULTS

Visual Examination of Completed Weld (QW-302.4) ACCEPTED

- Transverse root and face [QW-462.3(a)];  Longitudinal root and face [QW-462.3(b)];  Side [QW-462.2];
- Pipe bend specimen, corrosion-resistant overlay [QW-462.5(c)];  Plate bend specimen, corrosion-resistant overlay [QW-462.5(d)];
- Pipe specimen, macro test for fusion [QW-462.5(b)];  Plate specimen, macro test for fusion [QW-462.5(e)]

Type	Result	Type	Result	Type	Result	Type	Result
QW-462.2 (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 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 04-11-2013

(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)

Inspector Name and Number (Print) GUSTICA ROSE ONTARIO

Inspector Signature and Date [Signature] APRIL 11, 2013





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 <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>L1X 2E1</b>	Provincial Registration No. <b>QW2142.5R &amp; R2180.5</b>	
Employer Name <b>ALL - WELD COMPANY LIMITED</b>		Company PQR No. <b>3 &amp; 3A</b>		
Street Address <b>49 PASSMORE AVE</b>		Postal Code <b>M1V 4T1</b>	Company WPS No used <b>3-1</b>	
Welding Process(es) Used <b>SMAW</b>		Type(s) <input checked="" type="checkbox"/> manual <input type="checkbox"/> machine <input type="checkbox"/> semi-automatic <input type="checkbox"/> automatic		
Base Material(s) <b>SA-240-304 TO SA-240-304</b>		Thickness(es) <b>3/8"</b>	<input checked="" type="checkbox"/> Test Coupon <input type="checkbox"/> Production Weld	
<b>Variables for All Processes</b>				
		<b>Actual Values</b>	<b>Range Qualified</b>	
Backing material (with/without)		<b>WITHOUT</b>		
Base Metal P-Number to P-Number ( <input checked="" type="checkbox"/> ) Plate ( ) Pipe (enter diameter if pipe)		<b>8 to 8</b>		
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)		<b>0.375"</b>		
Consumable Insert for GTAW or PAW (QW-404)		<b>5.4 E308-16</b>		
Welding Position (1G, 5G, etc.) (QW-405)		<b>NONE</b>		
		<b>2G</b>		
		<b>1G &amp; 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>		
Filler Metal Product Form for GTAW, PAW (QW-404)		<b>F5</b>		
Weld deposit thickness for each welding process (QW-404)		<b>NONE</b>		
Process 1: _____ 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No		<b>3/8"</b>		
Process 2: _____ 3 layers minimum <input type="checkbox"/> Yes <input type="checkbox"/> No		<b>4</b>		
Vertical progression (uphill/downhill) (QW-405)		<b>NONE</b>		
GTAW, PAW or GMAW backing gas; or OFW fuel gas (QW-408)		<b>NONE</b>		
GMAW transfer mode (spray/globular or pulse to short circuit) (QW-409)		<b>NONE</b>		
GTAW welding current type & polarity (AC, DCEP, DCEN)(QW-409)		<b>NONE</b>		
<b>Machine Welding Variables (QW-361.2)</b>				
		<b>Actual Values</b>	<b>Range Qualified</b>	
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>		
<b>Automatic Welding Variables (QW-361.1)</b>				
		<b>Actual Values</b>	<b>Range Qualified</b>	
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				
(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 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)

OSSTICA ROSU ONT915  
Inspector Name and Number (Print)

DEC 10, 2012  
Inspector Signature and Date

ITEM	QTY	DESCRIPTION	SPEC
1	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
2	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
3	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
4	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
5	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
6	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
7	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
8	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
9	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
10	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
11	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
12	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
13	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
14	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
15	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
16	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
17	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
18	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
19	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
20	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
21	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
22	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
23	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
24	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
25	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
26	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
27	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
28	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
29	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
30	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
31	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
32	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
33	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
34	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
35	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
36	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
37	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
38	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
39	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
40	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
41	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
42	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
43	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
44	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
45	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
46	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
47	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
48	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
49	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
50	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
51	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
52	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
53	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
54	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
55	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
56	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
57	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
58	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
59	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
60	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
61	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
62	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
63	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
64	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
65	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
66	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
67	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
68	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
69	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
70	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
71	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
72	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
73	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
74	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
75	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
76	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
77	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
78	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
79	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
80	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
81	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
82	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
83	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
84	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
85	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
86	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
87	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
88	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
89	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING
90	1	1/4" DIA. VERTICAL LIFT ASSEMBLY	SEE DRAWING

**GENERAL NOTES:**

- MATERIALS OF CONSTRUCTION, SA-240 316/316L.
- WELD FINISH INSIDE AND OUT: FLUX & SPATTER REMOVED.
- SURFACE FINISH: INTERNAL - AS FABRICATED; EXTERNAL - AS FABRICATED.
- HEAT STAIN REMOVE AND/OR PASSIVATION AND EXTENSION BY ETCHING AND/OR PASSIVATION.
- ALL BOLT HOLES TO STRADDLE EITHER MAJOR OR MINOR AXIS.
- BLANK ALL OPENINGS FOR SUPPLEMENTARY GASKET AND PROTECTIVE COVER WITH FOUR BOLTS.
- NOZZLE FILLETS BLEND SMOOTHLY WITHOUT NOTCH, SHARP HOOKS OR UNDER CUTS.
- GASKET HARDNESS MUST BE LESS THAN THAT OF THE FLANGE HARDNESS. THIS MUST BE DOCUMENTED.
- VESSELS TO BE SHIPPED WITH THE HYDROTEST GASKETS AND SERVICE GASKETS.
- LIFTING LUGS DESIGN FOR VERTICAL LIFT ONLY.

**QUALITY ASSURANCE NOTES:**

- ASME DATA REPORT AND NAMEPLATE LABELING.
- WELDER QUALIFICATIONS, WPS, POR, MCE, AND HYDROTEST CERTIFICATES OBTAINED ON AS BUILT DRAWINGS.
- WATER TO BE LESS THAN 50PPM OF CHLORIDE.
- CERTIFICATE OF COMPLIANCE TO APPROVED DRAWINGS.
- ONLY SEAMLESS PIPE USED.
- PARTS TO HAVE HARD STAMPED THE HEAT NUMBERS.
- VISUAL INSPECT ALL WELDS.
- SERVICE GASKETS REQUIRED FOR HYDRO TESTING.
- PT ALL WELDS INTERNAL AND EXTERNAL OF VESSEL.
- ALL MATERIALS MUST MEET MAKE MROTS.
- INSURANCE MROTS/INSURANCE FOR SOLAR SPECIFICATION PART 2 PARAGRAPHS 7.3.3.2, 7.3.3.3, 7.3.3.4 AND A.2.1.4.

**DESIGN DATA:**

DESIGNED AND FABRICATED TO ASME SECTION VIII, DIV. 1 UN R101 2000 EDITION, 20th ADDENDA AND CSA B34-2008. REGISTERED WITH NATIONAL BOARD.

DESIGN PRESSURE: 1378 PSIG  
 DESIGN TEMPERATURE: 140 °F  
 M.A.E. W.P.: 1978 PSIG  
 M.A.E. W.P.: 1978 PSIG @ 140 °F  
 M.A.E. W.P.: 1752 PSIG @ 50 °F

CORROSION ALLOWANCE: FULL 100% (RT-1)  
 AS PER US BRIGHING 5A  
 RADIOGRAPHY: NOT REQUIRED AS PER UHA-5(G) OFF OF THE COAST OF ANGOLA

LOCATION OF INSTALLATION: 7475  
 SERIAL NO. 5: 7475  
 C.R.N.: 7475  
 NATIONAL BOARD NO.: M0355.5  
 WEIGHT: 73 U.S. GALLONS  
 24,000 LB. (EMPTY)  
 24,000 LB. (FULL WITH WATER)

**PLOTTED:**

**WELD MAP**

(2) REQUIRED

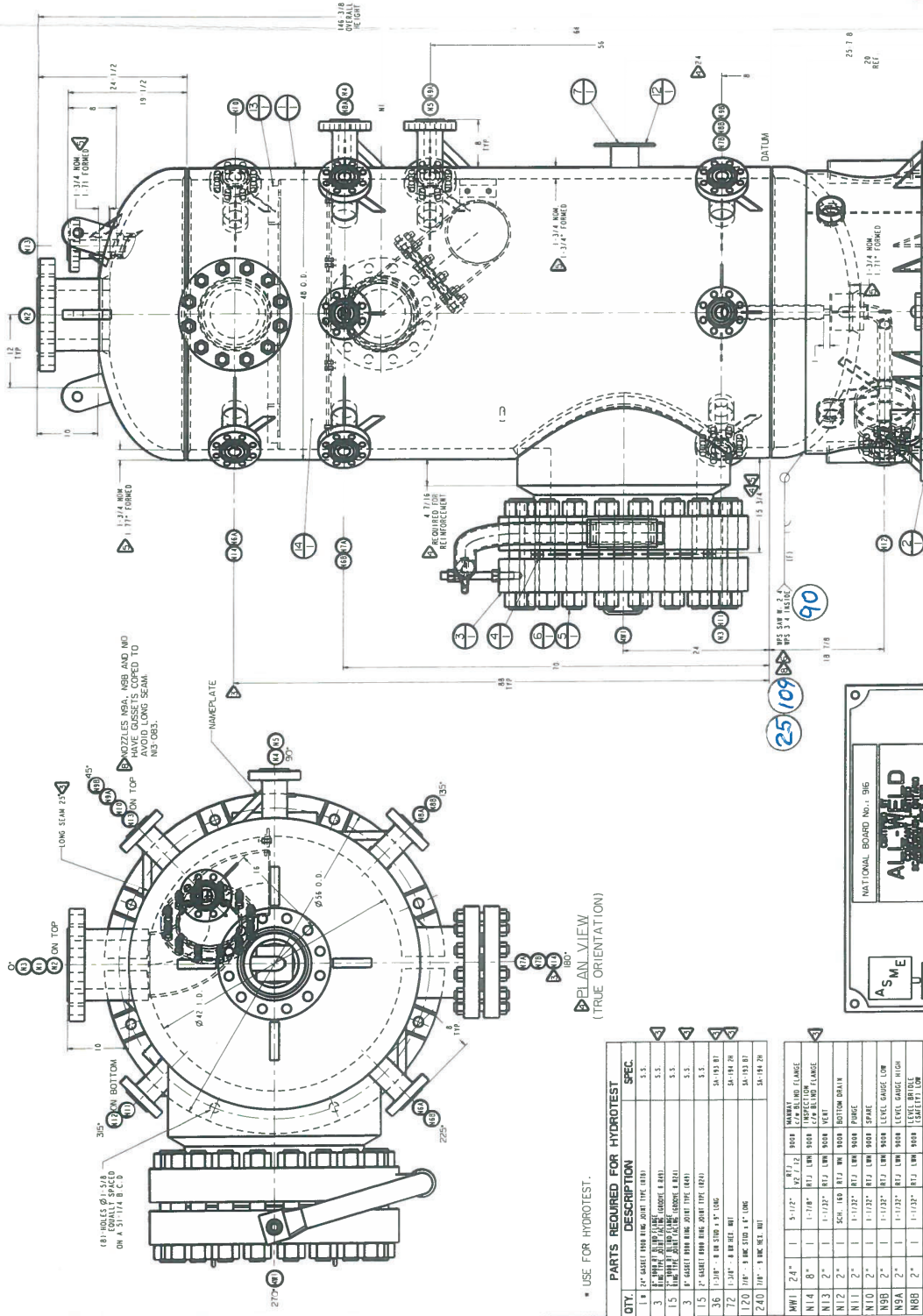
PURCHASE ORDER NUMBER: 1112

STANDARD TOLERANCES:  
 ALL DIMENSIONS UNLESS OTHERWISE NOTED  
 LENGTH ± 0.015"  
 L x W ± 0.015"  
 R ± 0.015"  
 Ø ± 0.015"

ASME NAMEPLATE STAMPING DETAIL  
 (SEE DRAWING 1073-B FOR ALL NAMEPLATE STAMPING)

ASME  
 W.L.  
 RT-1  
 NATIONAL BOARD No. 916  
 TAGR 772-VESE-203  
 M0355.5  
 7475 T50E 011  
 203

ITEM	SIZE	REQD	WELK	PLG.	RATE	SERVICE
MW1	2 1/4"	1	5-1122	R12	1000	1000
N14	8"	1	1-1184	R12	1000	1000
N12	2"	1	1-1122	R12	1000	1000
N11	2"	1	506	R12	1000	1000
N10	2"	1	1-1122	R12	1000	1000
N9B	2"	1	1-1122	R12	1000	1000
N9A	2"	1	1-1122	R12	1000	1000
N8B	2"	1	1-1122	R12	1000	1000
N8A	2"	1	1-1122	R12	1000	1000
N7B	2"	1	1-1122	R12	1000	1000
N7A	2"	1	1-1122	R12	1000	1000
N6B	2"	1	1-1122	R12	1000	1000
N6A	2"	1	1-1122	R12	1000	1000
N5	2"	1	1-1122	R12	1000	1000
N4	2"	1	1-1122	R12	1000	1000
N3	2"	1	1-1122	R12	1000	1000
N2	8"	1	1-1184	R12	1000	1000
N1	8"	1	1-1184	R12	1000	1000



**ITEMS REQUIRED FOR HYDROTEST**

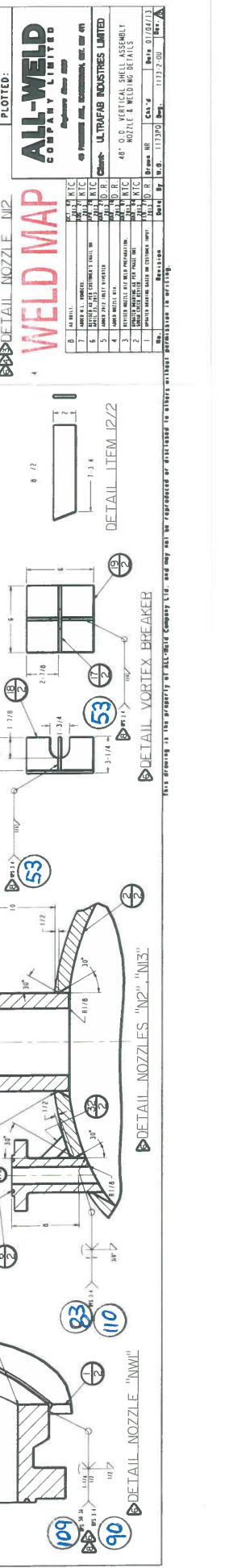
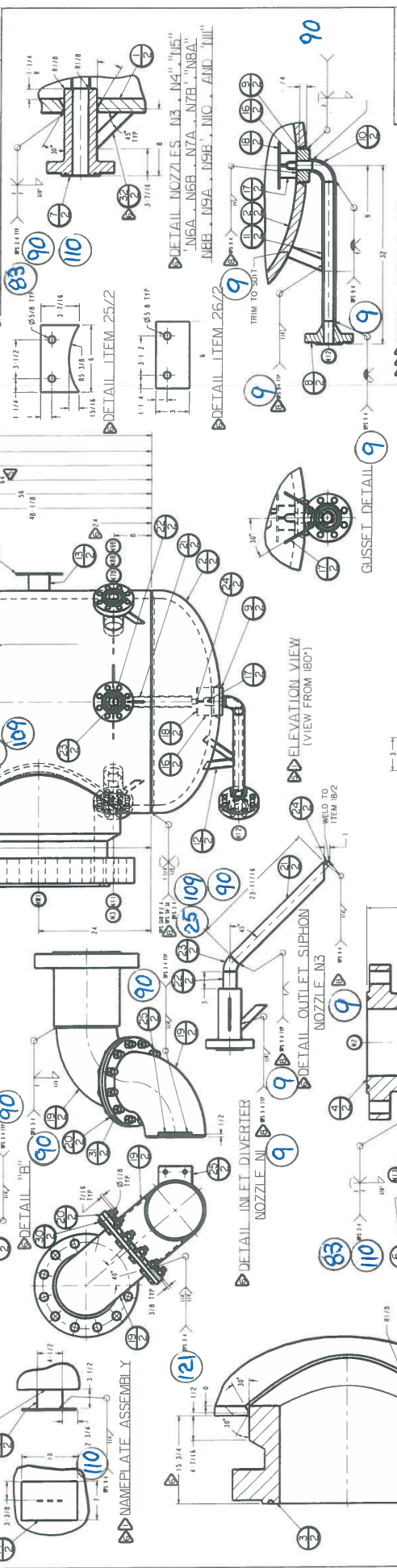
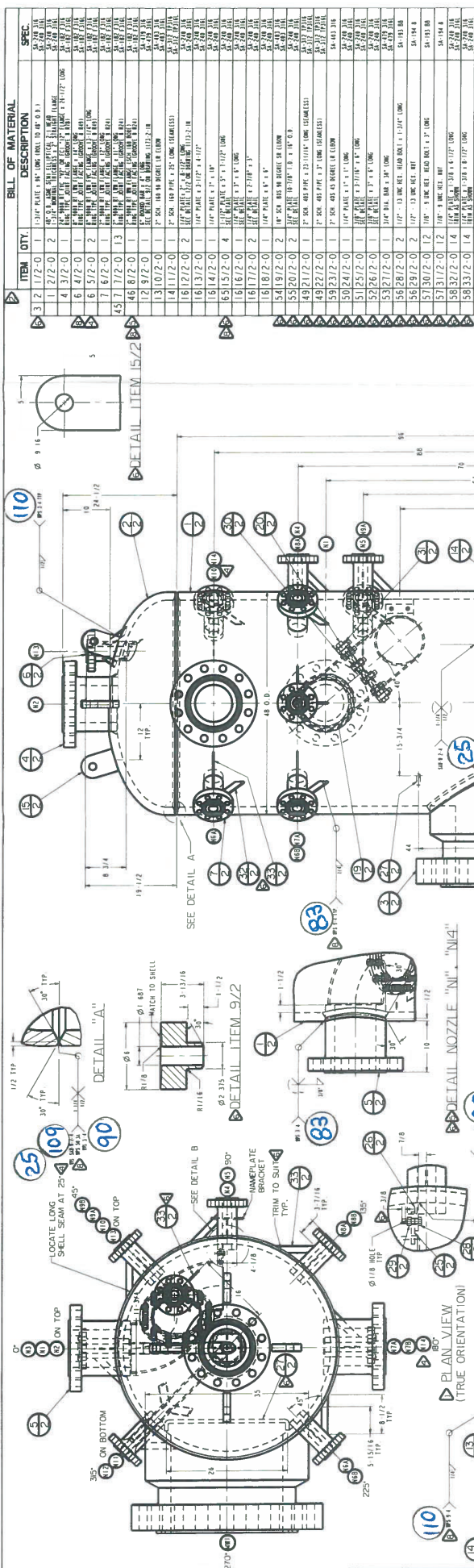
QTY.	DESCRIPTION	SPEC.
1	1" x 1/4" x 1/4" (1/4" DIA. VERTICAL LIFT ASSEMBLY)	S.S.
3	1/4" DIA. VERTICAL LIFT ASSEMBLY	S.S.
15	1/4" DIA. VERTICAL LIFT ASSEMBLY	S.S.
3	1/4" DIA. VERTICAL LIFT ASSEMBLY	S.S.
36	1/4" DIA. VERTICAL LIFT ASSEMBLY	S.S.
72	1/4" DIA. VERTICAL LIFT ASSEMBLY	S.S.
170	1/4" DIA. VERTICAL LIFT ASSEMBLY	S.S.
240	1/4" DIA. VERTICAL LIFT ASSEMBLY	S.S.

**NOZZLE SCHEDULE**

ITEM	SIZE	REQD	WELK	PLG.	RATE	SERVICE
MW1	2 1/4"	1	5-1122	R12	1000	1000
N14	8"	1	1-1184	R12	1000	1000
N12	2"	1	1-1122	R12	1000	1000
N11	2"	1	506	R12	1000	1000
N10	2"	1	1-1122	R12	1000	1000
N9B	2"	1	1-1122	R12	1000	1000
N9A	2"	1	1-1122	R12	1000	1000
N8B	2"	1	1-1122	R12	1000	1000
N8A	2"	1	1-1122	R12	1000	1000
N7B	2"	1	1-1122	R12	1000	1000
N7A	2"	1	1-1122	R12	1000	1000
N6B	2"	1	1-1122	R12	1000	1000
N6A	2"	1	1-1122	R12	1000	1000
N5	2"	1	1-1122	R12	1000	1000
N4	2"	1	1-1122	R12	1000	1000
N3	2"	1	1-1122	R12	1000	1000
N2	8"	1	1-1184	R12	1000	1000
N1	8"	1	1-1184	R12	1000	1000

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ITEM	QTY	DESCRIPTION	SPEC
3	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
4	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
5	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
6	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
7	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
8	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
9	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
10	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
11	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
12	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
13	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
14	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
15	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
16	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
17	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
18	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
19	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
20	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
21	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
22	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
23	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
24	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
25	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
26	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
27	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
28	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
29	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
30	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
31	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
32	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
33	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
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42	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
43	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
44	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
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47	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
48	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
49	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
50	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
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52	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
53	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
54	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
55	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
56	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
57	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
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63	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
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70	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
71	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
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73	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
74	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
75	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
76	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
77	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
78	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
79	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
80	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
81	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
82	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
83	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
84	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
85	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
86	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
87	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
88	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
89	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
90	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
91	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
92	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
93	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
94	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
95	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
96	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
97	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
98	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
99	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70
100	172-0	1/4" PLATE, 36" X 48" (SEE 3.1)	A516-70

**WELD MAP**

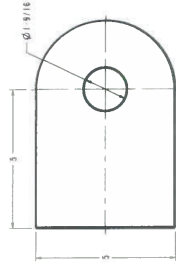
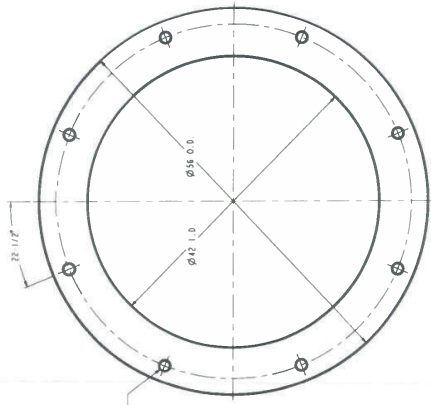
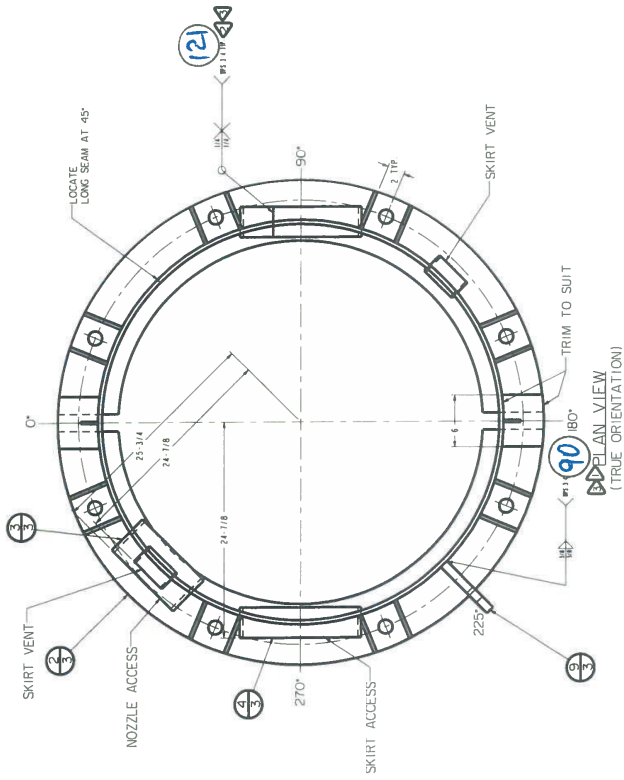
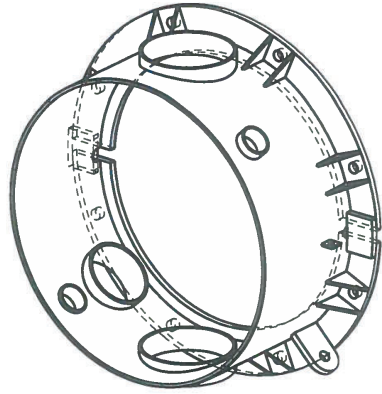
ALL-WELD COMPANY LIMITED  
 49 PARRIS AVE. COSSAUVILLE, MO. 63041  
 636-241-1000

ULTRAFAB INDUSTRIES LIMITED  
 48" O.D. VERTICAL SHELL ASSEMBLY  
 48" NOZZLE & WELDING DETAILS

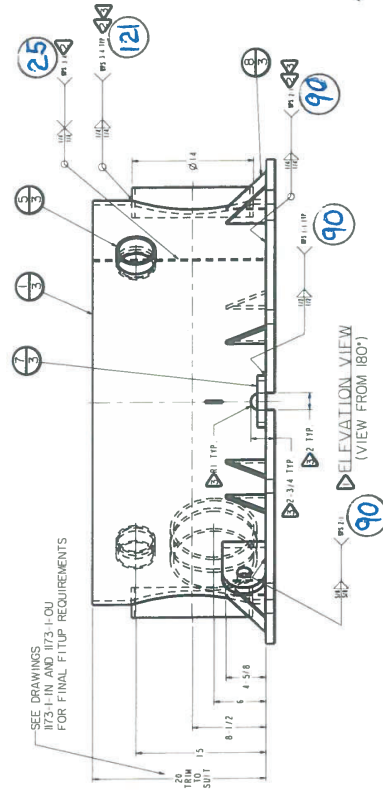
Rev. 01/2013  
 Scale: 1/8" = 1'-0"  
 Date: 01/2013

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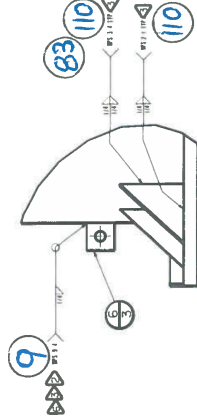
BILL OF MATERIAL		ITEM QTY.	DESCRIPTION	SPEC.
18	17/3	1	1/2" THICK, 3/4" DIA. 316L SS. 18"	316L SS.
19	2/3	1	3/4" THICK, 1/2" DIA. 316L SS. 18"	316L SS.
20	3/3	1	3/4" THICK, 1/2" DIA. 316L SS. 18"	316L SS.
21	4/3	2	1/2" THICK, 1/2" DIA. 316L SS. 18"	316L SS.
22	5/3	2	1/2" THICK, 1/2" DIA. 316L SS. 18"	316L SS.
23	6/3	2	1/2" THICK, 1/2" DIA. 316L SS. 18"	316L SS.
24	7/3	2	1/2" THICK, 1/2" DIA. 316L SS. 18"	316L SS.
25	8/3	16	1/2" THICK, 1/2" DIA. 316L SS. 18"	316L SS.
26	9/3	1	1/2" THICK, 1/2" DIA. 316L SS. 18"	316L SS.



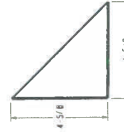
DETAIL ITEM 9/3



ELEVATION VIEW (VIEW FROM 180°)



DETAIL ITEM 6/3



DETAIL ITEM 8/3

DETAIL ITEM 2/3

PURCHASE ORDER NUMBER: III2

(4) REQUIRED  
PLOTTED:

**WELD MAP**

**ALL-WELD COMPANY LIMITED**  
Engineers & Welders

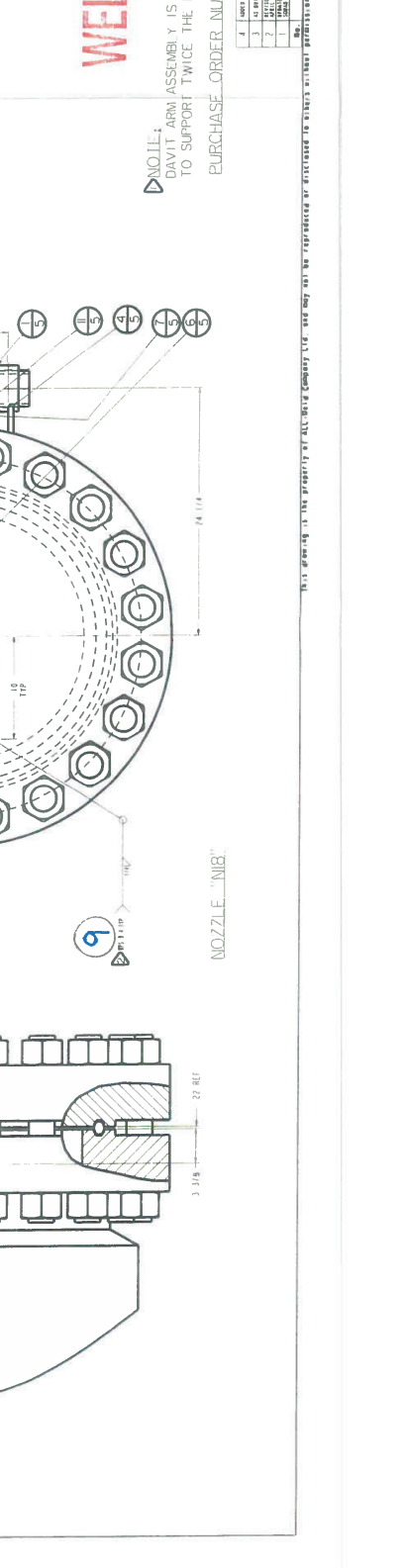
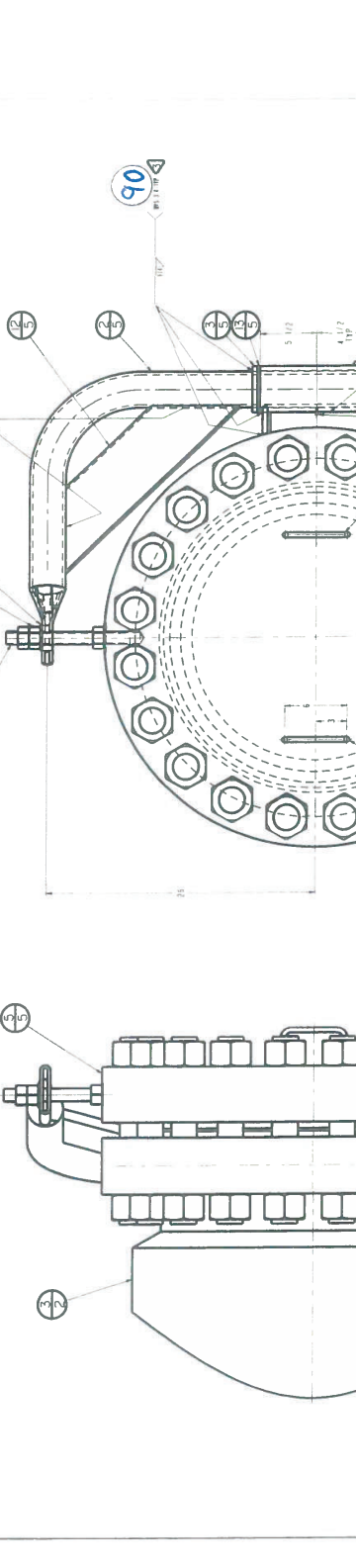
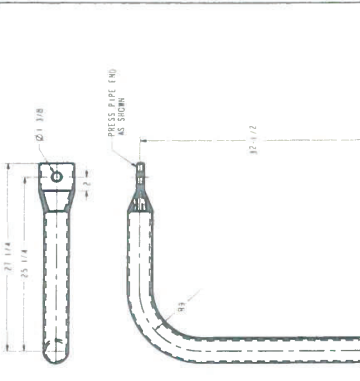
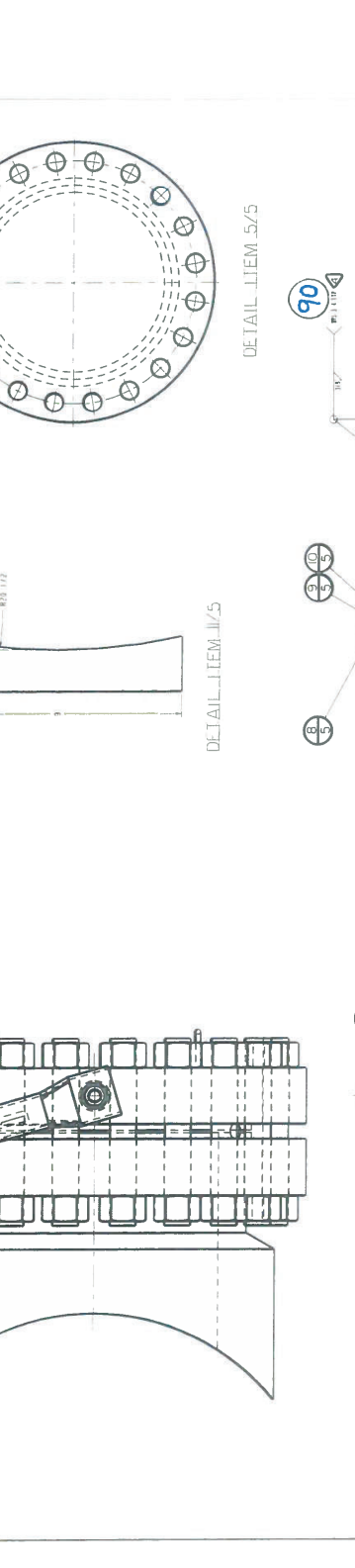
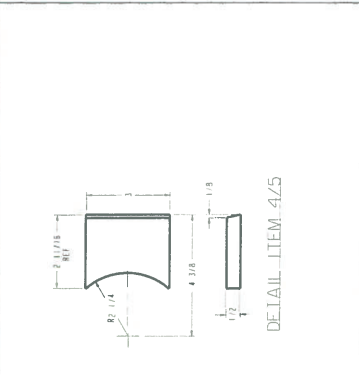
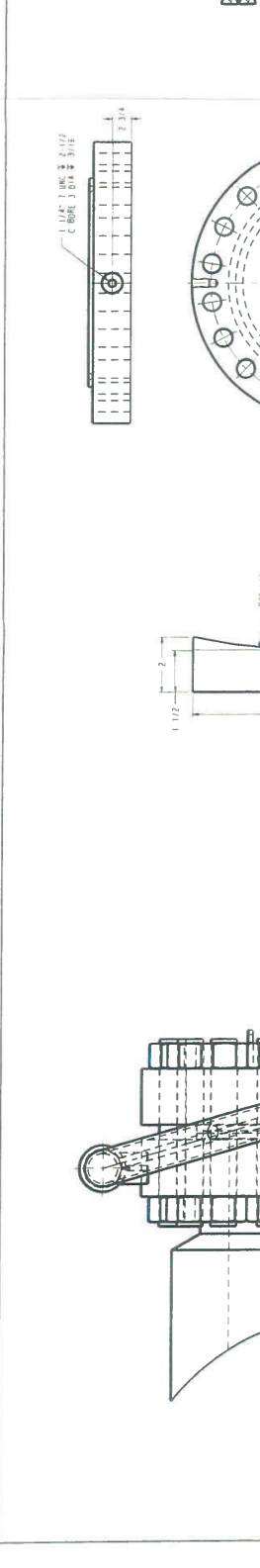
**ULTRAFAB INDUSTRIES LIMITED**  
WELD MAP DRAWING  
316L SS. STAINLESS STEEL SKIRT DETAILS  
Part No. 48 645-X Rev. 01/07/13

Mr. No. 1123/01 Rev. 11/23/3

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BILL OF MATERIAL		
ITEM QTY.	DESCRIPTION	SPEC.
23 17/5	1 4" DIA. 1/2" THICK 1/2" LONG	SA 312 P1A
23 24 2/5	1 5/8" DIA. 1/2" THICK 1/2" LONG	SA 312 P1A
23 37/5	1 4" DIA. 1/2" THICK 1/2" LONG	SA 312 P1A
26 47/5	2 1/2" DIA. 1/2" THICK 1/2" LONG	SA 312 P1A
9 5/5	1 1/2" DIA. 1/2" THICK 1/2" LONG	SA 312 P1A
21 67/5	2 1/2" DIA. 1/2" THICK 1/2" LONG	SA 312 P1A
28 77/5	1 1/2" DIA. 1/2" THICK 1/2" LONG	SA 312 P1A
31 87/5	1 1/2" DIA. 1/2" THICK 1/2" LONG	SA 312 P1A
32 97/5	1 1/2" DIA. 1/2" THICK 1/2" LONG	SA 312 P1A
33 107/5	1 1/2" DIA. 1/2" THICK 1/2" LONG	SA 312 P1A
26 117/5	1 1/2" DIA. 1/2" THICK 1/2" LONG	SA 312 P1A
70 127/5	1 1/2" DIA. 1/2" THICK 1/2" LONG	SA 312 P1A
71 137/5	1 1/2" DIA. 1/2" THICK 1/2" LONG	SA 312 P1A



NOZZLE "NB"

NOZZLE ASSEMBLY IS DESIGNED TO SUPPORT TWICE THE BLIND FLANGE WEIGHT.

PURCHASE ORDER NUMBER: III2

NOV 18 2013

DETAIL ITEM 2/5

WELD MAP

(2) REQUIRED

PLOTTED:

ALL-WELD COMPANY LIMITED

ULTRAFAB INDUSTRIES LIMITED

WELD MAP DRAWING

45" O.D. VERTICAL OUTLET SEPARATOR

25" HORIZONTAL ASSEMBLY FOR DAVIT ASSEMBLY

DATE: 11/13/13

BY: [Signature]

NO. 103-3

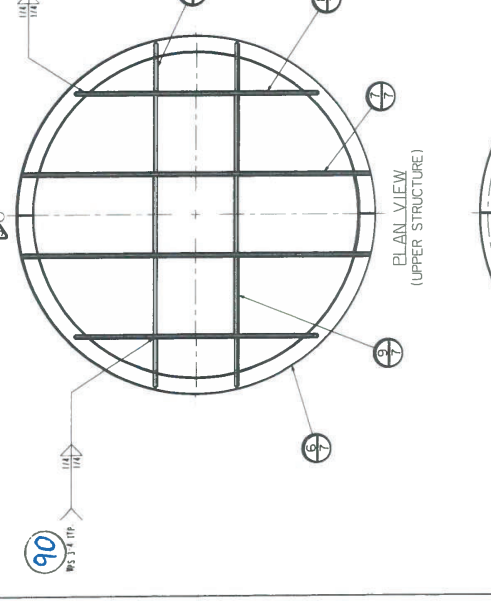
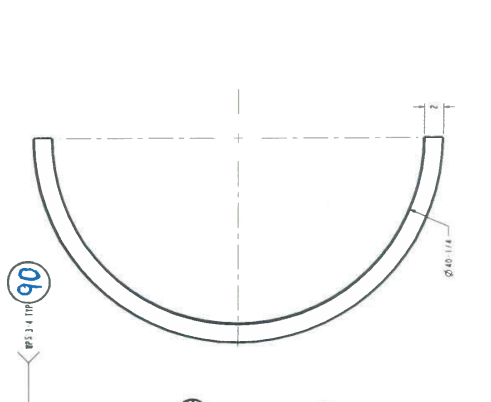
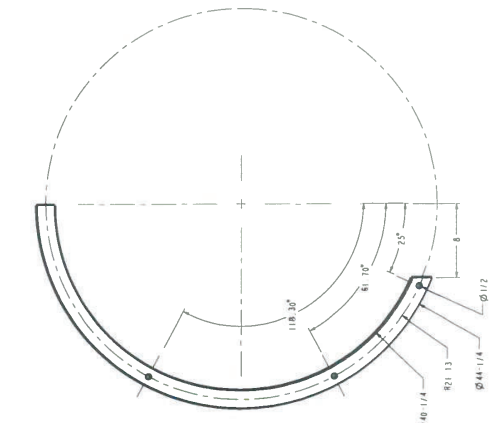
REV: A

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**BILL OF MATERIAL**

ITEM QTY	DESCRIPTION	SPEC.
1/27	2 1/2" x 1/2" FLUOROPOLYMER LINER	SA-479 340L
2/7	1 1/2" x 1/2" FLUOROPOLYMER LINER	316L S.S.
3/7	1 1/2" x 1/2" FLUOROPOLYMER LINER	316L S.S.
4/7	2 1/2" x 1/2" FLUOROPOLYMER LINER	316L S.S.
5/7	2 1/2" x 1/2" FLUOROPOLYMER LINER	316L S.S.
6/7	2 1/2" x 1/2" FLUOROPOLYMER LINER	316L S.S.
7/7	2 1/2" x 1/2" FLUOROPOLYMER LINER	316L S.S.
8/7	2 1/2" x 1/2" FLUOROPOLYMER LINER	316L S.S.
9/7	2 1/2" x 1/2" FLUOROPOLYMER LINER	316L S.S.
10/7	2 1/2" x 1/2" FLUOROPOLYMER LINER	316L S.S.
11/7	10" - 18" MC. 90L. 1/2" TYP. LONG	316L S.S.
12/7	10" - 18" MC. 90L. 1/2" TYP. LONG	316L S.S.



**WELD MAP**

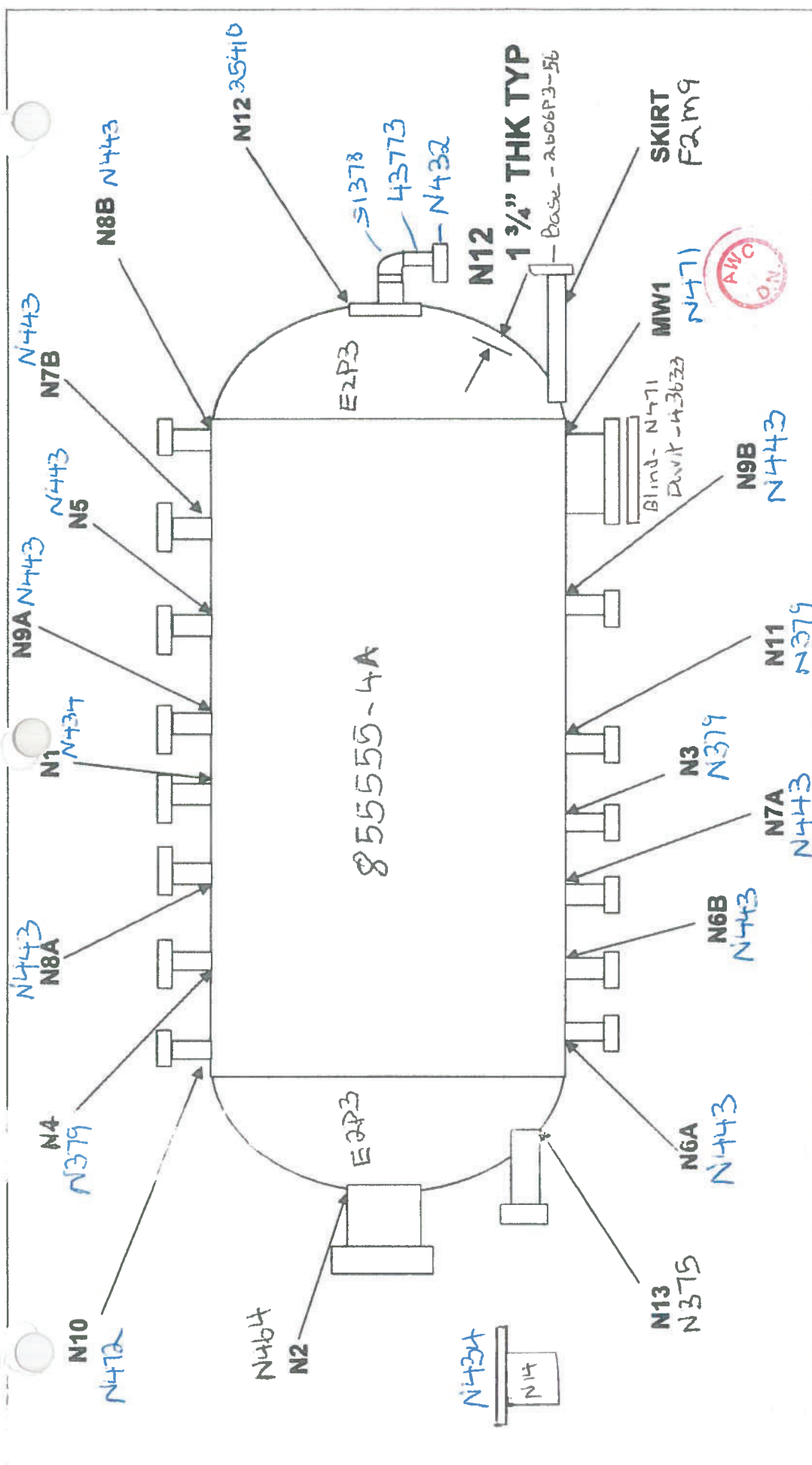
PURCHASE ORDER NUMBER: 1112

**ALL-WELD COMPANY LIMITED**  
 Fabrication & Welding Details  
 40 INDUSTRIAL AVENUE, UNIT 40  
 MISSISSAUGA, ONTARIO L4X 1L7, CANADA  
 Tel: (905) 270-8833 Fax: (905) 270-8833  
 Email: sales@all-weld.com Website: www.all-weld.com

**PLOTTED:**

DATE: 01/11/2010  
 TIME: 10:11:00 AM  
 USER: J. BROWN  
 PLOTTER: HP DesignJet T1100e  
 PLOTTER DRIVER: HPGL-ETL  
 PLOTTER PORT: LPT1

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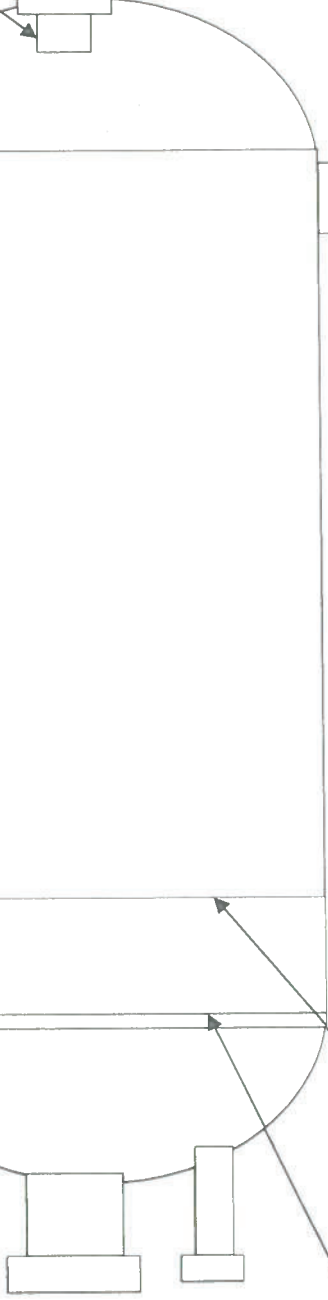
<b>ALL-WELD CO. LTD. - HEAT NUMBER MAP</b>	
CLIENT: ULTRAFAB	
WORK ORDER #: 1173PQ	SN 7475
JOB DESCRIPTION: 48" O.D. VERTICAL OUTLET	
DRAWING #: 1173-1-OU	
PREPARED BY: D.NESCI	
DATE: March 25, 2013	
HEAT NUMBER MAP - 1173PQ	
ASME SECTION VIII. DIV. 1	
MATERIAL SA-240 316/316L, SA-182 F316/316L	
P.O. 13-0225	

N3, N4, N5, N6A, N6B, N7A, N7B, N8A, N8B, N9A, N9B, N10, N11, N12, N13

16/2- E9w8  
17/2- E9w8

F9x7

15/2- E9C1



NAME  
BRACKET  
E9w8

117  
E7K6

6/7  
E5K2

DAVIT BRACKET-  
91N3

Item 2/3- 2606P3-56  
9/3- E9C1



ALL-WELD COMPANY LTD. -  
HEAT NUMBER MAP PARTS

HEAT NUMBER MAP PARTS- 1173PQ  
ASME SECTION VIII. DIV. 1

MATERIAL SA-240 316/316L

CLIENT: ULTRAFAB  
WORK ORDER #: 1173PQ SN 7475  
JOB DESCRIPTION: 48" O.D. VERTICAL OUTLET  
DRAWING #: 1173-1-OU  
PREPARED BY: D.NESCI  
DATE: September 17, 2013





6870 HIGHWAY 42 EAST

**METALLURGICAL TEST REPORT**

NORTH AMERICAN STAINL  
6870 HIGHWAY 42 EAST  
GHENT, KY 41045

Certificate: 789232 2      Mail To: JACQUET MID ATLANTIC      Ship To: JACQUET MID ATLANTIC      Date: 11/26/2012      Page: 1  
 Customer: 005417 005      CUSTOMER PICKUP      CUSTOMER PICKUP  
 12273 BROWN AVENUE      12273 BROWN AVENUE      12273 BROWN AVENUE      Steel: 316/316L  
 RIVERSIDE, CA 92509      RIVERSIDE, CA 92509      RIVERSIDE, CA 92509      Finish: HRAP

Your Order: 4436      NAS Order: IN 0157607 01      Corrosion: ASTM A262/02aE;180Bend-OK

**PRODUCT DESCRIPTION:**  
 STAINLESS STEEL PLATE, HRAP; UNS 31600/31603  
 ASTM A240/11b,A480/11b,A666/10;ASME SA240/11a,SA480/11a,SA666/11a  
 CHEM ONLY ON FOLLOWING ASTM: A276/10,A479/11,A484/11,A312/11  
 CHEM ONLY ON FOLLOWING ASME: SA312/11,SA479/11  
 AMS 5707F/5524L X MRK;  
 NACE MR0175/ISO 15156-3:2003 A, MR0103/07; QQS766D-A X MAG PERM  
 MIN. SOLUTION ANNEAL TEMP 1900F, WATER QUENCHED

**REMARKS:**  
 Mat'l is Free of Mercury Contamination. No weld repairs.  
 EN 10204:2004 3.1; ROHS Compliant  
 Material is Free of Radioactive Contamination  
 NAS Steel Making Process: EAF, AOD, & Cont. Casting  
 Product Mfg.by a Quality Mgt.Sys. in Conf. w/ISO 9001  
 \*Melted & Manufactured in the USA; Mat'l is DFARS Compliant

Product Id	Plate#	Skid #	Thickness	Width	Weight	Length	Mark	Pieces	Commodity Code
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	CM	C %	CR %	CU %	MN %	MO %	N %	NI %	P %	S %
E2P3	US	.0200	16.7990	.4640	1.4545	2.0220	.0434	10.0350	.0310	.0010
	SI %									

**MECHANICAL PROPERTIES**

Product Id#	Plate#	UTS	YIELD	ELONG	HARD	R of A
06E2P3 CA	06E2P3 CA	86.93	45.00	56.70	80.00	62.45

W.O.# 11730  
 M.L.# 1  
 THK # SEE CUT REPORT  
 P.O.# 12-1612-11730

HT# 2013  
 Qualifies to all requirements of Sect. II 10 Edition II Addenda

HT# 2013  
 MTR APPROVED DATE 11/16/12  
 TSP QUALITY CONTROL DEPT.

JACQUET NO. 27161

ACCEPTED/REVIEWED/RELEASED for and on behalf of: *Velocity America*  
 Print Name: *CA AMES II SA HA*  
 Signature: *[Signature]*

NAS hereby certifies that the analysis on this certification is correct. Based upon the results and the accuracy of the test methods used, the material meets the specifications stated. These results relate only to the items tested and this report cannot be reproduced, except in its entirety, without the written approval of NAS.

Technical Dept. Mgr. *[Signature]*  
 ERIC HESS      11/26/2012

# TRINITY HEADS, INC



FEBRUARY 15, 2013

ALL WELD CO LIMITED  
49 PASSMORE AVE  
TORONTO ON CANADA  
M1V 4T1

Attention:

Reference: Customer: 12-1612-1173Q Tag # 1173-1  
Trinity SO # 112328

Gentlemen:

Attached are copies of mill test reports for the following material provided on your referenced purchase order.

8-SA240-316/316L ELLIP-2:1 HEAD 48.00 OD 1.750 NOM 1.6100 MIN WITH 2.0" SF.

CODE	QTY	THICKNESS	PRODUCER	MELT	SLAB	GRADE
SMYJ	4	1.750	NAS	D5E5		SA240-316/316L
SMYI	4	1.750	NAS	E2P3		SA240-316/316L

Trinity Heads, Inc. certifies that heads manufactured from material represented by this report were hot formed, annealed at 1950F(+/-25F) for 53 minutes and water quenched.

The items listed above were formed in strict accordance with all applicable requirements of the ASME Boiler and Pressure Vessel Code Section VIII, Div. 1. Heads comply with UG-79, UG-80 and UG-81.

Attached mill test reports are in compliance with ASME code Section II latest edition.

If you have further questions, please contact your customer service representative in Navasota, TX at 1-800-392-3594.

VERY TRULY YOURS

*Charles Draus*  
CHARLES DRAUS  
QUALITY MANAGER

ACCEPTED/REVIEWED/RELEASED 046  
for and on behalf of: SBM  
Print Name: GANDISH SAHII  
Signature: [Signature]  
Date: Jan 26/13  
Applus<sup>®</sup> VELOSI  
Velosi America LLC



FEB 05 2013



# Certificate of Analysis and Tests

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

OUR ORDER 0282469 - 01

HEAT & PIECE 855555-4A 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

0032037ME 11/16/12 YOUR ORDER & DATE

HEAT & PIECE 855555 - 4A  
 WEIGHT 7564  
 FINISH 1  
 GRADE 316L / 316  
 DIMENSIONS 1.750 X 96.000 X 154.000 EXACT

ITEM DESCRIPTION UNS-S31603 / UNS-S31600  
 SPECIFICATIONS FROM SLABS IMPORTED FROM BRITAIN  
 \*\*\* MFG IN NEW CASTLE, IN, USA AMS 5507F WITH EXCEPTIONS  
 ASTM A240-12A ASMESA240-11ED AMS 5524L WITH EXCEPTIONS  
 ROLLED ALLOYS SPECS 316L/316 ASTM A480-12 ASMESA480 11ED  
 MEETS EU ELECTRICAL ROHS NAFTA CTRY ORIGIN= SLAB CTRY  
 NACE MRO175-2009/ISO 15156 LIST HEAT/PCE/SIZE ON INVCE  
 NO WELD REPAIRS NO GRIPPER MARKS  
 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)

046  
 ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBM  
 Print Name: GANESH SAHIL  
 Signature: [Signature]  
 Date: 11/16/13  
 Appius®  
 VELOSI  
 Velosi America LLC

MECHANICAL & OTHER TESTS

HARDNESS HRBW 81  
 GRAIN SIZE 6  
 YIELD STRENGTH (PSI) 46390  
 TENSILE STRENGTH (PSI) 80510  
 INTERGRANULAR CORROSION OK  
 ELONGATION % IN 2" 57.9  
 REDUCTION OF AREA % 59.3

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

CHEMICAL COMPOSITION

CARBON (C) .015  
 MANGANESE (MN) 1.70  
 PHOSPHORUS (P) .031  
 SULFUR (S) .001  
 SILICON (SI) .29  
 CHROMIUM (CR) 16.33  
 NICKEL (NI) 10.06  
 COBALT (CO) .27  
 COPPER (CU) .35  
 MOLY (MO) 2.04  
 NITROGEN (N) .08  
 COLUMBIUM (CB) .015  
 TITANIUM (TI) .007  
 ALUMINUM (AL) .006  
 TIN (SN) .007  
 TANTALUM (TA) .002

Certification of Material - Per ASME  
 HT# 855555-4A  
 Qualifies to all requirements of  
 SA 240-316/316L per  
 Sect. II 10 Edition 11a Addenda



FEB 05 2013

WE HEREBY CERTIFY THAT THE MATERIAL HEREIN HAS BEEN MADE AND TESTED IN ACCORDANCE WITH THE LISTED SPECIFICATION(S) AND THAT THE RESULTS OF ALL TESTS ARE ACCEPTABLE.

JAMES DOUBMAN, QUALITY ASSURANCE MANAGER

CERTIFICATE IN CONFORMANCE WITH EN10204-95 3.1.B/EN10204-2004 3.1

[Signature of James Douberman]

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 # 7475	Project	
Component		P.O. #	Worksheet #: 36451
Drawing	Rev.	Technician	Frank Marunde
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

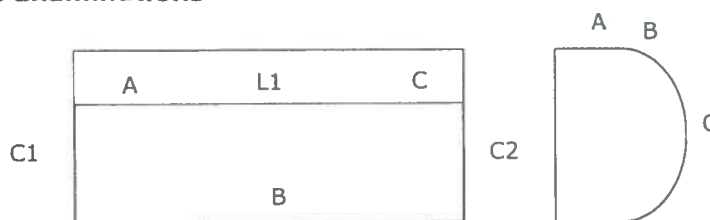
Diameter		Size	Beam Angle	Frequency	Manufacturer	Blocks
<input type="radio"/> 1/4"	<input type="radio"/> 3/4"	<input type="radio"/> 5/8" x 5/8"	<input type="radio"/> 45°	<input type="radio"/> 1.00 MHz	<input type="radio"/> Techsonic	<input type="radio"/> IIW A2
<input type="radio"/> 3/8"	<input type="radio"/>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

### Scope of Testing

### Thickness Examinations

	Shell	Head to C1	Head to C2
A	1.802	1.776	1.815
B	1.797	1.725	1.737
C	1.786	1.736	1.739

All Dimensions are in inches



FEB 28 2013

ACCEPTED/REVIEWED/RELEASED 046  
 for and on behalf of: SBM  
 Print Name: GAANESH SAHA  
 Signature: [Signature]  
 Test Area: Disposition  
 Date: Mar 26/13

**Applus Scanning**  
 VEF01  
 Velosi America LLC

Length	Depth	Amplitude

### Evaluation - Acceptance

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





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

REPORT NUMBER 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 ✓
	10.100 ✓
N	0.0710

Yield PSI	49,600 ✓
Tensile PSI	90,100 ✓
Elongation	52.8 ✓
Reduction of Area	76.1
Hardness	170/179 HBW ✓

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBM  
 Print Name: GABRIEL SAHA  
 Signature: [Signature]  
 Date: March 26/13  
 Applus VELO  
 Velosi America

W.O. # 11730  
 M.L. # 4(3/12)  
 THK. #  
 P.O. # 13-0074

Certification of Material - Per ASME  
 HT# N471  
 Qualifies to all requirements of  
SA182-F316/B16 per  
 Sect. II 10 Edition 11 Addenda

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 [Signature]

Name: Rene Ordonez Title: QA Representative



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

REPORT NUMBER 72426  
DATE 3/5/2013  
FCI ORDER NUMBER 59176

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

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

SCARBOROUGH ONT MIV 4T1 CANADA

Item Quantity Description

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

HEAT NUMBER: N464

MATERIAL TYPE: SA182F316/L

Manufactured in USA

I.A.W. ASME 2010 ED 11AD.

CHEMICAL ANALYSIS

PHYSICAL PROPERTIES

C	.028 ✓
Mn	1.740 ✓
P	.0450 ✓
S	.0090 ✓
Si	.380 ✓
Cr	16.610 ✓
Mo	2.030 ✓
Ni	10.040 ✓
N	0757

Yield PSI	39,100
Tensile PSI	80,300
Elongation	60.2
Reduction of Area	76.5
Hardness	149, 163 HBW

Certification of Material - Per ASME  
HT# N464  
Qualifies to all requirements of  
SA182-F316/BILL per  
Sect. II 10 Edition 11 Addenda

W.O. # 11730  
M.L. # 5(4)6(5/2)  
THK. # 1.938  
P.O. # 13-0074

Revised  
Apr 15, 2013  
Velocity America  
279

Q.C.I. N.D.

Q.C.I. E.Y.

APR 05 2013

APR 03 2013

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

Immediately following hot working, while at temperature above, parts were rapidly quenched.

We hereby certify that all test results and process information contained herein are correct and true as contained in the records of the company.

Prepared by P. Holley

Name: Phyllis Holley Title: QA Representative



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

REPORT NUMBER 72430

DATE 3/5/2013

FCI ORDER NUMBER 59176

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

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

SCARBOROUGH ONT MIV 4T1 CANADA

Item Quantity Description

5 4 2' X 900 X 12.50' LG RIJ LWN

ITEM 1173-7

HEAT NUMBER:  
N375

MATERIAL TYPE:  
SA182F316/L

Manufactured in  
USA

I.A.W. ASME 2010 ED 11AD.

CHEMICAL ANALYSIS

PHYSICAL PROPERTIES

C .018 ✓  
Mn 1.720 ✓  
P .0290 ✓  
S .0280 ✓  
Si .360 ✓  
Cr 16.990 ✓  
Mo 2.030 ✓

Yield PSI 37,000 ✓  
Tensile PSI 83,000 ✓  
Elongation 62 ✓  
Reduction of Area 71 ✓  
Hardness 155 HBW ✓

Ni 10.000 ✓

.0800

**N13**  
Certification of Material - Per ASME  
HT# N375  
Qualifies to all requirements of  
SA182-F316/B16L per  
Sect. II TC Edition 11 Addenda

W.O. # 11730  
M.L. # 7 (6/2)  
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  
for and on behalf of: SBM  
Print Name: GABRIEL SAAA  
Signature: [Signature]  
Date: Ham 26/13  
Applus® VELOSI  
Velosi America LLC



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

REPORT NUMBER 72428

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

4 9 2" X 900 X 11" LG RTJ LWN

ITEM 1173-7

HEAT NUMBER:  
N379

MATERIAL TYPE:  
SA182F316/L

Manufactured in  
USA

I.A.W. ASME 2010 ED 11AD.

CHEMICAL ANALYSIS

PHYSICAL PROPERTIES

C 018 ✓  
Mn 1.720 ✓  
P .0300 ✓  
S .0200 ✓  
Si .300 ✓  
Cr 16.690 ✓  
Mo 2.050 ✓

Yield PSI 43,000 ✓  
Tensile PSI 85,000 ✓  
Elongation 58 ✓  
Reduction of Area 71 ✓  
Hardness 174 HBW ✓

Ni 10.010 ✓

0880

**N3,4,11**  
Certification of Material - Per ASME  
IIT# **N379**  
Qualifies to all requirements of  
**SA182F316/316L** per  
Sect. II **10** Edition **11** Addenda

W.O. # **11730**  
M.L. # **7(7/2)**  
THK. # **1.075**  
P.O. # **13-0074**

Q.C.I.  
E.Y.

Q.C.I.  
N.D.

MAR 20 2013

MAR 18 2013

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

Immediately following hot working, while at temperature above, parts were rapidly quenched.

We hereby certify that all test results and process information contained herein are correct and true as contained in the records of the company.

Prepared by

Name: Rene Ordonez Title: QA Representative

ACCEPTED/REVIEWED/RELEASED **SBM** 046  
for and on behalf of:  
Print Name: **GANESH SAHA**  
Signature:   
Date: **March 26/13**  
Applus® VELOSI  
Velosi America LLC



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 RT J LWN

ITEM 1173-7

HEAT NUMBER: N443

MATERIAL TYPE: SA182F316L

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 ✓  
0.0740

**NGA**  
Certification of Material - Per ASME  
HT# N443  
Qualifies to all requirements of  
SA182-316L per  
Sect. II 10 Edition 11 Addenda

Q.C.I. # 11730  
P.L.# T(0/0/70)  
O.K.# 1078  
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: CHANDISH 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 72427

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

4 15 2" X 900 X 11" LG RTJ LWN

ITEM 1173-7

HEAT NUMBER: N443

MATERIAL TYPE: SA182F316/L

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 ✓  
  
Ni 10.150 ✓  
  
0740

Yield PSI 42,000 ✓  
Tensile PSI 85,000 ✓  
Elongation 58.9 ✓  
Reduction of Area 61.4 ✓  
Hardness 175 HBW ✓

*NS, 6B, 7A, 7B, 8A, 8B, 9A, 9B*

Certification of Material - Per ASME  
HT# N443  
Qualifies to all requirements of  
SA182-F316/316L per  
Sect. II 10 Edition 11 Addenda

W.O. # 1173  
M.L. # 7 (7/2)  
THK. # 1.074  
P.O. # 13-0074

Q.C.I. E.Y.

MAR 20 2013

Q.C.I. N.D.

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

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 *[Signature]*

Name Rene Ordonez Title QA Representative

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



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

REPORT NUMBER 72485

DATE 3/7/2013

FCI ORDER NUMBER 59176

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

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

SCARBOROUGH ONT MIV 4T1 CANADA

Item Quantity Description

1	1	24" X 900 X 26.50" LG RTJ I-2, 35" OD REINFORCEMENT	ITEM 1173-4
7	4	24" X 900 RTJ BLIND	ITEM 1173-9

HEAT NUMBER: N471

MATERIAL TYPE: SA182F316/L

Manufactured in USA

I.A.W. ASME 2010 ED 11AD.

CHEMICAL ANALYSIS

PHYSICAL PROPERTIES

C	.019	✓
Mn	1.410	✓
P	.0230	✓
S	.0003	✓
Si	.500	✓
Cr	16.430	✓
Mo	2.050	✓

Yield PSI	49,600	✓
Tensile PSI	90,100	✓
Elongation	52.8	✓
Reduction of Area	76.1	✓
Hardness	170/179 HBW	✓

Ni	10.100	✓
	.0710	

Certification of Material - Per ASME  
HT# N471  
Qualifies to all requirements of  
SA182-F316L per  
Sect. II 10 Edition 11 Addenda

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

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

Q.C.I.  
N.D.

MAR 18 2013

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

Immediately following hot working, while at temperature above, parts were rapidly quenched.

We hereby certify that all test results and process information contained herein are correct and true as contained in the records of the company.

Prepared by [Signature]

Name Rene Ordenez Title QA Representative

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

Regi & Mkt off: G-33 & 34, MIDC, Industrial Area, Tarapur, Thane (Dist), Maharashtra, INDIA - 401506, E-Mail: sales@viraj.com  
 Works: SURVEY No- 114,119 & 120, VILL. Mahagaon, Tal: Palgar, Dist: Thane-401501, MAHARASTRA, INDIA, vielqc@viraj.com

**TEST CERTIFICATE**

**CUSTOMER** \_\_\_\_\_ **ORDER NO** \_\_\_\_\_ **PACKING LIST NO** 51/935703/9 **INSPECTION NO** 100001546430 **DATE** 18.02.2012  
**GRADE** 316/316L **HEAT No** 25410

**BUNDLE NO :**  
 5182915 ,5182916 ,5182918 ,5182917 ,

**DESCRIPTION**  
 STAINLESS STEEL BRIGHT BARS

Certification of Material - Per ASME  
 HT# 25410  
 Qualifies to all requirements of  
 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 / FDBPY  
 123124  
 Overseas Branch, Mumbai-21

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: Velosi America  
 Print Name: WALISH SAHA  
 Signature: [Signature]  
 Date: 14/12  
**Applus®**  
 VELOSI AMERICA LLC

[Signature]  
 WORKS INSPECTOR  
 K R K MURTHY

File P05a137



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 Alloy WP316/316L Short PN 00005393 E/W LR 90° ELBOW 2.0000 160 Qty 4.0000

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

Raw Matl--Pipe Seamless

Chemical Composition:

Elem	Content	Elem	Content	Elem	Content
C	.01800	MN	1.45000	P	.02800
SI	.50000	CR	16.80000	NI	11.10000
				S	.00100
				MO	2.10000

TEST RESULTS:

W/O#: 69333 LOAD: TEST SET: 1

Tensile Test 1

Specimen Type	Before	After	Before	After
Size 1	in	in	in	in
Size 2	in	in	in	in
Area	.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 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

046  
 TED/RE: SBM OFFSHORE  
 on behalf of  
 name: LAURENCE SAH  
 signature: [Signature]  
 Date: APR 15 13  
 Applus<sup>®</sup> VELOSI  
 Velosi America LLC

Q.C.I. N.D.

HARDNESS IS ACCEPTABLE  
I.A.W. NACE MRO-175/ISO 15156

W.O.# 11730  
 M.L.# 13 (10/2)  
 TRK.# 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 MR0103-10 / NACE MR0175-3 / ISO 15156-3 : 2009

Certification of Material - Per ASME  
HT# 43773  
Qualifies to all requirements of  
SA312-316/316L per  
Sect. II 10 Edition 11 Addenda

Sales Item	Client Item	Delivery Nr	Prod. Order	Insp. Lot	Heat Nr	Pieces	Weight	Tot Lgth	Un Lgth
170		8110007615	100323631	200040492	37015	1	82 KG	7.31 M	5791-7315 MM
170		8110007615	100323631	200040493	43773	15	1 050 KG	94.32 M	5791-7315 MM

**RAW MATERIAL**

Heat Nr:	Supplier	Method
37015	ACERALAVA	Electric furnace+AOD
43773	ACERALAVA	Electric furnace+AOD

MAR 26 2013

CHEMICAL COMPOSITION (%)		*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  
6/2  
Velosi America  
K.S.  
April 1, 2013

Q.C.I.  
N.D.



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	Rp0.2	Rp1.0	Rm	A2"	A5
			°C	N/mm2	N/mm2	N/mm2	%	%
100323631	200040492	1	20	291	347	566	53	50
	200040493	1	20	296	354	578	54	51
		2	20					

**HARDNESS TEST**

Prod. Order	Ins. Lot	Sample	HRB1	HRB2
100323631	200040492	1	78	79
	200040493	1	77	78

**METALURGICAL TESTS**

INTERGRANULAR CORROSION TEST ACC. TO ASTM A262 PRACT."E": SATISFACTORY

**NON-DESTRUCTIVE TESTS**

100 % EDDY CURRENT TEST AT E.426, GOOD.

POSITIVE MATERIAL IDENTIFICATION TEST ON EACH TUBE/PIPE BY "X-RAY-FLUORESCENCE-ANALYZER": SATISFACTORY

VISUAL INSPECTION ON EACH TUBE: SATISFACTORY

DIMENSIONAL CHECKING ON EACH TUBE: SATISFACTORY

**TECHNOLOGICAL TESTS**

FLATTENING TEST: SATISFACTORY

*Reviewed*  
  
*April 1, 2013*

MAR 26 2013

**MARKING**

TUBACEX 2" SCH 160 ASME SA312 ASTM A312 TP316 TP316L CD SMLS NH ET  
HEAT/ PMI LOT NO/ SPAIN TX2 TX1

**REMARKS**

NO MERCURY, MERCURY COMPOUNDS OR MERCURY BEARING INSTRUMENTS AND/OR EQUIPMENT HAVE BEEN USED ALONG MANUFACTURING AND INSPECTION PROCESS.

NO WELD REPAIR WAS PERFORMED

MATERIAL MANUFACTURER APPROVED WITH CERTIFICATE NR. 07/2001/MUC BY TUV SUDDEUTSCHLAND (NOTIFIED BODY 0036) TO ISSUE CERTIFICATES OF SPECIFIC PRODUCT CONTROL IN ACCORDING TO PRESSURE EQUIPMENT DIRECTIVE 97/23/EC ANNEX I POINT 4.3

MATERIAL CHARACTERISTICS COMPLY WITH POINT 7.5 OF ANNEX I TO PED BY HAVING AN ELONGATION AFTER RUPTURE AT



**TUBACEX TUBOS  
INOXIDABLES**  
INGENIERIA DE CALIDAD

*[Handwritten signature]*



TUBACEX

INSPECTION CERTIFICATE  
EN 10204 3.1

Number: 519285  
Page: 3 / 3

Rev: 00

Created on:  
Date: 09.05.2011

Modified on:

REMARKS

TENSILE TEST NO LESS THAN 14% AND A BENDING RUPTURE ENERGY AT IMPACT TEST NO LESS THAN 27J AT 20°C.

MATERIAL IS FREE OF RADIATION CONTAMINATION



TUBACEX TUBOS  
INOXIDABLES  
INGENIERIA DE CALIDAD





# METALLURGICAL TEST REPORT

NORTH AMERICAN STAINLESS  
6870 HIGHWAY 42 EAST  
GHENT, KY 41045

153070

6870 HIGHWAY 42 EAST

Mail To:  
C.P.P. STAINLESS STEEL, INC.  
1940 BULLINGTON STREET E.  
HAMILTON, ON L9B3L4

Ship To:  
C.P.P. STAINLESS STEEL, INC.  
1940 BULLINGTON STREET E.  
HAMILTON, ON L9B3L4

Date: 1/29/2013 Page: 1

Steel: 316/316L

Finish: MAP

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

Your Order: C87097

NAS Order: IN 0161382 01

## PRODUCT DESCRIPTION

STAINLESS STEEL COIL, MAP; UNS 31600/31603  
ASTM A240/11b, A480/11a, A666/10, ASME SA240/11a, SA480/11a, SA666/11a  
CHEM ONLY ON FOLLOWING ASTM: A276/10, A479/11, A484/11, A312/11  
CHEM ONLY ON FOLLOWING ASME: SA312/11, SA479/11  
AMS 5507F/5524L X MRK;  
NACE MR0175/ISO 15156-3:2003 A, MR0103/07; Q08766D-A X MAG PHEN  
HTN. SOLUTION ANNEAL TEMP 1900F, WATER QUENCHED

## REMARKS:

Mat'l is Free of Mercury Contamination. No weld repairs.  
EN 10204:2004 3.1, MARK 1 & 2 Compliant  
Material is Free of Radioactive Contamination  
HAS Steel Making Process: MAP, AOD, & Coat. Casting  
Product Mfg. by a Quality Mgt. Sys. in Conf. w/ISO 9001  
Melted & Manufactured in the USA, Mat'l is DPABG Compliant

Product Id	Coil #	Skid #	Thickness	Width	Weight	Length	Mark	Pieces	Commodity Code
04E9W8 A	04E9W8 A		.2460	60.0000	14,610	COIL		1	1

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

HEAT	CM	C %	CR %	CU %	NI %	MO %	SI %	P %	S %
E9W8	US	.0139	16.6330	.4590	1.5125	2.0060	.0499	10.0750	.0365
									.0010

W.O. # 11730  
M.L. # 6(213, 14, 11, 18) (13)  
P.O. # 13-0165

## MECHANICAL PROPERTIES

Product Id#	Coil #	UTS	Y8	ELONG	Hard	Tail
		ksi	ksi	%-2"	RB	Hard
04E9W8 A	04E9W8 A	88.77	47.88	49.59	84.00	87.50

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SBM OFFSHORE  
Print Name: GARETH SULLIVAN  
Signature: [Signature]

JAN 1 2013

Certification of Material - Per ASME  
HT# E9W8  
Qualifies to all requirements of  
SA 240-316L per  
Sect. II 10 Edition 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 reported and report 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

SK 24016

6870 HIGHWAY 42 EAST

Certificate: 809250 2 Mail To:  
ROLARK STAINLESS STEEL, INC.  
71 CONAIR PARKWAY  
WOODBIDGE, ON L4H0S4

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

Date: 2/11/2013 Page: 1

Customer: 007050 001

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  
NAME 5507F/5524L X MRK;  
NACE MR0175/ISO 15156-3:2003 A, MR0103/07; QOS766D-A X MAG PERM  
MLN. 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

ACCEPTED FOR RELEASE  
for and on behalf of: Velosi America  
Signature: Mark Dulitz  
Date: 2/11/13  
Product Name: Applus  
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. # 11730  
M.L. # 17(1/3)  
THK. # .502  
P.O. # 13-0203

C.C.I. N.D.

## MECHANICAL PROPERTIES

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

C.C.I. E.Y.

Certification of Material - Per ASME  
IT# F2m9  
Applies to all requirements of SA240-316/316L per Sect. II IC Edition II Addenda

MAR 12 2013

NAS hereby certifies that the analysis on this certification is correct. Based upon the results and the accuracy of the test methods used, the material meets the specifications stated. These results relate only to the items 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



Inv: 1055184 Date: 03/19/2013  
 Contact: HELENE/BRIAN  
 Heat: 2606P3

**ESSAR STEEL**  
 ESSAR STEEL ALGOMA INC., 105 West Street, Sault Ste. Marie, Ontario, Canada P6A 7B4  
 000598

SO No., Item & Date: 906515 00020 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 Specification: HR STEEL PLATE Carbon Multi Cert ASTM A516 GR 70 (11A) Meets NACE MR 0175 latest Ed. BHN < 200 D CEO 43 max. Includes Shape Control Calcium Treated Normalized Temp 1670 F 34 min CVN. Req. 5/12 FT. LBF at 0.50 0 F Sid Thickness Tol PVG Top and Bottom Standard Surface Finishess 1/2 A20 Latest Ed. Addenda of ASME Code section II part A applies Fine Grain Fully Killed No Weld Repair!

Supplementary instructions: Test Cert 1519-837-2227  
 Insp Tr: Test Report As Per Spec  
 ESSAR STEEL ALGOMA 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 WITH THE WRITTEN APPROVAL OF ESSAR STEEL ALGOMA INC. IF YOU RECEIVE THIS DOCUMENT AND ARE NOT THE INTENDED RECEIVER PLEASE CALL 1905-945-4290 FOR INSTRUCTIONS ON METHOD OF DISPOSAL OF DOCUMENT.

MILLS (N10204 2004 - VPL 31) / QUALITY AND ENVIRONMENTAL CERTIFICATES AVAILABLE AT WWW.ESSARSTEELALGOMA.COM  
 ALL HEATS FULLY KILLED  
 HEATS INDICATED WITH (1) TYPIC GRANDED  
 HEATS INDICATED WITH (2) 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 384 00 "	ABB769	2606P3-56	13 068 LB	1	1 0000 " x 120 000 " x 384 00 "	ABB770	2606P3-56	13 068 LB	1
1 0000 " x 120 000 " x 384 00 "	ABB771	2797P3-05	13 068 LB	1					

Heat No. (wt%)	C	Mn	P	S	Si	Cr	Ni	Cu	Mo	Al	Nb	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
2797P3*	0.19	1.00	0.009	0.005	0.310	0.02	0.15	0.03	0.00	0.024	0.000	0.015	0.0002	0.003

Hardness Tests	SRCE	LAB	GAUGE	COND	LOC	MTHD	HARDNESS
2606P3	166"	ALG	1.0000	NORM B	B	HBW	153
2606P3	166"	ALG	1.0000	NORM B	B	HBW	153
2797P3	166"	ALG	1.0000	NORM B	B	HBW	150

W.O. # 11739  
 M.S. # 19(43)  
 P.K. #  
 P.O. # 13-0220  
 MILL TEST REPORTS APPROVED BY Q.C. P.O.  
 Q.C.I. E.Y.  
 Q.C.I. N.D.  
 K. UGHADPAGA  
 MANAGER METALLURGICAL SERVICES  
 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  
 Conforms to all requirements of SA 516B Part 1  
 Sect. II 10 Edition Addenda

**ESSAR 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:	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 RRP#3 20 ABERFOYLE, Ontario, Canada N1H 6H9	Ship to Customer Name and Address:	QUALITY PLATES & PROFILES LTD NICHOLAS BEAVER ROAD RRP#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. NACE MR 0175 latest Ed. BHN < 200 D.O.CEQ. 43 max. Inclusion Shape Control Calcium Treated Normalized Temp 1670 F. 34 min CVN/Req. 15/12 FT.LBF at 10-50 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			BOL NO:	1000023647							
Supplementary Instructions:	Test Cert 1-519-837-2227			Customer Part No:	ROBINSON TRANSPORT LTD - 205(661)							
Inspection Report:	Test Report As Per Spec			Carrier:								
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.												
MELTS EN 10204 2004 TYPE 3.1 ISO QUALITY AND ENVIRONMENTAL CERTIFICATES AVAILABLE AT WWW.ESSARSTEELALGOMA.COM												
MECHANICAL PROPERTIES												
Impact Tests	SRCE	LAB	GAUGE	COND	METH	DIR	LOC	SIZE	TEMP (°F)	ENERGY (ft-lb)	ENERGY (J)	
Heat No.	Batch No.	166	ALG	10000	NORM	CVN	L	B	FULL	-50	71 69 77	72
2606P3	AB8769	166	ALG	10000	NORM	CVN	L	B	FULL	-50	59 61 73	64
2606P3	AB8770	166	ALG	10000	NORM	CVN	L	B	FULL	-50	84 86 85	79
2797P3	AB8771											
Tensile Tests	SRCE	LAB	GAUGE	COND	METH	DIR	LOC	YIELD(KSI)	TENSILE(KSI)	EL SCALE	ELOING(%)	
Heat No.	Batch No.	166	ALG	10000	NORM	2	T	B	49.5	78.2	2	
2606P3	AB8769	166	ALG	10000	NORM	2	T	B	49.0	77.1	2	
2606P3	AB8770	166	ALG	10000	NORM	2	T	B	50.7	77.2	2	
2797P3	AB8771											

Velocity America 279  
 APR 03 2013  
 Q.C.I. E.Y.  
 Q.C.I. N.D.

K. UGHADPAGA  
 MANAGER METALLURGICAL SERVICES

Date 2013/01/07 Time 12 25 32 Page no 2 of 2

\*\*WARNING\*\* THE TEST RESULTS AND VALUES REPORTED HEREIN INDICATE ONLY THAT THE PARTICULAR STEEL FOR WHICH THIS CERTIFICATE IS ISSUED MEETS THE MINIMUM SPECIFIED YIELD STRENGTH AND (2) THE ANALYSIS AND PHYSICAL PROPERTIES OF SUCH STEEL, ARE IN CONFORMANCE WITH THE REQUIREMENTS OF THE SPECIFICATION INDICATED. THE 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 CALCULATION) AS REPRESENTING THE ACTUAL STRENGTH OF SUCH STEEL.



ASK 53751



NORTH AMERICAN STAINLESS  
6870 HIGHWAY 42 EAST  
GHENT, KY 41045

# METALLURGICAL TEST REPORT

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: 2/12/2013 Page: 1

Steel: 316/316L

Finish: HRAP

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

NAS Order: DS 0002765 03

Your Order: 53951

## PRODUCT DESCRIPTION:

STAINLESS STEEL CONT. MILL PLATE, HRAP; UNS 31600/31603  
ASTM A240/11b, A480/11b, A666/10; ASME SA240/11a, SA480/11a, SA666/11a  
CHEM ONLY ON FOLLOWING ASTM: A276/10, A479/11, A484/11, A312/11  
CHEM ONLY ON FOLLOWING ASME: SA312/11, SA479/11  
AMS 5507F/5524L X MRK;  
NACE MR0175/ISO 15156-3:2003 A, MR0103/07; QQS766D-A X MAG PERM  
MIN. SOLUTION ANNEAL TEMP 1900F, WATER QUENCHED

## 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

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 %									

Chemical Analysis per ASTM A751/08

Q.C.I. N.D. (Red Diamond)

Q.C.I. E.Y. (Red Diamond)

W.O. # 117388

M.L. # 20 (3/3, 4/3)

I.F.K. # 0382

P.O. # (3-0221)

Ben David

Venue America 279

## MECHANICAL PROPERTIES

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

Certification of Material - Per ASME  
HT# F3K0  
Qualifies to all requirements of  
SA240-316/316L per  
Sect. II - 10 Edition II Addenda

MAR 14 2013

NAS hereby certifies that the analysis on this certification is correct. Based upon the results and the accuracy of the test methods used, the material meets the specifications stated. These results relate only to the items tested and this report cannot be reproduced, except in its entirety, without the written approval of NAS.

Technical Dept. Mgr.



**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. Iodio (Alava)  
SPAIN

TL: +34 946719300  
FAX: +34 946725062  
E-MAIL: qualitytti@tubacex.es

**CUSTOMER DESCRIPTION**

<p><b>CLIENT SOLD TO</b> PINACLE STAINLESS STEEL INC. 455 AMBASSADOR DRIVE MISSISSAUGA, ONTARIO ON L5T 2J3 CANADA</p>	<p><b>CLIENT SHIP TO</b> PINACLE STAINLESS STEEL INC. 455 AMBASSADOR DRIVE MISSISSAUGA, ONTARIO ON L5T 2J3 CANADA</p>
---	---

**CLIENT ORDER:** 57733  
**SALES ORDER:** 101551

<p>MATERIAL: SEAML. STAINL. STEEL TUBES/PIPES, PICKLED-PASSIVATED GRADE: TP316/316L, STANDARD: ASTM A312M-09 / ASME SA312M ED.10 TOLERANCES: ASTM A999/A312 PLAIN ENDS, DIMENSIONS: 4" SCH 10 HOT FINISHED NACE MRO103-10 / MRC175 / ISO 15156-3 : 2009</p>	<div style="border: 1px solid red; padding: 5px;"> <p>W.O. # 1173 M.L. # 21 (5/3) TRK. # 244 P.O. # 13-0243-REV1</p> <p>Certification of Material - Per ASME HT# 43633 Qualifies to all requirements of <u>A312-316/316L</u> per Sect. II <u>10</u> Edition <u>11</u> Addenda</p> </div>
---	--

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	ACFRALAVA	Electric furnace+AOD

<b>CHEMICAL COMPOSITION (%)</b>										
*L: Ladle C-Products										
*	Heat	Seq	C	Mn	Si	P	S	Ni	Cr	Mo
L	43633	1	0.013	1.43	0.510	0.021	0.0090	11.20	16.70	2.12

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

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

  
 Review  
 R. S.  
 M. T. T. 2013

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

**Q.C.I.**  
**N.D.**

MAR 26 2013



**TUBACEX TUBOS INOXIDABLES**

INGENIERIA DE CALIDAD

*[Handwritten signature]*



**INSPECTION CERTIFICATE  
EN 10204 3.1**

Number: 516293	Rev: 00
Page: 2 / 2	

Created on: Date: 01.04.2011	Modified on:
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**HARDNESS TEST**

Prod. Order	Ins. Lot	✓ Sample	HRB1	HRB2
100323274	200038013	1	88	89

**METALURGICAL TESTS**

INTERGRANULAR CORROSION TEST ACC. TO ASTM A262 PRACT."E": SATISFACTORY

**NON-DESTRUCTIVE TESTS**

100 % HYDROSTATIC PRESSURE TESTED AT 1400 PSI, DURING 5 SEC, GOOD.

POSITIVE MATERIAL IDENTIFICATION TEST ON EACH TUBE/PIPE BY  
"X-RAY-FLUORESCENCE-ANALYZER": SATISFACTORY

VISUAL INSPECTION ON EACH TUBE: SATISFACTORY

DIMENSIONAL CHECKING ON EACH TUBE: SATISFACTORY

**TECHNOLOGICAL TESTS**

FLATTENING TEST: SATISFACTORY

**MARKING**

TUBACEX 4" SCH 40 ASME SA312 ASTM A312 TP316 TP316L HF SMLS HEAT/  
PMI LOT NO/ SPAIN TX3 TX1

**REMARKS**

NO MERCURY, MERCURY COMPOUNDS OR MERCURY BEARING INSTRUMENTS AND/OR EQUIPMENT HAVE BEEN USED ALONG MANUFACTURING AND INSPECTION PROCESS.

NO WELD REPAIR WAS PERFORMED

MATERIAL MANUFACTURER APPROVED WITH CERTIFICATE NR. 07/2001/MUC BY TUV SÜDDEUTSCHLAND (NOTIFIED BODY 0036) TO ISSUE CERTIFICATES OF SPECIFIC PRODUCT CONTROL IN ACCORDING TO PRESSURE EQUIPMENT DIRECTIVE 97/23/EC ANNEX 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



**TUBACEX TUBOS  
INOXIDABLES**  
INGENIERIA DE CALIDAD





Salzgitter Mannesmann Stainless Tubes France SAS (A01)  
 B.P.10 - F 21501 Montbard Cedex - FRANCE  
 www.smsl-tubes.com

Page/Selle  
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No/Nr/N° (A03)  
24546300937484

INSPECTION CERTIFICATE  
 Abnahmeprüfzeugnis  
 Certificat de réception  
 EN 10204: 2004 TYPE 3.1 (A02)

Salzgitter Mannesmann Stainless Tubes France SAS - B.P.10 - F 21501 Montbard Cedex - FRANCE  
 SHAW ALLOY PIPING PRODUCTS  
 740 MARKET  
 71107 SHREVEPORT  
 Elats-Unis  
 Purchaser/Besteller/Acheteur

Customer order no./Kunde Auftragsnr./N° Commande client (A07)  
 PO#51884  
 SMST-Tubes order no./Auftragsnr./N° Commande (A08)  
 0000245463  
 SMST-Tubes Item  
 0000245463-000009

Product Description/Produkt Beschreibung/Description 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 06 / 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 (B08-D01)  
 WO : 324546300901 - DMV-F - ASTM A 376 / ASTM A 312 / ASME SA 376 / ASME SA 312 - TP 316 / TP 316L - NPS 4 X SCH 120 - 23.43 FT - SML - 449090 - QL30037484 - FRANCE

Quantity/Menge/Quantité						Dimensions		Abmessungen	
Heat no Schmelze Nr. N° de Coulée	Quality lot Qualitätslos Lot qualité	SMST Item	Pieces Stück Pièces (B08)	Total weight Gesamtgewicht Masse totale (B13)	Total length Gesamtlänge Longueur totale	OD (B09)	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	7316 mm 24.00 Ft

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

Heat no./Schmelzen Nr./N° de coulée 449090  
 Melting Process/Erschmelzungsart/Élaboration (C70) VOD  
 Heat Origin/Urspr. der Schmelze/Origine de la Coule Germany  
 Heat Analysis / Analyse de coulée

	C	Si	Mn	P	S	Cr	Ni	Mo
Min	0.00	0.00	0.00	0.00	0.00	18.00	11.00	2.00
Max	0.030	0.75	2.00	0.045	0.0300	18.00	14.00	3.00
	0.015	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 2013

Q.C.I.  
N.D.

Q.C.I.  
E.Y.

W.O. # 1173  
 M.L. # 23 (14, 314)  
 THK. # 443  
 P.O. # 13-0243-REV 1

This certificate is issued by a computerized system and is valid without signature, in case the name of the original would release a copy of it he must attest its conformity and will be responsible for any falsification or misused use. Any alterations or falsification will be subject to law.  
 Dieses Zeugnis bzw. diese Bescheinigung wurde mit Hilfe der EDV erstellt und ist ohne Unterschrift gültig. Veränderungen sowie Verwendung für andere Erzeugnisse werden als Unkonformität 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 fraude et seront sujets à la juridiction pénale.

Salzgitter Mannesmann Stainless Tubes France SAS ISO9001 - LRQA N° 9264

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SAM Offshore  
 Print Name: GANESH SAHA  
 Signature: [Signature]  
 Date: 04/11/13  
 Velosi America LLC

046





Salzgitter Mannesmann Stainless Tubes France SAS (A01)  
B.P.10 - F 21501 Montbard Cedex - FRANCE  
www.smtl-tubes.com

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**INSPECTION CERTIFICATE**  
Abnahmeprüfzeugnis  
Certificat de réception  
EN 10204: 2004 TYPE 3.1 (A02)

No/No/N° (A03)  
24546300937484

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 Probenrichtung Direction (C02)	Yield strength/Dehngrenze/Limito d'élasticité (C11)			Tensile strength / Zugfestigkeit/ Résistance à la traction (C12)	Elongation/Bruchdehnung/Affongement (C13)					Reduction of area Z%
		0.2 %	0.5 %	1 %		2"	50 mm	5D	6,85 √So	4D	
		ksi	/	/	ksi	%	/	/	/	/	/
	Min	30	/	/	75	35	/	/	/	/	/
	Max	/	/	/	/	/	/	/	/	/	/
30128250	LONGITUDINAL	47.67	/	/	87.20	49.75	/	/	/	/	/

Hardness test/Härteprüfung/Essai de dureté (C30)

NACE MR0175/ISO 15156-3 NACE MR0103

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

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

ASTM A 999

Test Number	Result
30128249	OK
30128250	OK

Other testing

Quality Lot : QL30037484



This certificate is issued by a computerized system and is void 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 falsified or not allowed use. Any alterations or falsification will be subject to law.  
Dieses Zeugnis bzw. Diese Bescheinigung wurde mit Hilfe der EDV erstellt und ist ohne Unterschrift gültig. Veränderungen sowie Verwendung für andere Erzeugnisse werden als Urkundenfälschung und Betrug strafrechtlich verfolgt.  
Ce certificat est rédigé à l'aide d'un traitement électronique de données et est applicable sans signature. Tout changement ou application pour d'autres produits seront considérés comme falsification de documents et fraude et seront sujet à la juridiction pénale.

Salzgitter Mannesmann Stainless Tubes France SAS ISO9001 - LROA N° 825479

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: S.B.M. OFFSHORE  
Print Name: GANESH SAHAI  
Signature: [Signature]  
Date: 1 May 2013  
046  
Applus<sup>®</sup>  
VELOSI  
Velosi America LLC



No/Nr/N° (A03)

24546300937484

Salzgitter Mannesmann Stainless Tubes France SAS (A01)

B.P.10 - F 21501 Montbard Cedex - FRANCE

www.emst-tubes.com

**INSPECTION CERTIFICATE**  
Abnahmeprüfzeugnis  
Certificat de réception

EN 10204: 2004 TYPE 3.1

(A02)

Page/Selle  
3/4

Intergranular corrosion test/Prüfung Interkristallinen Korrosion/Essai de corrosion Intergranulaire

MIL-P-24691/3 Feb. 1991 Ad 1 ASTM A 262 PRACTICE E

Test Number	Result
3Q128249	Satisfactory
3Q128250	Satisfactory

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No/Num° (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/Solio

4/4

Other Tests and Declarations / Andere Prüfungen und Prüfergebnisse / Autres tests et déclarations  
QL30037484

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

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

Hydrostatic Test / Wassererfordrungsversuch / 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 Röhre sind frei von Quecksilberverunreinigungen und frei von radioaktiver Verunreinigung / Les tubes sont exempts de contamination par le mercure et de contamination radioactive

Confirmation with reference to Pressure Equipment Directive 97/23/EC:

The works operates a quality management system that has undergone a specific assessment for materials for pressure equipment and is certified by a competent body (TÜV-SÜD CERT.No:05/2011/MAN)

Bestätigung in Bezug auf Druckgeräterichtlinie 97/23/EC:

Das Werk wendet ein Qualitätsmanagementsystem an, das in Bezug auf Werkstoffe für Druckgeräte einer spezifischen Bewertung unterzogen wurde und von einer zuständigen Stelle (TÜV-SÜD CERT.No:05/2011/MAN) zertifiziert ist.

Confirmation concernant la Directive Equipements sous Pression 97/23/EC : L'usine applique un système de management de la qualité qui a fait l'objet d'une évaluation spécifique pour les matériaux pour équipements sous pression et qui est certifié par un organisme compétent (TÜV-SÜD CERT.No:05/2011/MAN)

SMST certify that the delivered products comply with the requirements stipulated in the order. / Die Erzeugnisse wurden bestellungsgemäß geprüft und für in Ordnung befunden. / SMST-Tubes attestent que les produits livrés sont conformes aux stipulations de la commande.

Validation by manufacturer's representative / Validation durch Vertreter des Herstellers

Mill's Inspector  
Werksachverständiger T POMMERY  
Le contrôleur usine

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

This certificate is issued by a computerized system and is valid without signature. In case the owner of the original would release a copy of it he must attest its conformity and will be responsible for any unlawful or not allowed use. Any alterations or falsification will be subject to law.

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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. # 11730  
M.L. # 24 (274)  
THK. # 436  
P.O. # 130243-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
180		8110006752	100323250	200037778	43633	8	1.091 KG	47,95 M	5791-7315 MM

Heat Nr:	Supplier	Method
43633	ACERALAVA	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	Rp1.0	Rm	A2"	A5	
			°C	N/mm2	N/mm2	N/mm2	%	%	
100323250	200037778	1	20	432	472	625	54	48	

Q.C.I.  
N.D.

Review  
RIS  
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.

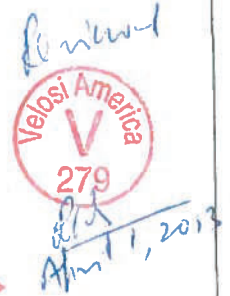
POSITIVE MATERIAL IDENTIFICATION TEST ON EACH TUBE/PIPE BY  
"X-RAY-FLUORESCENCE-ANALYZER": SATISFACTORY

VISUAL INSPECTION ON EACH TUBE: SATISFACTORY

DIMENSIONAL CHECKING ON EACH TUBE: SATISFACTORY

**TECHNOLOGICAL TESTS**

FLATTENING TEST: SATISFACTORY



**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  
901 TWIN RAIL DRIVE  
MINOOKA, IL 60447

**NORTH AMERICAN STAINLESS**

Mail To:  
ROLLED ALLOYS  
125 W. STEWES RD.  
TEMPERANCE, MI 48102

Ship To:  
ROLLED ALLOYS  
125 W. STEWES RD.  
TEMPERANCE, MI 48102

Date: 3/21/2006 Page: 1

Steel: 316/316L

Finish: BRAP

Corrosion: ASTM A276/02aE; 180Bend-OK

WAS Order: IN 0006185 01

Your Order: T56490

## PRODUCT DESCRIPTION:

STAINLESS STEEL PLATE, HOT ROLLED, ANNEALED AND PICKLED.  
ASTM A240/05a, 480/05, 666/03, ASME SA240/04-A05, 480/04-205, SA666/04  
ASTM A240/05a, 480/05, 666/03, ASME SA240/04-A05, 480/04-205, SA666/04  
(X GRAIN), QQS766D-A X MG PERM, AMS5507Y/AMS524K X MKK  
Chem only for following: ASTM A276/A312/3A79, ASME SA312/SA479

## REMARKS:

Material free from mercury contamination. No weld repairs.  
EN 10204 3.1 PED 97/23/EC Annex1, Para. 4.3 QQS763V Cond A  
Material is ROHS-Compliant  
MACE BRO 175 EN 10204 3.1.B  
Melted & Manufactured in the USA

## Mark Pieces Commodity Code

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

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SPAM OFFSHORE  
Print Name: SPAM OFFSHORE  
Signature: [Signature]  
Date: 4/14/10/13  
046  
Applus® VELOSI  
Velo America LLC

## CHEMICAL ANALYSIS

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

JUN 12 2006

## MECHANICAL PROPERTIES

Product Id#	Coil #	UTS KSI	.2% YS KSI	ELONG %-2"	HARD RB
0991N3 HC	0991N3 HC FT	80.82	37.73	58.95	76.50

Certification of Material - Per ASME

HT# 91N3  
Qualifies to all requirements of SA240-316L per Sect. II Edition II Addenda

W.O. # 117308119  
M.L. # 26444  
TIK. # 503  
P.O. # C76570500

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

Q.C.I. N.D.

TRACER# 129838

APR 7 4 2013

Q.C.I. E.V.

QC ENGINEER

ERIC HESS 3/21/2006

DEC 12 2006

**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. 67624											
C	Mn	Si	S	P	Ni	Cr	Mo	Cu	N	Co	
0.024	1.58	0.44	0.020	0.037	10.16	16.21	2.05	0.50	0.078	0.18	

**TEST RESULT**

.2% YIELD STRENGTH KSI	TENSILE STRENGTH KSI	ELONGATION %	REDUCTION OF AREA %	HARDNESS BHN	GRAIN SIZE
71	91	47	75	187	6

**Specification :**

MATERIAL CONFORMS TO ASTM A276-00a, A 479-01, A484-00, A282-89 PRACTICE E, RMS 80, ASTM A182-01b BSM CL1, A308-06ED, A182-01a AMS 8840/5053E, ASME SA-182 80ED, SA-479-06ED, SA-193-00 BSM C L1, QQ-S-783F, MILL-S-7720A AM2, NACE-MR-01-75-88, UNS#S316 80/531803, ASTM E 112-88(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 479-316/316L per  
Sect. II 10 Edition 11 Addenda

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

*K.R.K. Murthy*  
WORKS INSPECTOR  
(K. R. K. MURTHY)

Q.C.I.  
N.D.

APR 24 2013

Q.C.I.  
E.Y.

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: *SAM OFFSHORE*  
Print Name: *GANESH SAHAI*  
Signature: *[Signature]*  
Date: *JULY 10 2013*  
**Applus<sup>®</sup> VELOSI**  
Velosi America LLC





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

REPORT NUMBER 74244

DATE 4/23/2013

FCI ORDER NUMBER 60030

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

CUSTOMER ORDER NUMBER 13-0266  
SOLD/SHIPPED TO ALL-WELD CO., LTD.  
49 PASSMORE AVE.

SCARBOROUGH ONT MIV 4T1 CANADA

Item Quantity Description

1	4	8" X 900 X 13.25" LG RTJ LWN	ITEM# 1173-40
2	4	8" X 900 X RTJ BLIND	ITEM# 1173-41

HEAT NUMBER:  
N434

MATERIAL TYPE:  
SA182F316/L

Manufactured in  
USA

I.A.W. ASME 2010 ED 11AD.

CHEMICAL ANALYSIS

PHYSICAL PROPERTIES

C	.027 ✓
Mn	1.160 ✓
P	.0290 ✓
S	.0250 ✓
Si	.350 ✓
Cr	17.450 ✓
Mo	2.030 ✓
N	10.310 ✓
	.0980

Yield PSI	47,000 ✓
Tensile PSI	86,000 ✓
Elongation	77.1 ✓
Reduction of Area	79.6
Hardness	176 HBW



Certification of Material - Per ASME  
HT# N434  
Qualifies to all requirements of  
SA182F316/L per  
Sect. II 10 Edition 11 Addenda

W.O. # 11730  
M.L. # 40(5/2)41C(11)  
TIK. # 1-967  
P.O. # 13-0266

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

ACCEPTED/REVIEWED/RELEASED 046  
for and on behalf of: SAM OFF Shore MAY 27 2013  
Print Name: G. A. NESBIT 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 74745

DATE 5/7/2013

FCI ORDER NUMBER 60097

Processed I A W EN10204 3 1  
I A W NACE MR0175

CUSTOMER ORDER NUMBER 13-0294  
ORDER/SHIPPED TO ALL-WELD CO., LTD.  
49 PASSMORE AVE.

SCARBOROUGH ONT MIV 4T1 CANADA

Item Quantity Description

1 2 2" X 900 X 11" LG RTJ LWN

ITEM# 1173-45

HEAT NUMBER:  
N472

MATERIAL TYPE:  
SA182F316/L

Material Origin: ITALY  
Manufactured in USA

I.A.W. ASME 2010 ED 11AD.

CHEMICAL ANALYSIS

PHYSICAL PROPERTIES

C .017 ✓  
Mn 1.800 ✓  
P .0270 ✓  
S .0280 ✓  
Si .380 ✓  
Cr 16.710 ✓  
Mo 2.040 ✓

Yield PSI 41,000 ✓  
Tensile PSI 83,000 ✓  
Elongation 59.2 ✓  
Reduction of Area 61.1 ✓  
Hardness 169 HBW

MAY 27 2013

Ni 10.170 ✓  
.0780

W.O. # 11730  
M.L. # 45(7/2)  
THK. # 1.109  
P.O. # 13-0294

N10  
Certification of Material - Per ASME  
HT# N472  
Qualifies to all requirements of  
SA182-F316L316L per  
Sect. II 10 Edition 11 Addenda

ACCEPTED/REVIEWED/RELEASED 046  
for and on behalf of: SBM OFF SHORE  
Print Name: GANESH SAHA  
Signature: [Signature]  
Date: July 10 2013  
Q.C.I. N.D.  
Applus VELOSI  
Velosi America LLC

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



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. # 24160-407  
P.O. # 13-0279

N12  
Certification of Material - Per ASME  
HT# N432  
Qualifies to all requirements of  
SA182-F316/L per  
Sect. II 10 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 SHOOT  
Print Name: GANESH SAHA  
Signature: [Signature]  
Date: July 10 2013  
Applus<sup>®</sup> VELOSI  
Velosi America LLC

# L PALACE PIPE CO., LTD

## TEST CERTIFICATE

GRYS

DATE OF ISSUE: 2013/7/1

CERTIFICATE (No.: QAC0021058/A)

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

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SHANGHAI CRYSTAL PALACE PIPE CO., LTD  
 Signature: [Signature]  
 Date: 2013/7/13  
 PINGSHI VERIFIED APPLIED PINNACLES VERIFIED APPLIED Pinnacle LLC

CUSTOMER: [Blank]  
 P.O. NO.: [Blank]  
 CERTIFICATE NO.: 2013-05-021-1-17  
 ORDER NO.: 2013-05-021-1  
 COMMODITY: STAINLESS STEEL SEAMLESS PIPE.  
 CONDITION: COLD FINISH / SOLUTION TREATED / PICKLED / PLAIN END  
 GRADE: ASTM A312-12 TP316/316L  
 HEAT NO.: YT22057

### 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

NPS	Dimensions		Bundle No.	Pieces	Weight (kg)	0.2%YS (Mpa)	TS (Mpa)	EL (%)	FLATTENING TEST	HARDNESS HRB	EDDY CURRENT TEST (100%)
	W.T (SCH)	Length (feet)									
2"	40S	20	Z13-5-295	250	8428	≥ 205	≥ 515	≥ 35	OK	---	OK

REMARKS:  
 AS PER A312-12/SA312-10  
 IN COMPLIANCE TO NACE MR0175-2003, MR0175/ISO 15156  
 SOLUTION HEAT TREATMENT : 1050°C X 1.5m/min  
 NO WELD REPAIR WAS PERFORMED  
 FREE FROM MERCURY CONTAMINATION  
 FREE FROM RADIATION CONTAMINATION  
 IC TESTING ACCORDANCE TO ASTM A262 E - SATISFACTORY  
 COUNTRY OF ORIGIN: CHINA  
 PMI TESTING DONE.  
 MATERIAL TEST CERTIFICATE TO EN 10204/3.1  
 IN COMPLIANCE TO NACE MR0103-2003

1. WE HEREBY CERTIFY THAT THE MATERIAL DESCRIBED HEREIN HAS BEEN TESTED AND THE TEST RESULTS ARE IN COMPLIANCE WITH THE TERMS OF THE PURCHASE ORDER OR CONTRACT  
 2. THE CERTIFICATE SHALL NOT BE REPRODUCED, EXCEPT IN FULL, WITHOUT THE WRITTEN APPROVAL OF THE COMPANY.

SHANGHAI CRYSTAL PALACE PIPE CO., LTD  
 [Signature]  
 MANAGER OF QUALITY ASSURANCE DEPARTMENT / DING WEI-GUO





# METALLURGICAL TEST REPORT

NORTH AMERICAN STAINLESS  
8770 HIGHWAY 42 EAST  
GIBBET, KY 41045

NAS P50966

8770 HIGHWAY 42 EAST  
Certification: 728046 15  
Customer: 007050 001

Ship To:

Date: 4/12/2012 Page: 1

Steel: 310/316L

Finish: NMAP

Correction: NFE 2263/0205/100000-02

Your Order: 50966

NAS Order: DS 0000209 02

### PRODUCT DESCRIPTION

STAINLESS STEEL CORR. RESIST. FLAT, NMAP, UNS 31609/31603  
NFE 2263/11b, 2400/11b, 2600/10, 2600/11a, 2600/11c, 2600/11d, 2600/11e  
CENX ORZ ON FOLLOWING NFE: 2276/10, 2478/11, 2404/11, 2312/11  
CENX ORZ ON FOLLOWING NFE: 2432/11, 2447/11  
UNS 3077/3024L X NFE  
NFE 2601/15/200 15156-3:2003 A, 2601/03/07, 0057600-A X NFE  
NFE. SOLUTION ANNEAL TEMP 1900F, WATER QUENCHED

### REMARKS:

Mat'l is Free of Mercury Contamination. No weld repairs.  
EN 10204:2004 3.1) 0057639 Com A) NFE Compliant  
Material is Free of Indisociative Contamination  
NAS Steel Making Process: NMP, AOD, & Cont. Casting  
Product Mfg. by a Quality Mgt. Sys. in Conf. w/ISO 9001  
Special A Manufactured in the USA, Mat'l is NFE Compliant  
EN 10204 3.1.0

Product ID	Coil #	Mat'l	Thickness	Width	Weight	Length	Mark	Piece	Commodity Code
DA9040	058839 2		.2400	60.0000	3.090	600000		144.00	9 5

### CHEMICAL ANALYSIS

EN (Country of Mat'l) EN (Spain) US (United States) ZA (South Africa) JP (Japan)

EN	C	CR	CU	NI	MO	SI	P	S
3079	.0296	16.0325	.0025	1.0335	2.0004	.0436	10.0300	.0017
	SI							
		.4420						

W.O. # 11730  
M.L. # 5002729 (2)  
THK. # 218  
P.O. # 12-1361-102R

Q.C.I.  
N.D.

### MECHANICAL PROPERTIES

Product Id	Coil #	UTS ksi	YS ksi	ELONG % 2"	Hard HB	Tall Hard
DA8660	058839	72	84.23	43.69	40.97	84.00

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SRM OF S.MORE  
Print Name: G. MESSY S.F.H.A.  
Signature: G. MESSY S.F.H.A.  
APPLICOS VELOSI

AUG 16 2013

Certification of Material - Per ASME  
Mat'l # B914  
Qualifies to all requirements of  
SA 240-216316L per  
Sect. II 10 Edition II Addenda

Technical Page: Mgr.  
ERIC HESS  
12/2012

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



Outokumpu Stainless Plate, Inc.

**OUTOKUMPU**

**Certificate of Analysis and Tests**

OUR ORDER 0252379 - 13

HEAT & PIECE 836433-1E 06/23/06

SOLD TO: INTEGRIS METALS LTD. - Etobicoke  
161 THE WEST MALL  
ETOBICOKE, ON M9C 4V8

SHIP TO: INTEGRIS METALS LTD. - Etobicoke  
161 THE WEST MALL  
ETOBICOKE, ON M9C 4V8

ACCEPTED/REVIEWED BY LEAST  
 for and on behalf of: 35M CFF STORE  
 Print Name: Carroll Spahn  
 Signature: [Signature]  
 Date: Sept 3/13  
**Applus®**  
**VELOSI**  
 Velosi America LLC

YOUR ORDER & DATE  
539197 4/12/06 TAG# 7581-2043

ITEM DESCRIPTION  
HEAT & PIECE 836433 - 1E  
WEIGHT 2782  
FINISH 1  
GRADE 316L / 316  
DIMENSIONS .375 X 96.000 X 253.000 EXACT  
COUNTRY OF ORIGIN BRITAIN

SPECIFICATIONS  
FROM SLABS IMPORTED FROM BRITAIN  
ASTM A240-06  
ASTM A262-02A PRACTICE A  
NO GRIPPER MARKS  
\*\*\* **MEG IN NEW CASTLE, IN, USA**  
ASME SA240 04 EDITION 05 ADD  
ASTM A480/A480M-05  
ASTM A262-02A PRACTICE E  
NO WELD REPAIRS

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  
ISO 9001 2008  
DHI Cert  
30926  
Certification of Material - Per ASME  
HT# 836433-1E  
Qualifies to all requirements of  
SA 240-316316 per  
Sect. II 10 Edition II Addenda

CHEMICAL COMPOSITION		
CARBON	(C)	.018 ✓
MANGANESE	(MN)	1.69 ✓
PHOSPHORUS	(P)	.027 ✓
SULFUR	(S)	.001 ✓
SILICON	(SI)	.38 ✓
CHROMIUM	(CR)	16.27 ✓
NICKEL	(NI)	10.11 ✓
COBALT	(CO)	.38 ✓
COPPER	(CU)	.36 ✓
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

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

  
 Outokumpu Stainless Plate, Inc.  
 P.O. Box 370  
 New Castle, Indiana 47364

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBM OF FISHING  
 Print Name: CHANG SHIH SAHA  
 Signature: [Signature]  
 Date: Sept 3/13  
 Velosi America LLC  
 046

G.C.I.  
E.Y.

AUG 16 2013

G.C.I.  
N.D.

**WALSIN** WALSIN LIHWA CORPORATION YENSHUI PLANT

ISO-9001, ISO-14001 CERTIFIED

MILL TEST / INSPECTION CERTIFICATE

Customer	Steel Grade	Material	Commodity	Quantity (Pcs)	Weight (lbs)	Condition	Date	Order No.	File	
		ENERGY STEEL PRODUCTS, INC.	Austenitic Stainless Steel Round Bar				2008/06/27	299681	2008070925	
				129	2323	PL			22804	
				41	2048	PL				
				32	2292	PL				
Material is free from mercury contamination No welding repair Solution treatment at 1040°C · 1-2 hour · water quenched Grain size test by ASTM E112-96cl : fine Macro and micro structure : ok Material : V.O.D and hot rolled annealed. Certs to EN 10204/3.1.B. Country of Origin : Taiwan, Melt in Taiwan										
Kind of Test	Chemical Composition (WT%)									
	C	Si	Mn	P	S	Ni	Cr	Mo	Co	N
Spec.	0.03	1.00	1.25	0.040	0.02	10.00	16.00	2.00	0.75	0.10
1	MAX	0.38	1.69	0.029	0.028	10.00	16.70	2.03	MAX	MAX
2	0.02	0.42	1.68	0.028	0.028	10.02	16.93	2.04	0.19	0.06
3	0.02	0.37	1.80	0.030	0.028	10.02	16.70	2.02	0.20	0.05
Mechanical Properties										
	Hardness (HB)	Tensile Strength (N/mm2)	Yield Strength (N/mm2)	Elongation (%)	Reduction of Area (%)					
1	149	560.0	248.0	55.0	74.0					
2	140	565.0	264.0	59.0	72.0					
3	142	520.0	242.0	62.0	75.0					
Condition:	Invoice No. 08JUN-L396286TOR L/C No. A-Annealed Acc. To ASTM A192-94b B8M Class, A376-04a cond. A, A479-04 cond. A HR-Hot Rolled ASTM A314-97 (REAPPROVED 2003), A182-02a, A404-03a, A320-01 B8M Class CD-Cold Drawn ASTM A202-02 Practice B, ASME SA479-001 cond. A, SA182-E01 A03 ST-Smooth Turned SA193-E01 A03 B8M Class, SA320-01a B8M Class CG-Counterless Grinding NACE MR 0175, MIL 7789A, SAP-AMS QQR-763F cond. A, AMS S648K, S653F UNS S31600/31603 For 316/316L									
Shape: 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. R: Round H: Hexagonal S: Square SR: Square-Round E: Ellipse Fil: Rectangular										
MANAGER OF QUALITY ASSURANCE DEPARTMENT										

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

Certification of Material Per ASMB  
 HT# 2X469  
 Qualifies to all requirements of SA 479-316/316L per Sect. II 70 Edition Addenda



ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SBM OFFSHORE  
Print Name: LIANG SAH  
Signature: [Signature]  
Date: Sept 3/13  
APPLUS<sup>®</sup>  
VELCO<sup>®</sup>  
Velosi America, LLC

THIRD DIVISION  
/ DBA OF SC MFG. GROUP INC.  
No. 80 Dali Road, Heping District, Tianjin, China  
Tel.: 86-22-27319741 Fax.: 86-22-27319749

**INSPECTION CERTIFICATE AND MILL TEST REPORT**

According to  
DIN 50049 3. 1. B / EN 10204

Manufacturer's Symbol  
**SCDN**

**Customer:**  
PINACLE STAINLESS STEEL INC.  
455 AMBASSADOR DRIVE  
MISSISSAUGA, ONTARIO  
L5T 2J3

**Order No. 31054**      **SC MFG PO No. SC-1524**

**Chemical Analysis**

Item No.	Item Description	Sch.	Heat No.	QTY	%C	%Mn	%P	%S	%Si	%Ni	%Cr	%Mo
25	4" TEE	40S	85664	50	0.023	1.560	0.030	0.027	0.460	13.60	17.50	2.2
26	10" TEE	40S	37435	5	0.023	1.350	0.029	0.021	0.340	13.30	17.40	2.15
27	8" 45 ELBOW	80S	30185	10	0.018	1.500	0.024	0.020	0.370	13.20	17.80	2.3
28	4" 90LR ELBOW	80S	17145	50	0.025	1.560	0.027	0.025	0.670	13.60	16.80	2.35
29	6" 90LR ELBOW	80S	51670	20	0.025	1.42	0.022	0.012	0.56	13.1	17.5	2.1
30	10" 90SR ELBOW	80S	37463	2	0.027	1.700	0.026	0.024	0.720	13.20	17.30	2.3

**Mechanical Properties**

Heat No.	Item Description	Tensile MPa	Yield MPa	Elong. %	Red. Area %	Bend Test	Flattening Test	Hardness HB	Impact Test	Hydrostat. Test	Xray Test	Visual & Dimension
85664	4" TEE	580	265	57	-	ok	ok	130	ok	ok	-	ok
37435	10" TEE	565	250	52	-	ok	ok	145	ok	ok	-	ok
30185	8" 45 ELBOW	525	255	50	-	ok	ok	145	ok	ok	-	ok
17145	4" 90LR ELBOW	560	255	56	-	ok	ok	130	ok	ok	-	ok
51670	6" 90LR ELBOW	590	265	56	-	ok	ok	130	ok	ok	-	ok
37463	10" 90SR ELBOW	580	270	55	-	ok	ok	125	ok	ok	-	ok

**Heat Treatment:** SOLUTION TREATED, 1060 °C (20 Minutes) Water Quenched

**Misc:** Material in accordance with NACE MR0175-2001

Free from Mercury contamination  No  Yes  
Addition of filler metal?  No  Yes

**Steel Making Process:** Electric Furnace

CANADIAN REGISTRATION NUMBERS	
ONT	OA8868.5 NB 0A8868.57
QUE	CSA-0A8868.56 NFLD 0A8868.50
ALB	0A8868.52 NS 0A8868.58
BC	0A8868.51 PEI 0A8868.59
SASK	CSA-0A8868.56 NWT 0A8868.5T
MAN	CSA-0A8868.56 YUK 0A8868.5Y
	NUN 0A8868.5N

WE CERTIFY THIS MATERIAL HAS BEEN MANUFACTURED AND EXAMINED IN ACCORDANCE WITH ALL REQUIREMENTS OF THE SPECIFICATION(S) AND THE RESULTS OF ALL EXAMINATIONS ARE ACCEPTABLE.

W.O. # 11739  
M.L. # 542612-1912-e  
THK. # -532  
P.O. # 13-0707

Certification of Material - Per ASMB  
HT# 37463  
Qualifies to all requirements of SA403-316/316L per Sect. II 10 Edition II Addenda



AUG 1 2 2013

# MATERIAL TEST & INSPECTION CERTIFICATE

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

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

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

PURCHASE ORDER NO.	203095	SPEC. FOR MATERIAL	ASTM/ASME A/SASMP315/316L-W 07/07ED	CERTIFICATE NO.	QCLP2011011727
PJT NO.	N/A	SPEC. FOR INSPECTION	ASME B16.9	DATE OF ISSUE	2010.12.20
STARTING MATERIAL	STEEL PLATE	SKB NO.	2010072802	VISUAL & DIMENSION	SATISFACTORY
NO.	SEQUENCE/ITEM NO	DESCRIPTION	QTY	HEAT NO.	FORCOCODE/TAG NO
932		900 ELBOW(S)	5	490742	
933		900 ELBOW(S)	5	490742	
939		900 ELBOW(S)	5	490742	

### CHEMICAL COMPOSITION (%) (L : LADLE, P : PRODUCT)

STD.	SPEC.	C	Si	Mn	P	S	Ni	Cr	Mo	Cu	V	Nb	Fe	Ti	C.E	SPEC.	Y.S 0.2% offset	TENSILE TEST		RA
																		T.S	EL	
HEAT NO.	MIN	MAX	L	P	L	P	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	KSI	%	%	
490742	10.00	16.00	0.020	0.020	0.001	0.001	10.21	16.93	2.05				75.0	28.0			30.0	75.0	28.0	
	0.018	0.54	1.37	0.032	0.001	0.001	10.21	16.93	2.05				89.6	55.0			44.6	89.6	55.0	

IMPACT TEST	HEAT NO.	TEST TEMP.	SIZE OF SPECIMEN(mm)	ABSORBED ENERGY		LATERAL EXPANSION		PERCENT SHEAR		HARDNESS HRC		HEAT TREATMENT	SOLUTION TREATED, 1060°C, 40Min, 1hr2hr
				VALUE	STD./	VALUE	AVE.	VALUE	AVE.	MIN	MAX		
	490742		BIM									PMI	N/A
			HJAZ									FLATTENING TEST	N/A
			WTM									BENDING TEST	N/A
			BIM									HYDROSTATIC TEST	N/A
			HJAZ									CORROSION TEST	N/A
			WTM									GRAIN SIZE TEST	N/A
												HC TEST	N/A

- MATERIAL MEETS THE REQUIREMENTS OF NACE MR0175 - AUG 16 2013

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

REVIEWED BY: HT# 490742  
 WITNESSED BY: SA403-016  
 Sect. II 10 Edition II Addenda

Certification of Material - Per ASME  
 Qualifies to all requirements of

W.O. # 1173882-1  
 M.L. # 5469/20  
 P.O. # WA130707

Q.C.I. N.D.

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

Signature: *[Signature]* Date: *[Date]*

CM DIV. SENIOR MANAGING DIRECTOR  
 Q.C.I. REV (REVISED/RELEASED)  
 for and on behalf of: *[Signature]*



500284-1 200



Jessop Speciality Products  
500 Green Street  
Washington, PA 15301

Ship TO: **FRANCOIS HUGHES**  
LAVAL QC CANADA

CERTIFIED MATERIAL  
TEST REPORT

INTERDIS METAIS  
151 THE WEST MALL  
ETHELBOROUGH ON CANADA

YOUR ORDER NO.  
MEMO NO.  
DATE  
SALESMAN/NO.

104230  
453598  
27-03-00 DUAL TEST  
05/20/2003

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

MSR201000

H215A3000

ALC 316/316L STAINLESS HPAP  
ASTM A240/0401 ASME SA 240-04

Heat: 820113  
FROM S110 1728J PART# 7581-2540  
820237  
FROM S11P 19218 PART# 7581-2543

Heat: 820113  
820237

Lot No: 153806  
154576

5174  
96.0000 x 250.0000  
96.0000 x 246.0000

SI NT BR NO  
10.10 16.20 2.06  
10.13 16.25 2.05

Yield Strength  
43.9 KSI 87.0 KSI 58.0  
40.2 KSI 84.5 KSI 58.0

MATERIAL WAS NOT WELD REPAIRED  
MATERIAL WAS PRODUCED WITHOUT KNOWN CONTACT WITH MERCURY  
MATERIAL IS OF USA MILT AND MANUFACTURE  
MATERIAL WAS SOLUTION ANNEALED (HEAT TREATED) ABOVE 1900F AND WATER WELDED  
MIN 50049 3.1-B AND EN 10204 3.1-B CERTIFICATE

Certification of Material - Per ASME  
RTS 820113  
Qualifies to all requirements of  
SA 240-316/316L per  
Sec II 10 PART II ANNEAL

W.O. # 1173  
M.L. # 55  
THK. # -771  
P.O. # D545-110411

PAGE 1 FINAL PAGE

AUG 1 9 2003

ACCEPTED BY WELDER: SAH OFF-SHORE  
for and on behalf of: W.A. N. SAH  
Print Name: W.A. N. SAH  
Signature: [Signature]  
Date: Sept 3/13  
Appius Velosi  
Velosi America LLC

Q.C.I.  
N.D.

EXCEPT AS OTHERWISE NOTED, THIS MATERIAL HAS BEEN MANUFACTURED AND TESTED IN ACCORDANCE WITH THE LISTED SPECIFICATIONS AND ORDER REQUIREMENTS.





6870 HIGHWAY 42 EAST

# METALLURGICAL TEST REPORT

✓ INDC. P54189  
NORTH AMERICAN STAINLESS  
6870 HIGHWAY 42 EAST  
GHENT, KY 41045

Certificate: 824674 3  
Customer: 007050 001  
Mail To:  
ROLARK STAINLESS STEEL, INC.  
71 CONAIR PARKWAY  
WOODBIDGE, ON L4H0S4

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

Date: 4/05/2013 Page: 1  
Steel: 316/316L  
Finish: 1

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 WRK;  
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
DE6858	02F9X7 D		.2460	48.0000	4,890 SHEETS	240.00	20	5	

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
F9X7	US	.0189	16.6075	.5330	1.5035	2.0350	.0455	10.0350	.0350	.0010

ACCEPTED FOR RELEASE  
on behalf of: SEM DEFENSE  
Print Name: CIA NORTH  
Signature: [Signature]  
Date: Sept 3/13  
Applus®  
VELOSI  
Veloci America LLC

W.O. # 11730  
M.L. # 58 (30/24/33)  
P.O. # 13-0713

Q.C.I.  
N.D.

Product Id#	Coil #	UTS	% YS	ELONG	Hard	Tail
DE6858	02F9X7	87.91 KSI	48.72 KSI	50.01 %	RB	Hard

Certification of Material - Per ASME  
HT# F9x7  
Qualifies to all requirements of  
SA240-316 per  
Sect. II 16 Edition VI Addenda

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]  
FPTC HPC



ORDER NO: 9135311 (1) DATE: 16/12/2011

### MILL TEST REPORT

IN ACCORDANCE TO EN 10204 3.1

KANZEN TETSU SDN BHD  
PINACLE STAINLESS STEEL INC.

**Kanzen Tetsu Sdn Bhd**

201500150, 19022011 W  
40, Blok 7, 2, Lot 4 Pagar Utama Perumahan  
Kawasan 71, 40700, Seremban 2, Negeri Sembilan, Malaysia  
Tel: +603 5541 0200 Fax: +603 5541 0201  
http://www.kanzen-tetsu.com/ e-mail: info@kanzen-tetsu.com

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

CHEMICAL COMPOSITION (%)

	C	Mn	P	S	Si	Ni	Cr	Mg
2.12	43	83	30	1	1002	1653	201	
2.12	43	83	30	1	1002	1653	201	
3.0	52	96	36	6	804	1812		

MECHANICAL TESTS ACCORDANCE TO EN 10002

ITEM NO	YIELD STRENGTH (MPa)	TENSILE STRENGTH (MPa)	ELONGATION (%)
63V9605	292	598	59
63U8605	292	598	59
43X7401	312	685	52

QTY	TOTAL LENGTH	WEIGHT	AGS
20	PCS	100	
20		7	
20		51	

NP316/316L N X 8"  
X SCH10S X 45 LR ELBOW  
NP316/316L N X 4"  
X SCH40S X 45 LR ELBOW  
NP304/304L N X 8" X 4"  
X SCH10S X ECC REDUCER

W.O. # 117304  
M.L. # 59(24/12/28/12)  
THK. # -147  
P.O. # 13-0707

Certification of Material - Per ASME  
HT# 63U8605  
Qualifies to all requirements of  
SA403-316/316L per  
Sect. II (C) Edition II, Addenda

Q.C.I. N.D.

Q.C.I. E.Y.

AUG 12 2013

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SPM OFFSHORE  
Print Name: DANESH SATHAN  
Signature: [Signature]  
Date: 28 Sept 2013  
Applus  
VELOSI  
Velosi America LLC

1000 VERNE DELSUS QUERUES EN WATER

MANUFACTURED BY  
KANZEN TETSU SDN BHD

Hardness are in accordance to NACE MR 0175 / ISO 15156-3 and NACE MR 0103 (Latest Edition)

A subsidiary of P.A.C. Industries Private Limited

REVISION 01





**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:      Customer PO NO./Item: 18651-STK / 1

CANADIAN PLATE AND PROFILES IN      CANADIAN PLATE AND PROFILES IN      BOL NO.: 1000012968

KAMATO ROAD 920      KAMATO ROAD 920      Cust.Part No.:      TRIPLE K TRANSPORT LTD - 35099 (250)

MISSISSAUGA, Ontario, Canada      MISSISSAUGA, Ontario, Canada      Carrier:      TRIPLE K TRANSPORT LTD - 35099 (250)

L4W 2R6      L4W 2R6

Customer Specification: HR STEEL PLATE Carbon Multi-Cert ASTM A516 GR 70 (10) ASME SA516 GR 70 (11A) Meets NACE MR 0103 latest Ed. NACE MR 0175 latest Ed. BHN < 200. Calcium Treated for Sulphide Shape Control Normalized Temp 1670 °F 34 min CVNL Req. 15/12 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

Supplementary Instructions : Test Cert 1: drafting@canadianplate.com Test Cert 2: 905-206-1370      Cust Use : PVQ

Insp T/R : Test Report As Per Spec

ESSAR STEEL ALGOMA INC. HEREBY CERTIFIES THAT THE MATERIAL HEREIN DESCRIBED WAS MADE AND TESTED IN ACCORDANCE WITH THE RULES OF THE SPECIFICATION SHOWN. ALL RESULTS ARE RETAINED IN ACCORDANCE WITH THE COMPANY'S STANDARD RECORD KEEPING PRACTICES. THIS MILL TEST REPORT MAY NOT BE REPRODUCED EXCEPT IN FULL WITHOUT WRITTEN APPROVAL OF ESSAR STEEL ALGOMA INC. IF YOU RECEIVE THIS DOCUMENT AND ARE NOT THE INTENDED RECEIVER, PLEASE CALL (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"	AB0906	0811P3-54	16,335 LB	1

Heat No. (wt%)	CHEMICAL PROPERTIES										MECHANICAL PROPERTIES			
	C	Mn	P	S	Si	Cr	Ni	Cu	Mo	Nb	Al	B	TI	DO
0811P3*	0.19	1.08	0.009	0.004	0.330	0.05	0.16	0.04	0.01	0.030	0.000	0.015	0.002	0.4000

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

**LIMITS OF UNSPECIFIED ELEMENTS PER ASME SECTION II (SA-20)**

CU + Ni + CR + MO = 0.26  
CR + MO = 0.06

Certification of Material - Per ASME  
HT# 0811P3-02  
Qualifies to all requirements of SA516-GR70 per Sect. II 10 Edition 1 Addenda

W.O. # 11739  
M.S. # 60(113)  
THK. # 1"  
P.O. # 13-0720

ACCEPTED BY REVISED BY: [Signature]  
for and on behalf of: [Signature] S.A.M. [Signature]  
Print Name: U.A. WELSH S.A.M.  
Signature: [Signature]  
Date: 2013-07-13

APplus® VELOSI  
Velosi America LU

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

K. UGHADPAGA      AUG 20 2013  
MANAGER METALLURGICAL SERVICES

**\*\*WARNING\*\*** THE TEST RESULTS AND VALUES REPORTED HEREIN INDICATE ONLY THAT (1) THE PARTICULAR STEEL FOR WHICH THIS CERTIFICATE IS ISSUED MEETS THE MINIMUM SPECIFIED YIELD STRENGTH AND (2) THE ANALYSIS AND PHYSICAL PROPERTIES OF SUCH STEEL ARE IN CONFORMANCE WITH THE REQUIREMENTS OF THE SPECIFICATION INDICATED. THE RESULTS OR VALUES REPORTED HEREIN CAN NOT BE USED TO QUALIFY THE STEEL FOR ANY SPECIFICATION OTHER THAN THE ONE INDICATED AND CAN NOT BE RELIED UPON FOR ANY PURPOSE (INCLUDING DESIGN OR CALCULATIONS) AS REPRESENTING THE ACTUAL STRENGTH OF SUCH STEEL.

Date: 2013/02/12 Time: 13:39:46 Page no: 1 of 2





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

SO No., Item & Date.: 8004571 000010 2012/10/27	Shipment No. & Date.: 1000012968 2012/10/29	TC No., Date & Time : ESA-22183 2012/10/30 - 20:30:57
Sold to Customer Name and Address : CANADIAN PLATE AND PROFILES IN KAMATO ROAD 920 MISSISSAUGA, Ontario, Canada L4W 2R6	Ship to Customer Name and Address: CANADIAN PLATE AND PROFILES IN KAMATO ROAD 920 MISSISSAUGA, Ontario, Canada L4W 2R6	Customer PO NO./Item: 18651-STK / 1 BOL NO.: 1000012968 Cust. Part No.: Carrier: TRIPLE K TRANSPORT LTD - 35099 (250)
Customer Specification : HR STEEL PLATE Carbon Multi Cert ASTM A516 GR 70 (10) / ASME SA516 GR 70 (11A) Meets NACE MR 0103 latest Ed., NACE MR 0175 latest Ed., BHN < 200, Calcium Treated for Sulphide Shape Control Normalized Temp 1670 °F 34 min CVNL Reg. 15 / 12 FT-LBF at -50.0 F Std Thickness Tol PVQ Top and Bottom Standard Surface Flatness 1/2 A20 Latest Ed. + Addenda of ASME Code section II part A applies Fine Grain Fully Killed No Weld Repair		
Supplementary instructions : Test Cert 1: drafting@canadianplate.com Test Cert 2: 905-206-1370		

Insp TIR : Test Report As Per Spec

ESSAR STEEL ALGOMA INC. HEREBY CERTIFIES THAT THE MATERIAL HEREIN DESCRIBED WAS MADE AND TESTED IN ACCORDANCE WITH THE RULES OF THE SPECIFICATION SHOWN. ALL RESULTS ARE RETAINED IN ACCORDANCE WITH THE COMPANY'S STANDARD RECORD KEEPING PRACTICES. THIS MILL TEST REPORT MAY NOT BE REPRODUCED EXCEPT IN FULL WITHOUT WRITTEN APPROVAL OF ESSAR STEEL ALGOMA INC. IF YOU RECEIVE THIS DOCUMENT AND ARE NOT THE INTENDED RECEIVER, PLEASE CALL (705)945-1095 FOR INSTRUCTIONS ON METHOD OF DISPOSAL OF DOCUMENT.

MECHANICAL PROPERTIES

MEETS EN 10204:2004 TYPE 3.1  
ISO QUALITY AND ENVIRONMENTAL CERTIFICATES AVAILABLE AT WWW.ESSARSTEELALGOMA.COM

Heat No.	Batch No.	SRCE	LAB	GAUGE	COND	METH	DIR	LOC	SIZE	TEMP (°F)	FULL ENERGY (ft-lbf)	FULL AVG (ft-lbf)
0811P3	AB0907	166"	ALG	1.0000	N	CVN	L	B	FULL	-50	101 74 89	88
0811P3	AB0908	166"	ALG	1.0000	N	CVN	L	B	FULL	-50	89 108 107	101
Tensile Tests												
Heat No.	Batch No.	SRCE	LAB	GAUGE	COND	METH	DIR	LOC	YIELD (KSI)	TENSILE (KSI)	EL. SCALE	ELONG (%)
0811P3	AB0907	166"	ALG	1.0000	N	2	T	B	50.5	75.5	2"	36
0811P3	AB0908	166"	ALG	1.0000	N	2	T	B	50.0	77.0	2"	37

ACCEPTED/REVISITED/RELEASED  
for and on behalf of: SOM OFF SHORE  
Print Name: YIP CHAI SAH  
Signature: [Signature]  
Date: Sept 3/13  
Appius®  
VELOSI  
Velosi America LLC



AUG 20 2013

K. UGHADPAGA  
MANAGER METALLURGICAL SERVICES

**\*\*WARNING\*\*** THE TEST RESULTS AND VALUES REPORTED HEREIN INDICATE ONLY THAT (1) THE PARTICULAR STEEL FOR WHICH THIS CERTIFICATE IS ISSUED MEETS THE MINIMUM SPECIFIED YIELD STRENGTH AND (2) THE ANALYSIS AND PHYSICAL PROPERTIES OF SUCH STEEL ARE IN CONFORMANCE WITH THE REQUIREMENTS OF THE SPECIFICATION INDICATED. THE RESULTS OR VALUES REPORTED HEREIN CAN NOT BE USED TO QUALIFY THE STEEL FOR ANY SPECIFICATION OTHER THAN THE ONE INDICATED AND CAN NOT BE RELIED UPON FOR ANY PURPOSE (INCLUDING DESIGN OR CALCULATIONS) AS REPRESENTING THE ACTUAL STRENGTH OF SUCH STEEL.



# METALLURGICAL TEST REPORT

NORTH AMERICAN STAINLESS  
6870 HIGHWAY 42 EAST  
GHENT, KY 41045

1/11 155430  
L

6870 HIGHWAY 42 EAST

Certificate: 806076 1      Mail To:      Ship To:      Date: 1/30/2013      Page: 1  
ROLARK STAINLESS STEEL, INC.      ROLARK STAINLESS STEEL, INC.  
71 COMAIR PARKWAY      71 COMAIR PARKWAY  
WOODBRIDGE, ON L4H0S4      WOODBRIDGE, 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: EAP, AOD, & Cont. Casting  
Product Mfg. by a Quality Mgt. Sys. in Conf. w/ISO 9001  
\*Melted & Manufactured in the USA; Mat'l is DFARS Compliant

Product Id	Plate#	Skid #	Thickness	Width	Weight	Length	Mark	Pieces	Commodity Code
05E9C1 AA	05E9C1 AA		1.5075	60.0000	6,275	PLATE	240.00	1	1

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

HEAT	CM	C %	CR %	CU %	MN %	MO %	N %	NI %	P %	S %
E9C1	US	.0193	16.5860	.4350	1.5900	2.1020	.0498	10.0400	.0340	.0010

APPLUS®  
VELOSI  
Print Name: CIPRINSA SAH OF  
for analysis behalf of: SPM OFFSHORE  
Date: 8/13/13  
Velocity America LLC

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

MC# 65015/2

## MECHANICAL PROPERTIES

Product Id#	Plate#	Y S	UTS	ELONG	Hard	R of A
05E9C1 AA	05E9C1 AA	ksi	ksi	%-2"	RB	%
		90.42	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. ERIC HESS

1/30/2013





6870 HIGHWAY 42 EAST

# METALLURGICAL TEST REPORT

NORTH AMERICAN STAINLESS  
6870 HIGHWAY 42 EAST  
GHENT, KY 41045

VNOB7 P5-0022

Certificate: 791192 7 Mail To:  
ROLARK STAINLESS STEEL, INC.  
71 CONAIR PARKWAY  
WOODBIDGE, ON L4H0S4

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

Date: 12/03/2012 Page: 1

Steel: 316/316L

Finish: HRAP

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

NAS Order: DS 0002154 07

Your Order: 53232

## 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 MKK;  
WACE MR0175/ISO 15156-3:2003 A, MR0103/07; QQS766D-A X MAG PERM  
MIN. SOLUTION ANNEAL TEMP 1900F, WATER QUENCHED

## REMARKS:

Mat'l is Free of Mercury Contamination. No weld repairs.  
EN 10204:2004 3.1; RoHS Compliant  
Material is Free of Radioactive Contamination  
NAS Steel Making Process: EAF, AOD, & Cont. Casting  
Product Mfg. by a Quality Mgt. Sys. in Conf. w/ISO 9001  
\*Melted & Manufactured in the USA; Mat'l is DEARS Compliant  
EN 10204 3.1.B

Product Id	Coil #	Skid #	Thickness	Width	Weight	Length	Mark	Pieces	Commodity Code
DD2371	06E5K2 B		.3748	48.0000	2,545 SHEETS	240.00	16	2	

## CHEMICAL ANALYSIS CM(Country of Melt) ES(Spain) US(United States) ZA(South Africa) JP(Japan)

Chemical Analysis per ASTM A751/08

HEAT	CM	C %	CR %	CU %	MN %	MO %	N %	NI %	P %	S %
25K2	US	.0154	16.5720	.4135	1.4470	2.0650	.0461	10.0450	.0310	.0192

SI %  
- .3760

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: *[Signature]*

Print Name: *GANDISA SAHAI*  
Signature: *[Signature]*  
Date: *12/13/12*

## MECHANICAL PROPERTIES

Product Id#	Coil #	UTS	ELONG	Hard	Tail
		%-2"	RB	Hard	
DD2371	06E5K2	FT 85.68	48.52	51.53	87.00
				89.00	

Certification of Material - Per ASME  
HT# *ESK2*  
Qualifies to all requirements of  
*SA 240-316 B1C* per  
Sect. II *10* Edition *11* Addenda

Q.C.I. N.D.

AUG 16 2013

Q.C.I. 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

6870 HIGHWAY 42 EAST

Certificate: 794815 1  
Customer: 007050 001

Mail To:  
ROLARK STAINLESS STEEL, INC.  
71 COMAIR PARKWAY  
WOODBIDGE, OH 44084

Ship To:  
ROLARK STAINLESS STEEL, INC.  
71 COMAIR PARKWAY  
WOODBIDGE, OH 44084

Date: 12/14/2012 Page: 1  
Steel: 316/316L  
Finish: HRAP

ur Order: 53315

NAS Order: DS 000247 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; Q05766D-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 DEFRA Compliant  
EN 10204 3.1.B

Product Id	Coil #	Skid #	Thickness	Width	Weight	-----Length-----	Mark	Pieces	Commodity Code
DD4383	02E7K6 A		.3748	60.0000	4,750	SHEETS	240.00	9	3

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

HEAT	CM	C %	CR %	CU %	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% YR	ELONG	Hard	Tail
		KSI	KSI	%-2"	RB	Hard
DD4383	02E7K6	FT	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 BESS 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 (1/10/14)  
THK. # 376  
P.O. # 13-0713



AUG 16 2019

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SBM OFFSHORE  
Print Name: L. H. N. S. S. H. H.  
Signature: [Signature]  
Date: Sept 3/13  
Applus<sup>®</sup> VELOSI  
Velosi America LLC





# METALLURGICAL TEST REPORT

NORTH AMERICAN STAINLESS  
6870 HIGHWAY 42 EAST  
GHENT, KY 41045

6870 HIGHWAY 42 EAST

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

SHIP TO: ROLARK STAINLESS STEEL, INC.

Date: 1/04/2013 Page: 1

Customer: 007050 012

Steel: 316/316L

Finish: HRAP

Corrosion: ASTM A262/02a5;1808end-OK

Your Order: 53412

NAS Order: DS 0002333 01

## PRODUCT DESCRIPTION

STAINLESS STEEL COIL, HRAP; UNS 31600/31603  
ASTM A340/11b, A480/11b, A666/10; ASME SA240/11a, SA480/11a, SA666/11a  
CHEM ONLY ON FOLLOWING ASTM: A276/10, A479/11, A486/11, A512/11  
CHEM ONLY ON FOLLOWING ASME: SA312/11, SA479/11  
AMS 55077/5524L X MKK;  
NACE MR0175/ISO 15156-3:2003 A, MR0103/07; Q35765D-A X NAG PERH  
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 DPARS Compliant

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

## CHEMICAL ANALYSIS

CM(Country of Melt) ES(Spain) US(United States) ZA(South Africa) JP(Japan)  
Chemical Analysis per ASTM A731/08

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

W.O.# 11739  
M.L.# 631761017  
TICK # 378  
P.O.# 13-0713

## MECHANICAL PROPERTIES

Product Id#	Coil #	T	Y	TS	YS	ELONG	RED	TAI
0589B3 C	0589B3 C	87.49	54.04	49.86	87.00	90.50	RB	Hard

Certification of Material - Per ASME  
HT# E9 B3  
Qualifies to all requirements of  
SA 240-316/316L  
Sect. II Edition 11 Addenda

Q.C.I.  
E.Y.

AUG 16 2013

NAS hereby certifies that the analysis on this certification is correct. Based upon the results and the accuracy of the test methods used, the material meets the specifications stated. These results relate only to the items present in its entirety, without the written approval of NAS.

Technical Dept. Mgr.

ERIC HESS  
1/06/2013

APPLUS  
VELOSI  
Velos America LLC  
Signature: [Signature]  
Date: 8/13/13  
Print Name: [Name]  
For and on behalf of: [Name]  
ACCEPTED/REVIEWED/RELEASED  
046

**PHOENIX TUBE COMPANY, INC.**  
 Manufacturer of Stainless Ornamental and Structural Tubing  
**CERTIFICATION OF TEST**

Sold To: RYERSON CANADA  
 161 THE WEST MALL  
 PAUL MASSE@416-620-3865 FOR APPT  
 ETOBICOKE ON M9C  
 CAN

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  
 SIZE: 2" X 3/8" HRAP  
 SOURCE: USA D  
 VENDOR: NAS

Phone# 6223100 Ext:  
 ORDER#: 311820  
 QTY SHIPPED: 555.0  
 GRADE: 316L NO WELD: BAR  
 HEAT#: D5F9

Specification:

CHEMISTRY THIS COLUMN:  
 ASTM A276-13  
 ASME SA276-08 COND. A  
 ASTM A479-13  
 ASME SA479 '3, S2.1  
 QQ-S-766D, COND. A

W.O. # 11730  
 M.L. # 66 (1/10/13)  
 THK. # .375  
 P.O. # 13-0889

TEST REPORT#: TR010548  
 Report Date: 08/27/12

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 11 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.

*Ryerson Leguizoa*

1185 WIN DR, BETHLEHEM, PA., 19017 - (610) 865-5337  
 FAX NUMBER: 610-865-4073

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

# ALL-WELD COMPANY LIMITED

49 Passmore Avenue,  
Toronto, Ontario,  
Canada M1V 4T1  
[www.allweld.ca](http://www.allweld.ca)



## COMPRESS Pressure Vessel Design Calculations

**Item:** 48" OD Vertical Stainless Steel Inlet Separator  
**Vessel No:** 772-VESE-101/201  
**Customer:** Ultrafab Industries Limited  
**Designer:** Todd Clark, P. Eng.  
**Date:** Tuesday, July 16, 2013



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42. [Skirt Base Ring](#)
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.

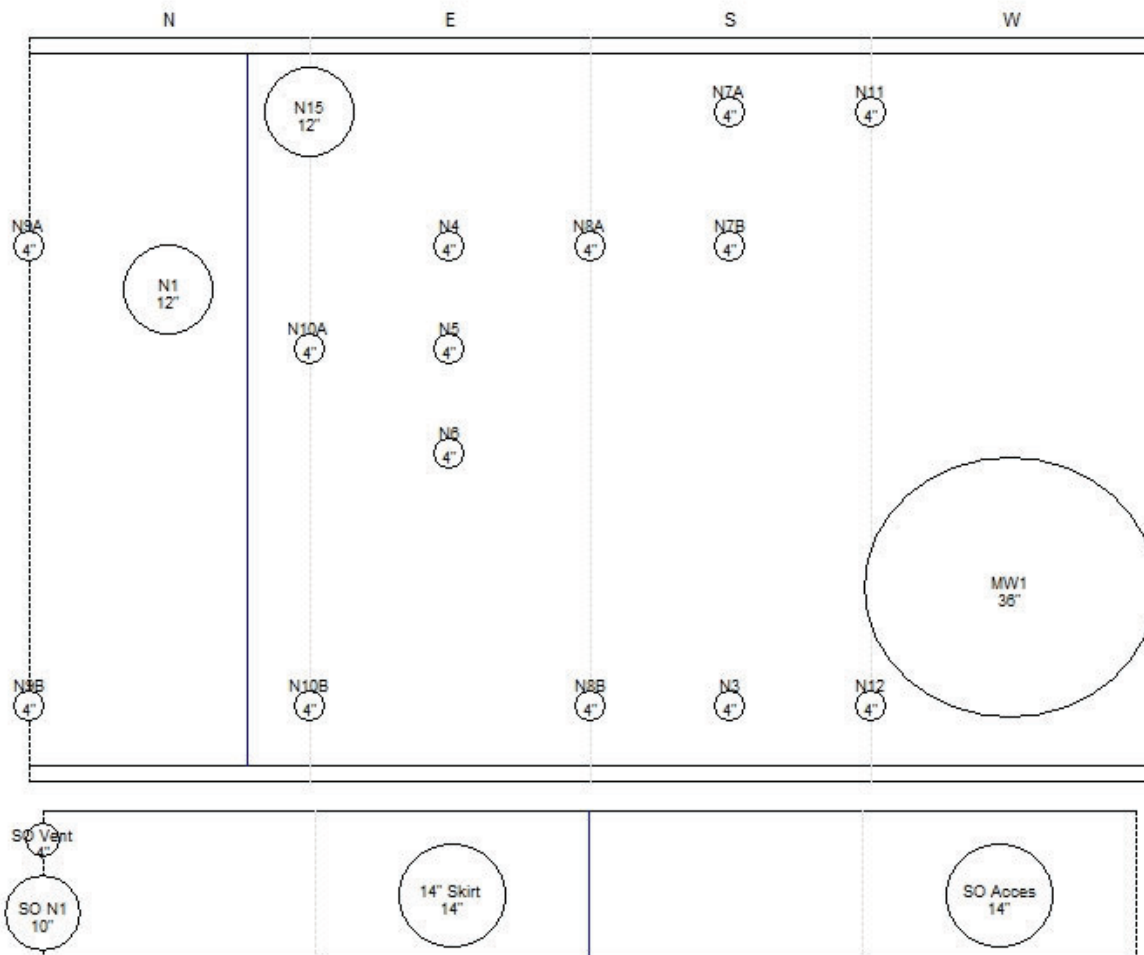
## Long Seam Summary

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:

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

$P_{th} = 2.03 \text{ psi (SG=1, } H_s=56.27\text{'' Horizontal test head)}$

Corrosion allowance: Inner C = 0" Outer C = 0"

Design MDMT =  $-20^\circ\text{F}$

Rated MDMT =  $-320^\circ\text{F}$

No impact test performed

Material is not normalized

Material is not produced to fine grain practice

PWHT is not performed

Do not Optimize MDMT / Find MAWP

Radiography: Category A joints - Seamless No RT  
Head to shell seam - Full UW-11(a) Type 1

Estimated weight\*: new = 1,349.3 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 =  $0.0625\text{''} + 0\text{''} = 0.0625\text{''}$

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:  $P = 1,378$  psi @ 140 °F

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

#### Static liquid head:

$P_s = 0$  psi (SG = 1.1,  $H_s = 0$ ", Operating head)  
 $P_{th} = 2.03$  psi (SG = 1,  $H_s = 56.23$ ", 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)**

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

**Design thickness = 1.6093"**

The governing condition is due to internal pressure.

The cylinder thickness of 1.77" is adequate.



## Thickness Required Due to Pressure + External Loads

Condition	Pressure P (psi)	Allowable Stress Before UG-23 Stress Increase (psi)		Temperature (°F)	Corrosion C (in)	Load	Req'd Thk Due to Tension (in)	Req'd Thk Due to Compression (in)
		S <sub>t</sub>	S <sub>c</sub>					
<a href="#">Operating, Hot &amp; Corroded</a>	1,378	20,000	<a href="#">13.729</a>	140	0	Wind	<a href="#">0.6305</a>	<a href="#">0.6304</a>
						Seismic	<a href="#">0.6311</a>	<a href="#">0.6293</a>
<a href="#">Operating, Hot &amp; New</a>	1,378	20,000	<a href="#">13.729</a>	140	0	Wind	<a href="#">0.6305</a>	<a href="#">0.6304</a>
						Seismic	<a href="#">0.6311</a>	<a href="#">0.6293</a>
<a href="#">Hot Shut Down, Corroded</a>	0	20,000	<a href="#">13.729</a>	140	0	Wind	<a href="#">0.0007</a>	<a href="#">0.0008</a>
						Seismic	<a href="#">0.0001</a>	<a href="#">0.0024</a>
<a href="#">Hot Shut Down, New</a>	0	20,000	<a href="#">13.729</a>	140	0	Wind	<a href="#">0.0007</a>	<a href="#">0.0008</a>
						Seismic	<a href="#">0.0001</a>	<a href="#">0.0024</a>
<a href="#">Empty, Corroded</a>	0	20,000	<a href="#">13.908</a>	70	0	Wind	<a href="#">0.0007</a>	<a href="#">0.0008</a>
						Seismic	<a href="#">0.0001</a>	<a href="#">0.0023</a>
<a href="#">Empty, New</a>	0	20,000	<a href="#">13.908</a>	70	0	Wind	<a href="#">0.0007</a>	<a href="#">0.0008</a>
						Seismic	<a href="#">0.0001</a>	<a href="#">0.0023</a>
<a href="#">Vacuum</a>	-15	20,000	<a href="#">13.729</a>	140	0	Wind	<a href="#">0.0108</a>	<a href="#">0.0109</a>
						Seismic	<a href="#">0.0099</a>	<a href="#">0.0125</a>
<a href="#">Hot Shut Down, Corroded, Weight &amp; Eccentric Moments Only</a>	0	20,000	<a href="#">13.729</a>	140	0	Weight	<a href="#">0.0008</a>	<a href="#">0.0009</a>

### Allowable Compressive Stress, Hot and Corroded- S<sub>cHC</sub>, (table HA-2)

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (24 / 1.77) \\
 &= 0.009219 \\
 B &= 13,729 \text{ psi} \\
 S &= 20,000 / 1.00 = 20,000 \text{ psi} \\
 S_{cHC} &= \min(B, S) = \underline{13.729 \text{ psi}}
 \end{aligned}$$

### Allowable Compressive Stress, Hot and New- S<sub>cHN</sub>

$$\begin{aligned}
 S_{cHN} &= S_{cHC} \\
 &= \underline{13.729 \text{ psi}}
 \end{aligned}$$

### Allowable Compressive Stress, Cold and New- S<sub>cCN</sub>, (table HA-2)

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (24 / 1.77) \\
 &= 0.009219 \\
 B &= 13,908 \text{ psi} \\
 S &= 20,000 / 1.00 = 20,000 \text{ psi} \\
 S_{cCN} &= \min(B, S) = \underline{13.908 \text{ psi}}
 \end{aligned}$$

### Allowable Compressive Stress, Cold and Corroded- S<sub>cCC</sub>

$$\begin{aligned}
 S_{cCC} &= S_{cCN} \\
 &= \underline{13.908 \text{ psi}}
 \end{aligned}$$

**Allowable Compressive Stress, Vacuum and Corroded-  $S_{cVC}$ , (table HA-2)**

$$\begin{aligned} A &= 0.125 / (R_o / t) \\ &= 0.125 / (24 / 1.77) \\ &= 0.009219 \\ B &= 13,729 \text{ psi} \\ S &= 20,000 / 1.00 = 20,000 \text{ psi} \\ S_{cVC} &= \min(B, S) = \underline{13.729 \text{ psi}} \end{aligned}$$

**Operating, Hot & Corroded, Wind, Bottom Seam**

$$\begin{aligned} t_p &= P \cdot R / (2 \cdot S_t \cdot K_s \cdot E_c + 0.40 \cdot |P|) && \text{(Pressure)} \\ &= 1,378 \cdot 22.23 / (2 \cdot 20,000 \cdot 1.20 \cdot 1.00 + 0.40 \cdot |1,378|) \\ &= 0.6309" \\ t_m &= M / (\pi \cdot R_m^2 \cdot S_t \cdot K_s \cdot E_c) && \text{(bending)} \\ &= 1,145 / (\pi \cdot 23.115^2 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\ &= 0" \\ t_w &= W / (2 \cdot \pi \cdot R_m \cdot S_t \cdot K_s \cdot E_c) && \text{(Weight)} \\ &= 1,759.7 / (2 \cdot \pi \cdot 23.115 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\ &= 0.0005" \\ t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\ &= 0.6309 + 0 - (0.0005) \\ &= \underline{0.6305"} \\ t_c &= |t_{mc} + t_{wc} - t_{pc}| && \text{(total, net tensile)} \\ &= |0 + (0.0005) - (0.6309)| \\ &= \underline{0.6304"} \end{aligned}$$

**Maximum allowable working pressure, Longitudinal Stress**

$$\begin{aligned} P &= 2 \cdot S_t \cdot K_s \cdot E_c \cdot (t - t_m + t_w) / (R - 0.40 \cdot (t - t_m + t_w)) \\ &= 2 \cdot 20,000 \cdot 1.20 \cdot 1.00 \cdot (1.77 - 0 + (0.0005)) / (22.23 - 0.40 \cdot (1.77 - 0 + (0.0005))) \\ &= 3,948.69 \text{ psi} \end{aligned}$$

**Operating, Hot & New, Wind, Bottom Seam**

$$\begin{aligned} t_p &= P \cdot R / (2 \cdot S_t \cdot K_s \cdot E_c + 0.40 \cdot |P|) && \text{(Pressure)} \\ &= 1,378 \cdot 22.23 / (2 \cdot 20,000 \cdot 1.20 \cdot 1.00 + 0.40 \cdot |1,378|) \\ &= 0.6309" \\ t_m &= M / (\pi \cdot R_m^2 \cdot S_t \cdot K_s \cdot E_c) && \text{(bending)} \\ &= 1,145 / (\pi \cdot 23.115^2 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\ &= 0" \\ t_w &= W / (2 \cdot \pi \cdot R_m \cdot S_t \cdot K_s \cdot E_c) && \text{(Weight)} \\ &= 1,759.7 / (2 \cdot \pi \cdot 23.115 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\ &= 0.0005" \\ t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \end{aligned}$$

$$= 0.6309 + 0 - (0.0005)$$

$$= \underline{0.6305''}$$

$$t_c = |t_{mc} + t_{wc} - t_{pc}| \quad \text{(total, net tensile)}$$

$$= |0 + (0.0005) - (0.6309)|$$

$$= \underline{0.6304''}$$

### Maximum allowable working pressure, Longitudinal Stress

$$P = 2 * S_t * K_s * E_c * (t - t_m + t_w) / (R - 0.40 * (t - t_m + t_w))$$

$$= 2 * 20,000 * 1.20 * 1.00 * (1.77 - 0 + (0.0005)) / (22.23 - 0.40 * (1.77 - 0 + (0.0005)))$$

$$= 3,948.69 \text{ psi}$$

### Hot Shut Down, Corroded, Wind, Bottom Seam

$$t_p = 0'' \quad \text{(Pressure)}$$

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

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

$$= 0''$$

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

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

$$= 0.0007''$$

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

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

$$= \underline{0.0007''}$$

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

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

$$= \underline{0.0008''}$$

### Hot Shut Down, New, Wind, Bottom Seam

$$t_p = 0'' \quad \text{(Pressure)}$$

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

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

$$= 0''$$

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

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

$$= 0.0007''$$

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

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

$$= \underline{0.0007''}$$

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

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

$$= \underline{0.0008''}$$

### Empty, Corroded, Wind, Bottom Seam

$$t_p = 0'' \quad \text{(Pressure)}$$

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

$$= 1,145 / (\pi * 23.115^2 * 13,907.75 * 1.20)$$

$$= 0"$$

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

$$= 1,759.7 / (2 \pi * 23.115 * 13,907.75 * 1.20)$$

$$= 0.0007"$$

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

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

$$= \underline{0.0007}"$$

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

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

$$= \underline{0.0008}"$$

### Empty, New, Wind, Bottom Seam

$$t_p = 0" \quad (\text{Pressure})$$

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

$$= 1,145 / (\pi * 23.115^2 * 13,907.75 * 1.20)$$

$$= 0"$$

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

$$= 1,759.7 / (2 \pi * 23.115 * 13,907.75 * 1.20)$$

$$= 0.0007"$$

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

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

$$= \underline{0.0007}"$$

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

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

$$= \underline{0.0008}"$$

### Vacuum, Wind, Bottom Seam

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

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

$$= -0.0101"$$

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

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

$$= 0"$$

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

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

$$= 0.0007"$$

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

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

$$= \underline{0.0108}"$$

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

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

$$= \underline{0.0109}"$$



### Maximum Allowable External Pressure, Longitudinal Stress

$$\begin{aligned} P &= 2 \cdot S_c \cdot K_s \cdot (t - t_{mc} - t_{wc}) / (R - 0.40 \cdot (t - t_{mc} - t_{wc})) \\ &= 2 \cdot 13,728.59 \cdot 1.20 \cdot (1.77 - 0 - 0.0007) / (22.23 - 0.40 \cdot (1.77 - 0 - 0.0007)) \\ &= 2,708.51 \text{ psi} \end{aligned}$$

### Hot Shut Down, Corroded, Weight & Eccentric Moments Only, Bottom Seam

$$\begin{aligned} t_p &= 0'' && \text{(Pressure)} \\ t_m &= M / (\pi \cdot R_m^2 \cdot S_c \cdot K_s) && \text{(bending)} \\ &= 826 / (\pi \cdot 23.115^2 \cdot 13,728.59 \cdot 1.00) \\ &= 0'' \\ t_w &= W / (2 \cdot \pi \cdot R_m \cdot S_c \cdot K_s) && \text{(Weight)} \\ &= 1,759.7 / (2 \cdot \pi \cdot 23.115 \cdot 13,728.59 \cdot 1.00) \\ &= 0.0009'' \\ t_t &= |t_p + t_m - t_w| && \text{(total, net compressive)} \\ &= |0 + 0 - (0.0009)| \\ &= \underline{0.0008''} \\ t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\ &= 0 + (0.0009) - (0) \\ &= \underline{0.0009''} \end{aligned}$$

### Operating, Hot & Corroded, Seismic, Bottom Seam

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

### Maximum allowable working pressure, Longitudinal Stress

$$\begin{aligned} P &= 2 \cdot S_t \cdot K_s \cdot E_c \cdot (t - t_m + t_w) / (R - 0.40 \cdot (t - t_m + t_w)) \\ &= 2 \cdot 20,000 \cdot 1.20 \cdot 1.00 \cdot (1.77 - 0.0007 + (0.0005)) / (22.23 - 0.40 \cdot (1.77 - 0.0007 + (0.0005))) \\ &= 3,947.25 \text{ psi} \end{aligned}$$

### Operating, Hot & New, Seismic, Bottom Seam

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

### **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

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

### Vacuum, Seismic, Bottom Seam

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

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

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



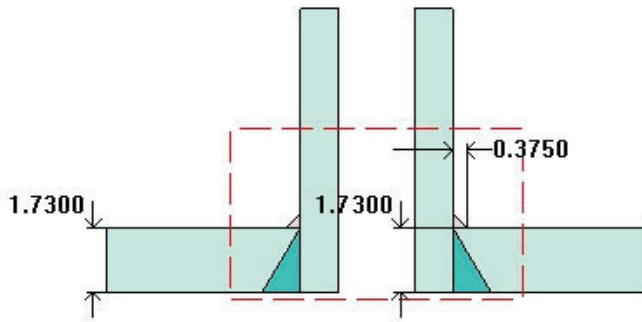
= 2,705.92 psi

## Vent (N14)

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

$$t_{w(\text{lower})} = 1.73 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

#### Location and Orientation

Located on:	48 OD TOP SE HEAD
Orientation:	315°
End of nozzle to datum line:	-19.5 in
Calculated as hillside:	Yes
Distance to head center, R:	16 in
Passes through a Category A joint:	No

#### Nozzle

Access opening:	No
Material specification:	SA-182 F316 <= 5 (II-D p. 70, In. 22)
Inside diameter, new:	2 in
Nominal wall thickness:	1.06 in
Corrosion allowance:	0 in
Opening chord length:	2.2234 in
Projection available outside vessel, L <sub>pr</sub> :	5.2776 in
Projection available outside vessel to flange face, L <sub>f</sub> :	7.0276 in
Local vessel minimum thickness:	1.73 in
Liquid static head included:	0 psi
Longitudinal joint efficiency:	1

#### ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 LWN A182 F316
Bolt Material:	SA-193 B7 Bolt <= 2 1/2 (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55 °F
(Per UHA-51(d)(1)(a))	
(Flange rated MDMT = -320 °F)	
Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F)	
Liquid static head:	0 psi

MAWP rating:	2,040 psi @ 140°F
MAP rating:	2,160 psi @ 50°F
Hydrotest rating:	3,250 psi @ 50°F
PWHT performed:	No

**Reinforcement Calculations for Chamber MAWP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For P = 1,378 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

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

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for internal pressure 1,378 psi @ 140 °F**

Nozzle Impact test exempt per UHA-51(g)(coincident ratio = 0.0678).

**Parallel Limit of reinforcement per UG-40**

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

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.73 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

**Required thickness t<sub>r</sub> from UG-37(a)**

$$\begin{aligned}
 t_r &= P \cdot D_o \cdot K / (2 \cdot S \cdot E + 2 \cdot P \cdot (K - 0.1)) \\
 &= 1,378 \cdot 48 \cdot 1 / (2 \cdot 20,000 \cdot 1 + 2 \cdot 1,378 \cdot (1 - 0.1)) \\
 &= 1.557 \text{ in}
 \end{aligned}$$

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



### UW-16(c) Weld Check

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

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

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

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

Interpretation VIII-1-83-66 has been applied.

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

$$\begin{aligned}t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0719, 0 ] \\ &= 0.0719 \text{ in}\end{aligned}$$

$$t_{b1} = 1.557 \text{ in}$$

$$\begin{aligned}t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.557, 0.0625 ] \\ &= 1.557 \text{ in}\end{aligned}$$

$$\begin{aligned}t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.2074, 1.557 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0719, 0.2074 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

**Reinforcement Calculations for MAEP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For Pe = 566.01 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for external pressure 566.01 psi @ 140 °F**

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.2205, 1.1103 + (1.06 - 0) + (1.73 - 0)) \\
 &= 3.9003 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.73 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-28 t<sub>m</sub> = 0.1383 in**

**From UG-37(d)(1) required thickness t<sub>r</sub> = 1.73 in**

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

**UW-16(c) Weld Check**

Fillet weld: t<sub>min</sub> = lesser of 0.75 or t<sub>n</sub> or t = 0.75 in  
 t<sub>c(min)</sub> = lesser of 0.25 or 0.7\*t<sub>min</sub> = [0.25](#) in  
 t<sub>c(actual)</sub> = 0.7\*Leg = 0.7\*0.375 = 0.2625 in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

Interpretation VIII-1-83-66 has been applied.

$$t_{a \text{ UG-28}} = 0.1383 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.1383, 0 ] \\ &= 0.1383 \text{ in} \end{aligned}$$

$$t_{b2} = 0.6623 \text{ in}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2}, t_{b \text{ UG16}} ] \\ &= \max[ 0.6623, 0.0625 ] \\ &= 0.6623 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b2} ] \\ &= \min[ 0.2074, 0.6623 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.1383, 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

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

$$L / D_o = 9.0272 / 4.12 = 2.1911$$

$$D_o / t = 4.12 / 0.1383 = 29.7856$$

From table G: A = 0.003548

From table HA-2: B = 12,644.1965 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 $P_a = 566.01 \text{ psi}$

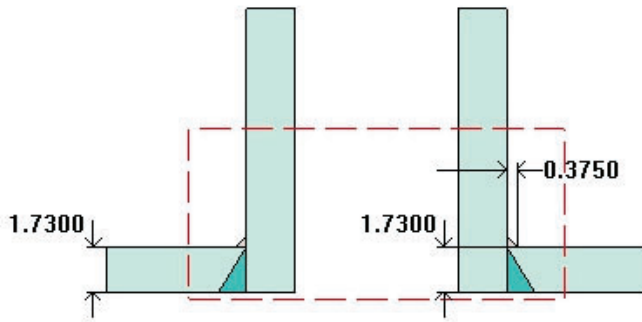
$$t_a = t + \text{Corrosion} = 0.1383 + 0 = 0.1383''$$

## 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

$A_1 = \text{larger of the following} = \underline{2.2534} \text{ in}^2$

$$\begin{aligned} &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 8 \cdot (1 \cdot 1.73 - 1 \cdot 1.4483) - 2 \cdot 1.875 \cdot (1 \cdot 1.73 - 1 \cdot 1.4483) \cdot (1 - 1) \\ &= 2.2534 \text{ in}^2 \\ &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2 \cdot (1.73 + 1.875) \cdot (1 \cdot 1.73 - 1 \cdot 1.4483) - 2 \cdot 1.875 \cdot (1 \cdot 1.73 - 1 \cdot 1.4483) \cdot (1 - 1) \\ &= 2.0309 \text{ in}^2 \end{aligned}$$

$A_2 = \text{smaller of the following} = \underline{13.7319} \text{ in}^2$

$$\begin{aligned} &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t \\ &= 5 \cdot (1.875 - 0.2875) \cdot 1 \cdot 1.73 \\ &= 13.7319 \text{ in}^2 \\ &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (1.875 - 0.2875) \cdot 1 \cdot 1.875 \\ &= 14.8828 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} A_{41} &= \text{Leg}^2 \cdot f_{r2} \\ &= 0.375^2 \cdot 1 \\ &= \underline{0.1406} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_{41} \\ &= 2.2534 + 13.7319 + 0.1406 \\ &= \underline{16.1259} \text{ in}^2 \end{aligned}$$

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><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><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

<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	0.2625	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)

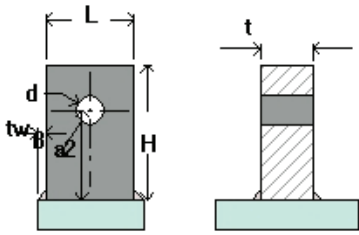
$$\begin{aligned} L / D_o &= 10.0264 / 11.75 = 0.8533 \\ D_o / t &= 11.75 / 0.3634 = 32.3334 \\ \text{From table G: } A &= 0.009195 \\ \text{From table HA-2: } B &= 13,725.7301 \text{ psi} \end{aligned}$$

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

### 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

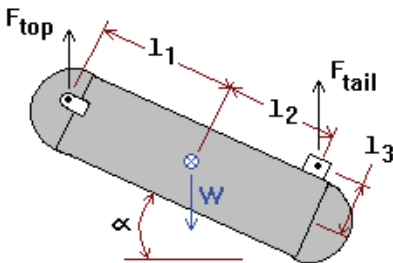
Required Lift Pin Diameter, $d_{reqd}$	<a href="#">0.8093"</a>
Required Lug Thickness, $t_{reqd}$	<a href="#">0.3048"</a>
Lug Stress Ratio, $\sigma_{ratio}$	<a href="#">0.21</a>
Weld Shear Stress Ratio, $\tau_{ratio}$	<a href="#">0.36</a>
Lug Design	Acceptable
Local Stresses	Acceptable

### 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

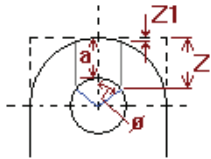
$$\begin{aligned} t_{\text{reqd}} &= [F_v / \sigma_s] / (2 * L_{\text{shear}}) \\ &= (13,703 / 13,320) / (2 * 2.0153) = \underline{0.2552"} \end{aligned}$$

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

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

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

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

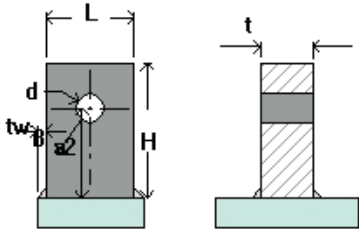
$$\begin{aligned} K_1 &= (1 - v_2^2) / ( (1/3 + v_1 * v_2) + \text{sqr}( (1/3 + v_1 * v_2)^2 + (1 - v_2^2) * v_1^2 ) ) \\ &= (1 - 0^2) / ( (1/3 + 0.0554 * 0) + \text{sqr}( (1/3 + 0.0554 * 0)^2 + (1 - 0^2) * 0.0554^2 ) ) \\ &= 1.4898 \end{aligned}$$

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

### 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

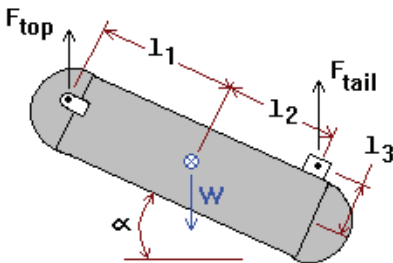
Required Lift Pin Diameter, $d_{reqd}$	<a href="#">0.8093"</a>
Required Lug Thickness, $t_{reqd}$	<a href="#">0.3048"</a>
Lug Stress Ratio, $\sigma_{ratio}$	<a href="#">0.22</a>
Weld Shear Stress Ratio, $\tau_{ratio}$	<a href="#">0.39</a>
Lug Design	Acceptable
Local Stresses	Acceptable

### 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

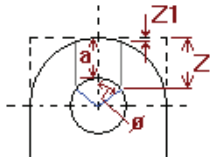
$$\begin{aligned} t_{\text{reqd}} &= [F_v / \sigma_s] / (2 * L_{\text{shear}}) \\ &= (13,703 / 13,320) / (2 * 2.0153) = \underline{0.2552"} \end{aligned}$$

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

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

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

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:  $P = 1,378 \text{ psi @ } 140 \text{ °F}$

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

#### Static liquid head:

$P_s = 0.64 \text{ psi}$  (SG = 1.1,  $H_s = 16"$ , Operating head)

$P_{th} = 2.03 \text{ psi}$  (SG = 1,  $H_s = 56.25"$ , Horizontal test head)

Corrosion allowance      Inner C = 0"                      Outer C = 0"

Design MDMT = -20 °F

Rated MDMT = -320 °F

No impact test performed

Material is not normalized

Material is not produced to Fine Grain Practice

PWHT is not performed

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)**

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

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

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

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

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

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

Ratio  $P_e \cdot P_e \leq$  MAEP design cylinder thickness is satisfactory.

**Design thickness = 1.61"**

The governing condition is due to internal pressure.

The cylinder thickness of 1.75" is adequate.

### Thickness Required Due to Pressure + External Loads

Condition	Pressure P (psi)	Allowable Stress Before UG-23 Stress Increase (psi)		Temperature (°F)	Corrosion C (in)	Load	Req'd Thk Due to Tension (in)	Req'd Thk Due to Compression (in)
		S <sub>t</sub>	S <sub>c</sub>					
<a href="#">Operating, Hot &amp; Corroded</a>	1,378	20,000	<a href="#">13.716</a>	140	0	Wind	<a href="#">0.6336</a>	<a href="#">0.6202</a>
						Seismic	<a href="#">0.6475</a>	<a href="#">0.6017</a>
<a href="#">Operating, Hot &amp; New</a>	1,378	20,000	<a href="#">13.716</a>	140	0	Wind	<a href="#">0.6336</a>	<a href="#">0.6202</a>
						Seismic	<a href="#">0.6475</a>	<a href="#">0.6017</a>
<a href="#">Hot Shut Down, Corroded</a>	0	20,000	<a href="#">13.716</a>	140	0	Wind	<a href="#">0.0021</a>	<a href="#">0.0165</a>
						Seismic	<a href="#">0.016</a>	<a href="#">0.0434</a>
<a href="#">Hot Shut Down, New</a>	0	20,000	<a href="#">13.716</a>	140	0	Wind	<a href="#">0.0021</a>	<a href="#">0.0165</a>
						Seismic	<a href="#">0.016</a>	<a href="#">0.0434</a>
<a href="#">Empty, Corroded</a>	0	20,000	<a href="#">13.895</a>	70	0	Wind	<a href="#">0.0021</a>	<a href="#">0.0163</a>
						Seismic	<a href="#">0.0152</a>	<a href="#">0.0418</a>
<a href="#">Empty, New</a>	0	20,000	<a href="#">13.895</a>	70	0	Wind	<a href="#">0.0021</a>	<a href="#">0.0163</a>
						Seismic	<a href="#">0.0152</a>	<a href="#">0.0418</a>
<a href="#">Vacuum</a>	-15	20,000	<a href="#">13.716</a>	140	0	Wind	<a href="#">0.007</a>	<a href="#">0.0266</a>
						Seismic	<a href="#">0.009</a>	<a href="#">0.0536</a>
<a href="#">Hot Shut Down, Corroded, Weight &amp; Eccentric Moments Only</a>	0	20,000	<a href="#">13.716</a>	140	0	Weight	<a href="#">0.0018</a>	<a href="#">0.0188</a>

#### Allowable Compressive Stress, Hot and Corroded- S<sub>cHC</sub>, (table HA-2)

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (24 / 1.75) \\
 &= 0.009115 \\
 B &= 13,716 \text{ psi} \\
 S &= 20,000 / 1.00 = 20,000 \text{ psi} \\
 S_{cHC} &= \min(B, S) = \underline{13.716 \text{ psi}}
 \end{aligned}$$

#### Allowable Compressive Stress, Hot and New- S<sub>cHN</sub>

$$\begin{aligned}
 S_{cHN} &= S_{cHC} \\
 &= \underline{13.716 \text{ psi}}
 \end{aligned}$$

#### Allowable Compressive Stress, Cold and New- S<sub>cCN</sub>, (table HA-2)

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (24 / 1.75) \\
 &= 0.009115 \\
 B &= 13,895 \text{ psi} \\
 S &= 20,000 / 1.00 = 20,000 \text{ psi} \\
 S_{cCN} &= \min(B, S) = \underline{13.895 \text{ psi}}
 \end{aligned}$$

#### Allowable Compressive Stress, Cold and Corroded- S<sub>cCC</sub>

$$\begin{aligned}
 S_{cCC} &= S_{cCN} \\
 &= \underline{13.895 \text{ psi}}
 \end{aligned}$$



**Allowable Compressive Stress, Vacuum and Corroded-  $S_{cVC}$ , (table HA-2)**

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (24 / 1.75) \\
 &= 0.009115 \\
 B &= 13,716 \text{ psi} \\
 S &= 20,000 / 1.00 = 20,000 \text{ psi} \\
 S_{cVC} &= \min(B, S) = \underline{13.716 \text{ psi}}
 \end{aligned}$$

**Operating, Hot & Corroded, Wind, Bottom Seam**

$$\begin{aligned}
 t_p &= P \cdot R / (2 \cdot S_t \cdot K_s \cdot E_c + 0.40 \cdot |P|) && \text{(Pressure)} \\
 &= 1,378 \cdot 22.25 / (2 \cdot 20,000 \cdot 1.20 \cdot 1.00 + 0.40 \cdot |1,378|) \\
 &= 0.6315" \\
 t_m &= M / (\pi \cdot R_m^2 \cdot S_t \cdot K_s \cdot E_c) && \text{(bending)} \\
 &= 270,826 / (\pi \cdot 23.125^2 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\
 &= 0.0067" \\
 t_w &= W / (2 \cdot \pi \cdot R_m \cdot S_t \cdot K_s \cdot E_c) && \text{(Weight)} \\
 &= 16,039 / (2 \cdot \pi \cdot 23.125 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\
 &= 0.0046" \\
 t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\
 &= 0.6315 + 0.0067 - (0.0046) \\
 &= \underline{0.6336"} \\
 t_c &= |t_{mc} + t_{wc} - t_{pc}| && \text{(total, net tensile)} \\
 &= |0.0067 + (0.0046) - (0.6315)| \\
 &= \underline{0.6202"}
 \end{aligned}$$

**Maximum allowable working pressure, Longitudinal Stress**

$$\begin{aligned}
 P &= 2 \cdot S_t \cdot K_s \cdot E_c \cdot (t - t_m + t_w) / (R - 0.40 \cdot (t - t_m + t_w)) \\
 &= 2 \cdot 20,000 \cdot 1.20 \cdot 1.00 \cdot (1.75 - 0.0067 + (0.0046)) / (22.25 - 0.40 \cdot (1.75 - 0.0067 + (0.0046))) \\
 &= 3,893.04 \text{ psi}
 \end{aligned}$$

**Operating, Hot & New, Wind, Bottom Seam**

$$\begin{aligned}
 t_p &= P \cdot R / (2 \cdot S_t \cdot K_s \cdot E_c + 0.40 \cdot |P|) && \text{(Pressure)} \\
 &= 1,378 \cdot 22.25 / (2 \cdot 20,000 \cdot 1.20 \cdot 1.00 + 0.40 \cdot |1,378|) \\
 &= 0.6315" \\
 t_m &= M / (\pi \cdot R_m^2 \cdot S_t \cdot K_s \cdot E_c) && \text{(bending)} \\
 &= 270,826 / (\pi \cdot 23.125^2 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\
 &= 0.0067" \\
 t_w &= W / (2 \cdot \pi \cdot R_m \cdot S_t \cdot K_s \cdot E_c) && \text{(Weight)} \\
 &= 16,039 / (2 \cdot \pi \cdot 23.125 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\
 &= 0.0046" \\
 t_t &= t_p + t_m - t_w && \text{(total required, tensile)}
 \end{aligned}$$

$$= 0.6315 + 0.0067 - (0.0046)$$

$$= \underline{0.6336''}$$

$$t_c = |t_{mc} + t_{wc} - t_{pc}| \quad \text{(total, net tensile)}$$

$$= |0.0067 + (0.0046) - (0.6315)|$$

$$= \underline{0.6202''}$$

### Maximum allowable working pressure, Longitudinal Stress

$$P = 2 * S_t * K_s * E_c * (t - t_m + t_w) / (R - 0.40 * (t - t_m + t_w))$$

$$= 2 * 20,000 * 1.20 * 1.00 * (1.75 - 0.0067 + (0.0046)) / (22.25 - 0.40 * (1.75 - 0.0067 + (0.0046)))$$

$$= 3,893.04 \text{ psi}$$

### Hot Shut Down, Corroded, Wind, Bottom Seam

$$t_p = 0'' \quad \text{(Pressure)}$$

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

$$= 270,826 / (\pi * 23.125^2 * 20,000 * 1.20 * 1.00)$$

$$= 0.0067''$$

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

$$= 16,039 / (2 * \pi * 23.125 * 20,000 * 1.20 * 1.00)$$

$$= 0.0046''$$

$$t_t = t_p + t_m - t_w \quad \text{(total required, tensile)}$$

$$= 0 + 0.0067 - (0.0046)$$

$$= \underline{0.0021''}$$

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

$$= 270,826 / (\pi * 23.125^2 * 13,715.98 * 1.20)$$

$$= 0.0098''$$

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

$$= 16,039 / (2 * \pi * 23.125 * 13,715.98 * 1.20)$$

$$= 0.0067''$$

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

$$= 0.0098 + (0.0067) - (0)$$

$$= \underline{0.0165''}$$

### Hot Shut Down, New, Wind, Bottom Seam

$$t_p = 0'' \quad \text{(Pressure)}$$

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

$$= 270,826 / (\pi * 23.125^2 * 20,000 * 1.20 * 1.00)$$

$$= 0.0067''$$

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

$$= 16,039 / (2 * \pi * 23.125 * 20,000 * 1.20 * 1.00)$$

$$= 0.0046''$$

$$t_t = t_p + t_m - t_w \quad \text{(total required, tensile)}$$

$$= 0 + 0.0067 - (0.0046)$$

$$= \underline{0.0021''}$$

$$\begin{aligned}
 t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\
 &= 270,826 / (\pi * 23.125^2 * 13,715.98 * 1.20) \\
 &= 0.0098" \\
 t_{wc} &= W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\
 &= 16,039 / (2 * \pi * 23.125 * 13,715.98 * 1.20) \\
 &= 0.0067" \\
 t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\
 &= 0.0098 + (0.0067) - (0) \\
 &= \underline{0.0165"}
 \end{aligned}$$

### Empty, Corroded, Wind, Bottom Seam

$$\begin{aligned}
 t_p &= 0" && \text{(Pressure)} \\
 t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\
 &= 270,826 / (\pi * 23.125^2 * 20,000 * 1.20 * 1.00) \\
 &= 0.0067" \\
 t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\
 &= 16,039 / (2 * \pi * 23.125 * 20,000 * 1.20 * 1.00) \\
 &= 0.0046" \\
 t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\
 &= 0 + 0.0067 - (0.0046) \\
 &= \underline{0.0021"} \\
 t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\
 &= 270,826 / (\pi * 23.125^2 * 13,894.91 * 1.20) \\
 &= 0.0097" \\
 t_{wc} &= W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\
 &= 16,039 / (2 * \pi * 23.125 * 13,894.91 * 1.20) \\
 &= 0.0066" \\
 t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\
 &= 0.0097 + (0.0066) - (0) \\
 &= \underline{0.0163"}
 \end{aligned}$$

### Empty, New, Wind, Bottom Seam

$$\begin{aligned}
 t_p &= 0" && \text{(Pressure)} \\
 t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\
 &= 270,826 / (\pi * 23.125^2 * 20,000 * 1.20 * 1.00) \\
 &= 0.0067" \\
 t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\
 &= 16,039 / (2 * \pi * 23.125 * 20,000 * 1.20 * 1.00) \\
 &= 0.0046" \\
 t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\
 &= 0 + 0.0067 - (0.0046) \\
 &= \underline{0.0021"} \\
 t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\
 &= 270,826 / (\pi * 23.125^2 * 13,894.91 * 1.20)
 \end{aligned}$$

$$= 0.0097''$$

$$\begin{aligned} t_{wc} &= W / (2\pi R_m S_c K_s) && \text{(Weight)} \\ &= 16,039 / (2\pi * 23.125 * 13,894.91 * 1.20) \\ &= 0.0066'' \end{aligned}$$

$$\begin{aligned} t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\ &= 0.0097 + (0.0066) - (0) \\ &= \underline{0.0163''} \end{aligned}$$

### Vacuum, Wind, Bottom Seam

$$\begin{aligned} t_p &= P * R / (2 * S_c * K_s + 0.40 * |P|) && \text{(Pressure)} \\ &= -15 * 22.25 / (2 * 13,715.98 * 1.20 + 0.40 * |15|) \\ &= -0.0101'' \end{aligned}$$

$$\begin{aligned} t_m &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\ &= 270,826 / (\pi * 23.125^2 * 13,715.98 * 1.20) \\ &= 0.0098'' \end{aligned}$$

$$\begin{aligned} t_w &= W / (2\pi R_m S_c K_s) && \text{(Weight)} \\ &= 16,039 / (2\pi * 23.125 * 13,715.98 * 1.20) \\ &= 0.0067'' \end{aligned}$$

$$\begin{aligned} t_t &= |t_p + t_m - t_w| && \text{(total, net compressive)} \\ &= |-0.0101 + 0.0098 - (0.0067)| \\ &= \underline{0.007''} \end{aligned}$$

$$\begin{aligned} t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\ &= 0.0098 + (0.0067) - (-0.0101) \\ &= \underline{0.0266''} \end{aligned}$$

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

$$\begin{aligned} P &= 2 * S_c * K_s * (t - t_{mc} - t_{wc}) / (R - 0.40 * (t - t_{mc} - t_{wc})) \\ &= 2 * 13,715.98 * 1.20 * (1.75 - 0.0098 - 0.0067) / (22.25 - 0.40 * (1.75 - 0.0098 - 0.0067)) \\ &= 2,647.17 \text{ psi} \end{aligned}$$

### Hot Shut Down, Corroded, Weight & Eccentric Moments Only, Bottom Seam

$$\begin{aligned} t_p &= 0'' && \text{(Pressure)} \\ t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\ &= 246,659 / (\pi * 23.125^2 * 20,000 * 1.00 * 1.00) \\ &= 0.0073'' \end{aligned}$$

$$\begin{aligned} t_w &= W / (2\pi R_m S_t K_s E_c) && \text{(Weight)} \\ &= 16,039 / (2\pi * 23.125 * 20,000 * 1.00 * 1.00) \\ &= 0.0055'' \end{aligned}$$

$$\begin{aligned} t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\ &= 0 + 0.0073 - (0.0055) \\ &= \underline{0.0018''} \end{aligned}$$

$$\begin{aligned} t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\ &= 246,659 / (\pi * 23.125^2 * 13,715.98 * 1.00) \\ &= 0.0107'' \end{aligned}$$

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

$$= 16,039 / (2\pi * 23.125 * 13,715.98 * 1.00)$$

$$= 0.008"$$

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

$$= 0.0107 + (0.008) - (0)$$

$$= \underline{0.0188}"$$

### Operating, Hot & Corroded, Seismic, Bottom Seam

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

$$= 1,378 * 22.25 / (2 * 20,000 * 1.20 * 1.00 + 0.40 * |1,378|)$$

$$= 0.6315"$$

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

$$= 830,156 / (\pi * 23.125^2 * 20,000 * 1.20 * 1.00)$$

$$= 0.0206"$$

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

$$= 16,039 / (2\pi * 23.125 * 20,000 * 1.20 * 1.00)$$

$$= 0.0046"$$

$$t_t = t_p + t_m - t_w \quad (\text{total required, tensile})$$

$$= 0.6315 + 0.0206 - (0.0046)$$

$$= \underline{0.6475}"$$

$$t_{wc} = (1 + V_{\text{Accel}}) * W / (2\pi R_m S_t K_s E_c) \quad (\text{Weight})$$

$$= 2.00 * 16,039 / (2\pi * 23.125 * 20,000 * 1.20 * 1.00)$$

$$= 0.0092"$$

$$t_c = |t_{mc} + t_{wc} - t_{pc}| \quad (\text{total, net tensile})$$

$$= |0.0206 + (0.0092) - (0.6315)|$$

$$= \underline{0.6017}"$$

### **Maximum allowable working pressure, Longitudinal Stress**

$$P = 2 * S_t * K_s * E_c * (t - t_m + t_w) / (R - 0.40 * (t - t_m + t_w))$$

$$= 2 * 20,000 * 1.20 * 1.00 * (1.75 - 0.0206 + (0.0046)) / (22.25 - 0.40 * (1.75 - 0.0206 + (0.0046)))$$

$$= 3,861.15 \text{ psi}$$

### Operating, Hot & New, Seismic, Bottom Seam

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

$$= 1,378 * 22.25 / (2 * 20,000 * 1.20 * 1.00 + 0.40 * |1,378|)$$

$$= 0.6315"$$

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

$$= 830,156 / (\pi * 23.125^2 * 20,000 * 1.20 * 1.00)$$

$$= 0.0206"$$

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

$$= 16,039 / (2\pi * 23.125 * 20,000 * 1.20 * 1.00)$$

$$= 0.0046"$$

$$t_t = t_p + t_m - t_w \quad (\text{total required, tensile})$$

$$= 0.6315 + 0.0206 - (0.0046)$$



$$= 0.6475''$$

$$\begin{aligned} t_{wc} &= (1 + V_{\text{Accel}}) * W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\ &= 2.00 * 16,039 / (2 * \pi * 23.125 * 20,000 * 1.20 * 1.00) \\ &= 0.0092'' \end{aligned}$$

$$\begin{aligned} t_c &= |t_{mc} + t_{wc} - t_{pc}| && \text{(total, net tensile)} \\ &= |0.0206 + (0.0092) - (0.6315)| \\ &= 0.6017'' \end{aligned}$$

### Maximum allowable working pressure, Longitudinal Stress

$$\begin{aligned} P &= 2 * S_t * K_s * E_c * (t - t_m + t_w) / (R - 0.40 * (t - t_m + t_w)) \\ &= 2 * 20,000 * 1.20 * 1.00 * (1.75 - 0.0206 + (0.0046)) / (22.25 - 0.40 * (1.75 - 0.0206 + (0.0046))) \\ &= 3,861.15 \text{ psi} \end{aligned}$$

### Hot Shut Down, Corroded, Seismic, Bottom Seam

$$t_p = 0'' \quad \text{(Pressure)}$$

$$\begin{aligned} t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\ &= 830,156 / (\pi * 23.125^2 * 20,000 * 1.20 * 1.00) \\ &= 0.0206'' \end{aligned}$$

$$\begin{aligned} t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\ &= 16,039 / (2 * \pi * 23.125 * 20,000 * 1.20 * 1.00) \\ &= 0.0046'' \end{aligned}$$

$$\begin{aligned} t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\ &= 0 + 0.0206 - (0.0046) \\ &= 0.016'' \end{aligned}$$

$$\begin{aligned} t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\ &= 830,156 / (\pi * 23.125^2 * 13,715.98 * 1.20) \\ &= 0.03'' \end{aligned}$$

$$\begin{aligned} t_{wc} &= (1 + V_{\text{Accel}}) * W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\ &= 2.00 * 16,039 / (2 * \pi * 23.125 * 13,715.98 * 1.20) \\ &= 0.0134'' \end{aligned}$$

$$\begin{aligned} t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\ &= 0.03 + (0.0134) - (0) \\ &= 0.0434'' \end{aligned}$$

### Hot Shut Down, New, Seismic, Bottom Seam

$$t_p = 0'' \quad \text{(Pressure)}$$

$$\begin{aligned} t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\ &= 830,156 / (\pi * 23.125^2 * 20,000 * 1.20 * 1.00) \\ &= 0.0206'' \end{aligned}$$

$$\begin{aligned} t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\ &= 16,039 / (2 * \pi * 23.125 * 20,000 * 1.20 * 1.00) \\ &= 0.0046'' \end{aligned}$$

$$\begin{aligned} t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\ &= 0 + 0.0206 - (0.0046) \end{aligned}$$

$$= 0.016"$$

$$\begin{aligned} t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\ &= 830,156 / (\pi * 23.125^2 * 13,715.98 * 1.20) \\ &= 0.03" \end{aligned}$$

$$\begin{aligned} t_{wc} &= (1 + V_{Accel}) * W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\ &= 2.00 * 16,039 / (2 * \pi * 23.125 * 13,715.98 * 1.20) \\ &= 0.0134" \end{aligned}$$

$$\begin{aligned} t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\ &= 0.03 + (0.0134) - (0) \\ &= 0.0434" \end{aligned}$$

### Empty, Corroded, Seismic, Bottom Seam

$$t_p = 0" \quad \text{(Pressure)}$$

$$\begin{aligned} t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\ &= 799,344 / (\pi * 23.125^2 * 20,000 * 1.20 * 1.00) \\ &= 0.0198" \end{aligned}$$

$$\begin{aligned} t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\ &= 16,039 / (2 * \pi * 23.125 * 20,000 * 1.20 * 1.00) \\ &= 0.0046" \end{aligned}$$

$$\begin{aligned} t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\ &= 0 + 0.0198 - (0.0046) \\ &= 0.0152" \end{aligned}$$

$$\begin{aligned} t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\ &= 799,344 / (\pi * 23.125^2 * 13,894.91 * 1.20) \\ &= 0.0285" \end{aligned}$$

$$\begin{aligned} t_{wc} &= (1 + V_{Accel}) * W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\ &= 2.00 * 16,039 / (2 * \pi * 23.125 * 13,894.91 * 1.20) \\ &= 0.0132" \end{aligned}$$

$$\begin{aligned} t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\ &= 0.0285 + (0.0132) - (0) \\ &= 0.0418" \end{aligned}$$

### Empty, New, Seismic, Bottom Seam

$$t_p = 0" \quad \text{(Pressure)}$$

$$\begin{aligned} t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\ &= 799,344 / (\pi * 23.125^2 * 20,000 * 1.20 * 1.00) \\ &= 0.0198" \end{aligned}$$

$$\begin{aligned} t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\ &= 16,039 / (2 * \pi * 23.125 * 20,000 * 1.20 * 1.00) \\ &= 0.0046" \end{aligned}$$

$$\begin{aligned} t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\ &= 0 + 0.0198 - (0.0046) \\ &= 0.0152" \end{aligned}$$

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

$$= 799,344 / (\pi * 23.125^2 * 13,894.91 * 1.20)$$

$$= 0.0285"$$

$$t_{wc} = (1 + V_{Accel}) * W / (2 * \pi * R_m * S_c * K_s) \quad (\text{Weight})$$

$$= 2.00 * 16,039 / (2 * \pi * 23.125 * 13,894.91 * 1.20)$$

$$= 0.0132"$$

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

$$= 0.0285 + (0.0132) - (0)$$

$$= \underline{0.0418}"$$

### Vacuum, Seismic, Bottom Seam

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

$$= -15 * 22.25 / (2 * 20,000 * 1.20 * 1.00 + 0.40 * |15|)$$

$$= -0.007"$$

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

$$= 830,156 / (\pi * 23.125^2 * 20,000 * 1.20 * 1.00)$$

$$= 0.0206"$$

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

$$= 16,039 / (2 * \pi * 23.125 * 20,000 * 1.20 * 1.00)$$

$$= 0.0046"$$

$$t_t = t_p + t_m - t_w \quad (\text{total required, tensile})$$

$$= -0.007 + 0.0206 - (0.0046)$$

$$= \underline{0.009}"$$

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

$$= -15 * 22.25 / (2 * 13,715.98 * 1.20 + 0.40 * |15|)$$

$$= -0.0101"$$

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

$$= 830,156 / (\pi * 23.125^2 * 13,715.98 * 1.20)$$

$$= 0.03"$$

$$t_{wc} = (1 + V_{Accel}) * W / (2 * \pi * R_m * S_c * K_s) \quad (\text{Weight})$$

$$= 2.00 * 16,039 / (2 * \pi * 23.125 * 13,715.98 * 1.20)$$

$$= 0.0134"$$

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

$$= 0.03 + (0.0134) - (-0.0101)$$

$$= \underline{0.0536}"$$

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

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

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

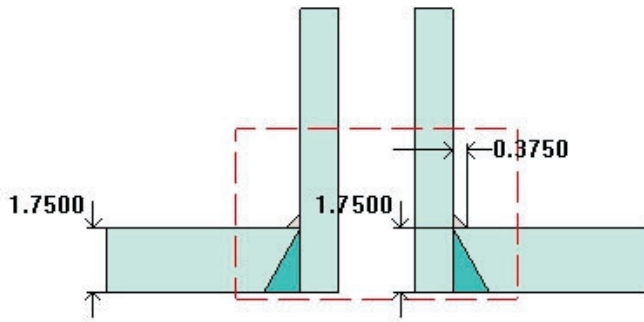
$$= 2,604.73 \text{ psi}$$

## Level Gauge High (N10A)

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

$$t_{w(\text{lower})} = 1.75 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

#### Location and Orientation

Located on:	48 OD SHELL
Orientation:	45°
Nozzle center line offset to datum line:	40 in
End of nozzle to shell center:	32 in
Passes through a Category A joint:	No

#### Nozzle

Access opening:	No
Material specification:	SA-182 F316 ≤ 5 (II-D p. 70, In. 22)
Inside diameter, new:	2 in
Nominal wall thickness:	1.06 in
Corrosion allowance:	0 in
Projection available outside vessel, L <sub>pr</sub> :	6.25 in
Projection available outside vessel to flange face, L <sub>f</sub> :	8 in
Local vessel minimum thickness:	1.75 in
Liquid static head included:	0 psi
Longitudinal joint efficiency:	1

#### ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 LWN A182 F316
Bolt Material:	SA-193 B7 Bolt ≤ 2 1/2 (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55°F
(Per UHA-51(d)(1)(a))	
(Flange rated MDMT = -320 °F)	
Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F)	
Liquid static head:	0 psi
MAWP rating:	2,040 psi @ 140°F
MAP rating:	2,160 psi @ 50°F

Hydrotest rating:  
PWHT performed:

3,250 psi @ 50°F  
No



**Reinforcement Calculations for Chamber MAWP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For P = 1,378 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

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

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for internal pressure 1,378 psi @ 140 °F**

Nozzle Impact test exempt per UHA-51(g)(coincident ratio = 0.0788).

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

**Required thickness t<sub>r</sub> from UG-37(a)**

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378) \\
 &= 1.6092 \text{ in}
 \end{aligned}$$

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

### UW-16(c) Weld Check

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

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

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

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

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

$$t_{a \text{ UG-22}} = 0.0835 \text{ in}$$

$$\begin{aligned}t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0719, 0.0835 ] \\ &= 0.0835 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= P*R_o / (S*E + 0.4*P) + \text{Corrosion} \\ &= 1,378*24 / (20,000*1 + 0.4*1,378) + 0 \\ &= 1.6092 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6092, 0.0625 ] \\ &= 1.6092 \text{ in}\end{aligned}$$

$$\begin{aligned}t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.2074, 1.6092 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0835, 0.2074 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

## Applied Loads

Radial load:	$P_r = 334$	$lb_f$
Circumferential moment:	$M_c = 2,965$	$lb_f\text{-in}$
Circumferential shear:	$V_c = 409$	$lb_f$
Longitudinal moment:	$M_L = 2,965$	$lb_f\text{-in}$
Longitudinal shear:	$V_L = 409$	$lb_f$
Torsion moment:	$M_t = 4,160$	$lb_f\text{-in}$
Internal pressure:	$P = 1,378$	psi
Mean shell radius:	$R_m = 23.125$	in
Local shell thickness:	$t = 1.75$	in
Shell yield stress:	$S_y = 27,900$	psi

### Maximum stresses due to the applied loads at the nozzle OD (includes pressure)

$$R_m / t = 23.125 / 1.75 = 13.2143$$

Pressure stress intensity factor,  $I = 1.05703$  (derived from PVP-Vol. 399, pages 77-82)

$$\text{Local circumferential pressure stress} = I * P * R_i / t = 18,519 \text{ psi}$$

$$\text{Local longitudinal pressure stress} = I * P * R_i / (2 * t) = 9,260 \text{ psi}$$

$$\text{Maximum combined stress } (P_L + P_b + Q) = 18,780 \text{ psi}$$

$$\text{Allowable combined stress } (P_L + P_b + Q) = +-3 * S = +-60,000 \text{ psi}$$

Note: The allowable combined stress  $(P_L + P_b + Q)$  is based on the strain hardening characteristics of this material.

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

$$\text{Maximum local primary membrane stress } (P_L) = 18,524 \text{ psi}$$

$$\text{Allowable local primary membrane stress } (P_L) = +-1.5 * S = +-30,000 \text{ psi}$$

The maximum local primary membrane stress  $(P_L)$  is within allowable limits.

Stresses at the nozzle OD per WRC Bulletin 107										
Figure	value	$\beta$	$A_u$	$A_l$	$B_u$	$B_l$	$C_u$	$C_l$	$D_u$	$D_l$
3C*	2.5705	0.0779	0	0	0	0	-21	-21	-21	-21
4C*	2.6145	0.0779	-22	-22	-22	-22	0	0	0	0
1C	0.2014	0.0779	0	0	0	0	-132	132	-132	132
2C-1	0.1661	0.0779	-109	109	-109	109	0	0	0	0
3A*	0.1676	0.0779	0	0	0	0	-7	-7	7	7
1A	0.1061	0.0779	0	0	0	0	-342	342	342	-342
3B*	0.6597	0.0779	-27	-27	27	27	0	0	0	0
1B-1	0.0616	0.0779	-199	199	199	-199	0	0	0	0
<b>Pressure stress*</b>			18,519	18,519	18,519	18,519	17,520	17,520	17,520	17,520
<b>Total circumferential stress</b>			18,162	18,778	18,614	18,434	17,018	17,966	17,716	17,296
<b>Primary membrane circumferential stress*</b>			18,470	18,470	18,524	18,524	17,492	17,492	17,506	17,506
3C*	2.5705	0.0779	-21	-21	-21	-21	0	0	0	0
4C*	2.6145	0.0779	0	0	0	0	-22	-22	-22	-22
1C-1	0.2031	0.0779	-133	133	-133	133	0	0	0	0
2C	0.1599	0.0779	0	0	0	0	-105	105	-105	105
4A*	0.2212	0.0779	0	0	0	0	-9	-9	9	9
2A	0.063	0.0779	0	0	0	0	-203	203	203	-203
4B*	0.1671	0.0779	-7	-7	7	7	0	0	0	0
2B-1	0.098	0.0779	-316	316	316	-316	0	0	0	0
<b>Pressure stress*</b>			8,760	8,760	8,760	8,760	9,260	9,260	9,260	9,260
<b>Total longitudinal stress</b>			8,283	9,181	8,929	8,563	8,921	9,537	9,345	9,149
<b>Primary membrane longitudinal stress*</b>			8,732	8,732	8,746	8,746	9,229	9,229	9,247	9,247
<b>Shear from <math>M_t</math></b>			89	89	89	89	89	89	89	89
<b>Circ shear from <math>V_c</math></b>			36	36	-36	-36	0	0	0	0
<b>Long shear from <math>V_L</math></b>			0	0	0	0	-36	-36	36	36
<b>Total Shear stress</b>			125	125	53	53	53	53	125	125
<b>Combined stress (<math>P_L+P_B+Q</math>)</b>			18,164	18,780	18,614	18,434	17,018	17,966	17,718	17,298

Note: \* denotes primary stress.

### Longitudinal stress in the nozzle wall due to internal pressure + external loads

$$\begin{aligned} \sigma_{n(P_m)} &= P \cdot R_i / (2 \cdot t_n) - P_r / (\pi \cdot (R_o^2 - R_i^2)) + M \cdot R_o / I \\ &= 1,378 \cdot 1 / (2 \cdot 1.06) - 334 / (\pi \cdot (2.06^2 - 1^2)) + 4,193.1 \cdot 2.06 / 13.3582 \\ &= 1,264 \text{ psi} \end{aligned}$$

The average primary stress  $P_m$  (see Division 2 5.6.a.1) across the nozzle wall due to internal pressure + external loads is acceptable ( $\leq S = 20,000$  psi)

### Shear stress in the nozzle wall due to external loads

$$\begin{aligned} \sigma_{\text{shear}} &= (V_L^2 + V_c^2)^{0.5} / (\pi \cdot R_i \cdot t_n) \\ &= (409^2 + 409^2)^{0.5} / (\pi \cdot 1 \cdot 1.06) \\ &= 174 \text{ psi} \end{aligned}$$

$$\begin{aligned} \sigma_{\text{torsion}} &= M_t / (2 \cdot \pi \cdot R_i^2 \cdot t_n) \\ &= 4,160 / (2 \cdot \pi \cdot 1^2 \cdot 1.06) \end{aligned}$$

= 625 psi

$$\begin{aligned}\sigma_{\text{total}} &= \sigma_{\text{shear}} + \sigma_{\text{torsion}} \\ &= 174 + 625 \\ &= 798 \text{ psi}\end{aligned}$$

UG-45: The total combined shear stress (798 psi) is below than the allowable ( $0.7 \cdot S_n = 0.7 \cdot 20,000 = 14,000$  psi)



**Reinforcement Calculations for MAEP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For Pe = 622.51 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for external pressure 622.51 psi @ 140 °F**

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-28 t<sub>m</sub> = 0.1482 in**

**From UG-37(d)(1) required thickness t<sub>r</sub> = 1.75 in**

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

**UW-16(c) Weld Check**

Fillet weld: t<sub>min</sub> = lesser of 0.75 or t<sub>n</sub> or t = 0.75 in  
 t<sub>c(min)</sub> = lesser of 0.25 or 0.7\*t<sub>min</sub> = [0.25](#) in  
 t<sub>c(actual)</sub> = 0.7\*Leg = 0.7\*0.375 = 0.2625 in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

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

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

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

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

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

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

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

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

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

$$L / D_o = 8.0886 / 4.12 = 1.9632$$

$$D_o / t = 4.12 / 0.1482 = 27.7945$$

From table G:  $A = 0.004502$

From table  
HA-2:  $B = 12,976.6933 \text{ psi}$

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

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

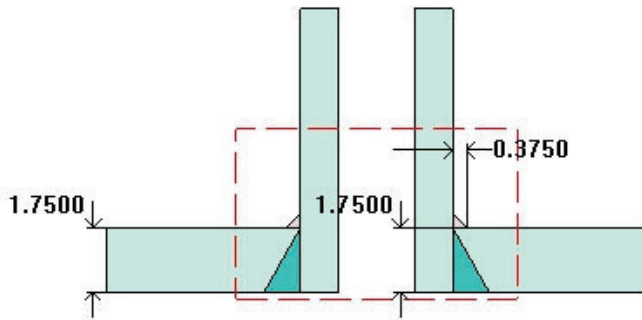
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482 \text{ in}$$

## Liquid Outlet (N3)

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

$$t_{w(\text{lower})} = 1.75 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

#### Location and Orientation

Located on:	48 OD SHELL
Orientation:	180°
Nozzle center line offset to datum line:	88 in
End of nozzle to shell center:	32 in
Passes through a Category A joint:	No

#### Nozzle

Access opening:	No
Material specification:	SA-182 F316 $\leq 5$ (II-D p. 70, In. 22)
Inside diameter, new:	2 in
Nominal wall thickness:	1.06 in
Corrosion allowance:	0 in
Projection available outside vessel, L <sub>pr</sub> :	6.25 in
Projection available outside vessel to flange face, L <sub>f</sub> :	8 in
Local vessel minimum thickness:	1.75 in
Liquid static head included:	0.3574 psi
Longitudinal joint efficiency:	1

#### ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 LWN A182 F316
Bolt Material:	SA-193 B7 Bolt $\leq 2 \frac{1}{2}$ (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55°F
(Per UHA-51(d)(1)(a))	
(Flange rated MDMT = -320 °F)	
Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F)	
Liquid static head:	0.3177 psi
MAWP rating:	2,040 psi @ 140°F
MAP rating:	2,160 psi @ 50°F

Hydrotest rating:  
PWHT performed:

3,250 psi @ 50°F  
No

**Reinforcement Calculations for Chamber MAWP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For P = 1,378.36 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

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

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for internal pressure 1,378.36 psi @ 140 °F**

Nozzle Impact test exempt per UHA-51(g)(coincident ratio = 0.0678).

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378.3574 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378.3574) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

**Required thickness t<sub>r</sub> from UG-37(a)**

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 1,378.3574 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378.3574) \\
 &= 1.6097 \text{ in}
 \end{aligned}$$

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



### UW-16(c) Weld Check

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

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

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

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$\begin{aligned}t_{a \text{ UG-27}} &= P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion} \\ &= 1,378.3574 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378.3574) + 0 \\ &= 0.0719 \text{ in}\end{aligned}$$

$$\begin{aligned}t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0719, 0 ] \\ &= 0.0719 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 1,378.3574 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378.3574) + 0 \\ &= 1.6097 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6097, 0.0625 ] \\ &= 1.6097 \text{ in}\end{aligned}$$

$$\begin{aligned}t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.2074, 1.6097 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0719, 0.2074 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

**Reinforcement Calculations for MAEP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For Pe = 622.51 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for external pressure 622.51 psi @ 140 °F**

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-28 t<sub>m</sub> = 0.1482 in**

**From UG-37(d)(1) required thickness t<sub>r</sub> = 1.75 in**

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

**UW-16(c) Weld Check**

Fillet weld: t<sub>min</sub> = lesser of 0.75 or t<sub>n</sub> or t = 0.75 in  
 t<sub>c(min)</sub> = lesser of 0.25 or 0.7\*t<sub>min</sub> = [0.25](#) in  
 t<sub>c(actual)</sub> = 0.7\*Leg = 0.7\*0.375 = 0.2625 in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

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

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.1482, 0 ] \\ &= 0.1482 \text{ in} \end{aligned}$$

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

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

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

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

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

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

$$L / D_o = 8.0886 / 4.12 = 1.9632$$

$$D_o / t = 4.12 / 0.1482 = 27.7945$$

From table G:  $A = 0.004502$

From table  
HA-2:  $B = 12,976.6933 \text{ psi}$

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

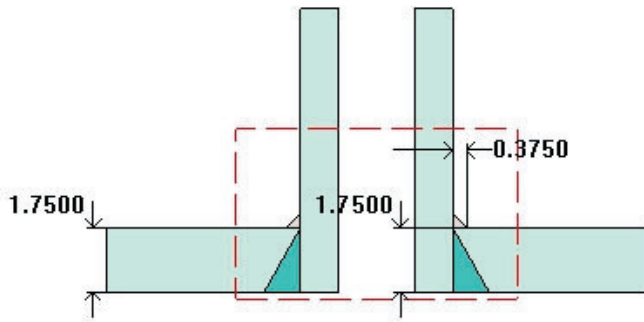
### Design thickness for external pressure $P_a = 622.51 \text{ psi}$

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

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

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

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

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 $P_a = 622.51 \text{ psi}$

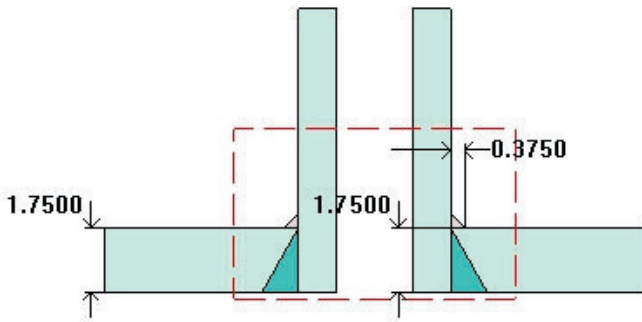
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

## 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 ≤ 5 (II-D p. 70, In. 22)
Inside diameter, new:	2 in
Nominal wall thickness:	1.06 in
Corrosion allowance:	0 in
Projection available outside vessel, L <sub>pr</sub> :	6.25 in
Projection available outside vessel to flange face, L <sub>f</sub> :	8 in
Local vessel minimum thickness:	1.75 in
Liquid static head included:	0 psi
Longitudinal joint efficiency:	1

#### ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 LWN A182 F316
Bolt Material:	SA-193 B7 Bolt ≤ 2 1/2 (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55°F
(Per UHA-51(d)(1)(a))	
(Flange rated MDMT = -320 °F)	
Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F)	
Liquid static head:	0 psi
MAWP rating:	2,040 psi @ 140°F
MAP rating:	2,160 psi @ 50°F



Hydrotest rating:  
PWHT performed:

3,250 psi @ 50°F  
No

## Reinforcement Calculations for Chamber MAWP

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For P = 1,378 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

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

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

### Calculations for internal pressure 1,378 psi @ 140 °F

Nozzle Impact test exempt per UHA-51(g)(coincident ratio = 0.0678).

#### Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

#### Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

#### Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

#### Required thickness t<sub>r</sub> from UG-37(a)

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378) \\
 &= 1.6092 \text{ in}
 \end{aligned}$$

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

### UW-16(c) Weld Check

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

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

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

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

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

$$\begin{aligned}t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0719, 0 ] \\ &= 0.0719 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378) + 0 \\ &= 1.6092 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6092, 0.0625 ] \\ &= 1.6092 \text{ in}\end{aligned}$$

$$\begin{aligned}t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.2074, 1.6092 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0719, 0.2074 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

**Reinforcement Calculations for MAEP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For Pe = 622.51 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for external pressure 622.51 psi @ 140 °F**

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-28 t<sub>m</sub> = 0.1482 in**

**From UG-37(d)(1) required thickness t<sub>r</sub> = 1.75 in**

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

**UW-16(c) Weld Check**

Fillet weld: t<sub>min</sub> = lesser of 0.75 or t<sub>n</sub> or t = 0.75 in  
 t<sub>c(min)</sub> = lesser of 0.25 or 0.7\*t<sub>min</sub> = [0.25](#) in  
 t<sub>c(actual)</sub> = 0.7\*Leg = 0.7\*0.375 = 0.2625 in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

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

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.1482, 0 ] \\ &= 0.1482 \text{ in} \end{aligned}$$

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

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

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

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

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

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

$$L / D_o = 8.0886 / 4.12 = 1.9632$$

$$D_o / t = 4.12 / 0.1482 = 27.7945$$

From table G:  $A = 0.004502$

From table HA-2:  $B = 12,976.6933 \text{ psi}$

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

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

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

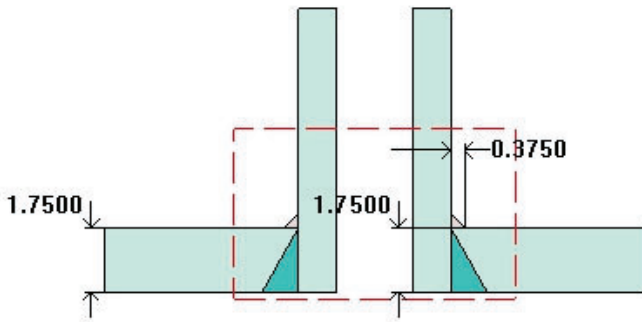


## Temperature Indicator (N6)

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

$$t_{w(\text{lower})} = 1.75 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

#### Location and Orientation

Located on:	48 OD SHELL
Orientation:	90°
Nozzle center line offset to datum line:	54 in
End of nozzle to shell center:	32 in
Passes through a Category A joint:	No

#### Nozzle

Access opening:	No
Material specification:	SA-182 F316 ≤ 5 (II-D p. 70, In. 22)
Inside diameter, new:	2 in
Nominal wall thickness:	1.06 in
Corrosion allowance:	0 in
Projection available outside vessel, L <sub>pr</sub> :	6.25 in
Projection available outside vessel to flange face, L <sub>f</sub> :	8 in
Local vessel minimum thickness:	1.75 in
Liquid static head included:	0 psi
Longitudinal joint efficiency:	1

#### ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 LWN A182 F316
Bolt Material:	SA-193 B7 Bolt ≤ 2 1/2 (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55°F
(Per UHA-51(d)(1)(a))	
(Flange rated MDMT = -320 °F)	
Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F)	
Liquid static head:	0 psi
MAWP rating:	2,040 psi @ 140°F
MAP rating:	2,160 psi @ 50°F

Hydrotest rating:  
PWHT performed:

3,250 psi @ 50°F  
No

**Reinforcement Calculations for Chamber MAWP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For P = 1,378 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

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

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for internal pressure 1,378 psi @ 140 °F**

Nozzle Impact test exempt per UHA-51(g)(coincident ratio = 0.0678).

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

**Required thickness t<sub>r</sub> from UG-37(a)**

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378) \\
 &= 1.6092 \text{ in}
 \end{aligned}$$

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

### UW-16(c) Weld Check

Fillet weld:  $t_{\min}$  = 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 $P_a = 622.51 \text{ psi}$

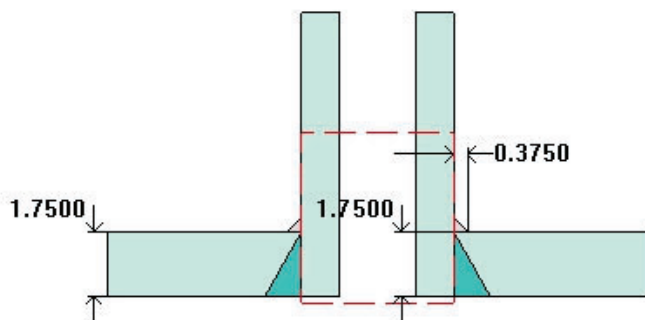
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

## Level Bridle - (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:  $t_{min} =$  lesser of 0.75 or  $t_n$  or  $t = 0.75$  in  
 $t_{c(min)} =$  lesser of 0.25 or  $0.7*t_{min} = \underline{0.25}$  in  
 $t_{c(actual)} = 0.7*Leg = 0.7*0.375 = 0.2625$  in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

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

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.1482, 0 ] \\ &= 0.1482 \text{ in} \end{aligned}$$

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

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

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

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

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

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

$$L / D_o = 8.0886 / 4.12 = 1.9632$$

$$D_o / t = 4.12 / 0.1482 = 27.7945$$

From table G:  $A = 0.004502$

From table  
HA-2:  $B = 12,976.6933 \text{ psi}$

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

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

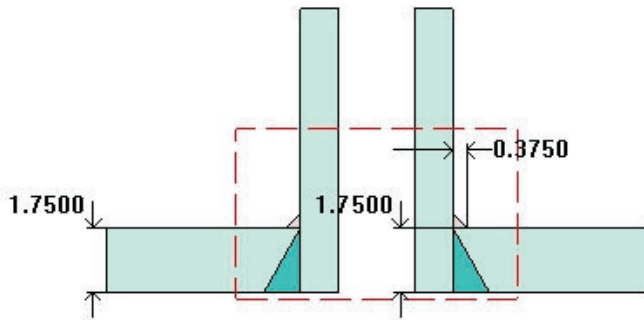
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

## Spare (N11)

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

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

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

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

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

$$\begin{aligned}t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0719, 0 ] \\ &= 0.0719 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378) + 0 \\ &= 1.6092 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6092, 0.0625 ] \\ &= 1.6092 \text{ in}\end{aligned}$$

$$\begin{aligned}t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.2074, 1.6092 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0719, 0.2074 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

## Reinforcement Calculations for MAEP

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For Pe = 622.51 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

Calculations for external pressure 622.51 psi @ 140 °F

### Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

### Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28  $t_m = 0.1482$  in

From UG-37(d)(1) required thickness  $t_r = 1.75$  in

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

### UW-16(c) Weld Check

Fillet weld:  $t_{min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$   
 $t_{c(min)} = \text{lesser of } 0.25 \text{ or } 0.7*t_{min} = \underline{0.25} \text{ in}$   
 $t_{c(actual)} = 0.7*Leg = 0.7*0.375 = 0.2625 \text{ in}$

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

#### UG-45 Nozzle Neck Thickness Check

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

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.1482, 0 ] \\ &= 0.1482 \text{ in} \end{aligned}$$

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

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

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

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

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

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

$$L / D_o = 8.0886 / 4.12 = 1.9632$$

$$D_o / t = 4.12 / 0.1482 = 27.7945$$

From table G:  $A = 0.004502$

From table HA-2:  $B = 12,976.6933 \text{ psi}$

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

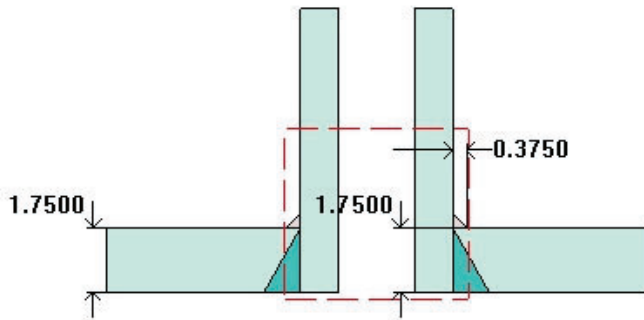
#### Design thickness for external pressure $P_a = 622.51 \text{ psi}$

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

## 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)

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378.3574 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378.3574) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

#### Required thickness t<sub>r</sub> from UG-37(a)

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 1,378.3574 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378.3574) \\
 &= 1.6097 \text{ in}
 \end{aligned}$$

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

### UW-16(c) Weld Check

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

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

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

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$\begin{aligned} t_{a \text{ UG-27}} &= P * R / (S * E - 0.6 * P) + \text{Corrosion} \\ &= 1,378.3574 * 1 / (20,000 * 1 - 0.6 * 1,378.3574) + 0 \\ &= 0.0719 \text{ in} \end{aligned}$$

$$t_{a \text{ UG-22}} = 0.0835 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0719, 0.0835 ] \\ &= 0.0835 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= P * R_o / (S * E + 0.4 * P) + \text{Corrosion} \\ &= 1,378.3574 * 24 / (20,000 * 1 + 0.4 * 1,378.3574) + 0 \\ &= 1.6097 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6097, 0.0625 ] \\ &= 1.6097 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.2074, 1.6097 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0835, 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

## Applied Loads

Radial load:	$P_r = 334$	$lb_f$
Circumferential moment:	$M_c = 2,965$	$lb_f\text{-in}$
Circumferential shear:	$V_c = 409$	$lb_f$
Longitudinal moment:	$M_L = 2,965$	$lb_f\text{-in}$
Longitudinal shear:	$V_L = 409$	$lb_f$
Torsion moment:	$M_t = 4,160$	$lb_f\text{-in}$
Internal pressure:	$P = 1,378.357$	psi
Mean shell radius:	$R_m = 23.125$	in
Local shell thickness:	$t = 1.75$	in
Shell yield stress:	$S_y = 27,900$	psi

### Maximum stresses due to the applied loads at the nozzle OD (includes pressure)

$$R_m / t = 23.125 / 1.75 = 13.2143$$

Pressure stress intensity factor,  $I = 1.05703$  (derived from PVP-Vol. 399, pages 77-82)

$$\text{Local circumferential pressure stress} = I * P * R_i / t = 18,524 \text{ psi}$$

$$\text{Local longitudinal pressure stress} = I * P * R_i / (2 * t) = 9,262 \text{ psi}$$

$$\text{Maximum combined stress } (P_L + P_b + Q) = 18,785 \text{ psi}$$

$$\text{Allowable combined stress } (P_L + P_b + Q) = + - 3 * S = + - 60,000 \text{ psi}$$

Note: The allowable combined stress  $(P_L + P_b + Q)$  is based on the strain hardening characteristics of this material.

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

$$\text{Maximum local primary membrane stress } (P_L) = 18,529 \text{ psi}$$

$$\text{Allowable local primary membrane stress } (P_L) = + - 1.5 * S = + - 30,000 \text{ psi}$$

The maximum local primary membrane stress  $(P_L)$  is within allowable limits.

Stresses at the nozzle OD per WRC Bulletin 107										
Figure	value	$\beta$	$A_u$	$A_l$	$B_u$	$B_l$	$C_u$	$C_l$	$D_u$	$D_l$
3C*	2.5705	0.0779	0	0	0	0	-21	-21	-21	-21
4C*	2.6145	0.0779	-22	-22	-22	-22	0	0	0	0
1C	0.2014	0.0779	0	0	0	0	-132	132	-132	132
2C-1	0.1661	0.0779	-109	109	-109	109	0	0	0	0
3A*	0.1676	0.0779	0	0	0	0	-7	-7	7	7
1A	0.1061	0.0779	0	0	0	0	-342	342	342	-342
3B*	0.6597	0.0779	-27	-27	27	27	0	0	0	0
1B-1	0.0616	0.0779	-199	199	199	-199	0	0	0	0
<b>Pressure stress*</b>			18,524	18,524	18,524	18,524	17,525	17,525	17,525	17,525
<b>Total circumferential stress</b>			18,167	18,783	18,619	18,439	17,023	17,971	17,721	17,301
<b>Primary membrane circumferential stress*</b>			18,475	18,475	18,529	18,529	17,497	17,497	17,511	17,511
3C*	2.5705	0.0779	-21	-21	-21	-21	0	0	0	0
4C*	2.6145	0.0779	0	0	0	0	-22	-22	-22	-22
1C-1	0.2031	0.0779	-133	133	-133	133	0	0	0	0
2C	0.1599	0.0779	0	0	0	0	-105	105	-105	105
4A*	0.2212	0.0779	0	0	0	0	-9	-9	9	9
2A	0.063	0.0779	0	0	0	0	-203	203	203	-203
4B*	0.1671	0.0779	-7	-7	7	7	0	0	0	0
2B-1	0.098	0.0779	-316	316	316	-316	0	0	0	0
<b>Pressure stress*</b>			8,762	8,762	8,762	8,762	9,262	9,262	9,262	9,262
<b>Total longitudinal stress</b>			8,285	9,183	8,931	8,565	8,923	9,539	9,347	9,151
<b>Primary membrane longitudinal stress*</b>			8,734	8,734	8,748	8,748	9,231	9,231	9,249	9,249
<b>Shear from <math>M_t</math></b>			89	89	89	89	89	89	89	89
<b>Circ shear from <math>V_c</math></b>			36	36	-36	-36	0	0	0	0
<b>Long shear from <math>V_L</math></b>			0	0	0	0	-36	-36	36	36
<b>Total Shear stress</b>			125	125	53	53	53	53	125	125
<b>Combined stress (<math>P_L+P_b+Q</math>)</b>			18,169	18,785	18,619	18,439	17,023	17,971	17,723	17,303

Note: \* denotes primary stress.

### Longitudinal stress in the nozzle wall due to internal pressure + external loads

$$\begin{aligned} \sigma_{n(P_m)} &= P^*R_i / (2^*t_n) - P_r / (\pi^*(R_o^2 - R_i^2)) + M^*R_o / I \\ &= 1,378.36^*1 / (2^*1.06) - 334 / (\pi^*(2.06^2 - 1^2)) + 4,193.1^*2.06 / 13.3582 \\ &= 1,264 \text{ psi} \end{aligned}$$

The average primary stress  $P_m$  (see Division 2 5.6.a.1) across the nozzle wall due to internal pressure + external loads is acceptable ( $\leq S = 20,000$  psi)

### Shear stress in the nozzle wall due to external loads

$$\begin{aligned} \sigma_{\text{shear}} &= (V_L^2 + V_c^2)^{0.5} / (\pi^*R_i^2*t_n) \\ &= (409^2 + 409^2)^{0.5} / (\pi^*1^2*1.06) \\ &= 174 \text{ psi} \end{aligned}$$

$$\begin{aligned} \sigma_{\text{torsion}} &= M_t / (2^*\pi^*R_i^2*t_n) \\ &= 4,160 / (2^*\pi^*1^2*1.06) \end{aligned}$$

= 625 psi

$$\begin{aligned}\sigma_{\text{total}} &= \sigma_{\text{shear}} + \sigma_{\text{torsion}} \\ &= 174 + 625 \\ &= 798 \text{ psi}\end{aligned}$$

UG-45: The total combined shear stress (798 psi) is below than the allowable ( $0.7 \cdot S_n = 0.7 \cdot 20,000 = 14,000$  psi)



## Reinforcement Calculations for MAEP

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For Pe = 622.51 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

Calculations for external pressure 622.51 psi @ 140 °F

### Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

### Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28  $t_m = 0.1482$  in

From UG-37(d)(1) required thickness  $t_r = 1.75$  in

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

### UW-16(c) Weld Check

Fillet weld:  $t_{min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$   
 $t_{c(min)} = \text{lesser of } 0.25 \text{ or } 0.7*t_{min} = \underline{0.25} \text{ in}$   
 $t_{c(actual)} = 0.7*Leg = 0.7*0.375 = 0.2625 \text{ in}$

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

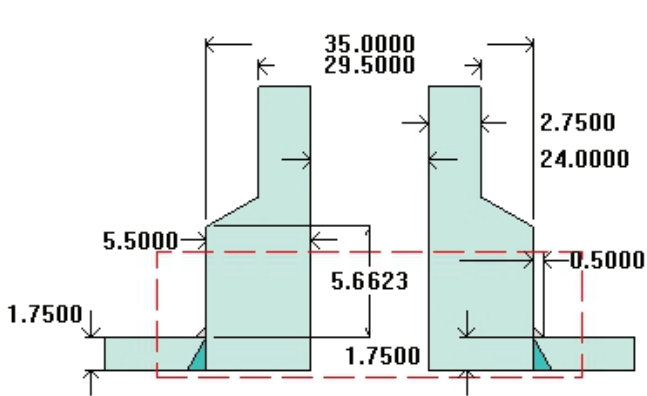
$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 12,976.69 / (3 \cdot (4.12 / 0.1482)) \\ &= 622.51 \text{ psi} \end{aligned}$$

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

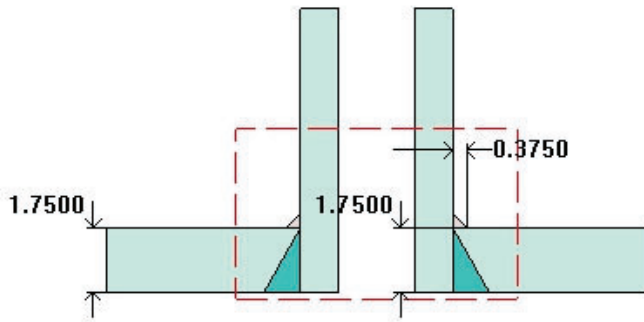
$$t_a = t + \text{Corrosion} = 1.1622 + 0 = 1.1622''$$

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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)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

### Calculations for internal pressure 1,378 psi @ 140 °F

Nozzle Impact test exempt per UHA-51(g)(coincident ratio = 0.0678).

#### Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

#### Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

#### Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

#### Required thickness t<sub>r</sub> from UG-37(a)

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378) \\
 &= 1.6092 \text{ in}
 \end{aligned}$$

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

### UW-16(c) Weld Check

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

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

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

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

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

$$\begin{aligned}t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0719, 0 ] \\ &= 0.0719 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378) + 0 \\ &= 1.6092 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6092, 0.0625 ] \\ &= 1.6092 \text{ in}\end{aligned}$$

$$\begin{aligned}t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.2074, 1.6092 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0719, 0.2074 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.



## Reinforcement Calculations for MAEP

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For Pe = 622.51 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

Calculations for external pressure 622.51 psi @ 140 °F

### Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

### Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28  $t_m = 0.1482$  in

From UG-37(d)(1) required thickness  $t_r = 1.75$  in

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

### UW-16(c) Weld Check

Fillet weld:  $t_{min} =$  lesser of 0.75 or  $t_n$  or  $t = 0.75$  in  
 $t_{c(min)} =$  lesser of 0.25 or  $0.7*t_{min} = 0.25$  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:  $B = 12,976.6933 \text{ psi}$

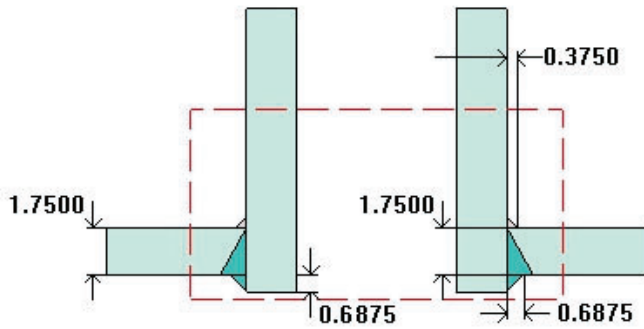
$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 12,976.69 / (3 \cdot (4.12 / 0.1482)) \\ &= 622.51 \text{ psi} \end{aligned}$$

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

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

## Inlet (N1)

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$$t_{w(\text{lower})} = 1.75 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$

$$\text{Leg}_{43} = 0.6875 \text{ in}$$

$$h_{\text{new}} = 0.6875 \text{ in}$$

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

#### Location and Orientation

Located on:	48 OD SHELL
Orientation:	0°
Nozzle center line offset to datum line:	32 in
End of nozzle to shell center:	34 in
Passes through a Category A joint:	No

#### Nozzle

Access opening:	No
Material specification:	SA-182 F316 $\leq 5$ (II-D p. 70, In. 22)
Inside diameter, new:	8 in
Nominal wall thickness:	1.875 in
Corrosion allowance:	0 in
Projection available outside vessel, L <sub>pr</sub> :	7.25 in
Internal projection, h <sub>new</sub> :	0.6875 in
Projection available outside vessel to flange face, L <sub>f</sub> :	10 in
Local vessel minimum thickness:	1.75 in
Liquid static head included:	0 psi
Longitudinal joint efficiency:	1

#### ASME B16.5-2009 Flange

Description:	NPS 8 Class 900 LWN A182 F316
Bolt Material:	SA-193 B7 Bolt $\leq 2 \frac{1}{2}$ (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55 °F
(Per UHA-51(d)(1)(a))	
(Flange rated MDMT = -320 °F	
Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F)	
Liquid static head:	0 psi
MAWP rating:	2,040 psi @ 140 °F

MAP rating:	2,160 psi @ 50°F
Hydrotest rating:	3,250 psi @ 50°F
PWHT performed:	No

**Reinforcement Calculations for Chamber MAWP**

<b>UG-37 Area Calculation Summary (in<sup>2</sup>)</b> For P = 1,378 psi @ 140 °F The opening is adequately reinforced							<b>UG-45 Nozzle Wall Thickness Summary (in)</b> The nozzle passes UG-45	
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
<a href="#">12.874</a>	<a href="#">18.208</a>	<a href="#">1.126</a>	<a href="#">13.8906</a>	<a href="#">2.5781</a>	--	<a href="#">0.6133</a>	<a href="#">0.3281</a>	1.875

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

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for internal pressure 1,378 psi @ 140 °F**

Nozzle rated MDMT per UHA-51(d)(1)(a) = -320 °F.

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(8, 4 + (1.875 - 0) + (1.75 - 0)) \\
 &= 8 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.875 - 0) + 0) \\
 &= 4.375 \text{ in}
 \end{aligned}$$

**Inner Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_I &= \text{MIN}(2.5*(t - C), 2.5*(t_i - C_n - C)) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.875 - 0 - 0)) \\
 &= 4.375 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 4 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.2875 \text{ in}
 \end{aligned}$$

**Required thickness t<sub>r</sub> from UG-37(a)**

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378)
 \end{aligned}$$



$$= 1.6092 \text{ in}$$

### Area required per UG-37(c)

Allowable stresses:  $S_n = 20,000$ ,  $S_v = 20,000$  psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$\begin{aligned} A &= d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1}) \\ &= 8 \cdot 1.6093 \cdot 1 + 2 \cdot 1.875 \cdot 1.6093 \cdot 1 \cdot (1 - 1) \\ &= \underline{12.874} \text{ in}^2 \end{aligned}$$

### Area available from FIG. UG-37.1

$$A_1 = \text{larger of the following} = \underline{1.126} \text{ in}^2$$

$$\begin{aligned} &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 8 \cdot (1 \cdot 1.75 - 1 \cdot 1.6093) - 2 \cdot 1.875 \cdot (1 \cdot 1.75 - 1 \cdot 1.6093) \cdot (1 - 1) \\ &= 1.126 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2 \cdot (1.75 + 1.875) \cdot (1 \cdot 1.75 - 1 \cdot 1.6093) - 2 \cdot 1.875 \cdot (1 \cdot 1.75 - 1 \cdot 1.6093) \cdot (1 - 1) \\ &= 1.0204 \text{ in}^2 \end{aligned}$$

$$A_2 = \text{smaller of the following} = \underline{13.8906} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t \\ &= 5 \cdot (1.875 - 0.2875) \cdot 1 \cdot 1.75 \\ &= 13.8906 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (1.875 - 0.2875) \cdot 1 \cdot 1.875 \\ &= 14.8828 \text{ in}^2 \end{aligned}$$

$$A_3 = \text{smaller of the following} = \underline{2.5781} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot t_i \cdot f_{r2} \\ &= 5 \cdot 1.75 \cdot 1.875 \cdot 1 \\ &= \underline{16.4063} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 5 \cdot t_i \cdot t_i \cdot f_{r2} \\ &= 5 \cdot 1.875 \cdot 1.875 \cdot 1 \\ &= \underline{17.5781} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 2 \cdot h \cdot t_i \cdot f_{r2} \\ &= 2 \cdot 0.6875 \cdot 1.875 \cdot 1 \end{aligned}$$

$$= \underline{2.5781} \text{ in}^2$$

$$\begin{aligned} A_{41} &= \text{Leg}^2 * f_{r2} \\ &= 0.375^2 * 1 \\ &= \underline{0.1406} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} A_{43} &= \text{Leg}^2 * f_{r2} \\ &= 0.6875^2 * 1 \\ &= \underline{0.4727} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_3 + A_{41} + A_{43} \\ &= 1.126 + 13.8906 + 2.5781 + 0.1406 + 0.4727 \\ &= \underline{18.208} \text{ in}^2 \end{aligned}$$

As Area  $\geq$  A the reinforcement is adequate.

### UW-16(c) Weld Check

Fillet weld:  $t_{\min}$  = lesser of 0.75 or  $t_n$  or  $t = 0.75$  in

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

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

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$\begin{aligned} t_{a \text{ UG-27}} &= P * R / (S * E - 0.6 * P) + \text{Corrosion} \\ &= 1,378 * 4 / (20,000 * 1 - 0.6 * 1,378) + 0 \\ &= 0.2875 \text{ in} \end{aligned}$$

$$t_{a \text{ UG-22}} = 0.2543 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.2875, 0.2543 ] \\ &= 0.2875 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= P * R_o / (S * E + 0.4 * P) + \text{Corrosion} \\ &= 1,378 * 24 / (20,000 * 1 + 0.4 * 1,378) + 0 \\ &= 1.6092 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6092, 0.0625 ] \\ &= 1.6092 \text{ in} \end{aligned}$$

$$t_b = \min[ t_{b3}, t_{b1} ]$$

$$\begin{aligned} &= \min[ 0.3281 , 1.6092 ] \\ &= 0.3281 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{UG-45} &= \max[ t_a , t_b ] \\ &= \max[ 0.2875 , 0.3281 ] \\ &= 0.3281 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.875$  in

The nozzle neck thickness is adequate.

## Applied Loads

Radial load:	$P_r = 2,720$	$lb_f$
Circumferential moment:	$M_c = 92,535$	$lb_f\text{-in}$
Circumferential shear:	$V_c = 3,332$	$lb_f$
Longitudinal moment:	$M_L = 92,535$	$lb_f\text{-in}$
Longitudinal shear:	$V_L = 3,332$	$lb_f$
Torsion moment:	$M_t = 130,858$	$lb_f\text{-in}$
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,  $I = 1.11447$  (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

$$\begin{aligned} P_a &= 4*B / (3*(D_o / t)) \\ &= 4*13,772.85 / (3*(11.75 / 0.3983)) \\ &= 622.51 \text{ psi} \end{aligned}$$

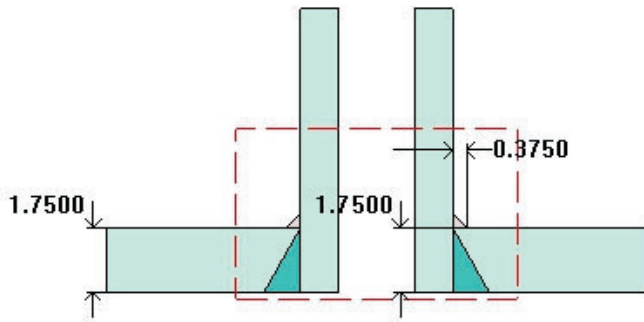
**Design thickness for external pressure  $P_a = 622.51$  psi**

$$t_a = t + \text{Corrosion} = 0.3983 + 0 = 0.3983''$$

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

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

Calculations for external pressure 622.51 psi @ 140 °F

### Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

### Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28  $t_m = 0.1482$  in

From UG-37(d)(1) required thickness  $t_r = 1.75$  in

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

### UW-16(c) Weld Check

Fillet weld:  $t_{min} =$  lesser of 0.75 or  $t_n$  or  $t = 0.75$  in  
 $t_{c(min)} =$  lesser of 0.25 or  $0.7*t_{min} = 0.25$  in  
 $t_{c(actual)} = 0.7*Leg = 0.7*0.375 = 0.2625$  in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

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

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.1482, 0 ] \\ &= 0.1482 \text{ in} \end{aligned}$$

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

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

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

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

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

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

$$L / D_o = 8.0886 / 4.12 = 1.9632$$

$$D_o / t = 4.12 / 0.1482 = 27.7945$$

From table G:  $A = 0.004502$

From table HA-2:  $B = 12,976.6933 \text{ psi}$

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

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

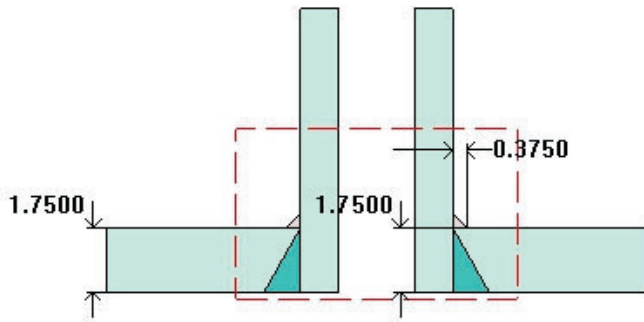
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

## Level Bridle - (Process) High (N8A)

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$$t_{w(\text{lower})} = 1.75 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

### Location and Orientation

Located on:	48 OD SHELL
Orientation:	135°
Nozzle center line offset to datum line:	26 in
End of nozzle to shell center:	32 in
Passes through a Category A joint:	No

### Nozzle

Access opening:	No
Material specification:	SA-182 F316 ≤ 5 (II-D p. 70, In. 22)
Inside diameter, new:	2 in
Nominal wall thickness:	1.06 in
Corrosion allowance:	0 in
Projection available outside vessel, L <sub>pr</sub> :	6.25 in
Projection available outside vessel to flange face, L <sub>f</sub> :	8 in
Local vessel minimum thickness:	1.75 in
Liquid static head included:	0 psi
Longitudinal joint efficiency:	1

### ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 LWN A182 F316
Bolt Material:	SA-193 B7 Bolt ≤ 2 1/2 (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55°F
(Per UHA-51(d)(1)(a))	
(Flange rated MDMT = -320 °F)	
Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F)	
Liquid static head:	0 psi
MAWP rating:	2,040 psi @ 140°F
MAP rating:	2,160 psi @ 50°F



Hydrotest rating:  
PWHT performed:

3,250 psi @ 50°F  
No

**Reinforcement Calculations for Chamber MAWP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For P = 1,378 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

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

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for internal pressure 1,378 psi @ 140 °F**

Nozzle Impact test exempt per UHA-51(g)(coincident ratio = 0.0678).

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

**Required thickness t<sub>r</sub> from UG-37(a)**

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378) \\
 &= 1.6092 \text{ in}
 \end{aligned}$$

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

### UW-16(c) Weld Check

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

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

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

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

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

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0719, 0 ] \\ &= 0.0719 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378) + 0 \\ &= 1.6092 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6092, 0.0625 ] \\ &= 1.6092 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.2074, 1.6092 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0719, 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

**Reinforcement Calculations for MAEP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For Pe = 622.51 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

<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 $P_a = 622.51 \text{ psi}$

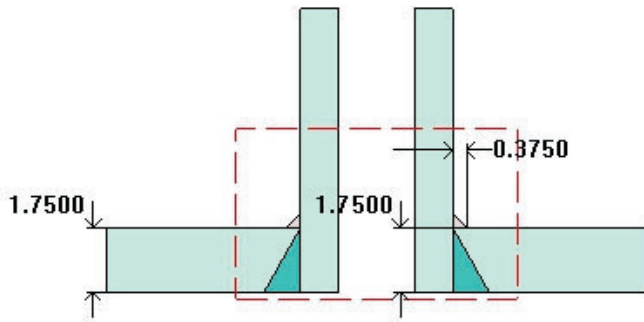
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

## Level Bridle - (Process) Low (N8B)

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$$t_{w(\text{lower})} = 1.75 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

### Location and Orientation

Located on:	48 OD SHELL
Orientation:	135°
Nozzle center line offset to datum line:	88 in
End of nozzle to shell center:	32 in
Passes through a Category A joint:	No

### Nozzle

Access opening:	No
Material specification:	SA-182 F316 $\leq 5$ (II-D p. 70, In. 22)
Inside diameter, new:	2 in
Nominal wall thickness:	1.06 in
Corrosion allowance:	0 in
Projection available outside vessel, L <sub>pr</sub> :	6.25 in
Projection available outside vessel to flange face, L <sub>f</sub> :	8 in
Local vessel minimum thickness:	1.75 in
Liquid static head included:	0.3574 psi
Longitudinal joint efficiency:	1

### ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 LWN A182 F316
Bolt Material:	SA-193 B7 Bolt $\leq 2 \frac{1}{2}$ (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55°F
(Per UHA-51(d)(1)(a))	
(Flange rated MDMT = -320 °F)	
Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F)	
Liquid static head:	0.3177 psi
MAWP rating:	2,040 psi @ 140°F
MAP rating:	2,160 psi @ 50°F



Hydrotest rating:  
PWHT performed:

3,250 psi @ 50°F  
No

**Reinforcement Calculations for Chamber MAWP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For P = 1,378.36 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

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

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for internal pressure 1,378.36 psi @ 140 °F**

Nozzle Impact test exempt per UHA-51(g)(coincident ratio = 0.0678).

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378.3574 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378.3574) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

**Required thickness t<sub>r</sub> from UG-37(a)**

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 1,378.3574 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378.3574) \\
 &= 1.6097 \text{ in}
 \end{aligned}$$

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

### UW-16(c) Weld Check

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

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

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

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$\begin{aligned} t_{a \text{ UG-27}} &= P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion} \\ &= 1,378.3574 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378.3574) + 0 \\ &= 0.0719 \text{ in} \end{aligned}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0719, 0 ] \\ &= 0.0719 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 1,378.3574 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378.3574) + 0 \\ &= 1.6097 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6097, 0.0625 ] \\ &= 1.6097 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.2074, 1.6097 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0719, 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

**Reinforcement Calculations for MAEP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For Pe = 622.51 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for external pressure 622.51 psi @ 140 °F**

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-28 t<sub>m</sub> = 0.1482 in**

**From UG-37(d)(1) required thickness t<sub>r</sub> = 1.75 in**

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

**UW-16(c) Weld Check**

Fillet weld: t<sub>min</sub> = lesser of 0.75 or t<sub>n</sub> or t = 0.75 in  
 t<sub>c(min)</sub> = lesser of 0.25 or 0.7\*t<sub>min</sub> = [0.25](#) in  
 t<sub>c(actual)</sub> = 0.7\*Leg = 0.7\*0.375 = 0.2625 in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

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

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.1482, 0 ] \\ &= 0.1482 \text{ in} \end{aligned}$$

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

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

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

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

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

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

$$L / D_o = 8.0886 / 4.12 = 1.9632$$

$$D_o / t = 4.12 / 0.1482 = 27.7945$$

From table G:  $A = 0.004502$

From table HA-2:  $B = 12,976.6933 \text{ psi}$

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

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

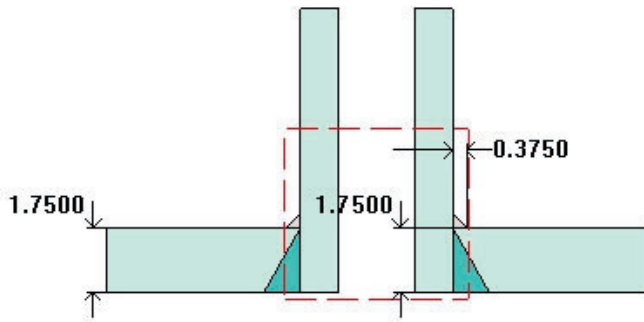
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

## Level Bridle - (Safety) Low (N9B)

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

$$t_{w(\text{lower})} = 1.75 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

#### Location and Orientation

Located on:	48 OD SHELL
Orientation:	315°
Nozzle center line offset to datum line:	88 in
End of nozzle to shell center:	32 in
Passes through a Category A joint:	No

#### Nozzle

Access opening:	No
Material specification:	SA-182 F316 $\leq 5$ (II-D p. 70, In. 22)
Inside diameter, new:	2 in
Nominal wall thickness:	1.06 in
Corrosion allowance:	0 in
Projection available outside vessel, L <sub>pr</sub> :	6.25 in
Projection available outside vessel to flange face, L <sub>f</sub> :	8 in
Local vessel minimum thickness:	1.75 in
User input radial limit of reinforcement:	2.5 in
Liquid static head included:	0.3574 psi
Longitudinal joint efficiency:	1

#### ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 LWN A182 F316
Bolt Material:	SA-193 B7 Bolt $\leq 2 \frac{1}{2}$ (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55°F
(Per UHA-51(d)(1)(a))	
(Flange rated MDMT = -320 °F	
Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F)	
Liquid static head:	0.3177 psi
MAWP rating:	2,040 psi @ 140°F



MAP rating:	2,160 psi @ 50°F
Hydrotest rating:	3,250 psi @ 50°F
PWHT performed:	No

**Reinforcement Calculations for Chamber MAWP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For P = 1,378.36 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

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

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for internal pressure 1,378.36 psi @ 140 °F**

Nozzle Impact test exempt per UHA-51(g)(coincident ratio = 0.0678).

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

$$L_R = 2.5 \text{ in (User Defined)}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378.3574 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378.3574) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

**Required thickness t<sub>r</sub> from UG-37(a)**

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 1,378.3574 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378.3574) \\
 &= 1.6097 \text{ in}
 \end{aligned}$$

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

### **UW-16(c) Weld Check**

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

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

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

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### **UG-45 Nozzle Neck Thickness Check**

$$\begin{aligned} t_{a \text{ UG-27}} &= P * R / (S * E - 0.6 * P) + \text{Corrosion} \\ &= 1,378.3574 * 1 / (20,000 * 1 - 0.6 * 1,378.3574) + 0 \\ &= 0.0719 \text{ in} \end{aligned}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0719, 0 ] \\ &= 0.0719 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= P * R_o / (S * E + 0.4 * P) + \text{Corrosion} \\ &= 1,378.3574 * 24 / (20,000 * 1 + 0.4 * 1,378.3574) + 0 \\ &= 1.6097 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6097, 0.0625 ] \\ &= 1.6097 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.2074, 1.6097 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0719, 0.2074 ] \\ &= 0.2074 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

## Reinforcement Calculations for MAEP

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For Pe = 622.51 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

Calculations for external pressure 622.51 psi @ 140 °F

### Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

### Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28  $t_m = 0.1482$  in

From UG-37(d)(1) required thickness  $t_r = 1.75$  in

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

### UW-16(c) Weld Check

Fillet weld:  $t_{min} =$  lesser of 0.75 or  $t_n$  or  $t = 0.75$  in  
 $t_{c(min)} =$  lesser of 0.25 or  $0.7*t_{min} = \underline{0.25}$  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 $P_a = 622.51 \text{ psi}$

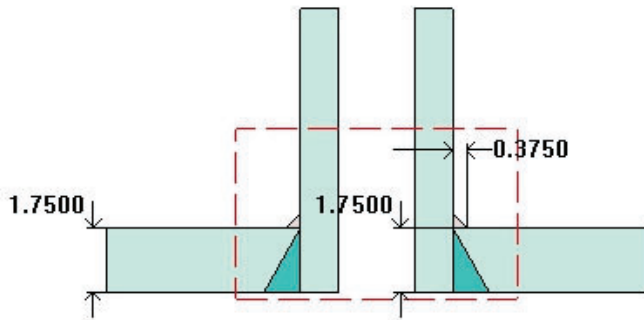
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

## 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)

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

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

#### Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

#### Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378.3574 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378.3574) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

#### Required thickness t<sub>r</sub> from UG-37(a)

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 1,378.3574 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378.3574) \\
 &= 1.6097 \text{ in}
 \end{aligned}$$

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

### UW-16(c) Weld Check

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

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

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

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$\begin{aligned}t_{a \text{ UG-27}} &= P*R / (S*E - 0.6*P) + \text{Corrosion} \\ &= 1,378.3574*1 / (20,000*1 - 0.6*1,378.3574) + 0 \\ &= 0.0719 \text{ in}\end{aligned}$$

$$t_{a \text{ UG-22}} = 0.0835 \text{ in}$$

$$\begin{aligned}t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.0719, 0.0835 ] \\ &= 0.0835 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= P*R_o / (S*E + 0.4*P) + \text{Corrosion} \\ &= 1,378.3574*24 / (20,000*1 + 0.4*1,378.3574) + 0 \\ &= 1.6097 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6097, 0.0625 ] \\ &= 1.6097 \text{ in}\end{aligned}$$

$$\begin{aligned}t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.2074, 1.6097 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.0835, 0.2074 ] \\ &= 0.2074 \text{ in}\end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

## Applied Loads

Radial load:	$P_r = 334$	$lb_f$
Circumferential moment:	$M_c = 2,965$	$lb_f\text{-in}$
Circumferential shear:	$V_c = 409$	$lb_f$
Longitudinal moment:	$M_L = 2,965$	$lb_f\text{-in}$
Longitudinal shear:	$V_L = 409$	$lb_f$
Torsion moment:	$M_t = 4,160$	$lb_f\text{-in}$
Internal pressure:	$P = 1,378.357$	psi
Mean shell radius:	$R_m = 23.125$	in
Local shell thickness:	$t = 1.75$	in
Shell yield stress:	$S_y = 27,900$	psi

### Maximum stresses due to the applied loads at the nozzle OD (includes pressure)

$$R_m / t = 23.125 / 1.75 = 13.2143$$

Pressure stress intensity factor,  $I = 1.05703$  (derived from PVP-Vol. 399, pages 77-82)

$$\text{Local circumferential pressure stress} = I * P * R_i / t = 18,524 \text{ psi}$$

$$\text{Local longitudinal pressure stress} = I * P * R_i / (2 * t) = 9,262 \text{ psi}$$

$$\text{Maximum combined stress } (P_L + P_b + Q) = 18,785 \text{ psi}$$

$$\text{Allowable combined stress } (P_L + P_b + Q) = +-3 * S = +-60,000 \text{ psi}$$

Note: The allowable combined stress  $(P_L + P_b + Q)$  is based on the strain hardening characteristics of this material.

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

$$\text{Maximum local primary membrane stress } (P_L) = 18,529 \text{ psi}$$

$$\text{Allowable local primary membrane stress } (P_L) = +-1.5 * S = +-30,000 \text{ psi}$$

The maximum local primary membrane stress  $(P_L)$  is within allowable limits.

Stresses at the nozzle OD per WRC Bulletin 107										
Figure	value	$\beta$	$A_u$	$A_l$	$B_u$	$B_l$	$C_u$	$C_l$	$D_u$	$D_l$
3C*	2.5705	0.0779	0	0	0	0	-21	-21	-21	-21
4C*	2.6145	0.0779	-22	-22	-22	-22	0	0	0	0
1C	0.2014	0.0779	0	0	0	0	-132	132	-132	132
2C-1	0.1661	0.0779	-109	109	-109	109	0	0	0	0
3A*	0.1676	0.0779	0	0	0	0	-7	-7	7	7
1A	0.1061	0.0779	0	0	0	0	-342	342	342	-342
3B*	0.6597	0.0779	-27	-27	27	27	0	0	0	0
1B-1	0.0616	0.0779	-199	199	199	-199	0	0	0	0
<b>Pressure stress*</b>			18,524	18,524	18,524	18,524	17,525	17,525	17,525	17,525
<b>Total circumferential stress</b>			18,167	18,783	18,619	18,439	17,023	17,971	17,721	17,301
<b>Primary membrane circumferential stress*</b>			18,475	18,475	18,529	18,529	17,497	17,497	17,511	17,511
3C*	2.5705	0.0779	-21	-21	-21	-21	0	0	0	0
4C*	2.6145	0.0779	0	0	0	0	-22	-22	-22	-22
1C-1	0.2031	0.0779	-133	133	-133	133	0	0	0	0
2C	0.1599	0.0779	0	0	0	0	-105	105	-105	105
4A*	0.2212	0.0779	0	0	0	0	-9	-9	9	9
2A	0.063	0.0779	0	0	0	0	-203	203	203	-203
4B*	0.1671	0.0779	-7	-7	7	7	0	0	0	0
2B-1	0.098	0.0779	-316	316	316	-316	0	0	0	0
<b>Pressure stress*</b>			8,762	8,762	8,762	8,762	9,262	9,262	9,262	9,262
<b>Total longitudinal stress</b>			8,285	9,183	8,931	8,565	8,923	9,539	9,347	9,151
<b>Primary membrane longitudinal stress*</b>			8,734	8,734	8,748	8,748	9,231	9,231	9,249	9,249
<b>Shear from <math>M_t</math></b>			89	89	89	89	89	89	89	89
<b>Circ shear from <math>V_c</math></b>			36	36	-36	-36	0	0	0	0
<b>Long shear from <math>V_L</math></b>			0	0	0	0	-36	-36	36	36
<b>Total Shear stress</b>			125	125	53	53	53	53	125	125
<b>Combined stress (<math>P_L+P_b+Q</math>)</b>			18,169	18,785	18,619	18,439	17,023	17,971	17,723	17,303

Note: \* denotes primary stress.

### Longitudinal stress in the nozzle wall due to internal pressure + external loads

$$\begin{aligned} \sigma_{n(P_m)} &= P^*R_i / (2^*t_n) - P_r / (\pi^*(R_o^2 - R_i^2)) + M^*R_o / I \\ &= 1,378.36^*1 / (2^*1.06) - 334 / (\pi^*(2.06^2 - 1^2)) + 4,193.1^*2.06 / 13.3582 \\ &= 1,264 \text{ psi} \end{aligned}$$

The average primary stress  $P_m$  (see Division 2 5.6.a.1) across the nozzle wall due to internal pressure + external loads is acceptable ( $\leq S = 20,000$  psi)

### Shear stress in the nozzle wall due to external loads

$$\begin{aligned} \sigma_{\text{shear}} &= (V_L^2 + V_c^2)^{0.5} / (\pi^*R_i^2*t_n) \\ &= (409^2 + 409^2)^{0.5} / (\pi^*1^2*1.06) \\ &= 174 \text{ psi} \end{aligned}$$

$$\begin{aligned} \sigma_{\text{torsion}} &= M_t / (2^*\pi^*R_i^2*t_n) \\ &= 4,160 / (2^*\pi^*1^2*1.06) \end{aligned}$$

= 625 psi

$$\begin{aligned}\sigma_{\text{total}} &= \sigma_{\text{shear}} + \sigma_{\text{torsion}} \\ &= 174 + 625 \\ &= 798 \text{ psi}\end{aligned}$$

UG-45: The total combined shear stress (798 psi) is below than the allowable ( $0.7 \cdot S_n = 0.7 \cdot 20,000 = 14,000$  psi)



## Reinforcement Calculations for MAEP

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For Pe = 622.51 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<a href="#">0.2074</a>	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

Calculations for external pressure 622.51 psi @ 140 °F

### Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

### Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28  $t_m = 0.1482$  in

From UG-37(d)(1) required thickness  $t_r = 1.75$  in

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

### UW-16(c) Weld Check

Fillet weld:  $t_{min} =$  lesser of 0.75 or  $t_n$  or  $t = 0.75$  in  
 $t_{c(min)} =$  lesser of 0.25 or  $0.7*t_{min} = \underline{0.25}$  in  
 $t_{c(actual)} = 0.7*Leg = 0.7*0.375 = 0.2625$  in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

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

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

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

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

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

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

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

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

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

$$L / D_o = 8.0886 / 4.12 = 1.9632$$

$$D_o / t = 4.12 / 0.1482 = 27.7945$$

From table G:  $A = 0.004502$

From table  
HA-2:  $B = 12,976.6933 \text{ psi}$

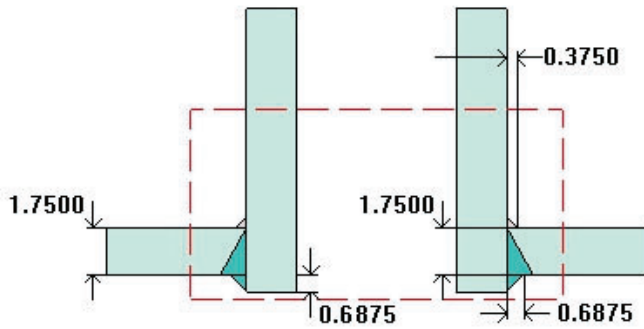
$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 12,976.69 / (3 \cdot (4.12 / 0.1482)) \\ &= 622.51 \text{ psi} \end{aligned}$$

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

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

## Inspection c/w Blind Flange (N15)

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



$$t_{w(\text{lower})} = 1.75 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$

$$\text{Leg}_{43} = 0.6875 \text{ in}$$

$$h_{\text{new}} = 0.6875 \text{ in}$$

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

#### Location and Orientation

Located on:	48 OD SHELL
Orientation:	45°
Nozzle center line offset to datum line:	8 in
End of nozzle to shell center:	34 in
Passes through a Category A joint:	No

#### Nozzle

Access opening:	No
Material specification:	SA-182 F316 $\leq 5$ (II-D p. 70, In. 22)
Inside diameter, new:	8 in
Nominal wall thickness:	1.875 in
Corrosion allowance:	0 in
Projection available outside vessel, $L_{pr}$ :	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)

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<a href="#">0.25</a>	0.2625	weld size is adequate

**Calculations for internal pressure 1,378 psi @ 140 °F**

Nozzle rated MDMT per UHA-51(d)(1)(a) = -320 °F.

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(8, 4 + (1.875 - 0) + (1.75 - 0)) \\
 &= 8 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.875 - 0) + 0) \\
 &= 4.375 \text{ in}
 \end{aligned}$$

**Inner Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_I &= \text{MIN}(2.5*(t - C), 2.5*(t_i - C_n - C)) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.875 - 0 - 0)) \\
 &= 4.375 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 4 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.2875 \text{ in}
 \end{aligned}$$

**Required thickness t<sub>r</sub> from UG-37(a)**

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378)
 \end{aligned}$$

$$= 1.6092 \text{ in}$$

### Area required per UG-37(c)

Allowable stresses:  $S_n = 20,000$ ,  $S_v = 20,000$  psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$\begin{aligned} A &= d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1}) \\ &= 8 \cdot 1.6093 \cdot 1 + 2 \cdot 1.875 \cdot 1.6093 \cdot 1 \cdot (1 - 1) \\ &= \underline{12.874} \text{ in}^2 \end{aligned}$$

### Area available from FIG. UG-37.1

$$A_1 = \text{larger of the following} = \underline{1.126} \text{ in}^2$$

$$\begin{aligned} &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 8 \cdot (1 \cdot 1.75 - 1 \cdot 1.6093) - 2 \cdot 1.875 \cdot (1 \cdot 1.75 - 1 \cdot 1.6093) \cdot (1 - 1) \\ &= 1.126 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2 \cdot (1.75 + 1.875) \cdot (1 \cdot 1.75 - 1 \cdot 1.6093) - 2 \cdot 1.875 \cdot (1 \cdot 1.75 - 1 \cdot 1.6093) \cdot (1 - 1) \\ &= 1.0204 \text{ in}^2 \end{aligned}$$

$$A_2 = \text{smaller of the following} = \underline{13.8906} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t \\ &= 5 \cdot (1.875 - 0.2875) \cdot 1 \cdot 1.75 \\ &= 13.8906 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (1.875 - 0.2875) \cdot 1 \cdot 1.875 \\ &= 14.8828 \text{ in}^2 \end{aligned}$$

$$A_3 = \text{smaller of the following} = \underline{2.5781} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot t_i \cdot f_{r2} \\ &= 5 \cdot 1.75 \cdot 1.875 \cdot 1 \\ &= \underline{16.4063} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 5 \cdot t_i \cdot t_i \cdot f_{r2} \\ &= 5 \cdot 1.875 \cdot 1.875 \cdot 1 \\ &= \underline{17.5781} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 2 \cdot h \cdot t_i \cdot f_{r2} \\ &= 2 \cdot 0.6875 \cdot 1.875 \cdot 1 \end{aligned}$$



$$= \underline{2.5781} \text{ in}^2$$

$$\begin{aligned} A_{41} &= \text{Leg}^2 * f_{r2} \\ &= 0.375^2 * 1 \\ &= \underline{0.1406} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} A_{43} &= \text{Leg}^2 * f_{r2} \\ &= 0.6875^2 * 1 \\ &= \underline{0.4727} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_3 + A_{41} + A_{43} \\ &= 1.126 + 13.8906 + 2.5781 + 0.1406 + 0.4727 \\ &= \underline{18.208} \text{ in}^2 \end{aligned}$$

As Area  $\geq$  A the reinforcement is adequate.

### UW-16(c) Weld Check

Fillet weld:  $t_{\min}$  = lesser of 0.75 or  $t_n$  or  $t = 0.75$  in  
 $t_{c(\min)}$  = lesser of 0.25 or  $0.7 * t_{\min} = \underline{0.25}$  in  
 $t_{c(\text{actual})} = 0.7 * \text{Leg} = 0.7 * 0.375 = 0.2625$  in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$\begin{aligned} t_{a \text{ UG-27}} &= P * R / (S * E - 0.6 * P) + \text{Corrosion} \\ &= 1,378 * 4 / (20,000 * 1 - 0.6 * 1,378) + 0 \\ &= 0.2875 \text{ in} \end{aligned}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.2875, 0 ] \\ &= 0.2875 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= P * R_o / (S * E + 0.4 * P) + \text{Corrosion} \\ &= 1,378 * 24 / (20,000 * 1 + 0.4 * 1,378) + 0 \\ &= 1.6092 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 1.6092, 0.0625 ] \\ &= 1.6092 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.3281, 1.6092 ] \\ &= 0.3281 \text{ in} \end{aligned}$$

$$\begin{aligned}t_{UG-45} &= \max[ t_a, t_b ] \\ &= \max[ 0.2875, 0.3281 ] \\ &= 0.3281 \text{ in}\end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.875$  in

The nozzle neck thickness is adequate.

**Reinforcement Calculations for MAEP**

<b>UG-37 Area Calculation Summary (in<sup>2</sup>)</b> For $P_e = 622.51 \text{ psi @ } 140 \text{ }^\circ\text{F}$ 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

$$t_{a \text{ UG-28}} = 0.3983 \text{ in}$$

$$t_a = \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ]$$

$$= \max[ 0.3983, 0 ]$$

$$= 0.3983 \text{ in}$$

$$t_{b2} = P * R_o / (S * E + 0.4 * P) + \text{Corrosion}$$

$$= 622.5059 * 24 / (20,000 * 1 + 0.4 * 622.5059) + 0$$

$$= 0.7378 \text{ in}$$

$$t_{b2} = \max[ t_{b2}, t_{b \text{ UG16}} ]$$

$$= \max[ 0.7378, 0.0625 ]$$

$$= 0.7378 \text{ in}$$

$$t_b = \min[ t_{b3}, t_{b2} ]$$

$$= \min[ 0.3281, 0.7378 ]$$

$$= 0.3281 \text{ in}$$

$$t_{\text{UG-45}} = \max[ t_a, t_b ]$$

$$= \max[ 0.3983, 0.3281 ]$$

$$= 0.3983 \text{ in}$$

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, ln. 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)**

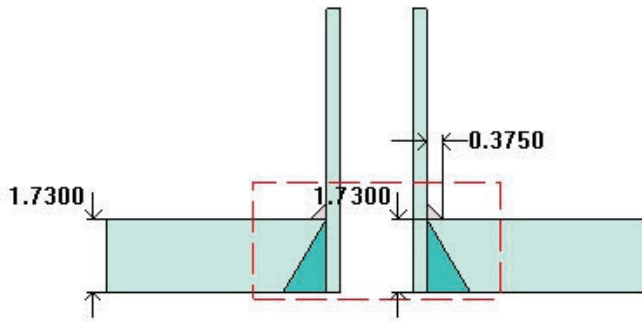
$$\begin{aligned}
 EFE &= (75 * t / R_f) * (1 - R_f / R_o) \\
 &= (75 * 1.77 / 8.4568) * (1 - 8.4568 / \infty) \\
 &= 15.6974\%
 \end{aligned}$$

## Bottom Drain (N13)

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$$t_{w(\text{lower})} = 1.73 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

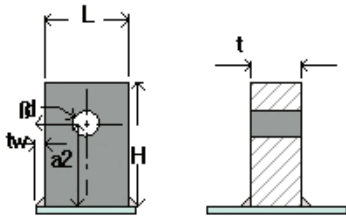
### Required thickness, compressive stress at base:

$$\begin{aligned}t &= (1 + V_{\text{Accel}}) * W / (\pi * D_t * S_c * E_c) + 48 * M / (\pi * D_t^2 * S_c * E_c) \\&= (1 + 1) * 19,538.66 / (\pi * 46.25 * 15,798 * 1) + 48 * 90,303.6 / (\pi * 46.25^2 * 15,798 * 1) \\&= \underline{0.0579} \text{ in}\end{aligned}$$

### 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

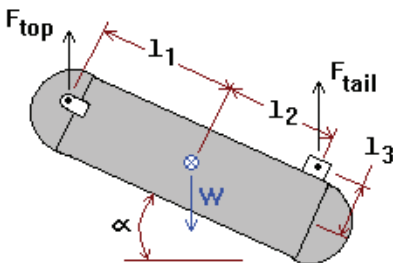
Required Lift Pin Diameter, $d_{reqd}$	<a href="#">0.8351"</a>
Required Lug Thickness, $t_{reqd}$	<a href="#">0.3246"</a>
Lug Stress Ratio, $\sigma_{ratio}$	<a href="#">0.37</a>
Weld Shear Stress Ratio, $\tau_{ratio}$	<a href="#">0.23</a>
Lug Design	Acceptable
Local Stresses	Acceptable
Base ring loading	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

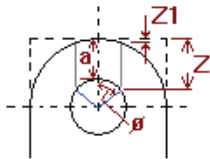
$$\begin{aligned} t_{\text{reqd}} &= [F_v / \sigma_s] / (2 * L_{\text{shear}}) \\ &= (14,592 / 13,320) / (2 * 2.0153) = \underline{0.2718"} \end{aligned}$$

$$t_{\text{reqd}} / t = 0.2718 / 1.5 = 0.18 \quad \text{Acceptable}$$

$$\begin{aligned} \tau &= F_v / A_{\text{shear}} \\ &= F_v / (2 * t * L_{\text{shear}}) \\ &= 14,592 / (2 * 1.5 * 2.0153) = 2,414 \text{ psi} \end{aligned}$$

$$\tau / \sigma_s = 2,414 / 13,320 = 0.18 \quad \text{Acceptable}$$

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



$$\begin{aligned} \phi &= 55 * D_p / d \\ &= 55 * 1.5 / 1.5625 \\ &= 52.8^\circ \end{aligned}$$

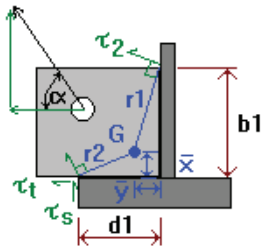
$$\begin{aligned} L_{\text{shear}} &= (H - a_2 - 0.5 * d) + 0.5 * D_p * (1 - \cos(\phi)) \\ &= (7.5 - 5 - 0.5 * 1.5625) + 0.5 * 1.5 * (1 - \cos(52.8)) \\ &= 2.0153" \end{aligned}$$

### 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

$$J_i = 0.707 * t_w * (L_i^3) / 12$$

$$J_1 = 0.707 * 0.625 * (4.625^3) / 12 = 3.643 \text{ in}^4$$

$$J_2 = 0.707 * 0.625 * (5^3) / 12 = 4.6029 \text{ in}^4$$

$$J = 2 * \Sigma (J_i + A_i * r_i^2) \quad \text{Parallel axis theorem (weld on both sides of lug)}$$

$$J = 2 * [3.6430 + 2.0437 * (1.7691)^2 + 4.6029 + 2.2094 * (1.6364)^2] = 41.12 \text{ in}^4$$

### Secondary shear

$$\tau_2 = M * r / J$$

$$= [F(\alpha) * \cos(\alpha) * (X - X_{\text{bar}}) - F(\alpha) * \sin(\alpha) * (Y - Y_{\text{bar}})] * r / J$$

$$= (14,592 * \cos(0.0) * (2.5 - 1.2987) - 14,592 * \sin(0.0) * (5 - 1.1112)) * 3.8645 / 41.1169$$

$$= 1,648 \text{ psi}$$

$$\tau_{\text{ratio}} = \text{sqr}(\tau_t + \tau_2 * \cos(\theta_r))^2 + (\tau_s + \tau_2 * \sin(\theta_r))^2 / \tau_{\text{allowable}} \leq 1$$

$$= \text{sqr}((1,484 + 1,648 * \cos(16.71))^2 + (0 + 1,648 * \sin(16.71))^2) / 13,320$$

$$= 0.23 \quad \text{Acceptable}$$

### 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)

$$\begin{aligned} A_c &= \pi(D_o^2 - D_i^2) / 4 - N\pi d_b^2 / 4 \\ &= \pi(56^2 - 42^2) / 4 - 8\pi(1.625)^2 / 4 \\ &= 1,060.9747 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} I_c &= \pi(D_o^4 - D_i^4) / 64 \\ &= \pi(56^4 - 42^4) / 64 \\ &= 330,004.7 \text{ in}^4 \end{aligned}$$

$$\begin{aligned} f_c &= N A_b \text{Preload} / A_c + W / A_c + 6 M D_o / I_c \\ &= 8 \times 0.929 \times 0 / 1,060.9747 + 18,270.39 / 1,060.9747 + 6 \times 23,645.6 \times 56 / 330,004.7 \\ &= 41 \text{ psi} \end{aligned}$$

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:,  $l / b = 0.3008$

$$M_x = 0.007 \times 41 \times 15.3758^2 = 68.7 \text{ lb}_f$$

$$M_y = -0.435 \times 41 \times 4.625^2 = -384.3 \text{ lb}_f$$

$$\begin{aligned} t_r &= (6 M_{\max} / S_p)^{0.5} \\ &= (6 \times 384.28 / 20,000)^{0.5} \\ &= 0.3395 \text{ in} \end{aligned}$$

The base plate thickness is satisfactory.

### Base plate bolt load (Jawad & Farr eq. 12.13, empty, corroded + Wind)

$$\text{Bolt load} = A_b f_s = 0.929 \times 521 = 484.47 \text{ lb}_f$$

$$\begin{aligned} t_r &= (3.91 F / (S_y (2b / w + w / (2l) - d_b (2 / w + 1 / (2l))))))^{0.5} \\ &= (3.91 \times 484.47 / (36,000 (2 \times 4.625 / 4 + 4 / (2 \times 2.25) - 1.625 (2 / 4 + 1 / (2 \times 2.25))))))^{0.5} \\ &= 0.1611 \text{ in} \end{aligned}$$

The base plate thickness is satisfactory.

### Check skirt for gusset reaction (Jawad & Farr eq. 12.14)

$$\begin{aligned} S_r &= 1.5 F b / (\text{gussets} \times \pi t_{sk}^2 h) \\ &= 1.5 \times 484.47 \times 4.625 / (2 \times \pi \times 0.5^2 \times 4.625) \\ &= 462.63 \text{ psi} \end{aligned}$$

As  $S_r \leq 30,000$  psi the skirt thickness is adequate to resist the gusset reaction.

### Anchor bolt load (empty, new + Wind)

$$\begin{aligned} P &= -W / N + 48 M / (N \times BC) \\ &= -18,270.39 / 8 + 48 \times 23,645.6 / (8 \times 51.25) \\ &= 484.47 \text{ lb}_f \end{aligned}$$

$$\text{Required area per bolt} = P / S_b = 0.0242 \text{ in}^2$$

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)

$$\begin{aligned} S_r &= 1.5 F b / (\text{gussets} \pi t_{sk}^2 h) \\ &= 1.5 \times 284.16 \times 4.625 / (2 \pi \times 0.5^2 \times 4.625) \\ &= 271.35 \text{ psi} \end{aligned}$$

As  $S_r \leq 30,000$  psi the skirt thickness is adequate to resist the gusset reaction.

### Anchor bolt load (operating, corroded + Seismic)

$$\begin{aligned} P &= -W / N + 48 M / (N BC) \\ &= -19,872.88 / 8 + 48 \times 90,303.6 / (8 \times 51.25) \\ &= 8,088.01 \text{ lb}_f \end{aligned}$$

$$\text{Required area per bolt} = P / S_b = 0.4044 \text{ in}^2$$

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

$$\begin{aligned}
 f_c &= C_c / (((t_c - t_s) + n * t_s) * (d / 2) * K_2) \\
 &= 56,766.59 / (((7 - 0.0483) + 9.2889 * 0.0483) * (49 / 2) * 1.4124) \\
 &= 222 \text{ psi}
 \end{aligned}$$

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:;  $l / b = 0.3008$

$$M_x = 0.007 * 222 * 15.3758^2 = 369 \text{ lb}_f$$

$$M_y = -0.435 * 222 * 4.625^2 = -2,062.9 \text{ lb}_f$$

$$\begin{aligned}
 t_r &= (6 * M_{\text{max}} / S_p)^{0.5} \\
 &= (6 * 2,062.91 / 20,000)^{0.5} \\
 &= 0.7867 \text{ in}
 \end{aligned}$$

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**

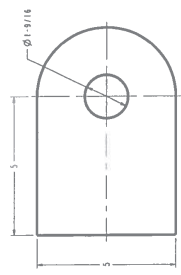
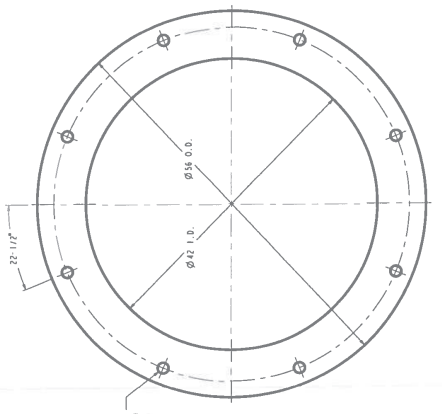
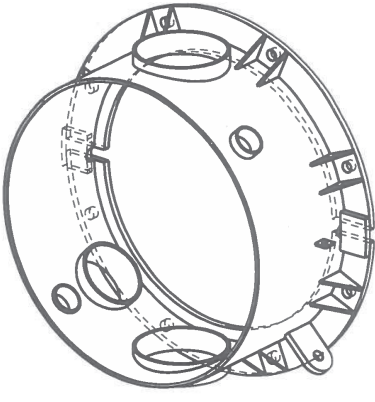
Location from datum 80"

Operating Liquid Specific Gravity 1.1

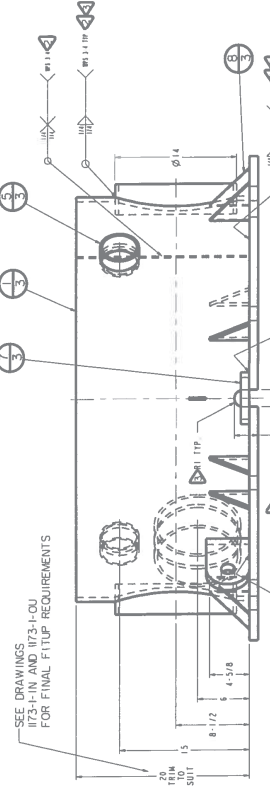
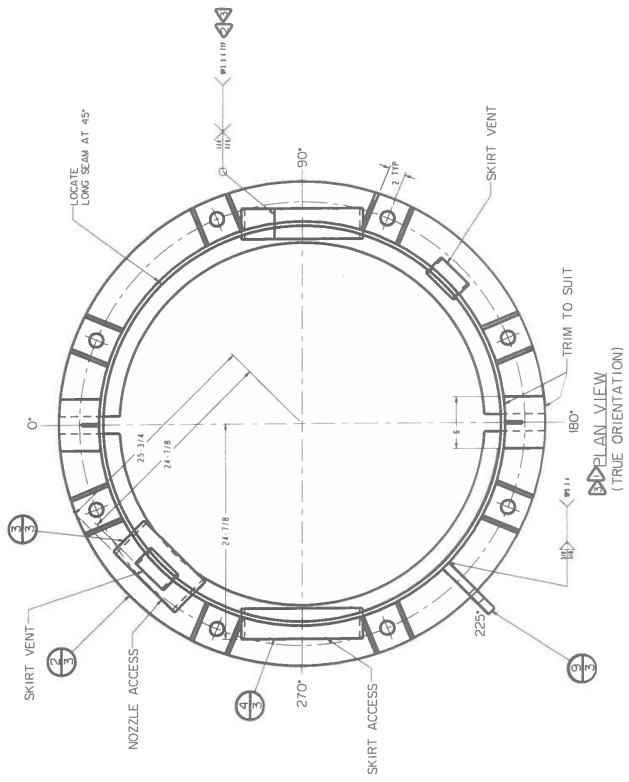




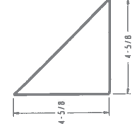
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1817173 1	1/4" PLATE 1/4" x 18" x 18" x 1/4"	A516-70
191273 1	1/4" PLATE 1/4" x 18" x 18" x 1/4"	A516-70
201373 1	1/4" PLATE 1/4" x 18" x 18" x 1/4"	A516-70
211573 2	1/4" PLATE 1/4" x 18" x 18" x 1/4"	A516-70
161673 2	1/4" PLATE 1/4" x 18" x 18" x 1/4"	A516-70
60773 2	1/4" PLATE 1/4" x 18" x 18" x 1/4"	A516-70
61873 15	1/4" PLATE 1/4" x 18" x 18" x 1/4"	A516-70
82973 1	1/4" PLATE 1/4" x 18" x 18" x 1/4"	A516-70



DETAIL ITEM 9/23



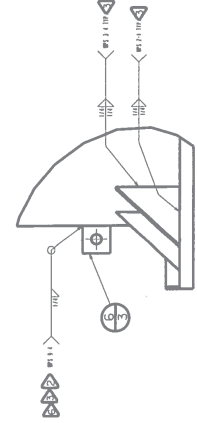
ELEVATION VIEW  
(VIEW FROM 180°)



DETAIL ITEM 8/3



DETAIL ITEM 6/3



ALL-WELD COMPANY LIMITED  
**CERTIFIED AS-BUILT**  
 BY [Signature]  
 DATE NOV 14, 2013

PURCHASE ORDER NUMBER: J112

(4) REQUIRED

PLOTTED:

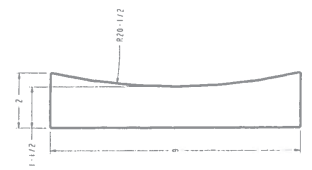
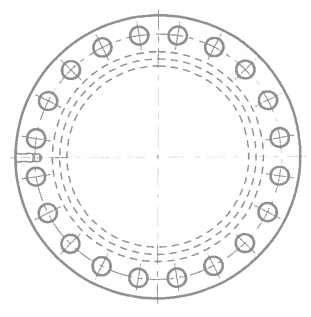
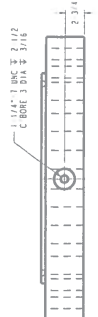
**ALL-WELD COMPANY LIMITED**  
 48" O.D. NOZZLE ACCESS PANEL  
 STAINLESS STEEL SKIRT DETAILS

No.	Revisions	Date	By	App.
5	REVISION			
4	REVISION			
3	REVISION			
2	REVISION			
1	ISSUED FOR FABRICATION			

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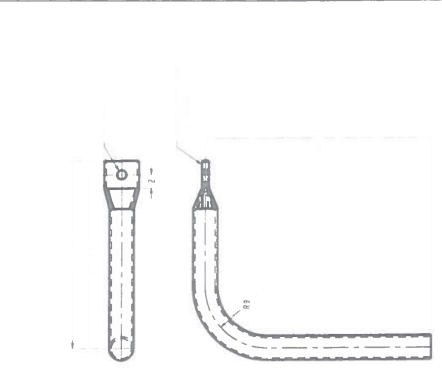


BILL OF MATERIAL		
ITEM QTY	DESCRIPTION	SPEC
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24 27.5	1 50% 1.50 1.11 1.06	SA 312 L4
25 24 27.5	1 50% 1.50 1.11 1.06	SA 312 L4
26 47.5	2 50% 1.50 1.11 1.06	SA 312 L4
27 67.5	2 100% 1.50 1.11 1.06	SA 312 L4
28 77.5	1 100% 1.50 1.11 1.06	SA 312 L4
31 87.5	1 100% 1.50 1.11 1.06	SA 312 L4
32 97.5	3 100% 1.50 1.11 1.06	SA 312 L4
33 107.5	2 100% 1.50 1.11 1.06	SA 312 L4
26 117.5	1 100% 1.50 1.11 1.06	SA 312 L4
70 127.5	1 100% 1.50 1.11 1.06	SA 312 L4
71 137.5	1 100% 1.50 1.11 1.06	SA 312 L4

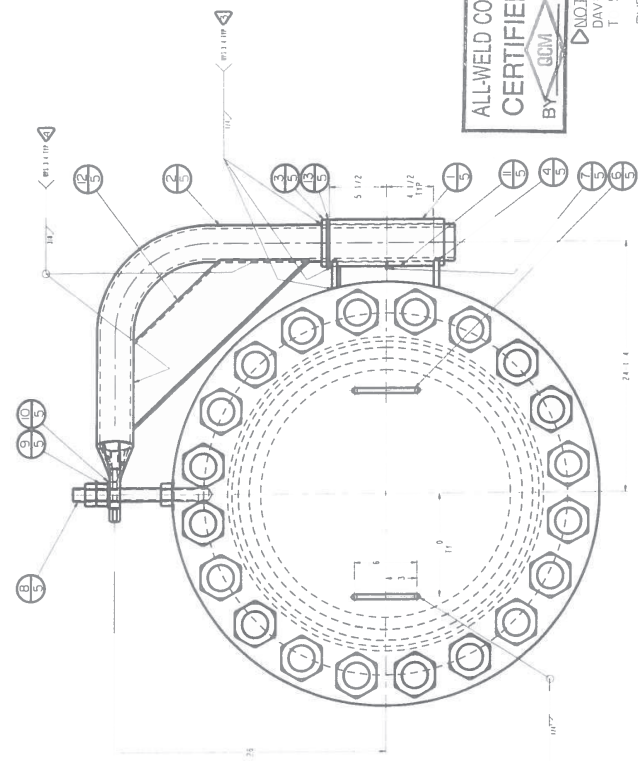


DETAIL ITEM 11/5

DETAIL ITEM 5/5



DETAIL ITEM



NOZZLE NR.

NOV 18 2013  
(2) REQUIRED

PLOTTED:

**ALL-WELD COMPANY LIMITED**  
 45, D. D. VERT. CAL. OUT. ET SE. ASSEMBL. 1  
 2-2- HANWAY ASSEMBLY C. & D. Y. ASSEM. 1  
 3- D. D. VERT. CAL. OUT. ET SE. ASSEMBL. 1  
 4- HANWAY ASSEMBLY C. & D. Y. ASSEM. 1

Client: ULTRAFAB INDUSTRIES LIMITED  
 45, D. D. VERT. CAL. OUT. ET SE. ASSEMBL. 1

ALL-WELD COMPANY LIMITED  
 CERTIFIED AS-BUILT  
 BY GCM DATE NOV 21 2013

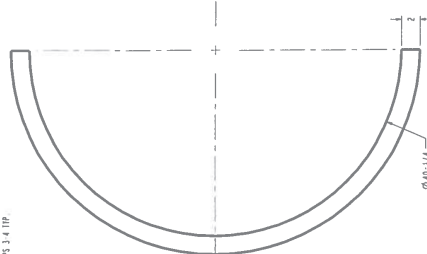
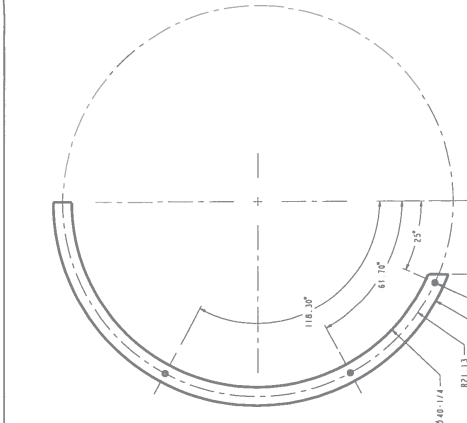
NOTE:  
 DAVIT ARM ASSEMBLY IS DESIGNED  
 TO SUPPORT TWICE THE BLIND FLANGE WEIGHT.  
 PURCHASE ORDER NUMBER: 11112

ITEM QTY	DESCRIPTION	SPEC
4	80% 1.50 1.11 1.06	SA 312 L4
3	50% 1.50 1.11 1.06	SA 312 L4
2	100% 1.50 1.11 1.06	SA 312 L4
1	100% 1.50 1.11 1.06	SA 312 L4

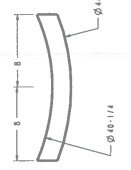
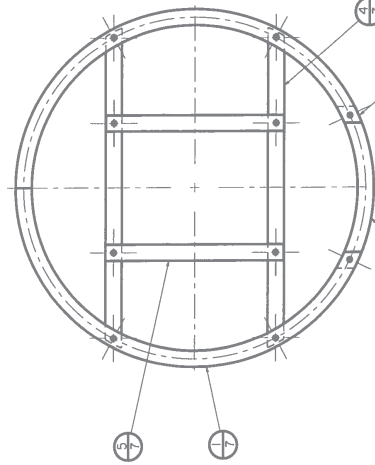
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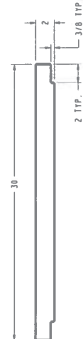
ITEM QTY.		DESCRIPTION		SPEC.
6.3	1/7   2	WELD TO ANCHOR PLATE & SHEET PILE	SA-470 3/16" x 1/4"	
6.3	2/7   1	WELD TO ANCHOR PLATE & SHEET PILE	3/16" x 5.5	
6.3	3/7   1	WELD TO ANCHOR PLATE & SHEET PILE	3/16" x 5.5	
6.3	4/7   2	WELD TO ANCHOR PLATE & SHEET PILE	3/16" x 5.5	
6.3	5/7   2	WELD TO ANCHOR PLATE & SHEET PILE	3/16" x 5.5	
6.3	6/7   2	WELD TO ANCHOR PLATE & SHEET PILE	3/16" x 5.5	
6.3	7/7   2	WELD TO ANCHOR PLATE & SHEET PILE	3/16" x 5.5	
6.3	8/7   2	WELD TO ANCHOR PLATE & SHEET PILE	3/16" x 5.5	
6.3	9/7   6	WELD TO ANCHOR PLATE & SHEET PILE	3/16" x 5.5	
6.3	10/7   4	WELD TO ANCHOR PLATE & SHEET PILE	3/16" x 5.5	
6.4	11/7   10	WELD TO ANCHOR PLATE & SHEET PILE	3/16" x 5.5	
6.4	12/7   10	WELD TO ANCHOR PLATE & SHEET PILE	3/16" x 5.5	



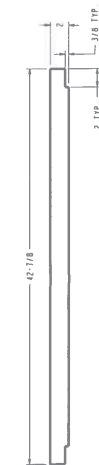
DETAIL\_ITEM\_1.ZZ



DETAIL\_ITEM\_2.ZZ



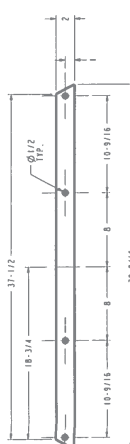
DETAIL\_ITEM\_3.ZZ



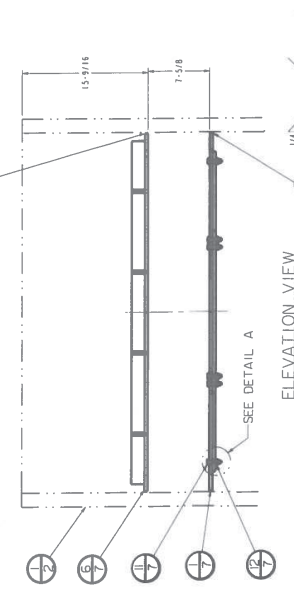
DETAIL\_ITEM\_4.ZZ



DETAIL\_ITEM\_5.ZZ



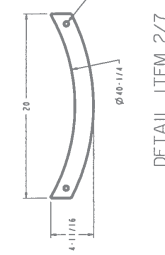
DETAIL\_ITEM\_6.ZZ



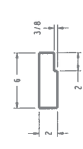
ELEVATION\_VIEW



DETAIL\_A



DETAIL\_ITEM\_7.ZZ



DETAIL\_ITEM\_8.ZZ

(4) REQUIRED

PLOTTED:

**ALL-WELD COMPANY LIMITED**

ULTRAFAB INDUSTRIES LIMITED

48° O.B. VERTICAL INLET / OUTLET SEPARATOR

C.P.A. FABRICATION & DELIVERY SERVICES

By: [Signature]

Date: 03/28/13

Sheet No. 11/301 Rev. 11/13

PURCHASE ORDER NUMBER: 1112

**ALL-WELD COMPANY LIMITED**

CERTIFIED AS-BUILT

BY: [Signature]

DATE: NOV 14 2013

NO.	REVISION	DATE	BY	CHK'D	APP'D
1	ISSUE FOR FABRICATION				
2	ISSUE FOR DELIVERY				
3	AS-BUILT				

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