

HISTORY DOCKET

CUSTOMER : ULTRAFAB INDUSTRIES LTD.,
WO. NO. : 1173PQ
A.W.C. SERIAL NO. : 7472
ITEM : 48" O.D. VERTICAL INLET SEPARATOR TAG # 772-VESE-101

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, N13-030, N13-036, N13-042 &
N13-048
- 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: 7472
ITEM: 48" O D VERTICAL INLET SEPARATOR TAG 772-VESE-101

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

SIGNATURE



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

DATE

NOV 07 2013

ALL-WELD

COMPANY LIMITED

Engineers Since 1920

A TRADITION OF QUALITY

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

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

COPY

1. Manufactured and certified by ALL-WELD COMPANY LIMITED, 49 PASSMORE AVE., SCARBOROUGH, ONT. M1V 4T1 CANADA
(Name and address of Manufacturer)
2. Manufactured for ULTRA FAB INDUSTRIES LTD., 261088 WAGON WHEEL CRES., ROCKY VIEW, ALBERTA, T4A 0E2 CANADA
3. Location of Installation OFF THE COAST OF ANGOLA
(Name and address)
4. Type VERTICAL 7472 M10135.5 1173-1-IN REV. 5 915 2013
(Horizontal or vertical tank) (Manufacturer's serial number) (CRN) (Drawing number) (National Board number) (Year built)
5. The chemical and physical properties of all parts meet the requirements of material specifications of the ASME BOILER AND PRESSURE VESSEL CODE. The design, construction, and workmanship conform to ASME Rules, Section VIII, Division 1. 2010
Year
- to 2011a N/A LETHAL UW-2(a)
[Addenda, if applicable (date)] (Code Case numbers) [Special service per UG-120(d)]
6. Shell: SA240-316 t.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., sngl., lap, butt)] [R T (spot or full)] (Eff. %) (H T temp) (Time, hr) [Girth (welded, dbl., sngl., lap, butt)] [R T (spot or full)] (Eff. %) (No. of courses)
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 t5 PSI at max. temp. 140°F 140°F
(Internal) (External) (Internal) (External)
- Min. design metal temp -20° F at 1378 PSI Hydro., pneu., or comb. test pressure HYDRO 1792 PSI
- Proof test N/A

10. Nozzles, inspection and safety valve openings:

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

11. Supports: Skirt YES Lugs N/A Legs N/A Other N/A Attached BOTTOM HEAD & WELDED
(Yes or no) (Number) (Number) (Describe) (Where and how)

12. Remarks: Manufacturer's Partial Data Reports properly identified and signed by Commissioned Inspectors have been furnished for the following items of the report: N/A

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

CERTIFICATE OF SHOP/FIELD COMPLIANCE

We certify that the statements made in this report are correct and that all details of design, material, construction, and workmanship of this vessel conform to the ASME BOILER AND PRESSURE VESSEL CODE Section VIII, Division 1, "U" Certificate of Authorization Number 21226 expires MAY 07, 2016

Date 7 NOV 2013 Co. name ALL-WELD COMPANY LIMITED. Signed R. Baugh
(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 09 24 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 NB 13106A, ONT 915
(Authorized Inspector) (National Board (incl. endorsements), State, Province and number)

As required by the Provisions of the Atomic Energy Control Act, R.S.C. (1985), Chapter A-2, Section 27, subsection 1.

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 7472
(Horizontal, vertical, or sphere) (Tank, separator, heat exch. etc.) (Manufacturer's serial number)

M10135.5 1173-1-IN REV. 5 915 2013
(CRN) (Drawing number) (National Board number) (Year built)

DATA REPORT ITEM NUMBER _____ REMARKS _____

ITEM 10:

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

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

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

Date: NOV 07, 2013 Name: [Signature] Commission: NB 13106A, ONT 915
(Authorized Inspector) (National Board (incl. endorsements), State, Province, and number)

ALL-WELD CO. LTD.

TRAVELLER

(SUMMARY REPORT) Pg. 1 of 2

DATE 2013-02-06	WORK ORDER 1173 P.Q	CUSTOMER PO 11112	REVIEWED <i>[Signature]</i>	BY A.I. <i>[Signature]</i>
SERIAL NO. 7472	C.R.N. M10135.5	DATE 2013-02-06		SIGN FEB 07.13
NATIONAL BOARD NO.				
CUSTOMER ULTRAFAB		ULTIMATE OWNER		
FOR DRAWINGS & DOCUMENTS/REV./DATE ISSUED TO Q.C. SEE Q.C. DOCUMENT CONTROL FORM		ASME CODE 2010		
VESSEL TYPE/JOB DESCRIPTION 60" ID VERTICAL INLET SEPARATOR OPERATIONS, INSPECTIONS & TEST POINTS		SECTION VIII DIV 1		
REVIEW APPVD DRWGS, CALCS, REVIEW TRAVELLER AND REVIEW INSPECTION AND TEST PLAN		ADD 2011		
REVIEW MATERIAL LIST		H = HOLD R = REVIEW		
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		N/A		
FINAL (ALL NCR'S HAVE BEEN CLEARED)				
FINAL COMPLETED VESSEL INSPECTION				
FINAL HYDROSTATIC TEST				
FINAL HYDROSTATIC TEST JACKET		N/A		
FINAL HYDROSTATIC TEST TUBE SIDE		N/A		
APPLICATION OF CODE STAMP + ATTACH NAMEPLATE				
DATA REPORT SIGN OFF				
GLASS BEAD BLASTING		N/A		
DATA PACKAGE SENT TO CUSTOMER				

ALL-WELD HYDROSTATIC TEST REPORT

JOB NUMBER
1173PQ

DATE
OCTOBER 24, 2013

CUSTOMER
ULTRA FAB INDUSTRIES LTD

SERIAL NO.
7472

VESSEL DESCRIPTION
48" OD VERTICAL OUTLET SEPARATOR TAG # 772-VESSE-101

TEST PRESSURE
VESSEL
1792 PSIG

TUBE

JACKET

TEST METAL TEMPERATURE
50 F

HOLDING TIME
1 HOUR MIN.

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

GAUGE #
LAST CALI. DATE

REMARKS

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

COMMENTS: ACCEPTED

WITNESSES BY MSS
DAN ZOOK
[Signature]
25/10/2013

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

MIKE KANYAR	<input type="checkbox"/>
REVIEWED	<input type="checkbox"/>
WITNESSED	<input checked="" type="checkbox"/>
FOR: ULTRA	DATE: 10/24/13

ACCEPTED/REVIEWED/RELEASED

Excl. - QA - Hydrostatic Test Report

for and on behalf of: SJM OFFSHORE

Print Name: GAMFISH SAHA

Signature: *[Signature]*

Date: Oct 25/2013

Applus®

VELOSI

Velosi America LLC

M. H. Kanyar



Winters Instruments
 121 Rainside 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

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

Technician: *[Signature]* Approved: *[Signature]*

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

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

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 ₄ ²⁻)	27.7

This report is subject to the following terms and conditions: 1. This report relates only to the specimen provided and there is no representation or warranty that it applies to similar substances or materials or the bulk of which the specimen is a part. 2. The content of this report is for the information of the customer identified above only and it shall not be reprinted, published or disclosed to any other party except in full. Prior written consent from Cambridge Materials Testing Limited is required. 3. The name Cambridge Materials Testing Limited shall not be used in connection with the specimen reported on or any substance or materials similar to that specimen without the prior written consent of Cambridge Materials Testing Limited. 4. Neither Cambridge Materials Testing Limited nor any of its employees shall be responsible or held liable for any claims, loss or damages arising in consequence of reliance on this report or any default, error or omission in its preparation or the tests conducted. 5. Specimens are retained 6 months, test reports and test data are retained 7 years from date of final test report and then disposed of, unless instructed otherwise in writing. * Cambridge Materials Testing Limited is accredited for tests listed on the scope of accreditation available for review at www.cambridgematerials.com. Test Report Template Revision March 2010

Cambridge Materials Testing Limited

Per Steve Brown **QUALITY ASSURANCE**

Per Rupinder Singh **TECHNICIAN**

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CERTIFIED BY
ALL-WELD

COMPANY LIMITED
SCARBOROUGH, ONTARIO
ENGINEERS SINCE 1920

SHELL MAWP	1378	PSI	AT	140	°F
SHELL MAEWP	15	PSI	AT	140	°F
SHELL MDMT	-20	°F	AT	1378	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. 7472 YEAR BUILT 2013

10135.5

772-1558-101

CERTIFIED BY
ALL-WELD

COMPANY LIMITED
 SCARBOROUGH, ONTARIO
 ENGINEERS SINCE 1920

W-L
 RT 1

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. 7472 YEAR BUILT 2013

C.R.N. M10135.5 T0-296008

TAG# 772-VESE-101

RADIOGRAPH REVIEW FORM

W.O. NO. 1173 PQ
SERIAL NO. 7472

- 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 10 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
Nom: Edwin Duitschaever
Reg. No: 515
No matricule: 515
Issue Date: 2011/11/28
Date d'émission: 2011/11/28

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

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

Signature:



Natural Resources
Canada

Ressources naturelles
Canada

Certification Certificate No. CAN-CCSB-48-9711

515

Method Méthode	Level Niveau	Sector Secteur	Cert. Date Date cert.	Date recert. Date recert.	Expires Expiration
MT	2	EMC	1978/06/01		2014/12/31
PT	2	EMC	1980/07/01		2014/12/31
RT	2	EMC	1978/06/01		2014/12/31

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

Manager, Certification Agency
Directeur général, Bénévolisme de certification

KV INSPECTION SERVICES LTD

Established 1980



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

www.kvinspection.com

Email: kvinsp1@aol.com

CHRIS VEENEMAN

Natural Resources Canada		Ressources naturelles Canada	
	Name Nom	Christopher Veeneman	
	Reg. 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] pres [X] distance		
	Signature: 		

Natural Resources Canada		Ressources naturelles Canada			
Qualifié(e) en CAN 1 056 46 9732		6651			
- (1) 100 20601 Qualification					
Method Méthode	Level Niveau	Section Secteur	Vert. Date Date cert.	Date recert. Date recert.	Expires Expiration
MT	2	EMC	1997/05/08		2013/12/31
PT	2	EMC	1997/11/07		2013/12/31
RT	2	EMC	2000/01/06		2013/12/31
UT	2	EMC	2010/06/03		2013/12/31

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Email: kvinsp1@aol.com

FRANK MARUNDE



Natural Resources
Canada

Ressources naturelles
Canada



Name/ Nom **Frank Marunde**

Reg. No.

8885

No. matricule

Issue Date/

2012/11/29

Date d'émission

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Cetle carte n'identifie pas l'individu d'être un employé ou un représentant de Ressources naturelles Canada, Gouvernement du Canada.

Corrective lenses for || near || far vision.

Verres correctifs pour la vision de || pres || distance.

Signature

(Handwritten signature)



Natural Resources
Canada

Ressources naturelles
Canada

Certified to Ceblete selon CAN/CSA 48.3712

8885

Method Méthode	Level Niveau	Sector Secteur	Cert. Date Date cert.	Date recert. Date recert.	Expires Expiration
BIT	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://nrc.certcan.gc.ca/> Pour la vérification de la certification, les politiques, et les définitions,
visitez le site web <http://nrc.certcan.gc.ca/>

Manager, Certifying Agency

(Le gestionnaire Ordre/organisme de certification)





(Handwritten signature)


KV INSPECTION SERVICES LTD

Established 1980

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 Office: (905) 844-9448 Fax: (905) 844-6697
 www.kvinspection.com Email: kvinsp1@aol.com

TODD CAMPBELL

	Natural Resources Canada	Ressources naturelles Canada
	Name Todd Campbell	
	Reg. No. 11748	
	No. matricule 11748	
	Issue Date 2011/12/06	
	Date d'émission 2011/12/06	
<p>This card does not identify the stated individual to be an employee or representative of Natural Resources Canada, Government of Canada. Cette carte n'identifie pas l'individu d'être un employé ou un représentant de Ressources naturelles Canada, Gouvernement du Canada.</p>		
<p>Corrective lenses for [X] near [X] far vision. Verres correctives pour la vision de [X] pres [X] distance.</p>		
<p>Signature: </p>		
		

	Natural Resources Canada	Ressources naturelles Canada			
11748		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

For verification of certificate status, policies and definitions, visit website:
<http://www.nrsc.gc.ca/14827014>
 Pour la vérification de la certification, des politiques, et des définitions,
 visitez le site web: <http://www.nrsc.gc.ca/14827014>
 Manager / Contrôleur Agence
 Vérification de la certification

KV INSPECTION SERVICES LTD

Established 1980

1486 Wallace Road, Oakville, Ontario L6L 2Y2
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SHERWIN SUYOM



Natural Resources
Canada

Ressources naturelles
Canada



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

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.

Forpective lenses for near far vision
Verres correctifs pour la vision de près distance

Signature:



Natural Resources
Canada

Ressources naturelles
Canada

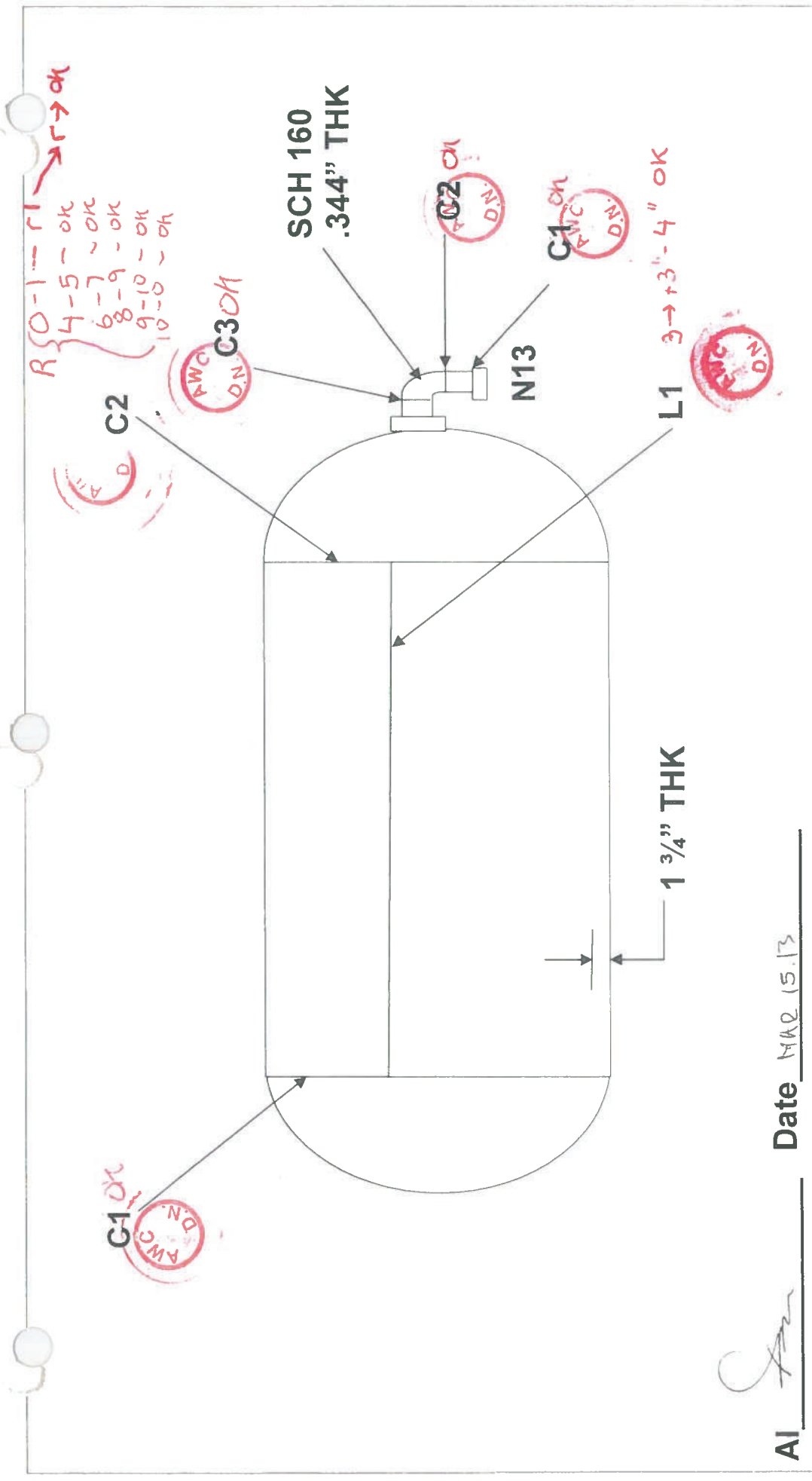
Le présent formulaire est en français et en anglais.

15133

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

For verification of certification status, process and deadlines, visit website: <http://pub.int.gov.ca>. Pour la vérification de la certification, des publications, et des échéances, visitez le site web: <http://pub.int.gov.ca>

For copies of the Training Agency's
Formulaires de la Commission de certification



AI _____ Date MAR 15.13

ALL-WELD CO. LTD. - RT MAP

CLIENT: ULTRAFAB
 WORK ORDER #: 1173PQ SN 7472/1
 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 WELD LTD	Date	MARCH 12/13
Location	SCARBOROUGH ON	P. O. #	
Project	VERTICAL SPINNER	Shop Order #	1173 P& SN 7472
Procedure	KW #5 REV 3	Worksheet #	36630
Technician	JACOBSON	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"

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"/>							<input checked="" type="checkbox"/>	
	1-2								<input checked="" type="checkbox"/>	
	2-3								<input checked="" type="checkbox"/>	
	3-4	3-2(3"-4")		<input checked="" type="checkbox"/>				SEE ATTACH	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	4-5								<input checked="" type="checkbox"/>	
	5-6								<input checked="" type="checkbox"/>	
	6-END								<input checked="" type="checkbox"/>	

MIKE KAMYAR
REVIEWED
WITNESSED
FOR:

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

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

KV Inspection Technician

Date

MAR 12/13

Customer Representative

Date

MAR 15 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	09 April 2013
Location	SCARBOROUGH	P. O. #	
Project	VESSEL	Shop Order #	1173PQ SN7472
Procedure	KU #5 Rev 03	Worksheet #	36804
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	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 No
Reinforcement	1/2"		Number of Exposures				1
Film Mfg.	KONAK		Minimum Source to Object Distance				18"
Film Type	AA		Maximum Distance from Source Side of Object to Film				2 1/4"

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
SN 7472										
L.R	3-4									✓

ACCEPTED/REVIEWED/RELEASED 046
 for and on behalf of: SOB MOFFSHOUSE
 Print Name: GANESH SATHI
 Signature: [Signature]
 Date: JUN 4 2013
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MIKE KAMYAB
 REVIEWED
 WITNESSED
 FOR:

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

KV Inspection Technician

Date

09 April 2013

Customer Representative

Date

APR 16 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: 24/9/2013
 Location: SCARBOROUGH P. O. #
 Project: VESSAL Shop Order #: WO #1173PQ - 7472
 Procedure: KV NDT #5 REV 03 Worksheet #: 37613
 Technician: D. McALHAN CGSB Reg #: 439 ASNT/SNT-TC-1A Level: II

Technical Data

Material Type: Carbon Alloys Isotope: Co60 IR 192 Other Physical/Focal Size: 199
 Base Material Thickness: 1 3/4" Exposure: Single Wall Double Wall Film per Cassette: 1
 Weld Thickness: 1 3/4" View: Single Wall Double Wall PWHT: Yes No
 Reinforcement: 1/4" ± Number of Exposures: 1
 Film Mfg.: KODAK Minimum Source to Object Distance: PANAROMIC
 Film Type: 400 AA Maximum Distance from Source Side of Object to Film: 2'4"

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
<u>C1</u>	<u>48" Ø</u>									
	<u>0-1</u>								<u>/</u>	
	<u>1-2</u>								<u>/</u>	
	<u>2-3</u>								<u>/</u>	
	<u>3-4</u>								<u>/</u>	
	<u>4-5</u>								<u>/</u>	
	<u>5-6</u>								<u>/</u>	
	<u>6-7</u>								<u>/</u>	
	<u>7-8</u>								<u>/</u>	
	<u>8-9</u>								<u>/</u>	
	<u>9-10</u>								<u>/</u>	
	<u>10-0</u>								<u>/</u>	

MIKE KAMYAB
REVIEWED
WITNESSED
FOR:

ACCEPTED/REVIEWED/RELEASED 046
 for and on behalf of: SAM OFFSHORE
 Print Name: GABRIEL SAH
 Signature: [Signature]
 Date: 20/9/2013
 Applus® VELOSI
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 SNT-TC-1A, LEVEL III
 RT/MT/PT



KV Inspection Technician
 Customer Representative

Date: 24/9/2013
 Date: SEP 26 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	09 April 2013
Location	SCARBOROUGH	P. O. #	
Project	VESSEL	Shop Order #	1173PQ SN7472
Procedure	KV#5 REV 03	Worksheet #	36804
Technician	J. MAC DONALD	CGSB Reg #	10375 ASNT/SNT-TC-1A Level 1

Technical Data Co60

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	.188"
Base Material Thickness	3/4"	Exposure	Single Wall <input checked="" type="radio"/> Double Wall <input type="radio"/>	Film per Cassette	1
Weld Thickness	3/4"	View	Single Wall <input checked="" type="radio"/> Double Wall <input type="radio"/>	PWHT	Yes <input type="radio"/> No <input checked="" type="radio"/>
Reinforcement	1/2"	Number of Exposures	1		
Film Mfg.	KODAK	Minimum Source to Object Distance	PANORAMIC		
Film Type	AA	Maximum Distance from Source Side of Object to Film	2 1/4"		

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
SN 7472										
P.P.	0-1	+1 1/2-5						SEE TRACKER		✓
	1-2								✓	
	2-3	✓							✓	
	3-4								✓	
	4-5	+9-10 ✓						SEE TRACKER		✓
	5-6	✓							✓	
	6-7	+2-23/4						SEE TRACKER		✓
	7-8	✓							✓	
	8-9	+12 1/2-14						SEE TRACKER		✓
	9-10	+18-24 +14-7						SEE TRACKER		✓
	10-0	10+2						11		✓

ACCEPTED/REVIEWED/RELEASED
for and on behalf of: S.M. Offshore
Print Name: Chander
Signature: [Signature]
Date: July 2013
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CGSB LEVEL II, Reg# 515
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SNT-TC-1A, LEVEL III
RT/MT/PT

KV Inspection Technician	<u>[Signature]</u>	Date	09 April 2013
Customer Representative	<u>[Signature]</u>	Date	APR 17 2013

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

Radiographic Examination Report RT

Specification - Acceptance Criteria

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

General Data

Customer	ALL WELD	Date	17 April 2013
Location	SCARBOROUGH	P. O. #	
Project	VESSEL	Shop Order #	1173PQ SN7472
Procedure	KU #5 REV 03	Worksheet #	36853
Technician	J. MACDONALD	CGSB Reg #	10375 ASNT/SNT-TC-1A Level 1

Technical Data 660

Material Type	Carbon <u>Alloys</u>	Isotope	IR 192 <u>Other</u>	Physical/Focal Size	.188"
Base Material Thickness	1 3/4"	Exposure	<u>Single Wall</u> Double Wall	Film per Cassette	1
Weld Thickness	1 3/4"	View	<u>Single Wall</u> Double Wall	PWHT	Yes <u>No</u>
Reinforcement	1/4"	Number of Exposures	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
SN7472										
CLR	0-1	#2 → 5/12						SEE ATTACHING		✓
	4-5								✓	
	6-7								✓	
	8-9								✓	
	9-10								✓	
	10-0								✓	

ACCEPTED/REVIEWED/RELEASED
for and on behalf of: SOM OFFSHORE
Print Name: GAMRESH SAHA
Signature: [Signature]
Date: July 5/13
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MIKE KAMYAB
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WITNESSED
FOR:

ED DUTSCHAEVER
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
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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	MAY 7/13
Location	SCARBOROUGH	P. O. #	
Project	VERTICAL SEPARATOR	Shop Order #	1173PQ-7472
Procedure	RV 5	Worksheet #	
Technician	C. Veeman	CGSB Reg #	6657 ASNT/SNT-TC-1A Level II

Technical Data 660

Material Type	Carbon <u>Alloys</u>	Isotope	IR 192 <u>Other</u>	Physical/Focal Size	.13"
Base Material Thickness	1 3/4"	Exposure	<u>Single Wall</u> Double Wall	Film per Cassette	1
Weld Thickness	"	View	<u>Single Wall</u> Double Wall	PWHT	Yes <u>No</u>
Reinforcement	L 1/4"	Number of Exposures			
Film Mfg.	KODAK	Minimum Source to Object Distance		PANORAMIC (4")	
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
02R	0-1	2-5 1/2"								✓

MIKE KAMPAS
REVIEWED
WITNESSED
FOR:

046

ACCEPTED/REVIEWED/RELEASED

for and on behalf of: SBM OFFSHORE

Print Name: CLARENCE SAH

Signature: [Signature]

Date: MAY 5/13

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Velosi America LLC

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

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

Radiographic Examination Report RT

Specification - Acceptance Criteria

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

General Data

Customer	ALL WELD	Date	23 July 2013
Location	SCARBOROUGH	P. O. #	
Project	VESSEL	Shop Order #	1173PQ-7472
Procedure	RV'S Rev 0.3	Worksheet #	37345
Technician	J. MacDonald	CGSB Reg # 10375	ASNT/SNT-TC-1A Level 1

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	0.199
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	< 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
----------	----------	------	--------	--------	-------	----------	------	--------	-----	-----

C2R	O-1									✓
-----	-----	--	--	--	--	--	--	--	--	---

MIKE KAMYAB
 REVIEWED
 WITNESSED
 FOR:

ACCEPTED/REVIEWED/RELEASED 046
 for and on behalf of: SBM OFFSHORE
 Print Name: GAMBELL SAHA
 Signature: [Signature]
 Date: July 26 2013
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 SNT-TC-1A, LEVEL III
 RT/MT/PT

KV Inspection Technician

Date 23 July 2013

Customer Representative

Date JUL 26 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 LOTS.	Date	Aug 13/13
Location	SCARBOROUGH ONT	P. O. #	
Project	ULTRAFAB.	Shop Order #	1173 PQ - 7472
Procedure	KW #6 RW2	Worksheet #	37436
Technician	C VEENEMAN	CGSB Reg #	6651 ASNT/SNT-TC-1A Level II

Technical Data

Material Type	Carbon	Alloys <input checked="" type="checkbox"/>	Isotope	IR 192 <input checked="" type="checkbox"/> Other	Physical/Focal Size	.13	
Base Material Thickness	5/160		Exposure	Single Wall	Double Wall <input checked="" type="checkbox"/>	Film per Cassette	1
Weld Thickness	5/160		View	Single Wall	Double Wall <input checked="" type="checkbox"/>	PWHT	Yes No <input checked="" type="checkbox"/>
Reinforcement	.125		Number of Exposures				3/weld
Film Mfg.	KODAK		Minimum Source to Object Distance				18"
Film Type	AA		Maximum Distance from Source Side of Object to Film				OD

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
N13	2"φ									
E1	A								<input checked="" type="checkbox"/>	
	B								<input checked="" type="checkbox"/>	
	C								<input checked="" type="checkbox"/>	
C2	2"φ									
	A								<input checked="" type="checkbox"/>	
	B								<input checked="" type="checkbox"/>	
	C								<input checked="" type="checkbox"/>	

MIKE KAMYAB
 REVIEWED
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 FOR:

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 for and on behalf of: SGM OFF SHORE
 Print Name: GANESH SAHA
 Signature: *[Signature]*
 Date: Aug 24/13
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 CGSB LEVEL II, Reg# 515
 RT/MT/PT
 SNT-TC-1A, LEVEL III
 RT/MT/PT

KV Inspection Technician

[Signature]

Date

Aug 13/13

Customer Representative



Date

AUG 20 2013

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. 9 / 13
Location	SCARBOROUGH	P. O. #	
Project	ULTRAFABS	Shop Order #	1173 PQ-7472
Procedure	KV 6 RA 2	Worksheet #	
Technician	C. Jeoniman	CGSB Reg #	6651 ASNT/SNT-TC-1A Level II

Technical Data

Material Type	Carbon <u>Alloys</u>	Isotope	IR 192 Other	Physical/Focal Size	.13"
Base Material Thickness	.344"	Exposure	Single Wall <u>Double Wall</u>	Film per Cassette	1
Weld Thickness	"	View	Single Wall <u>Double Wall</u>	PWHT	Yes <u>No</u>
Reinforcement	2 1/8"	Number of Exposures			3
Film Mfg.	KODAK	Minimum Source to Object Distance			18"
Film Type	RA	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
N12-C3	A								✓	
	B						✓		✓	
	C								✓	

✓

ACCEPTED/REVIEWED/RELEASED
 for and on behalf of: SAM OFFSHORE
 Print Name: GABRIEL SAHA
 Signature: [Signature]
 Date: OCT 23/13
046
Applus®
VELOSI
Velosi America LLC

KV Inspection Technician

[Signature]


Date

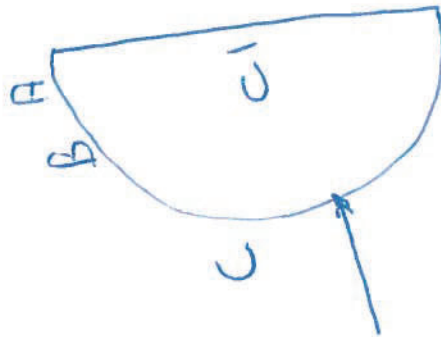
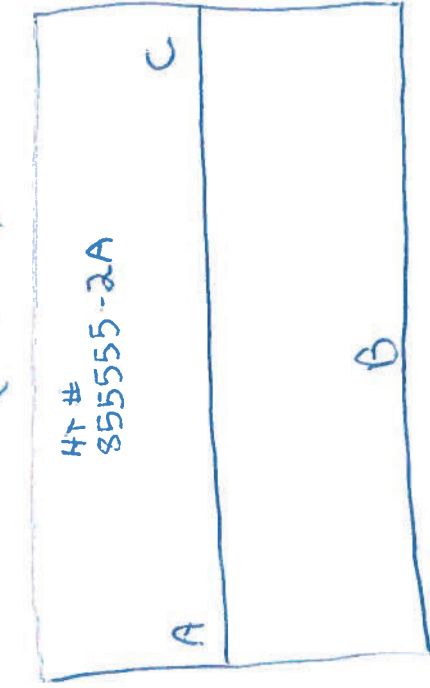
OCT 9 / 13

Customer Representative

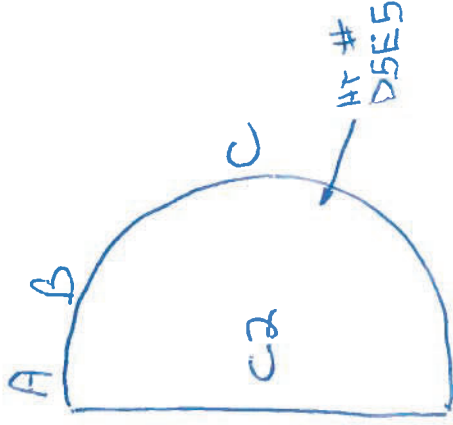
Date

OCT 10 2013

Thk(A,B,C)



Thk C1(A,B,C)



Thk(A,B,C)

ALL-WELD CO. LTD. -

CLIENT: Ultrafab

WORK ORDER #: 1173PO SN 7472

JOB DESCRIPTION:

DRAWING #:

PREPARED BY: D.NESCI

DATE: FEB 22 2013

UTMAP - Thk

ASME SECTION VIII. DIV. 1

material SA-240 316/316L

PO 13-0153 - 1173PO

General Data

Customer	All-Weld Company	Date	February 26, 2013
Shop Order	1173 PQ Serial # 7472	Project	
Component		P.O. #	Worksheet #: 36451
Drawing	Rev.	Technician	Frank Marunde SNT-TC-1A Level III
NDT Specification	ASTM E 797	Appendix	NDT Procedure KV-UT# 1 R.02

Technical Data – Ultrasonic Examination (UT)

Material Type	Stainless Steel	Technique	<input checked="" type="radio"/> Pulse Echo-Contact <input type="radio"/> Immersion <input type="radio"/> Dual
Material Thickness		Instrument Brand	<input checked="" type="radio"/> Olympus Epoch 1000i <input type="radio"/> Serial # 090054812
Weld Type	<input type="radio"/> Butt <input type="radio"/> T Joint <input type="radio"/> Fillet	Surface	<input checked="" type="radio"/> As Rolled <input type="radio"/> Ground <input type="radio"/> Machined <input type="radio"/> Shot Blasted
Weld Thickness	N/A	Couplant	<input checked="" type="radio"/> UT-X <input type="radio"/> Oil <input type="radio"/> Other <input type="radio"/> Temperature
Heat Treated	<input type="radio"/> YES <input type="radio"/> NO	Sensitivity (PRL)	75 dB
Heat Treatment		Surface Conditions	

Transducers/Calibration Blocks

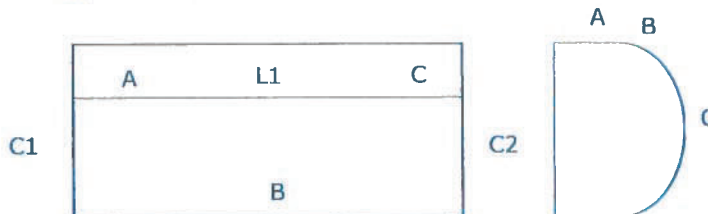
Diameter		Size	Beam Angle	Frequency	Manufacturer	Blocks
<input type="radio"/> 1/4"	<input type="radio"/> 3/4"	<input type="radio"/> 5/8" x 5/8"	<input type="radio"/> 45°	<input type="radio"/> 1.00 MHz	<input type="radio"/> Techsonic	<input type="radio"/> IIW A2
<input type="radio"/> 3/8"	<input type="radio"/> 1"	<input type="radio"/> 1/2" x 1"	<input type="radio"/> 60°	<input type="radio"/> 2.25 MHz	<input checked="" type="radio"/> Panametrics	<input type="radio"/> ASTM E164 MAB
<input checked="" type="radio"/> 1/2"	<input type="radio"/> 1 1/8"	<input type="radio"/> 1" x 1"	<input type="radio"/> 70°	<input checked="" type="radio"/> 5.00 MHz	<input type="radio"/> Krautkramer	<input type="radio"/> Back Reflection
<input type="radio"/>	<input 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	1.766	1.797	1.785
B	1.786	1.740	1.732
C	1.768	1.749	1.740

All Dimensions are in inches



FEB 28 2013

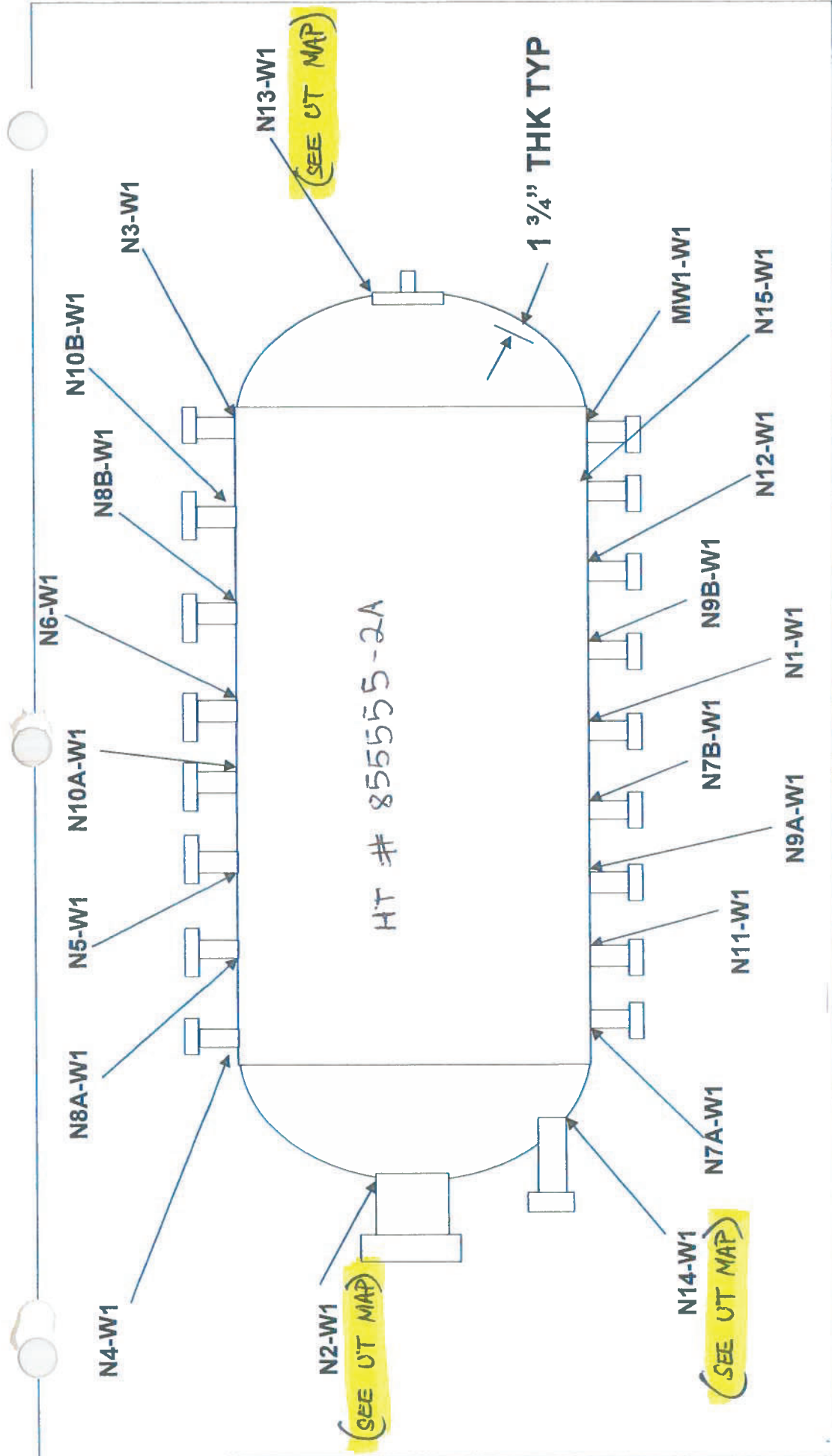
Scanning

Test Area	Disposition	From	Length	Depth	Amplitude

Evaluation – Acceptance

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

Revised for SBM office April 14/13



ALL-WELD CO. LTD. - RT MAP	
CLIENT: ULTRAFAB	RT MAP - 1173PQ
WORK ORDER #: 1173PQ SN 7472	Category D welds
JOB DESCRIPTION: 48" O.D. VERTICAL INLET	ASME SECTION VIII. DIV. 1
DRAWING #: 1173-1-IN	MATERIAL SA-240 316/316L, SA-182 F316/316L
PREPARED BY: D.NESCI	P.O. 13-0225
DATE: March 6, 2013	

General Data

Customer	All-Weld Company		Date	April 8, 2013		
Shop Order	1173 PQ Serial # 7472		Project			
Component			P.O. #			Worksheet #: 36763
Drawing	Rev.		Technician	Frank Marunde	SNT-TC-1A Level	III
NDT Specification	ASME Sec. VIII		Appendix	12	NDT Procedure	KV-UT# 1 R.02

Technical Data – Ultrasonic Examination (UT)

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

Transducers/Calibration Blocks

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

Scope of Testing

1173 PQ-7472: Examination of category D nozzle attachment welds
N2-W1 & N14-W1



APR 11 2013

046

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

Print Name: CLARENCE SAHAI

Signature: [Signature]

Date: APR 11 2013

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Velosi America LLC

Scanning

Test Area	Disposition	From	Length	Depth	Amplitude

Evaluation – Acceptance

<input checked="" type="radio"/> Accepted	KV Inspection Services – Technician	<u>[Signature]</u>	Date	April 08, 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 # 7472		Project			
Component			P.O. #			Worksheet #: 36888
Drawing	Rev.		Technician	Frank Marunde	SNT-TC-1A Level	III
NDT Specification	ASME Sec. VIII		Appendix	12	NDT Procedure	KV-UT# 1 R.02

Technical Data - Ultrasonic Examination (UT)

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

Transducers/Calibration Blocks

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

Scope of Testing

1173 PQ-7472: Examination of category D attachment welds
N14-W1



MAY 07 2013

Per NCR N13-036

Scanning

Test Area	Disposition	From	Length	Depth	Amplitude

ACCEPTED/REVIEWED/RELEASED 046

for and on behalf of: CBM OFFSHORE

Print Name: CHANESH SARA

Signature: [Signature]

Date: July 11 2013

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Evaluation - Acceptance

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

General Data

Customer	All-Weld Company	Date	September 30, 2013
Shop Order	1173PQ S/N 7472	Project	
Component		P.O. #	Worksheet #: 37595
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)	48 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"/> 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"/> 1/2" 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" 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 N13-W1



OCT 23 2013

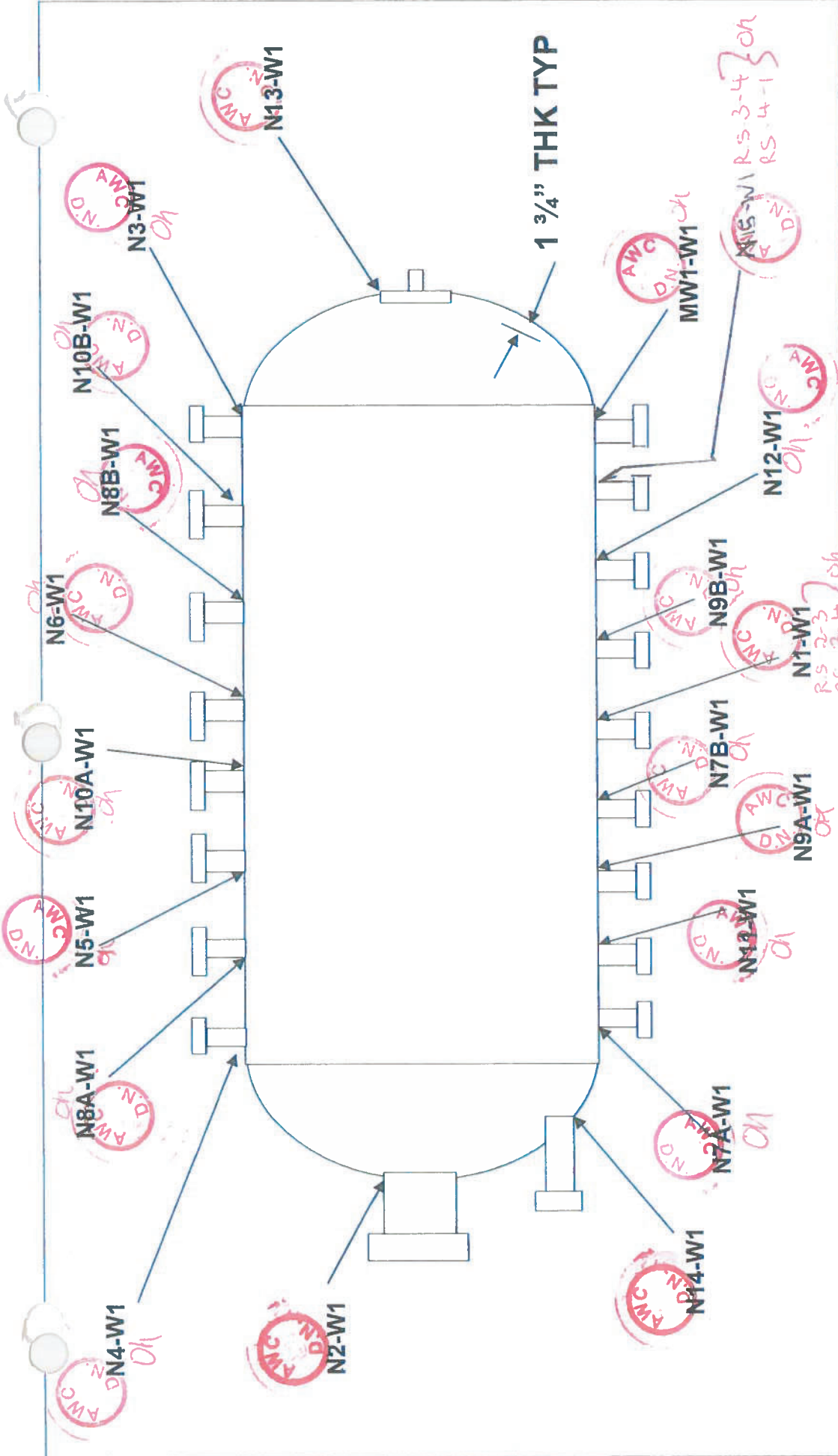
Scanning

Test Area	Disposition	From	Length	Depth	Amplitude
				<input checked="" type="checkbox"/>	

ACCEPTED/REVIEWED/RELEASED
for and on behalf of: SBM OIL SERVICE
Print Name: WANESSA SALLA
Signature: [Signature]
Date: OCT 23 2013
046
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Velosi America LLC

Evaluation – Acceptance

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



ALL-WELD CO. LTD. - UT MAP

UT MAP - 1173PQ

ASME SECTION VIII. DIV. 1

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

P.O. 13-0225

CLIENT: ULTRAFAB

WORK ORDER #: 1173PQ SN 7472

JOB DESCRIPTION: 48" O.D. VERTICAL INLET

DRAWING #: 1173-1-IN

PREPARED BY: D.NESCI

DATE: March 6, 2013

Radiographic Examination Report RT

Specification - Acceptance Criteria

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

General Data

Customer	ALL-WELID.	Date	24/9/2013
Location	50 ARBOROUGH	P. O. #	
Project	VESSEL	Shop Order #	NO# 1193PD 7472
Procedure	KV NDT#5 REV 03	Worksheet #	37613
Technician	S. MONAGHAN	CGSB Reg #	439 ASNT/SNT-TC-1A Level II

Technical Data

Material Type	Carbon	Alloys <input checked="" type="checkbox"/>	Isotope	IR 192	Other <input checked="" type="checkbox"/>	Physical/Focal Size	199
Base Material Thickness	1 3/4"		Exposure	Single Wall <input checked="" type="checkbox"/>	Double Wall	Film per Cassette	1
Weld Thickness	1 3/4"		View	Single Wall <input checked="" type="checkbox"/>	Double Wall	PWHT	Yes No <input checked="" type="checkbox"/>
Reinforcement	1/4" ±		Number of Exposures				12
Film Mfg.	KODAK		Minimum Source to Object Distance				22"
Film Type	400 AA		Maximum Distance from Source Side of Object to Film				2'4"

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
N1	Ø - 2								✓	
3"	2 - 3								✓	R/S
	3 - 4								✓	R/S
	4 - 1								✓	R/S
N15	1 - 2								✓	
8"	2 - 3								✓	
	3 - 4								✓	R/S
	4 - 1								✓	R/S
N9A	1 - 2								✓	
4"	2 - 3								✓	
	3 - 4								✓	
	4 - 1								✓	

ACCEPTED/REVIEWED/RELEASED
for and on behalf of: SBM AP'S HOLD
Print Name: ANDESHA SAHA
Signature: [Signature]
Date: Oct 29 2013
046
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R/S due to penny in weld

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

KV Inspection Technician

Customer Representative

Date

Date

24/9/2013

SEP 26 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	24/09/2013
Location	Scarborough, ON	P. O. #	
Project	Vessel	Shop Order #	WO# 1173 PQ -7472
Procedure	KU NDT#5 Rev. 03	Worksheet #	37613
Technician	B. Monaghan	CGSB Reg #	439 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	.199
Base Material Thickness	1 3/4"	Exposure	Single Wall <input checked="" type="checkbox"/> Double Wall <input type="checkbox"/>	Film per Cassette	1
Weld Thickness	1 3/4"	View	Single Wall <input checked="" type="checkbox"/> Double Wall <input type="checkbox"/>	PWHT	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>
Reinforcement	1/4" ± 7	Number of Exposures	12		
Film Mfg.	Kodak	Minimum Source to Object Distance	22"		
Film Type	400 AA	Maximum Distance from Source Side of Object to Film	2"+		

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
N1	1-2								<input checked="" type="checkbox"/>	
8"	2-3								<input checked="" type="checkbox"/>	
	3-4								<input checked="" type="checkbox"/>	
	4-1								<input checked="" type="checkbox"/>	
N15	1-2								<input checked="" type="checkbox"/>	
8"	2-3								<input checked="" type="checkbox"/>	
	3-4								<input checked="" type="checkbox"/>	
	4-1								<input checked="" type="checkbox"/>	
N9A	1-2								<input checked="" type="checkbox"/>	
4"	2-3								<input checked="" type="checkbox"/>	
	3-4								<input checked="" type="checkbox"/>	
	4-1								<input checked="" type="checkbox"/>	

ACCEPTED/REVIEWED/RELEASED
 for and on behalf of: SBM OFFSHORE
 Print Name: GAMESH SAHA
 Signature: [Signature]
 Date: 20/09/13
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ED DUISCHAEVER
 CGSB LEVEL II, Reg# 515
 RT/MT/PT
 SNT-TC-1A, LEVEL III
 RT/MT/PT

KV Inspection Technician	<u>[Signature]</u>	Date	24/09/2013
Customer Representative		Date	SEP 27 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-WORLD	Date	SEPT. 26 / 13
Location	SCARBOROUGH	P. O. #	
Project	CAT. 'D' WORDS	Shop Order #	1173PQ-7472
Procedure	KV S Rod 3	Worksheet #	37725
Technician	C. Veeneman	CGSB Reg #	6651 ASNT/SNT-TC-1A Level II

Technical Data 660

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

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
N5-W1	1-2								✓	
	2-3								✓	
	3-1								✓	
N8B-W1	1-2								✓	
	2-3								✓	
	3-1								✓	
N3-W1	1-2								✓	
	2-3								✓	
	3-1								✓	
N7A-W1	1-2								✓	
	2-3								✓	
	3-1								✓	
N11-W1	1-2								✓	
	2-3								✓	
	3-1	✓							✓	
N12-W1	1-2								✓	
	2-3								✓	
	3-1								✓	

ACCEPTED/REVIEWED/RELEASED 046
 for and on behalf of: SAM OBI'SHELB
 Print Name: GIANESTI SAHA
 Signature: *[Signature]*
 Date: Sept 25 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	<i>[Signature]</i>	Date	SEPT. 26 / 13
Customer Representative	<i>[Signature]</i>	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	ALL-WELD	Date	SEPT. 25 /13
Location	SCARBOROUGH	P. O. #	
Project	ORT 'S' WELDS	Shop Order #	1173PQ- 7472
Procedure	KV S' ROV 3	Worksheet #	
Technician	C. Veeman	CGSB Reg #	6651
		ASNT/SNT-TC-1A Level	II

Technical Data G60

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	(
Weld Thickness	"		View	Single Wall	Double Wall	PWHT	Yes (No)
Reinforcement	2 1/4"		Number of Exposures				3 PERK
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
N8AW1	1-2								✓	
	2-3								✓	
	3-1								✓	
N6-W1	1-2								✓	
	2-3								✓	
	3-1								✓	
N10A-W1	1-2								✓	
	2-3								✓	
	3-1								✓	

ACCEPTED/REVIEWED/RELEASED
for and on behalf of: SIBM OFFSHORE
Print Name: GANESH SAHA
Signature: *[Signature]*
Date: 2012/25/13
Applus[®] VELOSI
Velosi America LLC

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

KV Inspection Technician

[Signature]

Date SEPT. 25 /13

Customer Representative



Date SEP 27 2013

KV Inspection Services Ltd.

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

Radiographic Examination Report RT

Specification - Acceptance Criteria

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

General Data

Customer	ALL-WELD	Date	SEPT. 25 / 13
Location	SCARBOROUGH	P. O. #	
Project	ONT 'D' WELDS	Shop Order #	1173PQ-7472
Procedure	KV S-ROV 3	Worksheet #	
Technician	C. Veeman	CGSB Reg #	6651
		ASNT/SNT-TC-1A Level	II

Technical Data G60

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	(
Weld Thickness	"	View	<u>Single Wall</u> Double Wall	PWHT	Yes <u>(No)</u>
Reinforcement	2 1/4"	Number of Exposures			3 PERC
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
N10B-W1	1-2								✓	
	2-3								✓	
	3-1								✓	
N9B-W1	1-2								✓	
	2-3								✓	
	3-1								✓	
N7B-W1	1-2								✓	
	2-3								✓	
	3-1								✓	
N4-W1	1-2								✓	
	2-3								✓	
	3-1								✓	

ACCEPTED/REVIEWED/RELEASED
 for and on behalf of: SBM OFFSHORE
 Print Name: CHRISTINA SANA
 Signature: [Signature]
 Date: 2013/09/25
Applus[®]
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 Veloci America LLC

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

KV Inspection Technician	<u>[Signature]</u>	Date	SEPT. 25 / 13
Customer Representative	<u>[Signature]</u>	Date	SEP 27 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-WORLD	Date	OCT. 9/13
Location	SCANDONWCH	P. O. #	
Project	ULTRAFAB	Shop Order #	1173 PD-7472
Procedure	KV 5 RV 3	Worksheet #	
Technician	P. Jeenoman	CGSB Reg #	6651
		ASNT/SNT-TC-1A Level	A

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
Weld Thickness	"	View	<u>Single Wall</u>	Double Wall	PWHT
Reinforcement	2 1/4"	Number of Exposures	1		
Film Mfg.	KODAK	Minimum Source to Object Distance	PANORAMIC (32")		
Film Type	AA	Maximum Distance from Source Side of Object to Film	2"		

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
MWI-WI	0-1								/	
	1-2								/	
	2-3							HAZ C665	/	
	3-4								/	
	4-5								/	
	5-6								/	
	6-7								/	
	7-8								/	
	8-9								/	
	9-0								/	

✓

ACCEPTED/REVIEWED/RELEASED 046

for and on behalf of: SBM OFF SHORE

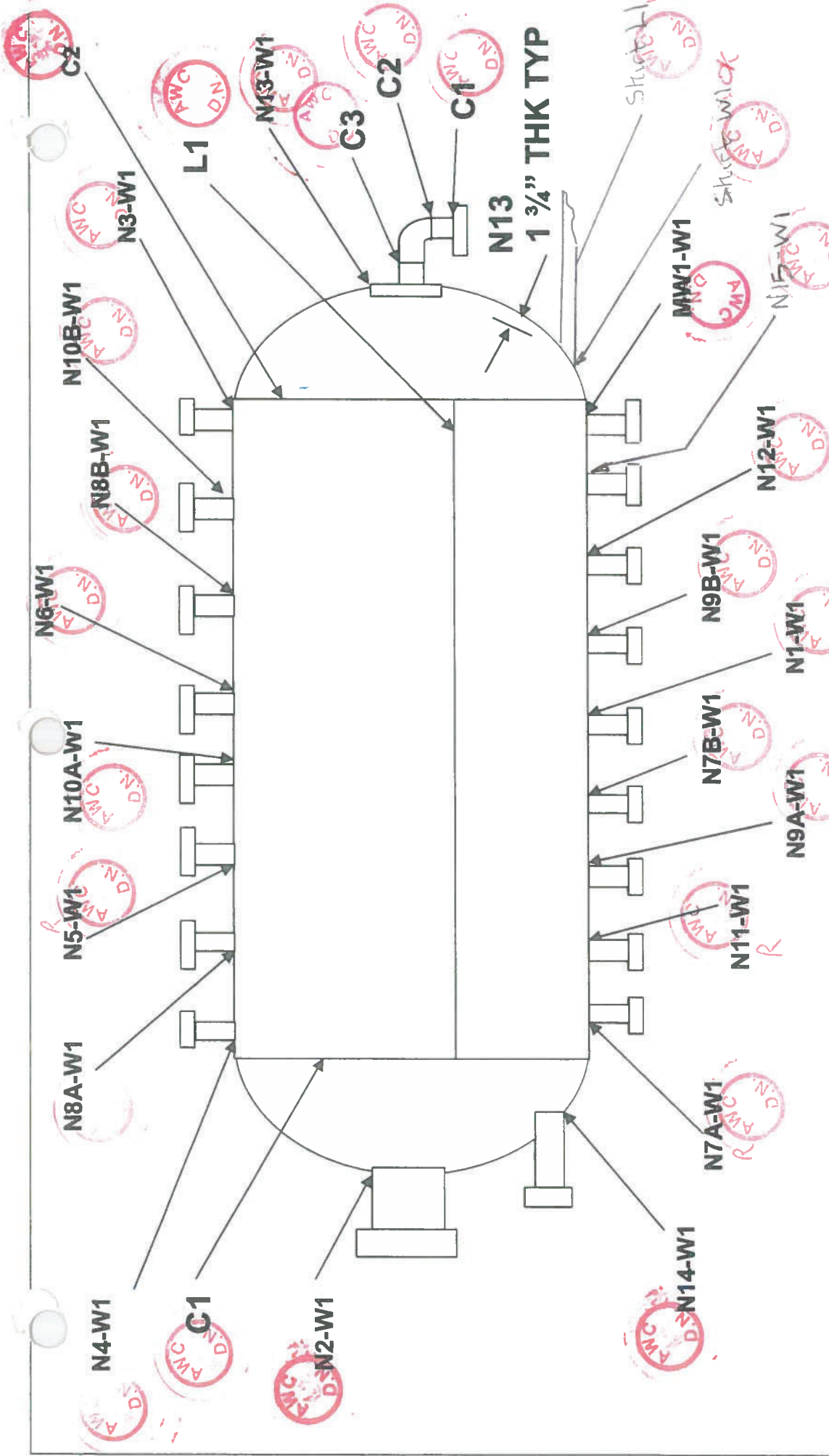
Print Name: GAJESH SAHAI

Signature: [Signature] **Applus®**

Date: Oct-25-13 **VELOSI**

Velosi America LLC

KV Inspection Technician		Date	OCT. 9/13
Customer Representative		Date	OCT 10 2013



ALL-WELD CO. LTD. - PT MAP

CLIENT: ULTRAFAB
 WORK ORDER #: 1173PQ SN 7472
 JOB DESCRIPTION: 48" O.D. VERTICAL INLET
 DRAWING #: 1173-1-IN
 PREPARED BY: D.NESCI
 DATE: March 6, 2013

PT MAP - 1173PQ

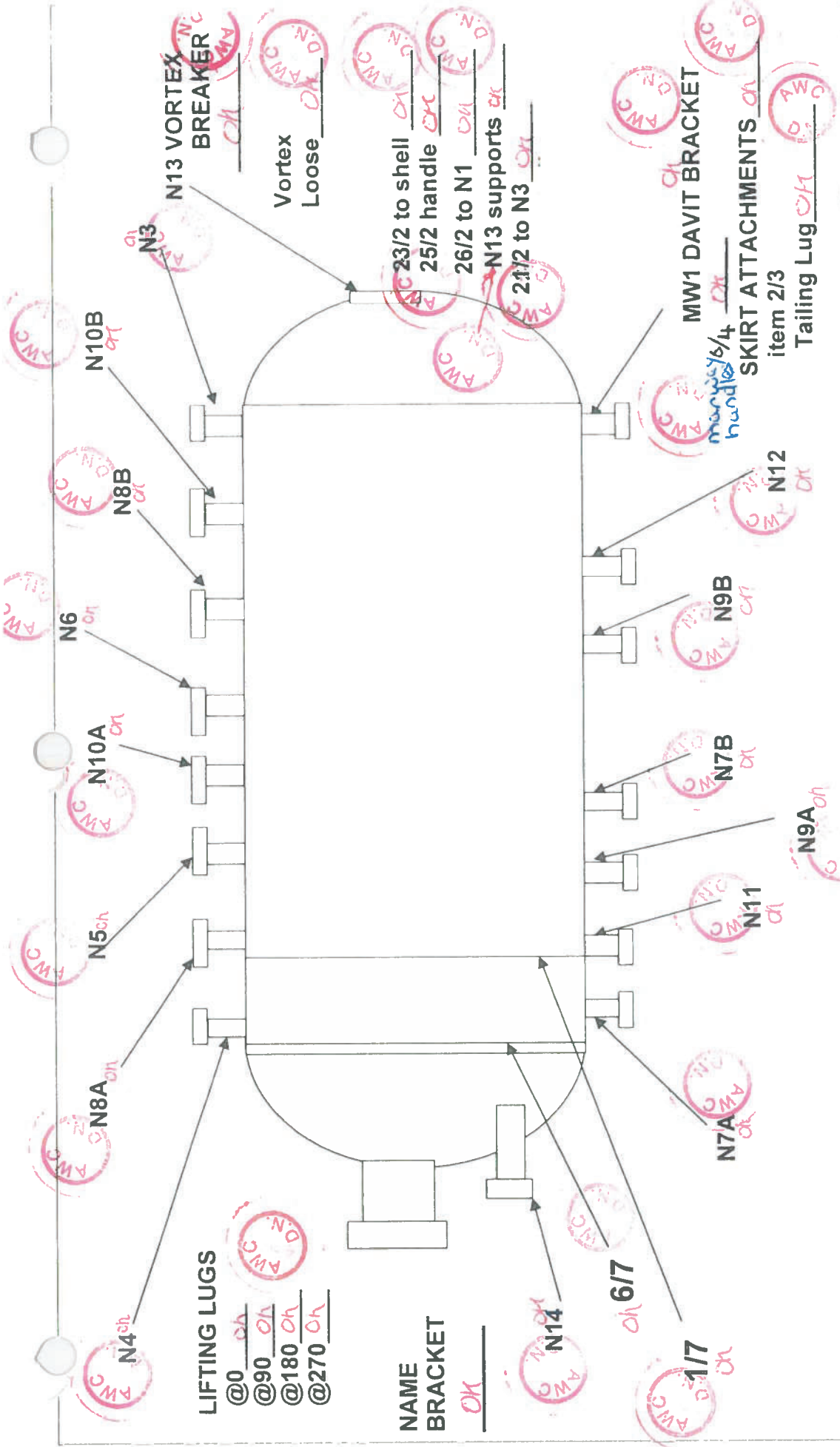
ASME SECTION VIII. DIV. 1

ALL WELDS INTERNAL / EXTERNAL EXCEPT WHERE NOTED

N13- C1, C2, C3 EXTERNAL ONLY

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

P.O. 13-0227



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

CLIENT: ULTRAFAB
 WORK ORDER #: 1173PQ SN 7472
 JOB DESCRIPTION: 48" O.D. VERTICAL INLET
 DRAWING #: 1173-1-IN
 PREPARED BY: D.NESCI
 DATE: March 6, 2013

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

P.O.



N13 VORTEX BREAKER
 Vortex Loose

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

MW1 DAVIT BRACKET
 SKIRT ATTACHMENTS item 2/3
 Tailing Lug

LIFTING LUGS
 @0
 @90
 @180
 @270

NAME BRACKET

1/7

6/7

N4, N5, N6, N8A, N8B, N9A, N9B, N10A, N10B, N11, N12, N13, N14, N17, N18, N19, N20, N21, N22, N23, N24, N25, N26, N27, N28, N29, N30, N31, N32, N33, N34, N35, N36, N37, N38, N39, N40, N41, N42, N43, N44, N45, N46, N47, N48, N49, N50, N51, N52, N53, N54, N55, N56, N57, N58, N59, N60, N61, N62, N63, N64, N65, N66, N67, N68, N69, N70, N71, N72, N73, N74, N75, N76, N77, N78, N79, N80, N81, N82, N83, N84, N85, N86, N87, N88, N89, N90, N91, N92, N93, N94, N95, N96, N97, N98, N99, N100, N101, N102, N103, N104, N105, N106, N107, N108, N109, N110, N111, N112, N113, N114, N115, N116, N117, N118, N119, N120, N121, N122, N123, N124, N125, N126, N127, N128, N129, N130, N131, N132, N133, N134, N135, N136, N137, N138, N139, N140, N141, N142, N143, N144, N145, N146, N147, N148, N149, N150, N151, N152, N153, N154, N155, N156, N157, N158, N159, N160, N161, N162, N163, N164, N165, N166, N167, N168, N169, N170, N171, N172, N173, N174, N175, N176, N177, N178, N179, N180, N181, N182, N183, N184, N185, N186, 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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

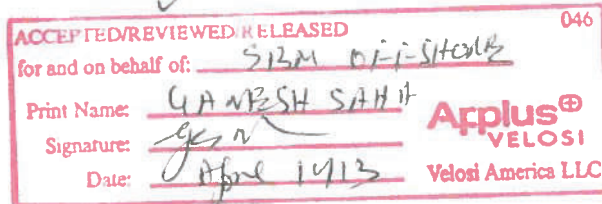
Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter Type: EA31
	<input type="radio"/> Chemetall Oakite 996	<input type="radio"/> Fluorescent	
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 970P25E	<input checked="" type="radio"/> Water Washable	Serial #: 070706809
Developer	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<input type="radio"/> Solvent Removable	Intensity: 1100 Lx
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B		

Lighting Equipment Description: Shop lights, Flashlight

Inspection

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
Serial # 7472	Long seam - L1 100% inspection (internal and external)		No relevant indications noted. Acceptable to specification



KV Inspection Technician		Date	March 12, 2013
Customer Representative		Date	MAR 14 2013

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 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 24, 2013		
Location	Scarborough, ON	P. O. #			
Project		Shop Order #	1173 S/N 7472		
Procedure	KV# 16 Rev. 03	Worksheet #	37649		
Technician	Frank Marunde	CGSB Level II, Reg #	8885	ASNT/SNT-TC-1A Level	II

Technical Data - Liquid Dye Penetrant (PT)

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

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

Lighting Equipment Description: Flashlight

Inspection

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
1)	Circular seam C1 (interior and exterior)		Acceptable to specifications
2)	Nozzle attachment welds N4-W1, N8A-W1, N8B-W1, N10A-W1, N6-W1, N10B-W1 N3-W1, N7B-W1, N9A-W1, N1-W1, N9B-W1, N12-W1, N15-W1 (interior and exterior)		Acceptable to specifications
3)	Skirt L1 (interior and exterior)		Acceptable to specifications

✓

ACCEPTED/REVIEWED/RELEASED 046
 for and on behalf of: SAM OFFSHORE
 Print Name: CHARBISH SANA
 Signature: [Signature]
 Date: Sept 23/13
Applus®
VELOSI
 Velosi America LLC

KV Inspection Technician	<u>[Signature]</u>	Date	September 24, 2013
Customer Representative		Date	

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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	
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Equipment & Method

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter	
	<input type="radio"/> Chemetall Oakite 996		<input type="radio"/> Fluorescent	Type: EA31
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 970P25E	<input checked="" type="radio"/> Water Washable	Serial #: 07076863	
Developer	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<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
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Ser# 7472	100% internal and external inspection of C2		Acceptable to specification.
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046

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

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

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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	May 7, 2013		
Location	Scarborough, ON.	P. O. #			
Project	Vertical Separator	Shop Order #	1173 PQ -7472		
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	<input type="radio"/> Carbon Steel	<input checked="" type="radio"/> Stainless Steel	<input type="radio"/> Other	Material Thickness	1 3/4"
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Equipment & Method

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter	
	<input type="radio"/> Chemetall Oakite 996		<input type="radio"/> Fluorescent	Type: EA31
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 970P25E	<input checked="" type="radio"/> Water Washable	Serial #: 07076863	
	<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: Trouble Light

Inspection

Description: Repair Areas Inside and Out

Item #	Description of Weld/Test Area	Defect Location	Interpretation
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C2R	0-1		Acceptable to specification
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✓

ACCEPTED/REVIEWED/RELEASED 046

for and on behalf of: SBM OFFSHORE

Print Name: GANESH SAHA

Signature: [Signature]

Date: July 11

Applus[®]
VELOSI
 Velosi America LLC

KV Inspection Technician		Date	May 7, 2013
Customer Representative		Date	MAY 07 2013

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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	July 23, 2013
Location	Scarborough, Ontario	P. O. #	
Project	1173PQ	Shop Order #	Ser# 7472
Procedure	KV# 16 Rev. 03	Worksheet #	37345
Technician	Sherwin Suyom	CGSB Level II, Reg #	15133 ASNT/SNT-TC-1A Level II

Technical Data - Liquid Dye Penetrant (PT)

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

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

Lighting Equipment Description: Headlamp & Flashlight

Inspection

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
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C2r	PT on repair area 0-1 External & internal		Acceptable to specifications
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ACCEPTED/REVIEWED/RELEASED
 for and on behalf of: SRM OFF SHORE 046
 Print Name: GABRIEL SARA
 Signature: [Signature]
 Date: July 23, 2013
Applus[®] VELOSI
 Velosi America LLC

KV Inspection Technician	<u>[Signature]</u>	Date	July 23, 2013
Customer Representative	<u>[Signature]</u>	Date	JUL 24 2013



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 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 08, 2013		
Location	Scarborough, ON.	P. O. #			
Project	Vessel	Shop Order #	1173 PQ		
Procedure	KV# 16 Rev. 03	Worksheet #	36763		
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

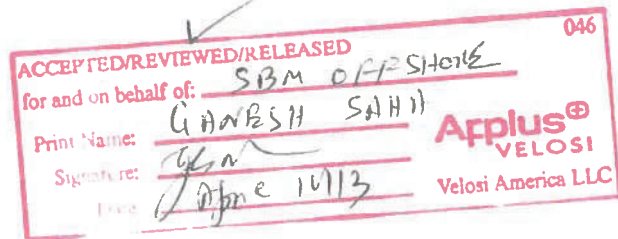
Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter
	<input type="radio"/> Chemetall Oakite 996	<input type="radio"/> Fluorescent	
	<input type="radio"/> Chemetall Oakite 970P25E		Type: EA31
Cleaner	<input checked="" type="radio"/> Chemetall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

Lighting Equipment Description: Flashlight

Inspection

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
Ser# 7472	N2-W1 -nozzle attachment weld (exterior and interior)		3 linear indications (exterior) Areas were repaired and re-tested. Acceptable to specification.
	N14-W1 -nozzle attachment weld (exterior and interior)		2 linear indications (exterior) Areas were repaired and re-tested. Acceptable to specification.



KV Inspection Technician		Date	April 08, 2013
Customer Representative		Date	APR 10 2013

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

Technical Data - Liquid Dye Penetrant (PT)

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

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter
	<input type="radio"/> Chemetall Oakite 996	<input type="radio"/> Fluorescent	
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 970P25E	<input checked="" type="radio"/> Water Washable	Serial #: 07076863
	<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

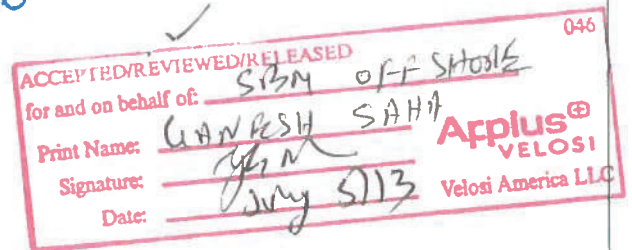
Inspection

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
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Ser# 7472	N14-W1 attachment weld (interior and exterior)		Acceptable to specification.
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Per NCR N13-036



KV Inspection Technician		Date	April 30, 2013
Customer Representative		Date	MAY 07 2013

**Liquid Dye Penetrant Inspection
 Report
 PT**

Specification – Acceptance Criteria

As per ASME Sec. VIII DIV.1 Appx 8

General Data

Customer	All-Weld Company	Date	September 24, 2013		
Location	Scarborough, ON	P. O. #			
Project		Shop Order #	1173 S/N 7472		
Procedure	KV# 16 Rev. 03	Worksheet #	37649		
Technician	Frank Marunde	CGSB Level II, Reg #	8885	ASNT/SNT-TC-1A Level	II

Technical Data – Liquid Dye Penetrant (PT)

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

Equipment & Method

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter	
	<input type="radio"/> Chemetall Oakite 996	<input type="radio"/> Fluorescent	Type: EA31	
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 970P25E	<input checked="" type="radio"/> Water Washable	Serial #: 07076802	
	<input type="radio"/> Chemetall Oakite 9PR50	<input type="radio"/> Solvent Removable	Intensity: 1400 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 Attachment welds N5-W1, N7A-W1, N11-W1 (interior and exterior)	As Marked	Linear indications detected Unacceptable to specifications

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

KV Inspection Technician	<u>[Signature]</u>	Date	September 24, 2013
Customer Representative	<u>[Signature]</u>	Date	OCT 01 2013



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

**Liquid Dye Penetrant Inspection
 Report
 PT**

Specification – Acceptance Criteria

As per ASME Sec. VIII DIV.1 Appx 8

General Data

Customer	All-Weld Company	Date	September 26, 2013		
Location	Scarborough, ON	P. O. #			
Project		Shop Order #	1173 PQ S/N 7472		
Procedure	KV# 16 Rev. 03	Worksheet #	37593		
Technician	Frank Marunde	CGSB Level II, Reg #	8885	ASNT/SNT-TC-1A Level	II

Technical Data – Liquid Dye Penetrant (PT)

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

Equipment & Method

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

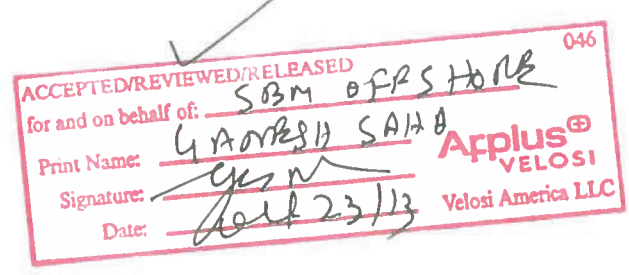
Lighting Equipment Description: Flashlight

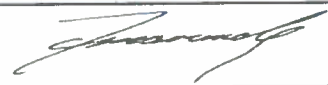
Inspection

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
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1)	Nozzle attachment welds N5-W1, N7A-W1 and N11-W1 (repair areas)		Acceptable to specifications
----	---	--	------------------------------



KV Inspection Technician		Date	September 26, 2013
Customer Representative		Date	

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 7472		
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		Type: EA31	
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 970P25E	<input type="radio"/> Fluorescent	Serial #: 07076802	
	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<input checked="" type="radio"/> Water Washable	Intensity: 1400 Lx	
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable		

Lighting Equipment Description: Flashlight

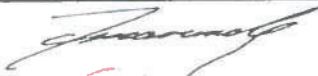

Inspection

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
Ser #7472	Nozzle attachment weld N13-W1 (interior and exterior)		Acceptable to specifications

✓

ACCEPTED/REVIEWED/RELEASED
 for and on behalf of: SBM OFFSHORE
 Print Name: GAVRISH SAH A
 Signature: [Signature]
 Date: 09 23/13
Applus[®] VELOSI
 Velosi America LLC

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

Liquid Dye Penetrant Inspection Report
PT

Specification – Acceptance Criteria

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

General Data

Customer	All-Weld Company	Date	August 13, 2013		
Location	@ KV Inspection, Oakville, ON	P. O. #			
Project	Ultrafab	Shop Order #	1173 PQ SN 7472		
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	
---------------	------------------------------------	--	-----------------------------	--------------------	--

Equipment & Method

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter	
	<input type="radio"/> Chemetall Oakite 996		Type: EA31	
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 970P25E	<input type="radio"/> Fluorescent	Serial #: 80613518	
	<input checked="" type="radio"/> Chemetall Oakite 9PR50	<input checked="" type="radio"/> Water Washable	Intensity: 1300 Lx	
Developer	<input checked="" type="radio"/> Chemetall Oakite 9D1B	<input type="radio"/> Solvent Removable		


Lighting Equipment Description: Shop & Exterior Lighting

Inspection

Description: **Nozzle 13**

Item #	Description of Weld/Test Area	Defect Location	Interpretation
SN# 7472	C1 – 2"Ø Butt weld		Acceptable to specification
	C2 – 2"Ø Butt Weld		Acceptable to specification

ACCEPTED/REVIEWED/RELEASED 046
for and on behalf of: SAM OFFSHORE
Print Name: GANESH SAHA
Signature: [Signature] **Applus[®] VELOSI**
Date: 04-23-2013 **Velosi America LLC**

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

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

Liquid Dye Penetrant Inspection Report PT

Specification - Acceptance Criteria

As per ASME Sec. VIII DIV.1 Appx 8

General Data

Customer	All-Weld Company	Date	October 9, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7472
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 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 type="radio"/> Chemetall Oakite 9D1B	<input checked="" type="radio"/> Water Washable <input type="radio"/> Solvent Removable	Serial #: 07076803
Developer			Intensity: 1400 Lx

Lighting Equipment Description: Flashlight

Inspection

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
1)	Nozzle attachment MW1-W1 (interior and exterior)		Acceptable to specifications
2)	N13-C3 weld		Acceptable to specifications

✓

ACCEPTED/REVIEWED/RELEASED 046
 for and on behalf of: SBM OFFSHORE
 Print Name: LIAM BISH SAH
 Signature: [Signature]
 Date: Oct 23/13
Applus[®] VELOSI
 Velosi America LLC

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



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

Liquid Dye Penetrant Inspection Report PT

Specification - Acceptance Criteria

As per ASME Sec. VIII DIV.1 Appx 8

General Data

Customer	All-Weld Company	Date	October 1, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7472
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	<ul style="list-style-type: none"> <input checked="" type="radio"/> Chemetall Oakite 906 <input type="radio"/> Chemetall Oakite 996 <input type="radio"/> Chemetall Oakite 970P25E 	<ul style="list-style-type: none"> <input checked="" type="radio"/> Visible <input type="radio"/> Fluorescent 	Light meter
Cleaner	<ul style="list-style-type: none"> <input checked="" type="radio"/> Chemetall Oakite 9PR50 	<ul style="list-style-type: none"> <input checked="" type="radio"/> Water Washable 	Type: EA31
Developer	<ul style="list-style-type: none"> <input checked="" type="radio"/> Chemetall Oakite 9D1B 	<ul style="list-style-type: none"> <input type="radio"/> Solvent Removable 	Serial #: 07076802

Lighting Equipment Description: Flashlight

Inspection

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
1)	Vortex Breaker welds (loose)		Acceptable to specifications
2)	Skirt-W1 and skirt-L1 (interior and exterior)		Several indications detected, were repaired and re-tested Acceptable to specifications
3)	4 Lifting lug attachment welds		Acceptable to specifications

046

ACCEPTED/REVIEWED/RELEASED
 for and on behalf of: SBIY OFFSHORE
 Print Name: GABRIEL SAHA
 Signature: [Signature]
 Date: Oct 25 2013
Applus[®] VELOSI
 Velosi America LLC

KV Inspection Technician		Date	October 1, 2013
Customer Representative		Date	OCT 23 2013

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

**Liquid Dye Penetrant Inspection
Report
PT**

Specification – Acceptance Criteria

As per ASME Sec. VIII DIV.1 Appx 8

General Data

Customer	All-Weld Company	Date	October 21, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173PQ S/N 7472
Procedure	KV# 16 Rev. 03	Worksheet #	37867
Technician	Frank Marunde	CGSB Level II, Reg #	8885 ASNT/SNT-TC-1A Level II

Technical Data – Liquid Dye Penetrant (PT)

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

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906 <input type="radio"/> Chemetall Oakite 996 <input type="radio"/> Chemetall Oakite 970P25E	<input checked="" type="radio"/> Visible <input type="radio"/> Fluorescent	Light meter
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# 7472	Item 6/4 – Manway cover welds		Acceptable to specifications
	MW1 Davit bracket attachment weld		Acceptable to specifications
	Nozzle support attachment welds N3, N4, N5, N6, N7A, N7B, N8A, N8B, N9A, N9B, N10A, N10B, N11, N12, N13, & N14.		Acceptable to specifications
	Name bracket attachment weld		Acceptable to specifications

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

KV Inspection Technician		Date	October 21, 2013
Customer Representative		Date	OCT 22 2013

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

Liquid Dye Penetrant Inspection Report PT

Specification - Acceptance Criteria

As per ASME Sec. VIII DIV.1 Appx 8

General Data

Customer	All-Weld Company	Date	October 16, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173PQ S/N 7472
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	<input type="radio"/> Carbon Steel <input checked="" type="radio"/> Stainless Steel <input type="radio"/> Other	Material Thickness	
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Equipment & Method

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906	<input checked="" type="radio"/> Visible	Light meter
	<input type="radio"/> Chemetall Oakite 996		
Cleaner	<input type="radio"/> Chemetall Oakite 970P25E	<input type="radio"/> Fluorescent	Serial #: 07076803
	<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# 7472	Attachment welds		
	Item 25/2 to shell		Acceptable to specifications
	Item 21/2 to N3		Acceptable to specifications
	Vortex breaker to N13		Acceptable to specifications

✓

ACCEPTED/REVIEWED/RELEASED 046
 for and on behalf of: SAM OFFSHORE
 Print Name: ANRISH SAHA
 Signature: [Signature]
 Date: Oct 23/13

Applus[®]
VELOSI
Velosi America LLC

KV Inspection Technician		Date	October 16, 2013
Customer Representative		Date	OCT 17 2013

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

Liquid Dye Penetrant Inspection Report PT

Specification – Acceptance Criteria

As per ASME Sec. VIII DIV.1 Appx 8

General Data

Customer	All-Weld Company	Date	October 23, 2013
Location	Scarborough, ON	P. O. #	
Project	Ultrafab	Shop Order #	1173PQ S/N 7472
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

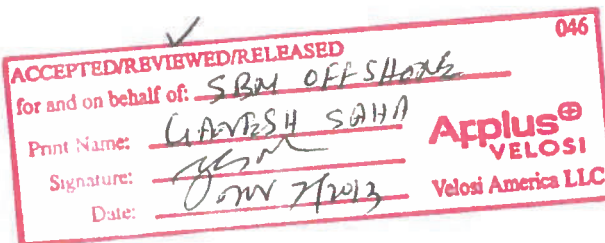
Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906 <input type="radio"/> Chemetall Oakite 996 <input type="radio"/> Chemetall Oakite 970P25E	<input checked="" type="radio"/> Visible <input type="radio"/> Fluorescent	Light meter
Cleaner	<input checked="" type="radio"/> Chemetall Oakite 9PR50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

Lighting Equipment Description: Trouble light

Inspection

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
1)	Tailing Lug Welds		Acceptable to specifications



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



**Liquid Dye Penetrant Inspection
Report
PT**

Specification – Acceptance Criteria

As per ASME Sec. VIII DIV.1 Appx 8

General Data

Customer	All-Weld Company	Date	October 1, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7472
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	<input type="radio"/> Carbon Steel <input checked="" type="radio"/> Stainless Steel <input type="radio"/> Other	Material Thickness	
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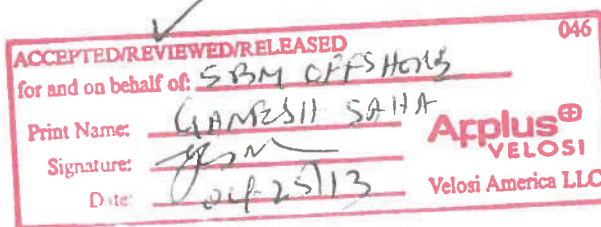
Equipment & Method

Penetrant	<input checked="" type="radio"/> Chemetall Oakite 906 <input type="radio"/> Chemetall Oakite 996 <input type="radio"/> Chemetall Oakite 970P25E	<input checked="" type="radio"/> Visible <input type="radio"/> Fluorescent	Light meter
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 #: 07076802
Lighting Equipment Description: Flashlight			Intensity: 1400 Lx

Inspection

Description:

Item #	Description of Weld/Test Area	Defect Location	Interpretation
Ser #7472	Internal attachment welds		Several indications detected, were repaired and re-tested
	Item 1/7- Shell		Acceptable to specifications
	Item 6/7- Shell		Acceptable to specifications
	Item 23/2- Shell		Acceptable to specifications
	Item 26/2 -N1		Acceptable to specifications
	Item 2/3 - Skirt		Acceptable to specifications



KV Inspection Technician

[Handwritten Signature]

Date

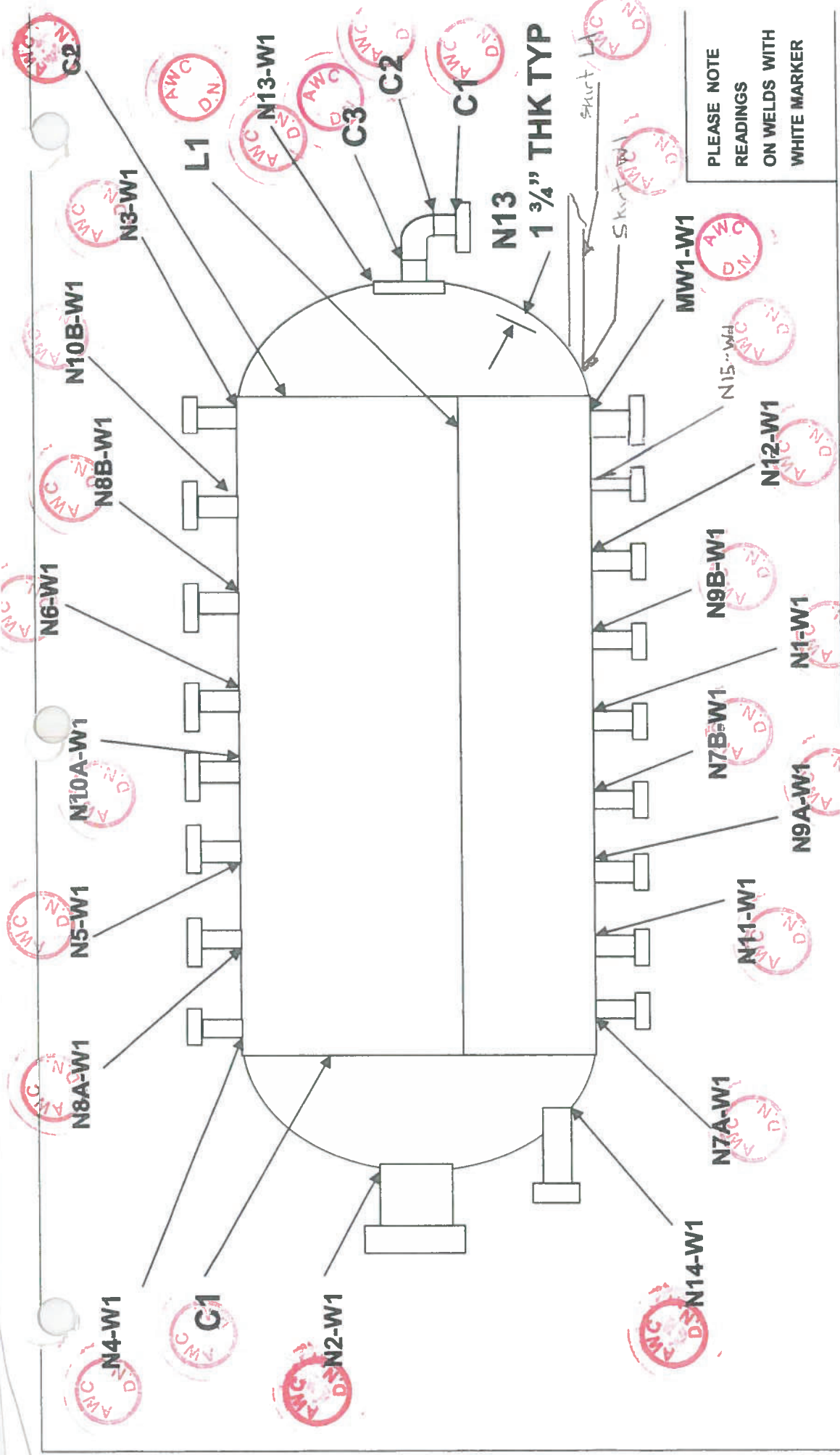
October 1, 2013

Customer Representative



Date

OCT 23 2013



N13
1 3/4" THK TYP

PLEASE NOTE
READINGS
ON WELDS WITH
WHITE MARKER

ALL-WELD CO. LTD. - HT MAP

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

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

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

P.O. 13-0228

CLIENT: ULTRAFAB

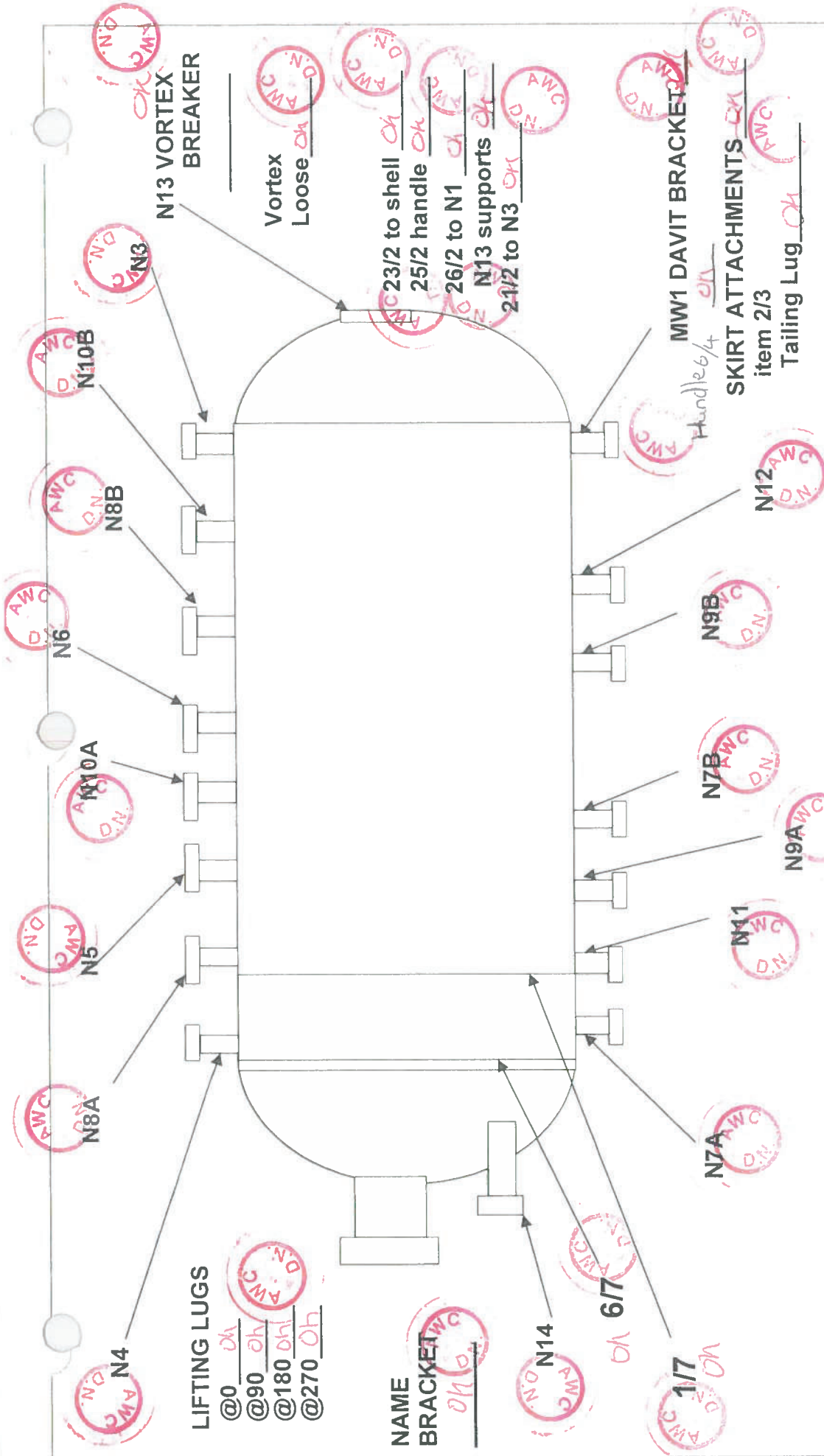
WORK ORDER #: 1173PQ SN 7472

JOB DESCRIPTION: 48" O.D. VERTICAL INLET

DRAWING #: 1173-1-IN

PREPARED BY: D.NESCI

DATE: March 6, 2013



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

CLIENT: ULTRAFAB
 WORK ORDER #: 1173PQ SN 7472
 JOB DESCRIPTION: 48" O.D. VERTICAL INLET
 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.



N13 VORTEX BREAKER

Vortex Loose Oh

23/2 to shell Oh
 25/2 handle Oh
 26/2 to N1 Oh
 N13 supports Oh
 24/2 to N3 Oh

MW1 DAVIT BRACKET
 Handle 6/4 Oh

SKIRT ATTACHMENTS Oh
 item 2/3
 Tailing Lug Oh

LIFTING LUGS
 @0 Oh
 @90 Oh
 @180 Oh
 @270 Oh

NAME
 BRACKET Oh

N14 Oh

617 Oh

117 Oh

N4 Oh

N8A Oh

N5 Oh

N10A Oh

N6 Oh

N8B Oh

N10B Oh

N13 Oh

N7A Oh

N11 Oh

N9A Oh

N7B Oh

N9B Oh

N12 Oh

N10C Oh

N10D Oh

N10E Oh

N10F Oh

N10G Oh

N10H Oh

N10I Oh

**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	✓ 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 # 7472 - L1	Parent Material	246
	H.A.Z	216
	Weld	233
	H.A.Z	224
	Parent Material	246

ACCEPTED/REVIEWED/RELEASED ✓
for and on behalf of: SBM OFFSHORE 0-36
Print Name: GARRETT SMITH
Signature: [Signature] **Applus^{CP}**
Date: March 12, 2013 **VELCISI**
Velosi America LLC

KV Inspection Technician		Date	March 12, 2013
Customer Representative		Date	MAR 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	September 23, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7472
Procedure	KV HT# 35 Rev.00	Worksheet #	37648
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:		

046
 ACCEPTED/REVIEWED/RELEASED
 for and on behalf of: *SAM O'HARA*
 Print Name: *GAMBELL SAKA*
 Signature: *[Signature]*
 Date: *Oct 23/13*
Applus®
VELOSI
 Velosi America LLC

Inspection

Description:

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7472	C1	153	153	182	209	206
	N1-W1	185	210	149	154	165
	N3-W1	190	201	164	200	173
	N4-W1	189	173	154	184	191
	N5-W1	197	180	159	171	193
	N6-W1	196	167	133	199	192
	N7A-W1	191	164	180	218	205
	N7B-W1	232	212	133	182	176
	Skirt W1	134	161	168	174	152
	Skirt L1	133	143	118	140	166

KV Inspection Technician	<i>[Signature]</i>	120	September 23, 2013
Customer Representative	<i>[Signature]</i>	Date	SEP 26 2013

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

Hardness Testing Report HT

Specification – Acceptance Criteria

248 HV Max

General Data

Customer	All-Weld Company	Date	April 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	✓ CGSB Reg # 10375

Technical Data – Hardness Testing (HT)

Material	Stainless Steel
Test Method & Equipment	
Technique	● Impact Load – Digital Readout
Equipment	● Equotip D Impact Device
Readings Taken	○ Average of 5 readings ● Average of 3 readings ○ Other
Scale	○ Brinell Hardness ● HV

Inspection

Description:

Item #	Description of Test Area	Parent Mat'l	HAZ	Weld	HAZ	Parent Mat'l
Ser# 7472	C2	200	183	173	178	147

✓

ACCEPTED/REVIEWED/RELEASED 046

for and on behalf of: SAM OFFSHORE

Print Name: CAMPESH SAHA

Signature: [Signature] **Appius®**

Date: JUN 11 2013 **VELOSI**

Velosi America LLC

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

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Phone: 905-844-9448
Fax: 905-844-6697

**Hardness Testing Report
HT**

Specification – Acceptance Criteria

248 HV10 Max

General Data

Customer	All-Weld Company	Date	July 23, 2013
Location	Scarborough, Ontario	P. O. #	
Project	Vessel	Shop Order #	1173 PQ
Procedure	KV HT# 50 Rev. 00	36980	37345
Technician	John MacDonald	HT Certified	<input checked="" type="checkbox"/> CGSB Reg #10375

Technical Data – Hardness Testing (HT)

Material: Stainless Steel

Test Method & Equipment

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

Inspection

Description:

Item #	Description of Test Area	Base Material	HAZ	Weld	HAZ	Base Material
Ser# 7472	C2 R (0-1)	241	247	234	218	242
	Pay N13-048					

✓

046

ACCEPTED/REVIEWED/RELEASED
for and on behalf of: SBM OFFSHORE
Print Name: GARY SAHA
Signature: [Signature]
Date: JUN 7 13
Applus®
VELOSI
Velosi America LLC

KV Inspection Technician

Date July 23, 2013

Customer Representative

Date NOV 06 2013



Hardness Testing Report HT

Specification - Acceptance Criteria

General Data

Customer	All-Weld Company	Date	April 08, 2013
Location	Scarborough, Ontario	P. O. #	
Project	Vessel	Shop Order #	1173 PQ
Procedure	KV HT# 35 Rev. 00	Worksheet #	36763
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

Technical Data - Hardness Testing (HT)

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

Inspection

Description:

Item #	Description of Test Area	Parent Mat'l	HAZ	Weld	HAZ	Parent Mat'l
Ser# 7472	N2-W1	205	202	170	172	171
	N14-W1	202	189	174	184	180

ACCEPTED/REVIEWED/RELEASED
 for and on behalf of: SAM OF FRSITONK 046
 Print Name: GANESH SAHA
 Signature: [Signature] **Applus®**
 Date: 04/08/13 **VELOSI**
 Velosi America LLC

KV Inspection Technician		Date	April 08, 2013
Customer Representative		Date	APR 15 2013

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

Hardness Testing Report HT

Specification – Acceptance Criteria

248 HV Max

General Data

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



Technical Data – Hardness Testing (HT)

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

Inspection

Description:

Item #	Description of Test Area	Parent Mat'l	HAZ	Weld	HAZ	Parent Mat'l
Ser# 7472	N14-W1	198	221	172	183	177
Per NCR N13-036						
<div style="border: 2px solid red; padding: 5px; display: inline-block;"> <p>ACCEPTED/REVIEWED/RELEASED 046 for and on behalf of: <u>SBM OFFSHORE</u> Print Name: <u>GAMESH SAHII</u> Signature: <u>[Signature]</u> Date: <u>July 5/13</u></p> <p style="text-align: right;">Applus® VELOSI Velosi America LLC</p> </div>						

KV Inspection Technician		Date	April 30, 2013
Customer Representative		Date	MAY 07 2013

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Fax: 905-844-6697

Hardness Testing Report HT


Specification – Acceptance Criteria

General Data			
Customer	All-Weld Company	Date	September 23, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7472
Procedure	KV HT# 35 Rev.00	Worksheet #	37648
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		<div style="border: 2px solid red; padding: 5px;"> <p style="font-size: 8px; margin: 0;">ACCEPTED/REVIEWED/RELEASED for and on behalf of: SBM O.P.C. STONE</p> <p style="font-size: 8px; margin: 0;">Print Name: GABRIEL SAHA</p> <p style="font-size: 8px; margin: 0;">Signature: <i>[Signature]</i></p> <p style="font-size: 8px; margin: 0;">Date: 09/23/13</p> <p style="font-size: 8px; margin: 0;">Atplus® VELOSI</p> <p style="font-size: 8px; margin: 0;">Veloci America LLC</p> </div>
Equipment	<input checked="" type="radio"/> Equotip D Impact Device		
Readings Taken	<input type="radio"/> Average of 5 readings <input checked="" type="radio"/> Average of 3 readings <input type="radio"/> Other		
Scale	<input type="radio"/> Brinell Hardness <input checked="" type="radio"/> HV Unit Setting: <input type="text"/>		

Inspection

Description:						
Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7472	N8A-W1	215	183	147	184	182
	N8B-W1	201	191	145	198	179
	N9A-W1	200	169	129	170	182
	N9B-W1	209	182	149	171	197
	N10A-W1	188	150	164	175	194
	N10B-W1	217	207	173	174	189
	N11-W1	167	194	158	206	216
	N12-W1	204	218	178	133	163
	N15-W1	190	180	140	185	174

KV Inspection Technician	<i>[Signature]</i>	120	September 23, 2013
Customer Representative		Date	SEP 26 2013

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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 7472
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 <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# 7472	N13	172	170	193	207	193

ACCEPTED/REVIEWED/RELEASED

for and on behalf of: SBM OPERATIONS 046

Print Name: GANESH SAHA

Signature: [Signature]

Date: 04/23/13

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Velosi America LLC

KV Inspection Technician		120	September 30, 2013
Customer Representative		Date	OCT 01 2013

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Fax: 905-844-6697

Hardness Testing Report HT

Specification – Acceptance Criteria

248 Max

General Data

Customer	All-Weld Company	Date	August 14, 2013
Location	@ KVI, Oakville, ON	P. O. #	
Project	Vessel	Shop Order #	1176 PQ Ser#7472
Procedure	KV HT# 35 Rev.00	Worksheet #	37440
Technician	Ed Duitschaever	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 515

Technical Data – Hardness Testing (HT)

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

Test Method & Equipment

Technique	<input checked="" type="radio"/> Impact Load – Digital Readout <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# 7472	N13 - C1	144	142	160	178	156
	N13 - C2	181	143	135	191	154

046

ACCEPTED/REVIEWED/RELEASED

for and on behalf of: SOM OFF SHORE

Print Name: CAROL S HAN

Signature: [Signature]

Date: July 23/13

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Velosi America LLC

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

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 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 7472
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# 7472	MW1	160	159	146	167	188
	N13-C3	167	149	161	147	153

046

ACCEPTED/REVIEWED/RELEASED

for and on behalf of: CSM OFF STORE

Print Name: GAMBH SAHA

Signature: [Signature]

Date: Oct 23/13

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Velosi America LLC

KV Inspection Technician

[Signature]

120

October 9, 2013

Customer Representative



Date

OCT 10 2013

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 7472
Procedure	KV HT# 35 Rev.00	Worksheet #	37733
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

046

ACCEPTED FOR RELEASE
for and on behalf of: SCM OFF STORE
YANBERT SAH
Print Name: _____
Signature: _____
Date: _____

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Velosi America LLC

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# 7472	Vortex breaker loose	119	134	108	121	163
	Skirt-W1	167	145	161	182	180
	Skirt-L1	156	143	106	129	128
	Item 2/3-Skirt	150	138	131	133	144
	Item 23/2- Shell	204	158	105	137	150
	Item 26/2-N1	173	178	144	180	138
	Item 1/7- Shell	210	183	130	191	194
	Item 6/7- Shell	193	187	114	181	188

MIKE KAMYAB
REVIEWED
WITNESSED
FOR:

KV Inspection Technician		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 1, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7472
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# 7472	Lifting lugs					
	0°	133	171	148	151	153
	90°	147	150	138	163	159
	180°	154	178	135	146	180
	270°	141	146	146	169	182

ACCEPTED/REVIEWED/RELEASED
 for and on behalf of: SBM OFFSHORE
 Print Name: GARRETT SAHA
 Signature: [Signature]
 Date: Oct 23/13
 046
Applus
 VIOSI
 MIKE KAMYAB
 REVIEWED
 WITNESSED
 FOR:

KV Inspection Technician		120	October 1, 2013
Customer Representative		Date	OCT 03 2013

**Hardness Testing Report
HT**

Specification – Acceptance Criteria

General Data

Customer	All-Weld Company	Date	October 16, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7472
Procedure	KV HT# 35 Rev.00	Worksheet #	37765
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: SOM OFF SHORE
AMESH SAHA
 Print Name: AMESH SAHA
 Signature: [Signature]
 Date: 10/16/13
Appius®
VELOS!
 Velosi America LLC

Inspection

Description:

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7472	N3 support welds					
	#1	192	180	155	152	124
	#2	205	175	147	142	139
	#3	167	147	160	147	117
	#4	181	147	151	138	130
	N4 support welds					
	#1	216	159	165	132	128
	#2	217	150	123	156	122
#3	183	146	120	149	125	
#4	169	141	127	152	122	

KV Inspection Technician

[Signature]


Date

October 16, 2013

Customer Representative

Date

OCT 17 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 16, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7472
Procedure	KV HT# 35 Rev.00	Worksheet #	37765
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

046
 ACCEPTED/REVIEWED/RELEASED
 for and on behalf of: SAM OF A STONE
 Print Name: GANBALT SAHA
 Signature: [Signature]
 Date: Oct 13 13
APPLUS
VELOSI
 Velocity America LLC

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# 7472	N5 support welds					
	#1	198	168	170	199	120
	#2	218	173	152	132	147
	#3	143	165	161	164	133
	#4	146	147	127	135	125
	N6 support welds					
	#1	197	147	170	152	131
	#2	211	154	135	133	123
#3	162	172	146	155	152	
#4	171	154	143	156	137	

KV Inspection Technician

[Signature]


Date

October 16, 2013

Customer Representative

Date

OCT 17 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 16, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7472
Procedure	KV HT# 35 Rev.00	Worksheet #	37765
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

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Velocity America LLC

ACCEPTED/REVIEWED/RELEASED
for and on behalf of: *SBM OFFS HOLD*
Print Name: *FRANK MARUNDE*
Signature: *[Signature]*
Date: *10/16/13*

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# 7472	N7A support welds					
	#1	212	179	134	178	138
	#2	231	184	139	154	121
	#3	193	144	154	150	148
	#4	184	156	157	157	129
	N7B support welds					
	#1	200	164	159	140	119
	#2	204	168	149	141	124
	#3	216	147	131	141	119
	#4	196	158	160	154	114

KV Inspection Technician	<i>[Signature]</i>	Date	October 16, 2013
Customer Representative		Date	Oct 17 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 16, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7472
Procedure	KV HT# 35 Rev.00	Worksheet #	37765
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:	

046
 ACCEPTED/REVIEWED/RELEASED
 for and on behalf of: **SBM OFFSHORE**
APPLUS
VELOSI
 Velocity America LLC
 Print Name: **YANBISH SAH**
 Signature: *[Signature]*
 Date: **Oct 23/13**

Inspection

Description:

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7472	N8A support welds					
	#1	210	169	154	153	146
	#2	205	163	151	145	133
	#3	178	168	153	142	124
	#4	134	134	129	166	138
	N8B support welds					
	#1	211	180	123	123	118
	#2	193	178	127	125	128
	#3	160	150	153	146	139
	#4	155	143	149	138	122

KV Inspection Technician

[Signature]

Date

October 16, 2013

Customer Representative

AWC

Date

OCT 17 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 16, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7472
Procedure	KV HT# 35 Rev.00	Worksheet #	37765
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

046
 ACCEPTED/REVIEWED/RELEASED
 for and on behalf of: SBM OFFSHORE
 Print Name: GAMBERT SAH A
 Signature: [Signature]
 Date: Oct 23/13
APPLUS®
VELOSI
 Velo America LLC

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# 7472	N9A support welds					
	#1	206	172	155	153	142
	#2	180	153	142	143	155
	#3	199	154	133	116	125
	#4	176	148	165	126	130
	N9B support welds					
	#1	197	152	143	168	151
	#2	216	158	160	176	147
#3	206	194	156	154	145	
#4	194	175	170	170	155	

KV Inspection Technician

[Signature]

Date: October 16, 2013

Customer Representative

AWC

Date: OCT 17 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 16, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7472
Procedure	KV HT# 35 Rev.00	Worksheet #	37765
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:

0-36
 ACCEPTED/REVIEWED/RELEASED
 for and on behalf of: *SOM O PISHORE*
 Print Name: *GAMBIT SAHA*
 Signature: *[Signature]*
 Date: *Oct 23 13*
Applus
 VELOSI
 Velosi America LLC

Inspection

Description:

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7472	N10A support welds					
	#1	197	163	151	167	149
	#2	180	174	182	142	127
	#3	221	185	155	166	158
	#4	206	173	151	152	135
	N10B support welds					
	#1	231	189	130	139	147
	#2	218	185	135	169	137
	#3	194	171	157	140	118
	#4	174	166	147	146	128

KV Inspection Technician

[Signature]

Date

October 16, 2013

Customer Representative



Date

OCT 17 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 16, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7472
Procedure	KV HT# 35 Rev.00	Worksheet #	37765
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

046
 ACCEPTED/REVIEWED/RELEASED
 for and on behalf of: S.P.M. OFFSHORE
 Print Name: LAUREN BETH SAHA
 Signature: [Signature]
 Date: Oct 23 2013
Applus
VELOSI
 Velosi America LLC

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# 7472	N11 support welds					
	#1	207	159	170	142	152
	#2	191	148	155	137	127
	#3	193	157	153	153	132
	#4	212	154	143	137	129
	N12 support welds					
	#1	189	169	183	151	127
	#2	183	186	189	145	114
	#3	164	159	153	153	123
	#4	156	156	166	180	133

KV Inspection Technician

[Signature]

Date

October 16, 2013

Customer Representative



Date

OCT 17 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 16, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7472
Procedure	KV HT# 35 Rev.00	Worksheet #	37765
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

APPLUS®
VELOSI

Velocity America LLC

ACCEPTED/REVISED/RELEASED
for and on behalf of: SJM OF STONE
GAMBH-CANA
 Print Name: gsm
 Signature: [Signature]
 Date: Jan 23 13

Inspection

Description:

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7472	N13 support welds					
	#1	127	174	138	135	144
	#2	137	120	155	137	161
	#3	146	151	143	148	117
	#4	148	161	146	146	123
	N14 support welds					
	#1	142	122	159	140	140
	#2	154	148	149	133	137
	#3	154	173	161	140	128
	#4	160	161	170	142	121

KV Inspection Technician		Date	October 16, 2013
Customer Representative		Date	OCT 17 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 16, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7472
Procedure	KV HT# 35 Rev.00	Worksheet #	37765
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# 7472	MW1 Davit bracket	184	209	203	201	190
	Vortex breaker	165	186	174	N/A	N/A
	Item 21/2 to N3	165	160	154	179	176
	Item 25/2 to shell 1	174	174	150	231	204
	Item 25/2 to shell 2	206	185	164	201	223
	Name bracket to shell	131	141	153	N/A	N/A

ACCEPTED/REVIEWED/RELEASED
 for and on behalf of: SBM OFFSHORE
 Print Name: GAMBISH SAAD
 Signature: [Signature]
 Date: 0425/13
Applus®
VELOSI
Velosi America LLC
046

KV Inspection Technician

[Signature]

Date

October 16, 2013

Customer Representative



Date

OCT 17 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 21, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1173 PQ S/N 7472
Procedure	KV HT# 35 Rev.00	Worksheet #	37867
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/REVIEWED/RELEASED
 for and on behalf of: SBM OFF SHORE
APPLUS®
VELOSI
 Print Name: Frank Marunde
 Signature: [Signature]
 Date: Oct 23 13
 Velosi America LLC

Inspection

Description:

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7472	Item 6/4 Manway #1	186	171	141	215	210
	Item 6/4 Manway #2	181	154	146	200	206
	Item 6/4 Manway #3	187	151	141	205	211
	Item 6/4 Manway #4	192	175	133	195	221

KV Inspection Technician [Signature] Date: October 21, 2013
 Customer Representative [Signature] Date: OCT 22 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 7472
Procedure	KV HT# 35 Rev.00	Worksheet #	37924
Technician	Chris Veeneman	HT Certified	<input checked="" type="checkbox"/> 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
	<input type="radio"/> Other	
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
Ser# 7472	Tailing Lug	198	182	169	184	175

046

ACCEPTED/REVIEWED/RELEASED ✓
 for and on behalf of: SUBM OFFSHORE
 Print Name: LAWRENCE SAHA
 Signature: [Handwritten Signature]
 Date: OCT 23 2013
Applus®
 VELOSI
 Veloci America LLC

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

QA COPY

NON-CONFORMANCE REPORT				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 DN		Other KVI	
Nature of NCR	Product <input checked="" type="checkbox"/>	System	Document	Vendor	Other
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 <input checked="" type="checkbox"/>	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 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		Engineer		ISO		
Sales		<input checked="" type="checkbox"/> QA	<i>DN</i>	<i>MAR 13/13</i>	Other -	
<input checked="" type="checkbox"/> Proj. Mgr	<i>[Signature]</i>	<input checked="" type="checkbox"/> AI	<i>[Signature]</i>	<i>MAR 15.13</i>	Other -	

Disposition Verification

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

Follow-Up Required

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

NCR No. N13-030

Work Order 1173PQ	Serial Number 7472	Customer Ultrafab	NCR Author DN	NCR Date 10-Apr-13
----------------------	-----------------------	----------------------	------------------	-----------------------

NCR Background

Discovered By	Customer	AWC	DN	Other	KV Inspection
Nature of NCR	Product X	System	Document	Vendor	Other

Description

X-ray repair in C2: films 0-1, 4-5, 6-7, 8-9, 9-10, & 10-0 linear slag indications. Welder #109

Immediate Action

NCR Disposition

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

Description

- 1) Grind out repairs.
- 2) PT repair areas.
- 3) Weld with WPS 3-4
- 4) QA inspect
- 5) RT repairs

See supplementary file for further Disposition File Name

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

<input checked="" type="checkbox"/>	Approvals Required - (Sign and Date)	NCR Approvals				
	Customer	Engineer	ISO			
	Sales	QA <i>DN 10/04/13</i>	Other -			
<input checked="" type="checkbox"/>	Proj Mgr <i>(MST) APR 10</i>	AI <i>SE MAY 29, 13</i>	Other -			

	Dwgs/Calcs	Prod-CPS	ISO		
	Purchasing	QA <i>DN 5/29/13</i>	Other -		
	Prod-AWC	AI <i>SE MAY 29, 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 -
--------------------------	-----------------------	--------------------------	---------------------------------	--------------------------	-----------------	--------------------------	---------

QA COPY

NON-CONFORMANCE REPORT				NCR No.
Work Order 1173PQ	Serial Number 7472	Customer Utrafab	NCR Author DN	N13-036
				NCR Date 12-Apr-13

NCR Background

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

Description

N14 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 and jack into position
 • REDD ALL NDE PT & UT THT
 Repair if required

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)	NCR Approvals			
	Customer	Engineer	ISO		
	Sales	QA <i>DN</i> Apr 19/13	Other -		
	Proj. Mgr <i>DN</i> Apr 19/13	AI	Other -		

Disposition Verification

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

Follow-Up Required

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

NON-CONFORMANCE REPORT				NCR No. N13-042
Work Order 1173PQ	Serial Number 7472	Customer Ultrafab	NCR Author DN	NCR Date 18-Apr-13

NCR Background

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

Description

X-ray repair in C2 @ 0 to 1 film segment (slag inclusion) *Weld 90*

Immediate Action

NCR Disposition

Decision	Scrap	Rework	Repair X	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 repair

See suplimentary file for further Disposition File Name

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

NCR Approvals

<input checked="" type="checkbox"/> Approvals Required - (Sign and Date)	Customer	Engineer	ISO
Sales	QA <i>Done 18/04/13</i>	Other -	
↓ Proj. Mgr <i>[Signature] Apr 18</i>	AI <i>[Signature] MAY 29, 13</i>	Other -	

Disposition Verification

(Sign and Date)	Dwgs/Calcs	Prod-CPS	ISO
Purchasing	QA <i>Done May 29/13</i>	Other -	
Prod-AWC	AI <i>[Signature] MAY 29, 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 -
--	--	--	----------------------------------

NON-CONFORMANCE REPORT				NCR No. N13-048
Work Order 1173PQ	Serial Number 7472	Customer Ultrafab	NCR Author DN	NCR Date 8-May-13

NCR Background

Discovered By	Customer	AWC		Other	
		DN		KVInspection	
Nature of NCR	Product <input checked="" type="checkbox"/>	System	Document	Vendor	Other
Description					
RT repair in C2 film # 0 to 1 @ 2 to 5 1/2" staggered slag indication.					
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.							
2) PT repair area.							
3) Weld with WPS 3-4							
4) QA Inspect							
5) RT repair							
6) Perform PT & HT on repair							
See suplimentary file for further Disposition				File Name			
Contract Adjustment (ECN Only)	Quote	Extra Amount	AWC Rep	Notes		Submitted	Dates
						Approved	

NCR Approvals

<input checked="" type="checkbox"/>	Approvals Required - (Sign and Date)					
	Customer	Engineer	ISO			
	Sales	QA <i>DN May 8/13</i>	Other -			
<input checked="" type="checkbox"/>	Proj. Mgr <i>DN May 8/13</i>	AI <i>DN May 08.13</i>	Other -			

Disposition Verification

<input type="checkbox"/>	Dwgs/Calcs	Prod-CPS	ISO			
	Purchasing	QA <i>DN Resn July 24/13</i>	Other -			
	Prod-AWC	AI <i>DN May 24. 2013</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 -
--	--	--	----------------------------------

Welding Procedure Specification (WPS)

CARBON STEEL

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

<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="text-align: center;">4</td> <td>Welding Process(es)</td> </tr> <tr> <td>1</td> <td style="text-align: center;">SMAW</td> </tr> <tr> <td>2</td> <td> </td> </tr> <tr> <td>3</td> <td> </td> </tr> </table>	4	Welding Process(es)	1	SMAW	2		3		<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td>Manual</td> <td style="text-align: center;">X</td> <td>Semi-auto.</td> <td> </td> <td>Auto.</td> <td> </td> </tr> <tr> <td>Manual</td> <td> </td> <td>Semi-auto.</td> <td> </td> <td>Auto.</td> <td> </td> </tr> <tr> <td>Manual</td> <td> </td> <td>Semi-auto.</td> <td> </td> <td>Auto.</td> <td> </td> </tr> </table>	Manual	X	Semi-auto.		Auto.		Manual		Semi-auto.		Auto.		Manual		Semi-auto.		Auto.	
4	Welding Process(es)																										
1	SMAW																										
2																											
3																											
Manual	X	Semi-auto.		Auto.																							
Manual		Semi-auto.		Auto.																							
Manual		Semi-auto.		Auto.																							

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

6	Base Metals (QW-403)	P. No. 1	Gr. No. 1 & 2	to P. No. 1	Gr. No. 1 & 2
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.					
NONE					
Thickness Range Qualified		Total 1) 1/16" to 1 1/2"			
Other 1) NO SINGLE PASS TO BE GREATER THAN 1/2"					

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

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

10	Postweld Heat Treatment (QW-407)
Temperature Range	NONE
Time Range	NONE
Other	NONE

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

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

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

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

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

1	Supplementary Comments
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

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

COPY

PROCEDURE QUALIFICATION RECORD

PQR - 1

Date APR 23, 1979

ALL-WELD COMPANY LIMITED
(Manufacturer)

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

Weld Proc. Spec. No. WPSI-1 Weld Process(es) SMAW Types MANUAL
(Manual, Automatic)

<p>JOINTS (QW-402)</p> <p>Groove Design Used</p>	<p>BASE METALS (QW-403)</p> <p>Material Spec. <u>Carbon Steel</u></p> <p>Type or Grade <u>SA53 GR.B</u></p> <p>P No. <u>1</u> to P No. <u>1</u></p> <p>Thickness <u>0.432"</u></p> <p>Diameter <u>6" Pipe</u></p> <p>Other <u>N/A</u> <i>NO SINGLE PASS GREATER THAN 1/2" THICK VOID</i> <i>10/4/79 3/3/85 (PW) 3/12/95 @ 14/3/95</i></p>
<p>FILLER METALS (QW-404)</p> <p>Weld Metal Analysis A No. <u>A1</u></p> <p>Size of Electrode <u>3/32 1/8</u></p> <p>Filler Metal F No. <u>F4</u></p> <p>SFA Specification <u>5.1</u></p> <p>AWS Classification <u>E7018</u></p> <p>Other <u>N/A</u></p>	<p>POSITION (QW-405)</p> <p>Position of Groove <u>A11</u></p> <p>Weld Progression <u>UP</u> (Uphill, Downhill)</p> <p>Other <u>N/A</u></p> <p>PREHEAT (QW-406)</p> <p>Preheat Temp. <u>NONE 50°F</u> <i>JUN 13/79</i></p> <p>Interpass Temp. <u>N/A</u></p> <p>Other <u>N/A</u></p>
<p>POSTWELD HEAT TREATMENT (QW-407)</p> <p>Temperature <u>None</u></p> <p>Time <u>N/A</u></p> <p>Other <u>N/A</u></p>	<p>GAS (QW-408)</p> <p>Type of Gas or Gases <u>N/A</u></p> <p>Composition of Gas Mixture <u>N/A</u></p> <p>Other <u>N/A</u></p>
<p>ELECTRICAL CHARACTERISTICS (QW-409)</p> <p>Current <u>DC</u></p> <p>Polarity <u>Reverse</u></p> <p>Amps. <u>12.0 - 150</u> Volts <u>22-24</u></p> <p>Travel Speed <u>N/A</u></p> <p>Other <u>N/A</u></p>	<p>TECHNIQUE (QW-410)</p> <p>String or Weave Bead <u>String</u></p> <p>Oscillation <u>N/A</u></p> <p>Multipass or Single Pass <u>Multipass</u> (per side)</p> <p>Single or Multiple Electrodes <u>Single</u></p>

TENSILE TEST (QW-150)

PAR-1

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

GUIDED BEND TESTS (QW-160)

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

TOUGHNESS TESTS (QW-170)

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

Type of Test _____
 Deposit Analysis _____
 Other _____

Weld Test Witnessed By _____
 H.L.P. Wright ^{Authorized Inspector}

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

Laboratory Test No. 282-0170

Warnock Hersey Professional Service L

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.

BOILERS AND PRESSURE VESSELS BRANCH

ACCEPTED

W.P. No. D.700-5 Pix Etch 01

Date 12-7-79

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



Consumer and Commercial Relations

Consommation et du Commerce

Vessels Safety Branch

des appareils sous pression

Résultat de méthode de soudage (RMS)

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

Company/Entreprise

Name/Nom: ALL-WELD COMPANY LIMITED
 Address/Adresse: 49 PASSMORE AVE
 SCARBOROUGH ONTARIO
 Postal Code/Code postal: M1H 1Y4

Welding Process(es)/Procédé(s) de soudage

1 SMAW Type MANUAL
 2
 3

Base Metals/Métaux de base (QW-403)

P No. | Gr No. | + 2 | to/a | P. N° | Gr N° | + 2

Specification/Spécification: SA-516-GR70 Tensile/Tension: 70,000
 SA-516-GR70 70,000

Thickness/Épaisseur: 1/4" Diameter/Diamètre

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

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

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

Other/Autre: MAX DEPOSITED METAL QUALIFIED 1/2"

Positions/Positions (QW-405)

Position(s) of Groove/Position(s) du joint: 1 G

Welding Progression/Progression du soudage: Up/Montant Down/Descendant

Preheat/Préchauffage (QW-406)

Preheat Temperature/Temperature de préchauffage: 50°F MIN.
 Interpass Temperature/Température de l'interpasse: 350°F MAX

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

3 Record Identification/Désignation du résultat

PQR No. RMS N°: 1-A
 WPS No. DMS N°: 1A-1

5

Groove Design used/Croquis du joint utilisé

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

Temperature/Température: NONE
 Time/Durée: — || —
 Other/Autre: — || —

11 Gas/Gaz (QW-408)

Shielding Gas Composition/Composition du gaz de protection: NONE
 Gas Flow Rate/Débit du gaz: — || —
 Backing Gas Composition/Composition du gaz de soutien: — || —
 Gas Flow Rate/Débit du gaz: — || —
 Other/Autre: — || —

12 Technique/Technique (QW-410)

String or Weave Bead/Cordon droit ou oscillant: STRING
 Oscillation/Oscillation: N/A
 Multipass or Single Pass (per side)/Passe unique ou multiple (par côté): MULTIPLE
 Single or Multiple Electrode/Électrode unique ou multiple: SINGLE
 Other/Autre: — || —

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

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

14 Tensile Tests/Essais à la traction					Reference: Référence:	
Specimen Éprouvette	Dimensions Dimensions		Area Surface	Ultimate Total Load Charge limite	Ultimate Unit Stress Contrainte limite	Character and Location of Failure Nature et endroit de la rupture
	Width Largeur	Thickness Épaisseur				
T1	0.748	0.243	0.1818	15640	86046	FRACTURED IN
T2	0.757	0.242	0.1832	15670	85538	BASE MET.

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

16 Toughness Tests/Essais de résilience					Reference: Référence:			
Specimen Éprouvette	Notch Location Endroit de l'entaille	Notch Type Forme de l'entaille	Specimen Temperature Température de l'éprouvette	Impact Value Énergie de rupture	Lateral Expansion Expansion latérale		Drop Weight Essai en chute libre	
					Shear % cisaillement	Mills Millimètres	Break Cassé	No Break Non cassé

17 Fillet Weld Test/Essai de soudure d'angle				Reference: Référence:					
Result - Satisfactory Résultat satisfaisant	Yes 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"/>

18 Other Tests/Autres essais		Reference: Référence:	

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

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

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

Nous certifions que les renseignements concernant ce résultat sont exacts et que les essais de soudage ont été préparés, soudés et exécutés conformément aux exigences de la section IX du Code ASME.

20 Company Representative's
Signature Robert C Bentley Date 27 JUNE 1995

21 Department Use Only/Réservé au ministère

Samples Welded on Pièces soudées le <u>JUNE 27/95</u>	Inspector Inspecteur <u>R E Kelly</u>
Record verified on Résultats vérifiés le <u>JULY 17/95</u>	Inspector Inspecteur <u>R E Kelly</u>

W.P.S.: WP-R 2365
SIGNED: yw
DATE: 95.08.03

1A-1

14 Tensile Tests/Essais à la traction						Reference: Référence:
Specimen Éprouvette	Dimensions Dimensions		Area Surface	Ultimate Total Load Charge limite	Ultimate Unit Stress Contrainte limite	Character and Location of Failure Nature et endroit de la rupture
	Width Largeur	Thickness Épaisseur				
T1	0.715	1.487	1.0632	84700	79667	FRACTURED BASE METAL
T2	0.726	1.484	1.0774	86280	80082	FRACTURED BASE METAL

15 Guided Bend Tests/Essais de pliage guidé						Reference: Référence:			
Specimen Éprouvette	Face Face	Root Racine	Side Côté	Result Résultat	Specimen Éprouvette	Face Face	Root Racine	Side Côté	Result Résultat
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	Mils Millimètres	Break Cassé	No Break Non cassé

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

18 Other Tests/Autres essais		Reference: Référence:

19 Welder's Name
Nom du soudeur KELVIN RAMNATH Stamp No. / N° de symbole 34

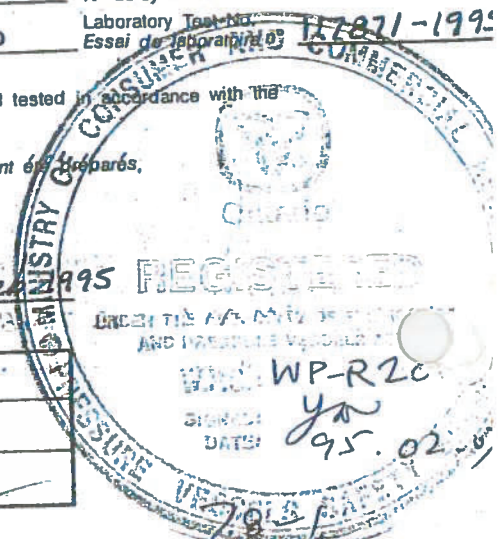
Tests conducted by
Essais effectués par CAMBRIDGE MATERIALS TESTING LTD Laboratory Test No. / Essai de laboratoire 117871-199

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 / Date 1 Feb 1995

21 Department Used Only / Réservé au ministère

Samples Welded on Pièces soudées le <u>JAN 26/95</u>	Inspector Inspecteur <u>H E Kelly</u>
Record verified on Résultats vérifiés le <u>Feb 1/95</u>	Inspector Inspecteur <u>H E Kelly</u>



Welding Procedure Specification (WPS)

STAINLESS TO
CARBON STEEL

**Customer
Work Order #**

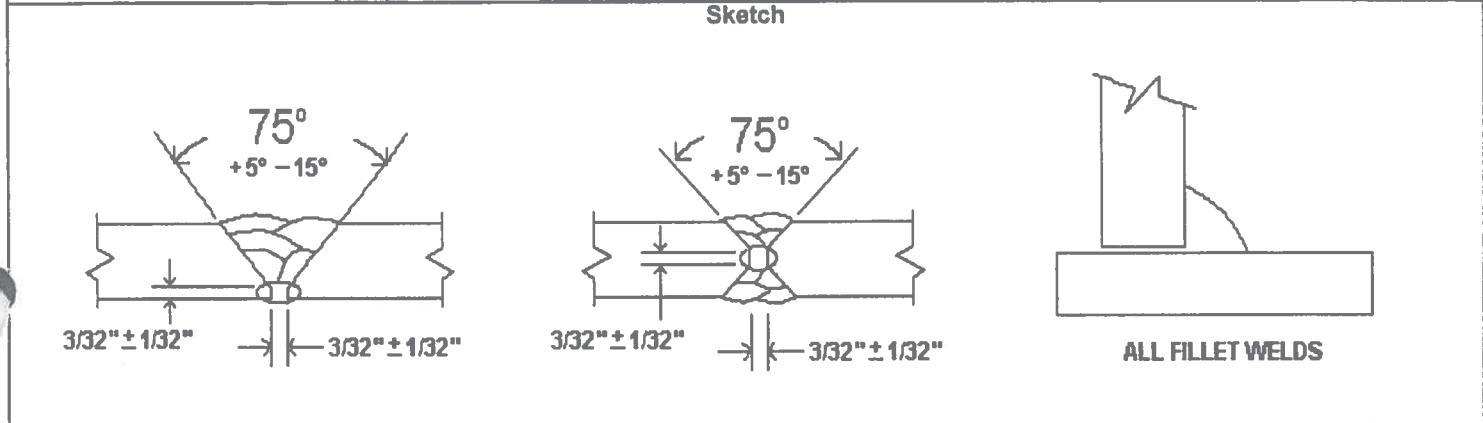
1 Company	
Name/ ALL-WELD COMPANY LIMITED	
Address / 49 PASSMORE AVE. , 14 PASSMORE AVE. PLANT 1 PLANT 2	
SCARBOROUGH, ONTARIO	
Postal Code (PLANT 1) M1V-4T1	Postal Code (PLANT 2) M1V-2R6

2 Provincial Registration	WP G186.5
----------------------------------	-----------

3 Procedure Identification			
WPS NO.	2-1	Revision No.	4
Code Section	IX	Date	14 April, 07
PQR No.	2		

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

5 Joints (QW-402)				
Design	SINGLE & DOUBLE V GROOVE		Backing Material	WELD METAL
Backing	Yes	No	Other	NONE



6 Base Metals (QW-403)	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"

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

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

10 Postweld Heat Treatment (QW-407)	
Temperature Range	NONE
Time Range	NONE
Other	NONE

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

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

12	Electrical Characteristics and Technique (QW-409)-(QW-410)	
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Weld Layer(s)	Process	Filler Metal		Current				Travel Speed Range
		Classification	Diameter	Type	Polarity	Amp. Range	Volt Range	
ROOT	SMAW	E309-16	3/32"	DC	RP	65-95	N/A	N/A
ROOT	SMAW	E309-16	1/8"	DC	RP	90-120	N/A	N/A
FILL	SMAW	E309-16	5/32"	DC	RP	120-160	N/A	N/A
FILL	SMAW	E309-16	3/16"	DC	RP	155-195	N/A	N/A
Tungsten Electrode Size and Type		NONE						
Mode of Metal Transfer for GMAW		NONE						
String or Weave Bead		STRING						
Method of Back Gouging		GRINDING OR ARC AIR GOUGING AND GRINDING TO SOUND METAL						
Initial and Interpass Cleaning (Brushing, Grinding, etc.)		WIRE BRUSH OR GRINDING						
Orifice or Gas Cup Size		NONE						
Oscillation	NONE	Width	NONE	Frequency	NONE			
Contact Tube to Work Distance		NONE						
Multiple or Single Pass (per side)		SINGLE AND OR MULTIPLE						
Multiple or Single Electrode		SINGLE						
Electrode Wire feed speed range		NONE						
Other	Preheat Requirements: When welding to or together for the thickness noted below the preheat requirements must be followed. For P1 -Thickness and minimum temperature 0 to 3/4" thick preheat to 50° F, 1" thick and up 200° F.							

(13)	Supplementary Comments
	NONE

(14)	Company Representative Signature <u><i>Stephen White</i></u> 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

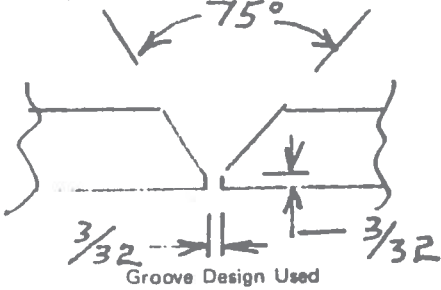
PROCEDURE QUALIFICATION RECORD

PQR-2

Date December 1, 1981

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

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

<p>JOINTS (QW-402)</p>  <p>Groove Design Used</p>	<p>BASE METALS (QW-403)</p> <p>Material Spec. <u>SA240 & SA 285C</u></p> <p>Type or Grade <u>304 & 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> <i>NO WELD PASS GREATER THAN 1/2 INCH THICK. 3/3/95 @ 14/3/95</i></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>

G 186.5

TENSILE TEST (QW-150)

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

GUIDED BEND TESTS (QW-160)

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

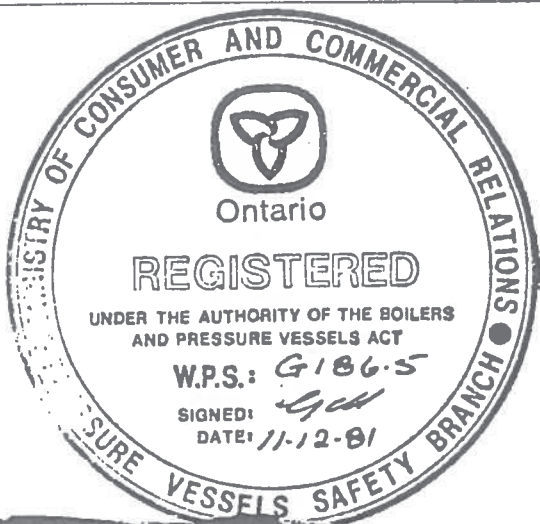
TOUGHNESS TESTS (QW-170)

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

Type of Test _____
 Deposit Analysis _____
 Other _____

Weld Test Witnessed By Mr. J. Clark
Authorized Inspector

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



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

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

Customer Work Order #

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

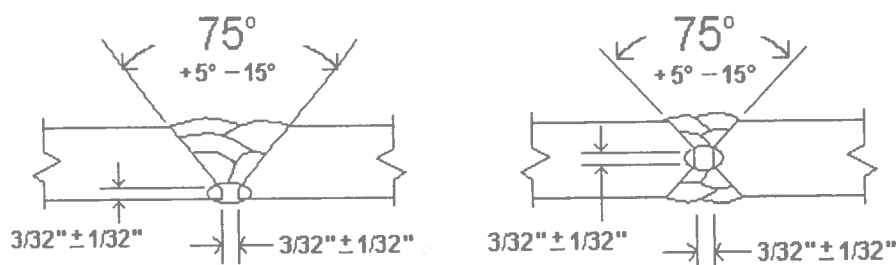
2 Provincial Registration	WP T4628.5
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3 Procedure Identification			
WPS NO.	3-4	Revision No.	1
Code Section	IX	Date	27 March, 2013
PQR No.	3-3X		

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

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

Sketch



ALL FILLET WELDS

6 Base Metals (QW-403)	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"			

7 Filler Metals (QW-404)									
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				

8 Positions (QW-405)	
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

90 Postweld Heat Treatment (QW-407)	
Temperature Range	NONE
Time Range	NONE
Other	NONE

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

Shielding Gas Composition	NONE
Gas Flow Rate	NONE
Backing Gas Composition	NONE
Trailing Shield Gas Composition	NONE
Other	NONE

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

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

13	Supplementary Comments
1) CHARPY V NOTCH IMPACT TESTED TO -50 F 2) MACROETCH TO ASTM E3-11	
3) VICKERS HARDNESS TEST TO NACE MR0175/ISO 15156-2:2009/CIR. 1 : 2011	

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

Registration of this Welding Procedure (Specification plus Qualification Record) is required pursuant to the provisions of Section 36 (1) of the Boilers and Pressure Vessels Act of Ontario.

The registration becomes invalid when any essential variable changes, or any requirement of the ASME Code Section IX, affecting this procedure, is altered.

14 Tensile Tests				Reference:		
Specimen	Dimensions in Inches		Area in Inches ²	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)
 636411-2013, 636412-2013, 636413-2013
 634851-2013, 634803-2013, 634805-13

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

20 Company Representative's Signature Robert C. Bentley Date 18 MARCH 2013
 ROBERT C. BENTLEY, C.E.T. **Boilers and Pressure Vessels Safety Program**

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

Welding Procedure Specification (WPS)

STEEL

Customer Work Order #

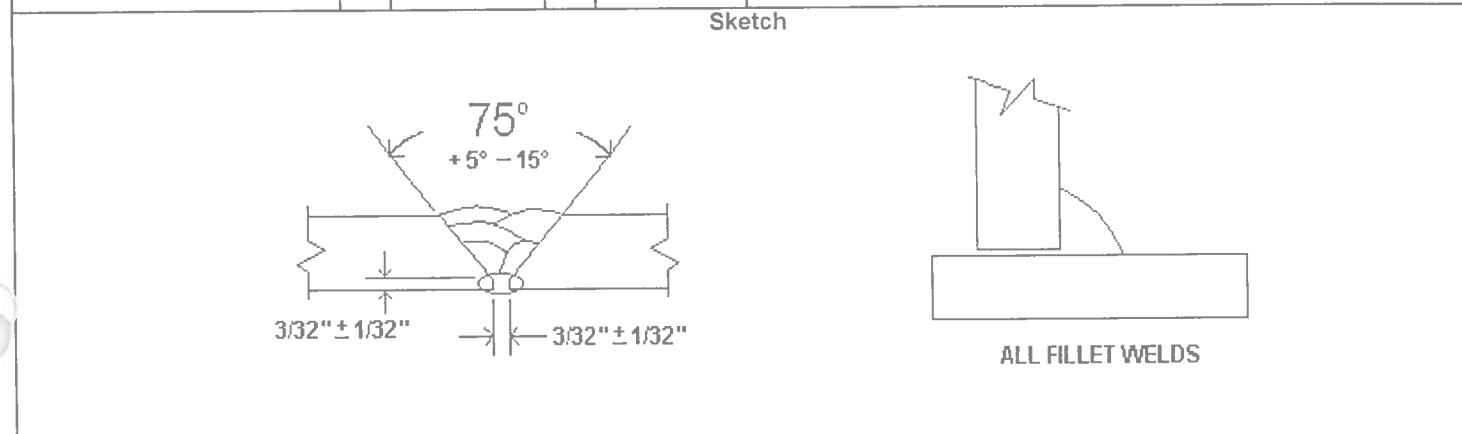
1	Company
Name/ ALL-WELD COMPANY LIMITED	
Address / 49 PASSMORE AVE. , 14 PASSMORE AVE. PLANT 1 PLANT 2	
SCARBOROUGH, ONTARIO	
Postal Code (PLANT 1) M1V-4T1	Postal Code (PLANT 2) M1V-2R6

2	Provincial Registration	WP R3578.5 , R4056.5 R7674.5, D852.5
----------	--------------------------------	--

3	Procedure Identification	
WPS NO.	9-4	Revision No. 7
Code Section	IX	Date 09 April, 13
PQR No.	9, 9AB , 54 & 105	

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

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



6	Base Metals (QW-403)	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-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"	

7	Filler Metals (QW-404)									
1. AWS No	ER316L	Product Form - Solid	SFA	5,9	F-No	6	A-No.	8	Dia.	1/16"
2. AWS No.	ER316L		SFA	5,9	F-No	6	A-No.	8	Dia.	3/32"
3. AWS No.			SFA		F-No		A-No.		Dia.	
Flux Tradename	NONE		Electrode Flux Classification			NONE				
Consumable Insert	NONE		Other MAX. DEPOSITED METAL 1 1/2" THICK NON Impact & 1/2" Impact							

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

10	Postweld Heat Treatment (QW-407)	
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		

Shielding Gas Composition	ARGON 99%
Gas Flow Rate	25 CFH
Backing Gas Composition	ARGON 99%
Trailing Shield Gas Composition	ARGON 99%
Other	NONE

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

Weld Layer(s)	Process	Filler Metal		Current				Travel Speed Range
		Classification	Diameter	Type	Polarity	Amp. Range	Volt Range	
ROOT	GTAW	ER316L	1/16"	DC	SP	80-110	8-11	7-8 IPM
FILL	GTAW	ER316L	3/32"	DC	SP	130-200	11-18	7-8 IPM
For - 200 F IMPACT TEST APPLICATION SEE BELOW per PQR 105 WP-R4056.5								
Heat Input (Per QW-409.1) = 16,800 j / in								
ROOT	GTAW	ER316L	1/16"	DC	SP	80 - 110	8 - 11	7 - 8 IPM
FILL	GTAW	ER316L	1/16"	DC	SP	110 - 140	8 - 14	7 - 8 IPM

Tungsten Electrode Size and Type	1/8" & 3/32" 2% THORIATED TUNGSTEN (ZIRCONIUM TUNGSTEN)		
Mode of Metal Transfer for GMAW	NONE		
String or Weave Bead	STRING		
Method of Back Gouging	GRINDING OR ARC AIR GOUGING AND GRINDING TO SOUND METAL		
Initial and Interpass Cleaning (Brushing, Grinding, etc.)	WIRE BRUSH OR GRINDING		
Orifice or Gas Cup Size	1/2 TO 5/8		
Oscillation	NONE	Width	NONE
		Frequency	NONE
Contact Tube to Work Distance	1/2 TO 3/4		
Multiple or Single Pass (per side)	MULTIPLE		
Multiple or Single Electrode	SINGLE		
Electrode Wire feed speed range	NONE		

13 Supplementary Testing Done

1) Vickers Hardness per NACE MR0175/ISO 15156-1:2009(E) Lab Report 637323- 13 Report A

2) Macroetch Evaluation Test Per ASTM E3-11 Lab Report 637323-13 Report B

Comments
NONE

14 Company Representative Signature Robert C Bentley Date 09-Apr-
 Robert C. Bentley C.E.T.

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



Ministry of Consumer and Commercial Relations
 Boilers and Pressure Vessels Branch
 Technical Standards Division

Tel. (416) 965-4100
 400 University Avenue
 Toronto, Ontario
 M5G 1S5
 RECEIVED
 PRESSURE VESSEL
 SAFETY DIVISION

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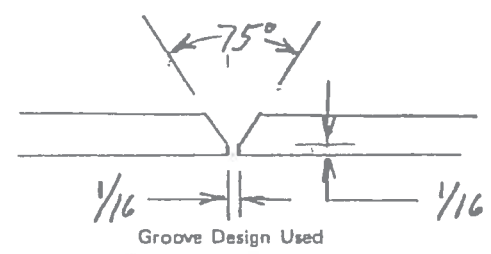
8:10'92

PROCEDURE QUALIFICATION RECORD

PQR 9

Date October 10, 1979

All-Weld Company Limited 2/15/90 49 PASSMORE AVE., SCARBOROUGH, ONTARIO M1V 4T1
 (Manufacturer) (Address)
 Weld Proc. Spec. No. WPS 9-1 Weld Process(es) GTAW Types MANUAL
D852.5 (Manual, Automatic)

<p>JOINTS (QW-402)</p>  <p>Groove Design Used</p>	<p>BASE METALS (QW-403)</p> <p>Material Spec. <u>SA 312</u></p> <p>Type or Grade <u>304 Stainless Steel</u></p> <p>P No. <u>8</u> to P No. <u>8</u></p> <p>Thickness <u>.218</u></p> <p>Diameter <u>2" Pipe</u></p> <p>Other <u>N/A</u></p>
<p>FILLER METALS (QW-404)</p> <p>Weld Metal Analysis A No. <u>8</u></p> <p>Size of Electrode <u>3/32</u></p> <p>Filler Metal F No. <u>6</u></p> <p>SFA Specification <u>5.9</u></p> <p>AWS Classification <u>ER316</u></p> <p>Other <u>N/A</u></p>	<p>POSITION (QW-405)</p> <p>Position of Groove <u>ALL POSITIONS</u></p> <p>Weld Progression <u>UPHILL</u> (Uphill, Downhill)</p> <p>Other <u>N/A</u></p> <p>PREHEAT (QW-406)</p> <p>Preheat Temp. <u>N/A</u></p> <p>Interpass Temp. <u>N/A</u></p> <p>Other <u>N/A</u></p>
<p>POSTWELD HEAT TREATMENT (QW-407)</p> <p>Temperature <u>N/A</u></p> <p>Time <u>N/A</u></p> <p>Other <u>N/A</u></p>	<p>GAS (QW-408)</p> <p>Type of Gas or Gases <u>ARGON</u></p> <p>Composition of Gas Mixture <u>N/A</u></p> <p>Other <u>N/A</u></p>
<p>ELECTRICAL CHARACTERISTICS (QW-409)</p> <p>Current <u>D.C.</u></p> <p>Polarity <u>STRAIGHT</u></p> <p>Amps. <u>110-140</u> Volts</p> <p>Travel Speed <u>7" - 8" I.P.M.</u></p> <p>Other <u>N/A</u></p>	<p>TECHNIQUE (QW-410)</p> <p>String or Weave Bead <u>STRING</u></p> <p>Oscillation <u>N/A</u></p> <p>Multipass or Single Pass <u>MULTIPASS</u> (per side)</p> <p>Single or Multiple Electrodes <u>SINGLE</u></p>

TENSILE TEST (QW-150)

PQR-9

SPECIMEN NO.	WIDTH	THICKNESS	AREA	ULTIMATE TOTAL LOAD LB.	ULTIMATE UNIT STRESS PSI	CHARACTER OF FAILURE & LOCATION
TS-1	.494	.192	.0948	7830	82600	WELD
TS-2	.515	.211	.109	8990	82500	WELD

GUIDED BEND TESTS (QW-160)

TYPE AND FIGURE NO.	RESULT	TYPE AND FIGURE NO.	RESULT
NO. 1 RB	SATISFACTORY	NO. 2 FB	SATISFACTORY
NO. 3 RB	SATISFACTORY	NO. 4 FB	SATISFACTORY

TOUGHNESS TESTS (QW-170)

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

Type of Test _____
 Deposit Analysis _____
 Other _____

Warnock Hersey

Weld Test Witnessed By _____
 Authorized Inspector
G. EWING

Tensile Test Made By Professional Service Ltd
 Laboratory Test No. 282-388

BOILERS AND PRESSURE VESSELS BRANCH

ACCEPTED

W.P. No. D. 52:5 P. X.T. 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 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	0.250	0.0350"	0.0236	1987 lbf	84000 PSI	BOTH FRACTURE BASE METAL
T2	0.249"	0.0350"	0.0235"	1975 lbf	84000 PSI	" "

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

16 Toughness Tests/Essais de résilience						Reference: Référence:		
Specimen Éprouvette	Notch Location Endroit de l'entaille	Notch Type Forme de l'entaille	Specimen Temperature Température de l'éprouvette	Impact Value Énergie de rupture	Lateral Expansion Expansion latérale		Drop Weight Essai en chute libre	
					Shear % cisaillement	Mills Millimètres	Break Cassé	No Break Non cassé

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

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 Robert C. Bentley Date 18, APRIL, 2002

Signature du représentant de l'entreprise ROBERT C. BENTLEY

REGISTERED

W.P.S.:... W.P.R.76.74.5

Signed: [Signature]

Date: 20.02.04.05

9-A

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

14	Tensile Tests/Essais à la traction				Reference: SECT IX ASME CODE		
	Specimen Éprouvette	Dimensions Dimensions		Area Surface	Ultimate Total Load Charge limite	Ultimate Unit Stress Contrainte limite	Character and Location of Failure Nature et endroit de la rupture
		Width Largeur	Thickness Épaisseur				
T2	0.746	0.750	0.5595	49340	88184	FRACTURED IN WEI	
T3	0.751	0.751	0.5640	49630	87990	FRACTURED IN	

5	Guided Bend Tests/Essais de pliage guidé				Reference: SECT IX Q.W. 462:2					
	Specimen Éprouvette	Face Face	Root Racine	Side Côté	Result Résultat	Specimen Éprouvette	Face Face	Root Racine	Side Côté	Result Résultat
S2			✓	— v —	S4			✓	— v —	

16	Toughness Tests/Essais de résilience				Reference:				
	Specimen Éprouvette	Notch Location Endroit de l'entaille	Notch Type Forme de l'entaille	Specimen Temperature Température de l'éprouvette	Impact Value Énergie de rupture	Lateral Expansion Expansion latérale		Drop Weight Essai en chute libre	
						Shear % cisaillement	Mills Millimètres	Break Cassé	No Break Non cassé

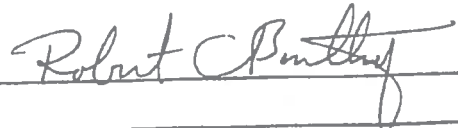
17	Fillet Weld Test/Essai de soudure d'angle				Reference:			
	Result - Satisfactory Résultat satisfaisant	Yes Oui <input type="checkbox"/>	No Non <input type="checkbox"/>	Penetration into Parent Metal Pénétration dans métal de base	Yes Oui <input type="checkbox"/>	No Non <input type="checkbox"/>		

18	Other Tests/Autres essais				Reference:			

19	Welder's Name Nom du soudeur	ROBIN GREER	Stamp No. N° de symbole	9
	Tests conducted by Essais effectués par	CAMBRIDGE MATERIALS TESTING LTD	Laboratory Test No. Essai de laboratoire n°	152211-1996

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

Nous certifions que les renseignements concernant ce résultat sont exacts et que les essais de soudage ont été préparés, soudés et exécutés conformément aux exigences de la section IX du Code ASME.

20	Company Representative's Signature Signature du représentant de l'entreprise		Date Date	4 Oct 1996
----	---	---	--------------	------------

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

WP-R35
ya
26.10.17
54-1

Résultat de méthode de soudage (RMS)

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

Company/Entreprise	
ALL-WELD COMPANY LTD	
49 PASSMORE AVE	
SCARBOROUGH	
ONTARIO	
Postal Code/Code postal M1L1Y1T1	
4 Welding Process(es)/Procédé(s) de soudage	
1	GTA W Type MANUAL
2	
3	
5 Base Metals/Métaux de base (QW-403)	
P No. 8	Gr No. 1
SA-240-316L TU 70,000	
SA-240-316L 70000	
Thickness Épaisseur	1/4"
Diameter/Diamètre	
Other Autre NO SINGLE PASS > 1/2"	
7 Filler Metals/Métaux d'apport (QW-404)	
Classification (AWS)	SFA-No.
ER316L	5.9
F - No.	A - No.
6	8
Other Autre MAX DEPOSITED METAL 1/2"	
8 Positions/Positions (QW-405)	
Position(s) of Groove Position(s) du joint 1G THROUGH 6G	
Welding Progression Progression du soudage	Up Montant <input checked="" type="checkbox"/> Down Descendant <input type="checkbox"/>
Other Autre	
9 Preheat/Préchauffage (QW-406)	
Preheat Temperature Température de préchauffage	50°F
Interpass Temperature Température de l'interpasse	300°F MAX
Other Autre	

2	Provincial Registration Enregistrement provincial	WP MS	WP-R405-5
3	Record Identification/Désignation du résultat		
PQR No. RMS N°	105		
WPS No. DMS N°	105-1		
5			
Groove Design used/Croquis du joint utilisé			

10	Postweld Heat Treatment/ Traitement thermique postsoudage	(QW-407)
Temperature Température	NONE	
Time Durée	-	
Other Autre	-	
11	Gas/Gaz (QW-408)	
Shielding Gas Composition Composition du gaz de protection	ARGON 98% + OXY 2%	
Gas Flow Rate Débit du gaz	25 CFH	
Backing Gas Composition Composition du gaz de soutien	NONE	
Gas Flow Rate Débit du gaz	-	
Other Autre	-	
12	Technique/Technique (QW-410)	
String or Weave Bead Cordon droit ou oscillant	STRING	
Oscillation Oscillation	N/A	
Multipass or Single Pass (per side) Passe unique ou multiple (par côté)	MULTI PASS	
Single or Multiple Electrode Électrode unique ou multiple	SINGLE	
Other Autre		

13 Electrical Characteristics and Technique/Caractéristiques électriques et techniques (QW-409) + (QW-410)								
Weld Layer(s) Couche(s) de soudure	Process Procédé	Filler Metal Métal d'apport			Current Courant			Travel Speed Vitesse
		Classification	Diameter Diamètre	Type	Polarity Polarité	Amp Ampérage	Volt Voltage	
T	GTA W	ER316L	1/16	DC	SP	80-110	11	7-8 IPM
FILL	GTA W	ER316L	1/16"	DC	SP	110-140	14	7-8 IPM

14 Tensile Tests/Essais à la traction						Reference: Référence:
Specimen Éprouvette	Dimensions Dimensions		Area Surface	Ultimate Total Load Charge limite	Ultimate Unit Stress Contrainte limite	Character and Location of Failure Nature et endroit de la rupture
	Width Largeur	Thickness Épaisseur				
1	0.748	0.249	0.1863	16560	88924	FRACTURED IN BASE METAL
76	0.754	0.247	0.1862	16840	90440	FRACTURED IN BASE METAL

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

16 Toughness Tests/Essais de résilience						Reference: Référence:		
Specimen Éprouvette	Notch Location Endroit de l'entaille	Notch Type Forme de l'entaille	Specimen Temperature Température de l'éprouvette	Impact Value Énergie de rupture	Lateral Expansion Expansion latérale		Drop Weight Essai en chute libre	
					Shear % cisaillement	Millis Millimètres	Break Cassé	No Break Non cassé
1	WELD	CHARPY V-NOTCH	-200°F	94	100	80		
2	WELD			96		86		
3	WELD			94		78		
4	HAZ			89		78		
5	HAZ			70		70		
6	HAZ			82		72		
7	BASE			89		74		
8	BASE			100		75		
	BASE			96		75		

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

18 Other Tests/Autres essais		Reference: Référence:

9 Welder's Name
Nom du soudeur ROBIN GREER


Stamp No.
N° de symbole 9

Tests conducted by
Essais effectués par CAMBRIDGE MATERIALS TESTING LTD

Laboratory Test No.
Essai de laboratoire n° 169712-1997

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

Nous certifions que les renseignements concernant ce résultat sont exacts et que les essais de soudage ont été préparés, exécutés et vérifiés conformément aux exigences de la section IX du Code ASME.



Boilers and
Pressure
Vessels
Safety
Division

REGISTERED

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

Signed: JA

Date: 97.06.17

0 Company Representative's
Signature Robert C Bentley Date 13 JUNE 1997

Signature du représentant de
l'entreprise

1 Department Use Only/Réservé au ministère

Welds
Soudées le

Inspector
Inspecteur

Record verified on
Résultats vérifiés le

Inspector
Inspecteur

Customer Work Order #

1 Company	
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

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

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

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



6 Base Metals (QW-403)	P. No. 8 Gr. No. 1 to P. No. 8 Gr. No. 1
or Specifications type and grade	SA-240, 316L to SA-240, 316L, 316, 304L & 304
or Chemical Analysis and Mech. Prop.	
Thickness Range Qualified	Total 1) 5/8 " to 8 " for Impact use 2) 3/16" to 8" Non Impact use
Other 1) NO SINGLE PASS TO BE GREATER THAN 1/2" 2) IMPACT TEST QUALIFIED TO - 50 F	

7 Filler Metals (QW-404)					
1. AWS No E316LTO-1	Product Form : Flux Core	SFA 5.22	F-No 6	A-No. 8	Dia. 0.045"
2. AWS No.		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 "		

8 Positions (QW-405)	
Position(s) of Groove	1G TO 6G
Welding Progression	UP
Position(s) of Fillet	ALL
Other	NONE

10 Postweld Heat Treatment (QW-407)	
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	
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
Heat Input (Per QW-409.1) = 59,400 j / in								

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)

1 Company	
Name / ALL-WELD COMPANY LIMITED	
Address / 49 PASSMORE AVENUE	
SCARBOROUGH, ONTARIO	
Postal Code M | 1 | V | 4 | T | 1	
4 Welding Process(es)	
1	FCAW Type MANUAL
2	Type
3	Type
6 Base Metals (QW-403)	
P No. 8	Gr No. 1 to P. No. 8 Gr No. 1
Specification Tensile	
SA-240-316L 70,000 psi	
Thickness 1 3/4 "	Diameter N/A
Other NONE	
7 Filler Metals (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 No Single Pass Greater than 1/2 "	
8 Positions QW-405	
Position(s) of Groove 3G	
Welding Progression Up <input type="checkbox"/> Down <input type="checkbox"/>	
Other NONE	
9 Preheat (QW-406)	
Preheat Temperature 50°F	
Interpass Temperature 350°F	
Other NONE	

2 Provincial Registration		WP T4646-5
3 Record Identification		
PQR No.	50-X	
WPS No.	50-3A	
5 Groove Design used		
<p style="text-align: center;">75° +5° - 15° 3/32" ± 1/32" 3/32" ± 1/32" ALL FILLET WELDS</p>		
10 Postweld Heat Treatment /		
Temperature	NONE	
Time	NONE	
Other	NONE	
11 Gas (QW-408)		
Shielding Gas Composition	CO2	
Gas Flow Rate	45 CFH	
Backing Gas composition	NONE	
Gas Flow Rate	NONE	
Other	NONE	
12 Technique (QW-410)		
String or Weave Bead	STRING	
Oscillation	NONE	
Multipass or Single Pass (per side)	MULTIPLE	
Single or Multiple Electrode	SINGLE	
Other	Transfer : Spray	

13 Electrical Characteristics and Technique (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

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

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

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

17 Fillet Weld Test			Reference:
Result - Satisfactory	Yes <input type="checkbox"/>	No <input type="checkbox"/>	Penetration Into Parent Metal
			Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>
HEAT INPUT = 59,400 j / in Maximum			W.P.S.: WP-146465
			Signed: [Signature]

18 Other Tests		Reference:
1) MACROETCH EXAMINATION PER LAB REPORT 636455-13 (Report A)		Date: April 11, 2013
2) NACE MR0175/ISO 15156-2:2009/CIR..2011(E) VICKERS HARDNESS PER LAB REPORT 636455-13 (Report B)		

19 Welder's Name Steve Liew Stamp No. WPS# 50-3A 90

Tests conducted by CAMBRIDGE MATERIAL TESTING LTD. 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 #**

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

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

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

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

6	Base Metals (QW-403)	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"		

7	Filler Metals (QW-404)	
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"

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

10	Postweld Heat Treatment (QW-407)
Temperature Range	NONE
Time Range	NONE
Other	NONE

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

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

12	Electrical Characteristics and Technique (QW-409)-(QW-410)								
Weld Layer(s)	Process	Filler Metal		Current				Travel Speed Range	
		Classification	Diameter	Type	Polarity	Amp. Range	Volt Range		
ROOT	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 J / 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							

13	Supplementary Comments
1) Impact Testing to - 50 F per Laboratory No 636543-2013	
2) NACE MR0175 / ISO 1516-2:2009 / Cir.1:2011 (E) per Laboratory No 636546--13 (Report B)	
3) Macroetch per ASTM E3-11 per Laboratory No 636546-13 (Report A)	

14	Company Representative Signature		Date	21 March, 13
		Robert Bentley QCM		

Registration of this Welding Procedure (Specification plus Qualification Record) is required pursuant to the provisions of Section 36 (1) of the Boilers and Pressure Vessels Act of Ontario.

The registration becomes invalid when any essential variable changes, or any requirement of the ASME Code Section IX, affecting this procedure, is altered.

RESULTAT DE METHODE DE SOUDAGE (RMS)

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

Company/Entreprise								
Nom ALL-WELD COMPANY LTD.								
Address/Adresse 49 PASSMORE AVE.								
SCARBOROUGH								
ONTARIO			Postal Code/Code postal M 1 V 4 T 1					
4 Welding Process(es)/Procédé(s) de soudage								
1	SAW	Type	AUTOMATIC					
2		Type						
3		Type						
6 Base Metals/Métaux de base (QW-403)								
P No.	8	Gr No.	-- to/a 8 P. N° -- Gr N°					
Spécification/Spécification		Tensile/Tension						
SA-240-304		75000						
SA-240-304		75000						
Thickness Épaisseur	1 1/2"	Diameter/ Diamètre	--					
Other/Autre								
7 Filler Metals/Métaux d'apport (QW-404)								
Classification (AWS)	SFA-No.	F - No.	A - No.					
ER 308	5.9	6	8					
Other/Autre								
8 Positions/Positions (QW-405)								
Position(s) of Groove Position(s) du joint "V" GROOVE								
Welding Progression Progression du soudage	1G	Up Montant <input type="checkbox"/>	Down Descendant <input type="checkbox"/>					
Other/Autre								
9 Preheat/Préchauffage (QW-406)								
Preheat Temperature Température de préchauffage	50°F							
Interpass Temperature Température de l'interpassage	350°F MAX.							
Other/Autre								
13 Electrical Characteristics and Technique/Caractéristiques électriques et techniques (QW-409) + (QW-410)								
Weld Layer(s) Couches(s) de soudure	Process Procédé	Filler Metal Métal d'apport		Current Courant				Travel Speed Vitesse
		Classification	Diameter Diamètre	Type	Polarity Polarité	Amp Ampérage	Volt Voltage	
T	SAW	ER308	5/32"	DC	POS	600	28	28"/M
L	SAW	ER308	5/32"	DC	POS	600	28	28"/M

2 Provincial Registration Enregistrement provincial	WP MS - R4428.5
3 Record Identification/Désignation du résultat	
PQR No. RMS N°	SAW-2A1
WPS No. DMS N°	SAW-2A
5	
<p style="text-align: center;">Groove Design used/Croquis du joint utilisé</p>	
10 Postweld Heat Treatment/ Traitement thermique postsoudage (QW-407)	
Temperature Température	NONE
Time Durée	--
Other/Autre --	
11 Gas/Gaz (QW-408)	
Shielding Gas Composition Composition du gaz de protection	NONE
Gas Flow Rate Débit du gaz	--
Backing Gas Composition Composition du gaz de soutien	--
Gas Flow Rate Débit du gaz	--
Other/Autre	
12 Technique/Technique (QW-410)	
String or Weave Bead Cordon droit ou oscillant	STRING
Oscillation Oscillation	N/A
Multipass or Single Pass (per side) Passe unique ou multiple (par côté)	MULTIPASS
Single or Multiple Electrode Électrode unique ou multiple	SINGLE
Other/Autre	

Specimen Epreuve	Dimensions Dimensions		Area Surface	Ultimate Total Load Charge limite	Ultimate Unit Stress Contrainte limite	Character and Location of Failure Nature et endroit de la rupture
	Width Largeur	Thickness Epaisseur				
	0.755"	1.504"	1.1355	99,440	87,573	FRACTURED BASE
	0.750"	1.507"	1.1302	99,950	88,433	FRACTURED BA

15 Guided Bend Tests/Essais de pliage guidé Reference: Réference:

Specimen Epreuve	Face Face	Root Racine	Side Côté	Result Résultat	Specimen Epreuve	Face Face	Root Racine	Side Côté	Result Résultat
B1			X	ACCEPTED	B3			X	ACCEPTED
B2			X	ACCEPTED	B4			X	ACCEPTED

16 Toughness Tests/Essais de résilience Reference: Réference:

Specimen Epreuve	Notch Location Endroit de l'entaille	Notch Type Forme de l'entaille	Specimen Temperature Température de l'éprouvette	Impact Value Énergie de rupture	Lateral Expansion Expansion latérale		Drop Weight Essai en chute libre	
					Shear % cisaillement	Mills Millèmes	Break Cassé	No Break Non cassé

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

Result - Satisfactory Résultat satisfaisant	Yes <input type="checkbox"/> Oui	No <input type="checkbox"/> Non	Penetration into Parent Metal Pénétration dans métal de base	Yes <input type="checkbox"/> Oui	No <input type="checkbox"/> Non
Macro - Results Résultats macroscopiques					


18 Other Tests/Autres essais Reference: Réference:

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.
 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 prise Robert C Bentley Date Date 7 JAN. 1998
ROBERT C. BENTLEY

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



Boilers and Pressure Vessels Safety Division
REGISTERED
 W.P.S.: WP-R4428.5
 Signed: [Signature]
 Date: 98.01.15

WPS 2-1
W-0-1173 PQ

PO# 13-065

5

HOBART BROTHERS

McKay

CERTIFICATE OF ANALYSIS

CUSTOMER:	EXOCOR C/O USF HOLLAND BUFFALO	P.O. #:	021702
MARKED FOR:		DATE:	5/7/2013 2:14:09 PM
PACK SLIP/ORDER #:	A503500	WORK ORDER:	
LBS SHIPPED:	60		

PRODUCT TYPE:	STERL AP 309/309L 1/8 10 CAN	STOCK NUMBER:	S483944-033
LOT NO:	23R056	HEAT NO:	743678
SPECIFICATION:	AWS A5.4, ASME SFA 5.4	CLASS:	E309/309L-16

ACTUAL CHEMICAL ANALYSIS (%)

C	0.028 ✓
Mn	1.060 ✓
P	0.034 ✓
S	0.007 ✓
Si	0.534 ✓
Cu	0.114 ✓
Cr	22.859 ✓
Ni	12.983 ✓
Mo	0.120 ✓

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

Measured FN :	9
DeLong FN :	13
Schaeffler :	9

TYPICAL MECHANICAL PROPERTIES

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

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

Authorized Signature :

Brian Simpson, Q.A. Technician

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



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

HOBART BROTHERS

McKay

CERTIFICATE OF ANALYSIS

CUSTOMER: MARKED FOR: PACK SLIP/ORDER #: LBS SHIPPED:	EXOCOR % USF HOLLAND BUFFALO A7841/00 60	P.O. #: DATE: WORK ORDER:	021769 5/21/2013 7:33:39 AM
PRODUCT TYPE: LOT NO: SPECIFICATION:	STERL AP 309/309L 1/8 10 CAN 24R046 ✓ AWB A5.4, ASME SFA 5.4 ✓	STOCK NUMBER: HEAT NO: CLASS:	S483944-033 744873 ✓ E308/309L-16 ✓

ACTUAL CHEMICAL ANALYSIS (%)

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

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

Measured FN : 10
 Delong FN : 13
 Schaeffler : 9

TYPICAL MECHANICAL PROPERTIES

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

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

Authorized Signature :

Tim Wagner, Q.A. Technician

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



CERTIFICATE OF ANALYSIS

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

ACTUAL CHEMICAL ANALYSIS (%)

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

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

Measured FN : 9
 Delong FN : 14
 Schaeffler : 10

TYPICAL MECHANICAL PROPERTIES

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

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

Authorized Signature :



Brian Simpson, Q.A. Technician

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

HOBART BROTHERS

McKay

W.O.N. 1
1173 PQ

SMAW
WPS 3-4

(6)

CERTIFICATE OF ANALYSIS

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

P.O. #:
DATE: 1/19/2013 5:28:19 AM
WORK ORDER:

PRODUCT TYPE: STERL AP 316/316L 1/8 10 CAN STOCK NUMBER: S482944-033
LOT NO: 21R006 HEAT NO: 741891
SPECIFICATION: AWS A5.4, ASME SFA 5.4 EN10204 3.1 CLASS: 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

SMCW
WPS. 3-4

(6)

McKay

CERTIFICATE OF ANALYSIS

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

P.O. #:
DATE: 12/5/2012 12:57:15 PM
WORK ORDER:

PRODUCT TYPE:
LOT NO:
SPECIFICATION:

STERL AP 318/316L 5/32 10 CAN
31P050
AWS A5.4, ASME SFA 5.4 EN10204 3.1

STOCK NUMBER: S482951-033
HEAT NO: 741891
CLASS: E316L-16 E316-16

ACTUAL CHEMICAL ANALYSIS (%)

C 0.03
Mn 1.02
P 0.022
S 0.009
Si 0.44
Cu 0.25
Cr 17.68
Ni 12.87
Mo 2.14

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

Measured FN: 2
DeLong FN: 1
Schaeffler: 3

TYPICAL MECHANICAL PROPERTIES

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

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



Authorized Signature :

Brian Simpson, Q.A. Technician

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

GTAW 9-f

PO#13-0511

(7)

Inspection Certificate
Schedule F
As Per: AWS/ASME SFA.5.01
Certificate No: EXP1320157 24

Bohler Welding Group USA, Inc.
10401 Greenbough Drive
Stafford, TX 77477
Tel: 281-499-1212; 800-527-0791
Fax: 281-499-4347



Bohler Welding
GROUP

Test Object: welding wire for GTAW

Trade Designation: AVESTA ER316/316L

Marking of Product

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

Dimensions: 3.2mm (1/8") x 914mm (36") x 4.5kg (10 lb)

Lot No : E48111

Delivery Qty:

Chemical Composition in %

All weld metal

Lot/Heat	C	Mn	Si	P	S	Cu	Ni	Cr	Mo	N	WRC-92
E48111	0.013	1.64	0.64	0.023	0.003	0.20	11.26	18.23	2.54	0.074	7.5FN
Test Result											

Tensile Test	As per Test Temp. T °C	ASTM E8 Yield Point ReH MPa	Specimen Preparation Tensile Strength Rp MPa	AWS B4.0 Elongation A % Lo=4d	RA %	Note
Minimum:						This product meets the requirements of the filler metal specifications when tested in accordance with that specification. This certificate was issued by DP-equipment and does not require signature. Authorized inspection representative:
Maximum:						
Impact Test:	As per Test Temp T °C	ASTM E23 Absorbed Energy Minimum Values KV	Specimen Preparation Average J	AWS B4.0 Lateral Expansion MM	Shear Fracture %	



Russel Fuchis
 Loc: Houston, TX
 Date:

W.O.NI 1173P
50-3A

KOBELCO

INSPECTION CERTIFICATE

CERTIFICATE No 220121137
DATE OF ISSUE 2012.09.18

PURCHASER

FLUX CODED WIRE

TRADE DESIGNATION		DIMENSION		WFG.No		APPLICABLE SPECIFICATION AND CLASSIFICATION							
DW-316L		0.045 inch		F2G2315		AMS A5.22 E316LTO-1 AMS 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	FM							FS = FERRITE % (SCHAEFFLER DIAGRAM)					
DEPOSITED METAL	7							FN = FERRITE NUMBER (DELONG DIAGRAM)					
MECHANICAL PROPERTY ACCORDING TO EN10204 TYPE 3.1													
TENSILE TEST OF DEPOSITED METAL				IMPACT TEST OF DEPOSITED METAL				HARDNESS TEST					
YIELD POINT	YIELD STRENGTH AT 0.2% OFFSET	TENSILE STRENGTH		ELONGATION		TEST TEMP.		ABSORBED ENERGY					
- ksi	- ksi	81	ksi	28	%	-	F	AVG.	-	ft-lbf			
WELDING CONDITIONS													
TYPE OF CURRENT	DCEP	SHIELDING GAS		G02 G08		POSTWELD HEAT TREATMENT							
AMPERAGE	200 A					- F X -							
ARC VOLTAGE	29 V												
<p>WE HEREBY CERTIFY THAT THE ABOVE TEST RESULTS ARE AS DESCRIBED HEREIN AND SATISFY THE REQUIREMENTS OF THE APPLICABLE SPECIFICATION.</p> <p style="text-align: right;"> H. Sugawara WELDING BUSINESS FUJISAWA PLANT KOBELCO STEEL, LTD. APPROVED BY CHIEF INSPECTOR </p>													

BISULPHID(S) CONTENT IN DEPOSIT METAL IS NO LESS THAN 0.002%.



120118000194310161200001040214

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

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



Product: Lincolnweld® 316/316L
 Classification: ER316, ER316L
 Specification: AWS A5.9:2006, ASME SFA-5.9
 Date: March 06, 2012

This is to certify that the product named above and supplied on the referenced order number is of the same classification, manufacturing process, and material requirements as the material which was used for the test that was concluded on the date shown, the results of which are shown below. All tests required by the specifications shown for classification were performed at that time and the material tested met all requirements. It was manufactured and supplied according to the Quality System Program of the Lincoln Electric Company, Cleveland, Ohio, U.S.A., which meets the requirements of ISO9001, NCA3800, AWS A5.01, and other specification and Military requirements, as applicable. The Quality System Program has been approved by ASME, ABS, and VdTUV.

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

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

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

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

WPS SAW-W-L-T 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 ₂ O	2%	SiO ₂	19%	MnO	7%	Cr	5%
MgO	28%	CaO	1%	FeO	1%		
Al ₂ O ₃	8%	TiO ₂	1%	CaF ₂	8%		
ZrO ₂	24%						

- Density (g/cm³): 1.4

- Flux Classification: EN 760 – S A AS 2
EN 760 – S A ZS 2

Philip J. Woodring
Philip J. Woodring, Certification Supervisor, Date



Technical Standards and Safety Authority

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

Welder/Welding Operator Certificate

Technical Standards and Safety Act
Boilers and Pressure Vessels Regulation

No. 258822

Welder's Last Name GREER	Initial GR	First Name ROBIN	Signature <i>Robin Greer</i>	Stamp No 9
Res Address 835 MOUNTAIN ASH ROAD, PETERBOROUGH, ONTARIO		Postal Code K9J8K2	Provincial Registration No R35785, D8525 & R7645	
Employer Name ALL - WELD COMPANY LIMITED		Company POR No 54,9,9AB		
Street Address 49 PASSMORE AVE		Postal Code M1V4T1	Company WPS No used 9-3	
Welding Process(es) Used GTAW		Type(s) <input checked="" type="checkbox"/> manual	<input type="checkbox"/> machine	<input type="checkbox"/> semi-automatic
Base Material(s) SA-312-316		Thickness(es) 0.188"	<input checked="" type="checkbox"/> Test Coupon	<input type="checkbox"/> Production Weld
Variables for All Processes		Actual Values		Range Qualified
Backing material (with/without)		WITHOUT		WITH OR WITHOUT
Base Metal P-Number to P-Number () Plate (X) Pipe (enter diameter if pipe)		8 to 8		P1 THRU P15F, P34, & P4X PLATE AND PIPE 1/2" OD AND UP
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)		5.9 ER 316		
Consumable Insert for GTAW or PAW (QW-404)		NONE		
Welding Position (1G, 5G, etc.) (QW-405)		6G		6G
Manual or Semi-automatic Variables (QW-350)		Actual Values		Range Qualified
Filler Metal F-No (QW-404)		F6		F6
Filler Metal Product Form for GTAW, PAW (QW-404)		SOLID		SOLID
Weld deposit thickness for each welding process (QW-404)		0.188"		0.375" MAX PLATE GROOVE + PIPE 1/2" OD + UP
Process 1: _____ 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No		3		+ ALL FILLETS
Process 2: _____ 3 layers minimum <input type="checkbox"/> Yes <input type="checkbox"/> No		NONE		NONE
Vertical progression (uphill/downhill) (QW-405)		UPHILL		NONE
GTAW, PAW or GMAW backing gas or OFW fuel gas (QW-408)		ARGON 99.9%		ARGON 99.9%
GMAW transfer mode (spray/globular or pulse to short circuit) (QW-409)		NONE		NONE
GTAW welding current type & polarity (AC, DCEP, DCEN) (QW-409)		DC / SP		DC / SP
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 ₂ to YAG etc.)		NONE		
Continuous drive or inertia welding (FW)		NONE		
Vacuum or out of vacuum (EBW)		NONE		

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

RESULTS

Visual Examination of Completed Weld (QW-302.4) ACCEPTED

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

Type	Result	Type	Result	Type	Result	Type	Result
QW-462.3 (a) (Face)	ACCEPTED	QW-462.3 (a) (ROOT)	ACCEPTED	QW-462.3 (a) (Face)	ACCEPTED	QW-462.3 (a) (ROOT)	ACCEPTED

Alternative radiographic examination results (QW-191) NONE

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

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

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

Other tests NONE

Film or specimens evaluated by NONE Company NONE

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

Welding supervised by (Print name) ANDREW LEWIS

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

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

Organization ALL - WELD COMPANY LIMITED Signature *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 ROBU CNT 915
Inspector Name and Number (Print)

[Signature] MAR 07, 2012
Inspector Signature and Date



Technical Standards and Safety Authority

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

Welder/Welding Operator Certificate

Technical Standards and Safety Act
Boilers and Pressure Vessels Regulation

No. 262465

Welder's Last Name GABBIDON		Initial	First Name ALPHONSO	Signature 	Stamp No. 25
Res. Address 49 HAVAGAL CRES MARKHAM, ONT			Postal Code L 3 P 7 G 6	Provincial Registration No. R4428.5	
Employer Name ALL - WELD COMPANY LIMITED			Company PQR No. SAW - W-2-A1		
Street Address 49 PASSMORE AVE			Company WPS No. used SAW - W - 2 - 4		
SCARBOROUGH, ONT			Postal Code M 1 V 4 T 1		
Welding Process(es) Used SAW			Type(s)	<input type="checkbox"/> manual <input type="checkbox"/> machine <input type="checkbox"/> semi-automatic <input checked="" type="checkbox"/> automatic	
Base Material(s) SA - 240 - 316L			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)			BASE & WELD METAL		BASE & WELD METAL
Base Metal P-Number to P-Number			P8 to P8		P1 THRU P15F, P34 & P4X PLATE AND PIPE 2 7/8" OD AND UP
<input checked="" type="checkbox"/> Plate <input type="checkbox"/> Pipe (enter diameter if pipe)			1 3/4"		
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)			5.9 ER316L		
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 3/4"		MAX TO BE WELDED
Process 1: _____ 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No			14		
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-381.2)			Actual Values		Range Qualified
Direct or remote visual control			NONE		
Automatic arc voltage control (GTAW)			NONE		
Automatic joint tracking			NONE		
Multiple or single pass per side			NONE		
Automatic Welding Variables (QW-381.1)			Actual Values		Range Qualified
Filler Metal (EBW or LBW)			NONE		
Laser type for LBW (CO ₂ 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				

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)

CERTICA 2010 ONT 315
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. 262459

Welder's Last Name NIRZA	Initial HAFEZ (ABDUL)	Signature 	Stamp No. 53
Res. Address 2050 BRIDLETOWN CRICLE, #607, SCARBOROUGH ONTARIO		Postal Code M 1 W 2 V 5	Provincial Registration No. T 4628.5
Employer Name ALL - WELD COMPANY LIMITED		Company PQR No. 3 - 3X	
Street Address 49 PASSMORE AVE		Company WPS No. used 3-38	
SCARBOROUGH, ONT		Postal Code M 1 V 4 T 1	
Welding Process(es) Used SMAW		Type(s) <input checked="" type="checkbox"/> manual <input type="checkbox"/> machine <input type="checkbox"/> semi-automatic <input type="checkbox"/> automatic	
Base Material(s) SA-240-316 TO SA-240-316		Thickness(es) 1 3/4"	<input checked="" type="checkbox"/> Test Coupon <input type="checkbox"/> Production Weld
Variables for All Processes			
Backing material (with/without)		Actual Values Range Qualified	
Base Metal P-Number to P-Number		WITH WITH	
(X) Plate () Pipe (enter diameter if pipe)		8 to 8 P1 THRU P15F, P34 & P4X PLATE AND PIPE 2 7/8" OD AND UP	
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)		1 3/4" (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-350)			
Filler Metal F- No. (QW-404)		Actual Values Range Qualified	
Filler Metal Product Form for GTAW, PAW (QW-404)		F5 F5	
Weld deposit thickness for each welding process (QW-404)		NONE 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-406)		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-361.2)			
Direct or remote visual control		Actual Values Range Qualified	
Automatic arc voltage control (GTAW)		NONE	
Automatic joint tracking		NONE	
Multiple or single pass per side		NONE	
Automatic Welding Variables (QW-361.1)			
Filler Metal (EBW or LBW)		Actual Values Range Qualified	
Laser type for LBW (CO ₂ 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				
(SIDE)		(SIDE)					

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 03-28-2013
(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)

LOSTICA 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. 258824

Welder's Last Name MIRZA	Initial HAFEEZ	First Name HAFEEZ	Signature 	Stamp No 53
Res. Address 2050 BRIDLETOWN CIRCLE # 607, ONTARIO		Postal Code M 1 W 2 V 5	Provincial Registration No R3578.5, D852.5 & R764.5	
Employer Name ALL - WELD COMPANY LIMITED		Company PQR No 54, 9, 9AB		
Street Address 49 PASSMORE AVE		Postal Code M 1 V 4 T 1	Company WPS No. used 9-3	
SCARBOROUGH, ONT				
Welding Process(es) Used GTAW		Type(s) <input checked="" type="checkbox"/> manual <input type="checkbox"/> machine <input type="checkbox"/> semi-automatic <input type="checkbox"/> automatic		
Base Material(s) SA-312-316		Thickness(es) 0.188 "	<input checked="" type="checkbox"/> Test Coupon <input type="checkbox"/> Production Weld	
Variables for All Processes		Actual Values		Range Qualified
Backing material (with/without)		WITHOUT		WITH OR WITHOUT
Base Metal P-Number to P-Number		8 to 8		P1 THRU P15F, P34, & P4X PLATE AND PIPE 1/2" OD AND UP
() Plate (<input checked="" type="checkbox"/>) Pipe (enter diameter if pipe)		1/2" SCH 160		
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)		5.9 ER 316		
Consumable Insert for GTAW or PAW (QW-404)		NONE		
Welding Position (1G, 5G, etc.) (QW-405)		6G		6G
Manual or Semi-automatic Variables (QW-350)		Actual Values		Range Qualified
Filler Metal F- No (QW-404)		F6		F6
Filler Metal Product Form for GTAW, PAW (QW-404)		SOLID		SOLID
Weld deposit thickness for each welding process (QW-404)		0.188 "		0.376" MAX PLATE GROOVE + PIPE 1/2" OD + UP
Process 1: _____ 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No		3		+ ALL FILLETS
Process 2: _____ 3 layers minimum <input type="checkbox"/> Yes <input type="checkbox"/> No		NONE		NONE
Vertical progression (uphill/downhill) (QW-405)		UPHILL		NONE
GTAW, PAW or GMAW backing gas, or OFW fuel gas (QW-408)		ARGON 99.9 %		ARGON 99.9 %
GMAW transfer mode (spray/globular or pulse to short circuit) (QW-409)		NONE		NONE
GTAW welding current type & polarity (AC, DCEP, DCEN) (QW-409)		DC / SP		DC / SP
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 ₂ 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 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)

LOSTICA ROSE ONT915
Inspector Name and Number (Print)

MAR 07, 2012
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)	WITHOUT	WITH OR WITHOUT
ASME P or S No. to ASME P or S No.	P1 to P1	P1 THRU P11 & P4X PLATE &
(<input checked="" type="checkbox"/>) Plate () Pipe (enter diameter if pipe)	5/16"	PIPE 2 7/8" O.D. & HP
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)	(5.4) E308-16	
Consumable insert for GTAW or PAW (QW-404)	--	
Welding Position (1G, 5G, etc.) (QW-405)	2G	2G
Manual or Semi-automatic Variables (QW-350)		
Filler Metal F-No. (QW-404)	F5	F5
Filler Metal Product Form for GTAW, PAW (QW-404)	--	--
Weld deposit thickness for each welding process (QW-404)	5/16"	5/8" MAX.
Progression (uphill/downhill) (QW-405)	--	--
GTAW, PAW or GMAW backing gas, or OFW fuel gas (QW-408)	--	--
GMAW transfer mode (QW-409)	--	--
GTAW welding current type & polarity (QW-409)	--	--
Machine Welding Variables (QW-361-2)		
Direct or remote visual control	--	--
Automatic voltage control (GTAW)	--	--
Automatic joint tracking	--	--
Multiple or single pass per side	--	--
Automatic Welding Variables (QW-361-1)		
Filler metal (EBW or LBW)	--	--
Laser type for LBW (CO ₂ to YAG etc.)	--	--
Continuous drive or inertia welding (FW)	--	--
Vacuum or out of vacuum (EBW)	--	--

Manufacturer's Copy

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

RESULTS

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

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

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

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

Type	Result	Type	Result	Type	Result
QW462.3(a)	ACCEPTED	QW462.3(a)	ACCEPTED		
ROOT		FACE			

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

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

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

Other tests **--**

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

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

Welding supervised by **ANDREW LEWIS**

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

Organization **ALL-WELD COMPANY LIMITED** Signature *Robert Bentley* Date **FEB. 23, 2006**



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

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

FAN YANG
Welder

83
Symbol

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

ALL-WELD COMPANY LIMITED

Subject to the limitations of this certificate

Authorized Examiner

Director

Office Use Only

Test Requested By **ROBERT BENTLEY**

(Print Person's Name)

ALL-WELD COMPANY LIMITED

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

(Print Address)

District # **13**

Inspector # **OW1057**

Fee **105/-**



Technical Standards and Safety Authority

11th Floor Centre Tower
3300 Bloor Street West
Toronto, Ontario M8X 2X4
Web site www.tssa.org

Welder/Operator Identification Card
Technical Standards and Safety Act
Boilers and Pressure Vessels Regulation
No. 16944

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.: **R3578.5**
D852.5 + 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.)	WITHOUT	WITH OR WITHOUT
ASME P or S No. to ASME P or S No.	P 8 to P 8	P1 THRU P11 & P4X PLATE & ALL
() Plate (<input checked="" type="checkbox"/>) Pipe (enter diameter if pipe)	2 3/8" O.D.	PIPE 1" O.D. & UP
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)	6G	6G
Manual or Semi-automatic Variables (QW-350)	Actual Values	Range Qualified
Filler Metal F- No. (QW-404)	F6	F6
Filler Metal Product Form for GTAW, PAW (QW-404)	SOLID	SOLID
Weld deposit thickness for each welding process (QW-404)	0.218"	1/16" TO 0.436" MAX
Progression (uphill/downhill) (QW-405)	UPHILL	
GTAW, PAW or GMAW backing gas; or OFW fuel gas (QW-408)	ARGON 99%	ARGON 99%
G transfer mode (QW-409)	N/A	N/A
GTAW welding current type & polarity (QW-409)	DC/SP	DC/SP
Machine Welding Variables (QW-361-2)	Actual Values	Range Qualified
Direct or remote visual control	---	---
Automatic 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 ₂ 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
(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 *P.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 # --- Inspector # --- Fee ---



Welder's Last Name: **HUYNH** Initial: **HU** First Name: **VAN-LY** Signature: *[Handwritten Signature]* Stamp No: **87**

Res. Address: **134 GOLDEN GATE CIR. WOODBRIDGE, ONTARIO** Postal Code: **L4H1N6** Provincial Registration No: **D852.5 + R3578.5 + R7674.5**

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

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

SCARBOROUGH, ONTARIO Postal Code: **M1V4T1**

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

Base Material(s): **SA 106-B / SA 106-B** Thickness(es): **0.218"**

Variables for All Processes	Actual Values	Range Qualified
Backing material (metal, weld metal, welded from both sides, flux, etc.)	WITHOUT	WITH OR WITHOUT
ASME P or S No. to ASME P or S No.	P1 to P1	P1 THRU P11 & P4X PLATE & ALL
() Plate (<input checked="" type="checkbox"/>) Pipe (enter diameter if pipe)	2 3/8" O.D.	PIPE 1" O.D. & UP
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)	6G	6G
Manual or Semi-automatic Variables (QW-350)	Actual Values	Range Qualified
Filler Metal F- No (QW-404)	F6	F6
Filler Metal Product Form for GTAW, PAW (QW-404)	SOLID	SOLID
Weld deposit thickness for each welding process (QW-404)	0.218"	1/16" TO 0.436" MAX
Progression (uphill/downhill) (QW-405)	UPHILL	--
GTAW, PAW or GMAW backing gas, or OFW fuel gas (QW-408)	ARGON 99%	ARGON 99%
GMAW transfer mode (QW-409)	N/A	N/A
GTAW welding current type & polarity (QW-409)	DC/SP	DC/SP
Machine Welding Variables (QW-361-2)	Actual Values	Range Qualified
Direct or remote visual control	--	--
Automatic 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 ₂ 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
(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 *[Handwritten Signature]* Date **MAY 31, 2006**



Issued under Ontario's **Technical Standards and Safety Act**
Boilers and Pressure Vessels Regulation **PER ASME SECT. IX**

Expiry Date **87**

VAN-LY HUYNH Welder Symbol

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

ALL-WELD COMPANY LIMITED

Subject to the limitations of this certificate

Authorized Examiner *[Handwritten Signature]*

Office Use Only

Test Requested By **ROBERT BENTLEY**
(Print Person's Name)

ALL-WELD COMPANY LIMITED
49 PASSMORE AVE., SCARBOROUGH, ON

Tested At (Print Address)

Distnct # **13** Inspector # **001-037** 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. 258718

Welder's Last Name: Liew Initial: SL First Name: Steve Signature: [Signature] Stamp No.: 90

Res. Address: 11 Indian Mound Crescent, Scarborough, Ontario Postal Code: M1H1W2 Provincial Registration No: D700.5 & R2363.5 R2060.5

Employer Name: All-Weld Company Limited Company POR No: 78, 1 + 1-A

Street Address: 49 Passmore Ave Company WPS No used: 1 - 1

Scarborough, Ontario Postal Code: M1V4T1

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

Base Material(s): SA 516-GR 70 / SA 516-GR 70 Thickness(es): 3/8"

Variables for All Processes	Actual Values	Range Qualified
Backing material (metal, weld metal, welded from both sides, flux, etc.)	<u>without</u>	<u>with or without</u>
ASME P or S No. to ASME P or S No.	<u>P1 to P1</u>	<u>P1 thru P15, P34 & P4X Plate & all</u>
(<input checked="" type="checkbox"/>) Plate () Pipe (enter diameter if pipe)	<u>3/8"</u>	<u>pipe 2 7/8" U.D. & up</u>
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)	<u>(5.1) E7018 - 1H4</u>	
Consumable Insert for GTAW or PAW (QW-404)	<u>--</u>	
Welding Position (1G, 5G, etc.) (QW-405)	<u>2G</u>	<u>2G</u>
Manual or Semi-automatic Variables (QW-350)	Actual Values	Range Qualified
Filler Metal F- No. (QW-404)	<u>F4</u>	<u>F4</u>
Filler Metal Product Form for GTAW, PAW (QW-404)	<u>--</u>	<u>--</u>
Weld deposit thickness for each welding process (QW-404)	<u>3/8"</u>	<u>3/4" max</u>
Process 1: _____ 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<u>4</u>	<u>--</u>
Process 2: _____ 3 layers minimum <input type="checkbox"/> Yes <input type="checkbox"/> No	<u>--</u>	<u>--</u>
Progression (uphill/downhill) (QW-405)	<u>--</u>	<u>--</u>
GTAW, PAW or GMAW backing gas; or OFW fuel gas (QW-408)	<u>--</u>	<u>--</u>
GMAW transfer mode (spray/globular or pulse to short circuit) (QW-409)	<u>--</u>	<u>--</u>
GTAW welding current type & polarity (AC, DCEP, DCEN) (QW-409)	<u>--</u>	<u>--</u>
Machine Welding Variables (QW-361-2)	Actual Values	Range Qualified
Direct or remote visual control	<u>--</u>	<u>--</u>
Automatic arc voltage control (GTAW)	<u>--</u>	<u>--</u>
Automatic joint tracking	<u>--</u>	<u>--</u>
Multiple or single pass per side	<u>--</u>	<u>--</u>
Automatic Welding Variables (QW-361-1)	Actual Values	Range Qualified
Filler metal (EBW or LBW)	<u>--</u>	<u>--</u>
Laser type for LBW (CO ₂ to YAG etc.)	<u>--</u>	<u>--</u>
Continuous drive or inertia welding (FW)	<u>--</u>	<u>--</u>
Vacuum or out of vacuum (EBW)	<u>--</u>	<u>--</u>

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

RESULTS

Visual Examination of Completed Weld (QW-302.4) accepted

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

Inspector Name and Number (Print): MIHIR SOM ANICD92 Inspector Signature: [Signature]



Technical Standards and Safety Authority

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

Welder/Welding Operator Certificate

Technical Standards and Safety Act
Boilers and Pressure Vessels Regulation

No. 262466

Welder's Last Name LIEW	Initial SL	First Name STEVE	Signature 	Stamp No. 90
Res. Address 11 INDIAN BOUND CRESCENT, ONTARIO			Postal Code M 1 H 1 W 2	Provincial Registration No. WP-T46285
Employer Name ALL - WELD COMPANY LIMITED			Company PQR No. 3-3X	
Street Address 48 PASSMORE AVE			Company WPB No. used 3-3B	
SCARBOROUGH, ONT			Postal Code M 1 V 4 T 1	
Welding Process(es) Used SBAW			Type(s) <input checked="" type="checkbox"/> manual <input type="checkbox"/> machine <input type="checkbox"/> semi-automatic <input type="checkbox"/> automatic	
Base Material(s) SA-240-316 TO SA-240-316			Thickness(es) 1 3/4"	<input checked="" type="checkbox"/> Test Coupon <input type="checkbox"/> Production Weld
Variables for All Processes				
Backing material (with/without)			Actual Values	
Base Metal P-Number to P-Number			Range Qualified	
<input checked="" type="checkbox"/> Plate <input type="checkbox"/> Pipe (enter diameter if pipe)			WITH	
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)			WITH	
Consumable Insert for GTAW or PAW (QW-404)			P1 THRU P15F, P34 & P4X PLATE AND PIPE 1/8" OD AND UP AND ALL FILLETS	
Welding Position (1G, 5G, etc.) (QW-405)			1G & 2G	
Manual or Semi-automatic Variables (QW-360)				
Filler Metal F-No. (QW-404)			F5	
Filler Metal Product Form for GTAW, PAW (QW-404)			NONE	
Weld deposit thickness for each welding process (QW-404)			1 3/4"	
Process 1: _____ 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No			MAX TO BE WELDED	
Process 2: _____ 3 layers minimum <input type="checkbox"/> Yes <input type="checkbox"/> No			NONE	
Vertical progression (uphill/downhill) (QW-405)			NONE	
GTAW, PAW or GMAW backing gas; or OPW fuel gas (QW-408)			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-361.3)				
Direct or remote visual control			NONE	
Automatic arc voltage control (GTAW)			NONE	
Automatic joint tracking			NONE	
Multiple or single pass per side			NONE	
Automatic Welding Variables (QW-361.1)				
Filler Metal (EBW or LBW)			NONE	
Laser type for LBW (CO ₂ to YAG etc.)			NONE	
Continuous drive or inertia welding (FW)			NONE	
Vacuum or out of vacuum (EBW)			NONE	

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

RESULTS

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

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

Type	Result	Type	Result	Type	Result	Type	Result
QW-462.2	ACCEPTED	QW-462.3	ACCEPTED	QW-462.3	ACCEPTED	QW-462.3	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. **634823-2013 & 634851-2013**

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 Date **03-15-2013**
(mm-dd-yyyy)

FOR TSSA INSPECTOR USE ONLY

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

Check (✓) applicable box below:

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

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

Inspector Name and Number (Print) **OUT915**

Inspector Signature and Date **MAR 15, 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. 258828

Welder's Last Name ALROUBAYI	Initial A	First Name RAZZAK	Signature 	Stamp No. 109
Res. Address 140 QUANTRELL TRIAL SCARBOROUGH, ONT		Postal Code M 1 B 1 L B	Provincial Registration No. R4428.5	
Employer Name ALL - WELD COMPANY LIMITED		Company PQR No. SAW-2A1		
Street Address 49 PASSMORE AVE		Company WPS No used SAW - W - 2 - 1		
SCARBOROUGH, ONT		Postal Code M 1 V 4 T 1		
Welding Process(es) Used SAW		Type(s)	<input type="checkbox"/> manual <input type="checkbox"/> machine <input type="checkbox"/> semi-automatic <input checked="" type="checkbox"/> automatic	
Base Material(s) SA - 240 - 304	Thickness(es) 1"	<input checked="" type="checkbox"/> Test Coupon <input type="checkbox"/> Production Weld		
Variables for All Processes		Actual Values		Range Qualified
Backing material (with/without)		BASE & WELD METAL		BASE & WELD METAL
Base Metal P-Number to P-Number (<input checked="" type="checkbox"/>) Plate () Pipe (enter diameter if pipe)		P8 to P6		P1 THRU P15F, P34 & P4X PLATE AND PIPE 2 7/8" OD AND UP
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)		5.9 ER308		
Consumable insert for GTAW or PAW (QW-404)		NONE		
Welding Position (1G, 5G, etc.) (QW-405)		1G		1G
Manual or Semi-automatic Variables (QW-350)		Actual Values		Range Qualified
Filler Metal F- No. (QW-404)		6		6
Filler Metal Product Form for GTAW, PAW (QW-404)		NONE		
Weld deposit thickness for each welding process (QW-404)		1"		MAX TO BE WELDED
Process 1: _____ 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No		12		
Process 2: _____ 3 layers minimum <input type="checkbox"/> Yes <input type="checkbox"/> No		NONE		
Vertical progression (uphill/downhill) (QW-405)		NONE		
GTAW, PAW or GMAW backing gas; or OFW fuel gas (QW-408)		NONE		
GMAW transfer mode (spray/globular or pulse to short circuit) (QW-409)		NONE		
GTAW welding current type & polarity (AC, DCEP, DCEN) (QW-409)		NONE		
Machine Welding Variables (QW-361.2)		Actual Values		Range Qualified
Direct or remote visual control		NONE		
Automatic arc voltage control (GTAW)		NONE		
Automatic joint tracking		NONE		
Multiple or single pass per side		NONE		
Automatic Welding Variables (QW-361.1)		Actual Values		Range Qualified
Filler Metal (EBW or LBW)		NONE		
Laser type for LBW (CO ₂ 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				

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 - 08 - 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

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: M1C4P6 Provincial Registration No: QW2142.5R & R2180.5
 Employer Name: ALL - WELD COMPANY LIMITED Company POR No: 3 & 3A
 Street Address: 49 PASSMORE AVE Company WPS No used: 3-1
 SCARBOROUGH, ONT Postal Code: M1V4T1
 Welding Process(es) Used: SMAW Type(s): manual machine semi-automatic automatic
 Base Material(s): SA-240-304 TO SA-240-304 Thickness(es): 3/8" Test Coupon Production Weld
 Variables for All Processes
 Backing material (with/without): WITHOUT WITH OR WITHOUT
 Base Metal P-Number to P-Number: 8 10 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
 Manual or Semi-automatic Variables (QW-350)
 Filler Metal F-No (QW-404): F5 F5
 Filler Metal Product Form for GTAW PAW (QW-404): NONE
 Weld deposit thickness for each welding process (QW-404): 3/8" 3/4" MAX
 Process 1: 3 layers minimum Yes No PLATE GROOVE + PIPE 2 7/8" OD + UP + ALL FILLETS
 Process 2: 3 layers minimum Yes No NONE
 Vertical progression (uphill/downhill) (QW-405): NONE
 GTAW, PAW or GMAW backing gas, or OFW fuel gas (QW-408): NONE
 GMAW transfer mode (spray/globular or pulse to short circuit) (QW-409): NONE
 GTAW welding current type & polarity (AC, DCEP, DCEN) (QW-409): NONE
 Machine Welding Variables (QW-361.2)
 Direct or remote visual control: NONE
 Automatic arc voltage control (GTAW): NONE
 Automatic joint tracking: NONE
 Multiple or single pass per side: NONE
 Automatic Welding Variables (QW-361.1)
 Filler Metal (EBW or LBW): NONE
 Laser type for LBW (CO2 to YAG etc.): NONE
 Continuous drive or inertia welding (FW): NONE
 Vacuum or out of vacuum (EBW): NONE

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

Visual Examination of Completed Weld (QW-302.4) ACCEPTED

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

Type	Result	Type	Result	Type	Result	Type	Result
QW-462.3 (a) (Face)	ACCEPTED	QW-462.3 (a) (ROOT)	ACCEPTED				

Alternative radiographic examination results (QW-191) NONE

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

Other tests NONE
 Film or specimens evaluated by NONE Company NONE
 Mechanical tests conducted by ALL - WELD COMPANY LIMITED Laboratory test no. NONE
 Welding supervised by (Print name) ANDREW LEWIS
 Test requested by (Print name) ROBERT BENTLEY Tested at (Print address) 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)

COSITA ROSU ONTARIO
 Inspector Name and Number (Print)

[Signature]
 Inspector Signature and Date



Technical Standards and Safety Authority

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

Welder/Welding Operator Certificate
Technical Standards and Safety Act
Boilers and Pressure Vessels Regulation

No. 257507

Welder's Last Name: INNIS Initial: ANDREW First Name: ANDREW Signature: *Andrew Innis* Stamp No.: 110
 Res. Address: 21 BORNHOLM DRIVE TORONTO, ONTARIO Postal Code: M1V4T1
 Employer Name: ALL - WELD COMPANY LIMITED Provincial Registration No: R3578 5, D852 5 & R764 5
 Street Address: 49 PASSMORE AVE Company PQR No: 54, 9, 9AB
 SCARBOROUGH, ONT Postal Code: M1V4T1 Company WPS No used: 9-1
 Welding Process(es) Used: GTAW Type(s): manual machine semi-automatic automatic

Base Material(s): SA-312-304 Thickness(es): 0.218" 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 1" OD AND UP
() Plate (X) Pipe (enter diameter if pipe)	2.3/8"	
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)	5.9 ER 308	
Consumable Insert for GTAW or PAW (QW-404)	NONE	
Welding Position (1G, 5G, etc.) (QW-405)	6G	6G

Manual or Semi-automatic Variables (QW-350)	Actual Values	Range Qualified
Filler Metal F-No. (QW-404)	F6	F6
Filler Metal Product Form for GTAW, PAW (QW-404)	SOLID	SOLID
Weld deposit thickness for each welding process (QW-404)	0.218"	0.436" MAX PLATE GROOVE + PIPE 1" OD + UP
Process 1 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	3	+ ALL FILLETS
Process 2 3 layers minimum <input type="checkbox"/> Yes <input type="checkbox"/> No	NONE	NONE
Vertical progression (uphill/downhill) (QW-405)	UPHILL	NONE
GTAW, PAW or GMAW backing gas, or OFW fuel gas (QW-408)	ARGON 99%	ARGON 99%
GMAW transfer mode (spray/globular or pulse to short circuit) (QW-409)	NONE	NONE
GTAW welding current type & polarity (AC, DCEP, DCEN) (QW-409)	DC / SP	DC / SP

Machine Welding Variables (QW-361.2)	Actual Values	Range Qualified
Direct or remote visual control	NONE	
Automatic arc voltage control (GTAW)	NONE	
Automatic joint tracking	NONE	
Multiple or single pass per side	NONE	

Automatic Welding Variables (QW-361.1)	Actual Values	Range Qualified
Filler Metal (EBW or LBW)	NONE	
Laser type for LBW (CO2 to YAG etc.)	NONE	
Continuous drive or inertia welding (FW)	NONE	
Vacuum or out of vacuum (EBW)	NONE	

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

Visual Examination of Completed Weld (QW-302.4) ACCEPTED
 Transverse root and face [QW-462.3(a)] Longitudinal root and face [QW-462.3(b)] Side (QW-462.2)
 Pipe bend specimen, corrosion-resistant overlay [QW-462.5(c)] Plate bend specimen, corrosion-resistant overlay [QW-462.5(d)]
 Pipe specimen, macro test for fusion [QW-462.5(b)] Plate specimen, macro test for fusion [QW-462.5(e)]

Type	Result	Type	Result	Type	Result	Type	Result
QW-462.3 (a)	ACCEPTED	QW-462.3 (a)	ACCEPTED	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)
WOSITCA ROW ONT915 2009-2012
 Inspector Name and Number (Print) Inspector Signature and Date



Technical Standards and Safety Authority

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

Welder/Welding Operator Certificate
Technical Standards and Safety Act
Boilers and Pressure Vessels Regulation

No. 262463

Welder's Last Name: INNISS Initial: ANDREW First Name: ANDREW Signature: [Signature] Stamp No: 118

Res. Address: 21 BORNHOLM DRIVE TORONTO, ONTARIO Postal Code: M1B1L8 Provincial Registration No: W/P T-4645 5
Employer Name: ALL - WELD COMPANY LIMITED Company PQR No: 50-X
Street Address: 49 PASSMORE AVE 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)	E316LTO-1	
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)	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	
Machine Welding Variables (QW-361.2)	Actual Values	Range Qualified
Direct or remote visual control	NONE	
Automatic arc voltage control (GTAW)	NONE	
Automatic joint tracking	NONE	
Multiple or single pass per side	NONE	
Automatic Welding Variables (QW-361.1)	Actual Values	Range Qualified
Filler Metal (EBW or LBW)	NONE	
Laser type for LBW (CO2 to YAG etc.)	NONE	
Continuous drive or inertia welding (FW)	NONE	
Vacuum or out of vacuum (EBW)	NONE	

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

Visual Examination of Completed Weld (QW-302.4) ACCEPTED

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

Type	Result	Type	Result	Type	Result	Type	Result
QW-462.2 (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:

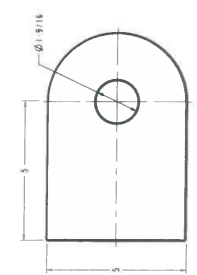
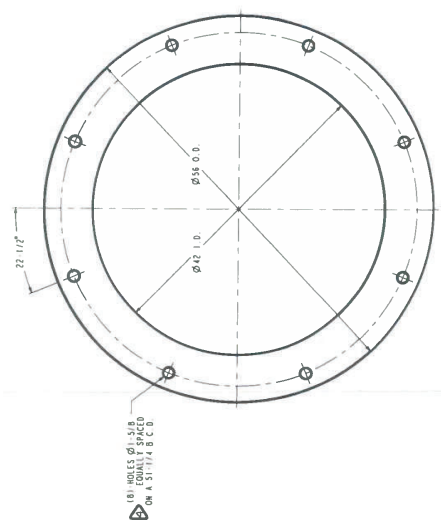
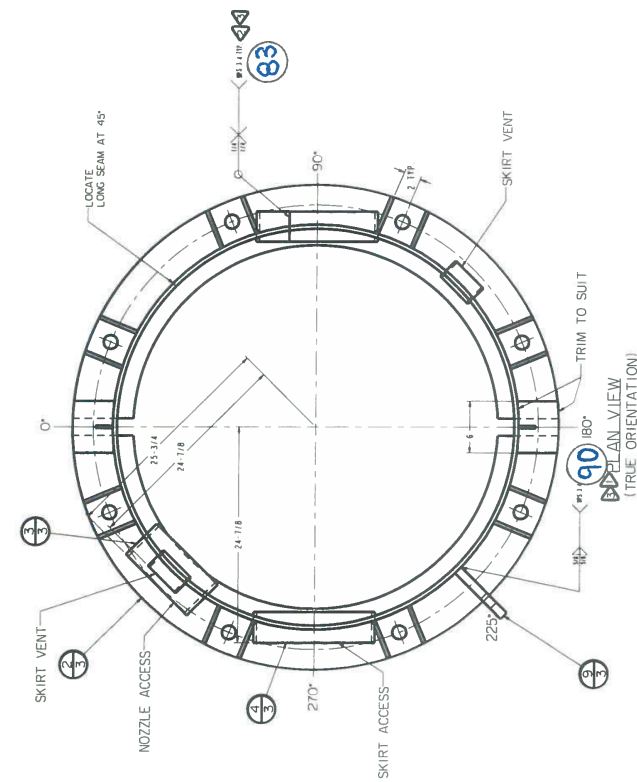
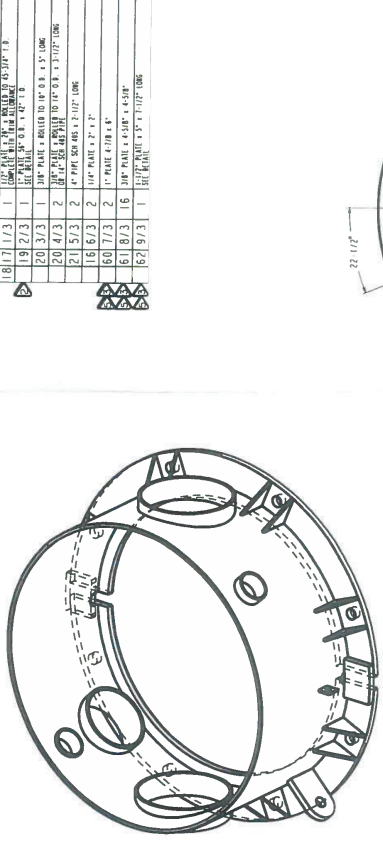
- To weld for the Employer named above only.
 For seeking employment only.

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

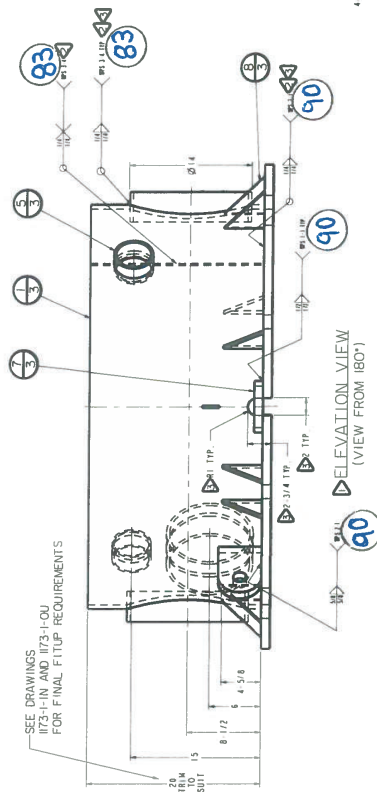
Inspector Name and Number (Print) GUSTICA ROSE 01915

Inspector Signature and Date [Signature] APRIL 11, 2013

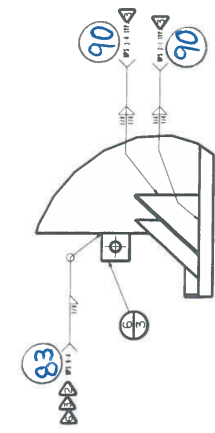
BILL OF MATERIAL		DESCRIPTION	SPEC.
ITEM QTY			
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19	2	3/4" PLATE	SA-516M
20	3	1/2" PLATE	SA-516M
21	5	1/4" PLATE	SA-516M
22	2	1/2" PLATE	SA-516M
23	2	1/2" PLATE	SA-516M
24	2	1/2" PLATE	SA-516M
25	2	1/2" PLATE	SA-516M
26	2	1/2" PLATE	SA-516M
27	2	1/2" PLATE	SA-516M
28	2	1/2" PLATE	SA-516M
29	2	1/2" PLATE	SA-516M
30	2	1/2" PLATE	SA-516M
31	2	1/2" PLATE	SA-516M
32	2	1/2" PLATE	SA-516M
33	2	1/2" PLATE	SA-516M
34	2	1/2" PLATE	SA-516M
35	2	1/2" PLATE	SA-516M
36	2	1/2" PLATE	SA-516M
37	2	1/2" PLATE	SA-516M
38	2	1/2" PLATE	SA-516M
39	2	1/2" PLATE	SA-516M
40	2	1/2" PLATE	SA-516M
41	2	1/2" PLATE	SA-516M
42	2	1/2" PLATE	SA-516M
43	2	1/2" PLATE	SA-516M
44	2	1/2" PLATE	SA-516M
45	2	1/2" PLATE	SA-516M
46	2	1/2" PLATE	SA-516M
47	2	1/2" PLATE	SA-516M
48	2	1/2" PLATE	SA-516M
49	2	1/2" PLATE	SA-516M
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DETAIL ITEM 9/3



DETAIL ITEM 8/3



DETAIL ITEM 2/3

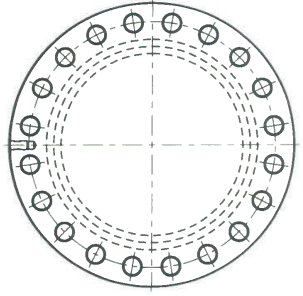
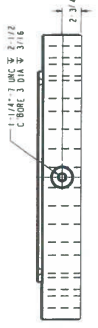
PURCHASE ORDER NUMBER: III2
 (4) REQUIRED
 PLOTTED:

WELD MAP

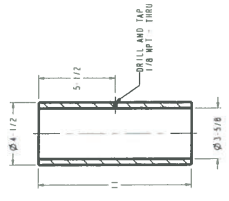
ALL-WELD COMPANY LIMITED
 WELD MAP DRAWING
 48" O.D. VERTICAL SEPARATOR
 STAINLESS STEEL SKIRT DETAILS

BILL OF MATERIAL

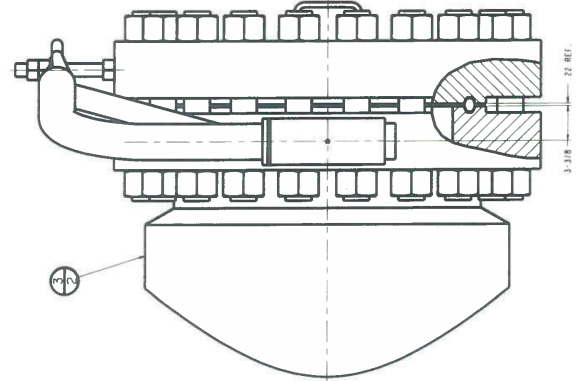
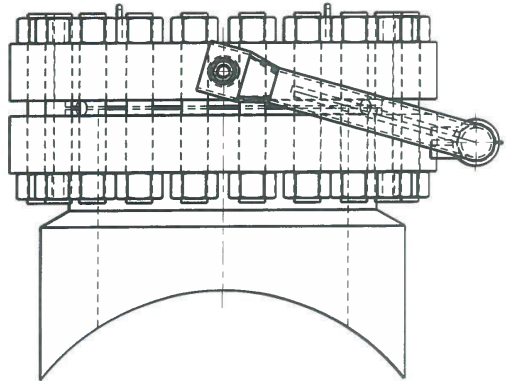
ITEM QTY.	DESCRIPTION	SPEC.
23 11/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
25 24 2/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
26 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
27 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
28 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
29 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
30 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
31 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
32 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
33 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
34 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
35 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
36 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
37 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
38 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
39 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
40 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
41 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
42 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
43 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
44 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
45 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
46 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
47 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
48 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
49 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
50 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
51 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
52 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
53 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
54 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
55 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
56 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
57 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
58 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
59 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
60 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
61 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
62 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
63 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
64 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
65 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
66 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
67 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
68 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
69 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
70 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
71 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
72 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
73 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
74 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
75 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
76 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
77 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
78 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
79 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
80 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
81 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
82 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
83 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
84 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
85 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
86 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
87 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
88 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
89 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
90 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
91 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
92 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
93 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
94 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
95 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
96 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
97 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
98 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2
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100 1/4	1/2" DIA. X 1/2" LONG	SA 307 1/2



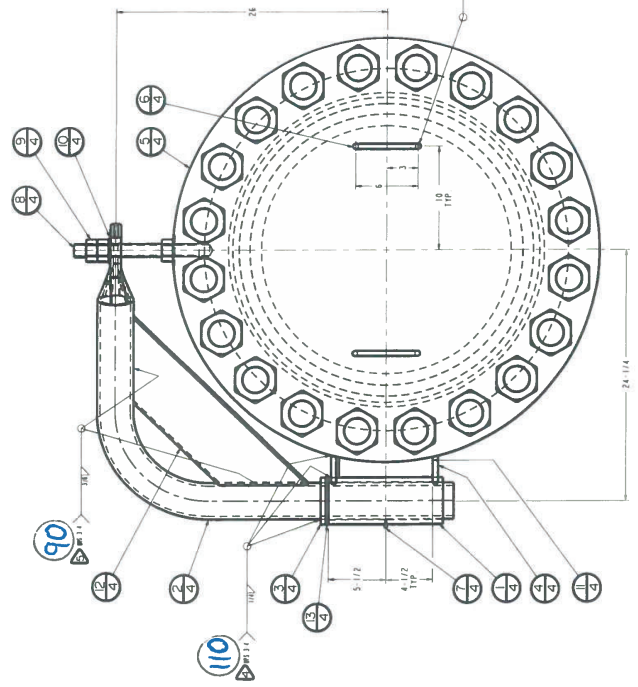
DETAIL ITEM 5/4



DETAIL ITEM 1/4



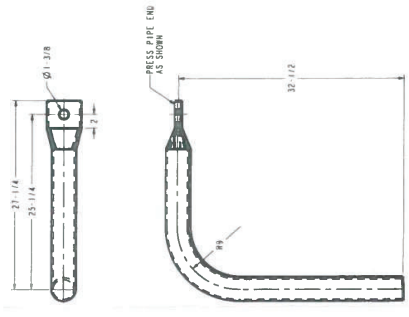
NOZZLE 1/18"



WELD MAP

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

DETAIL ITEM 2/4



DETAIL ITEM 4/4

DETAIL ITEM 11/4

NOV 18 2013
(2) REQUIRED
PLOTTED:



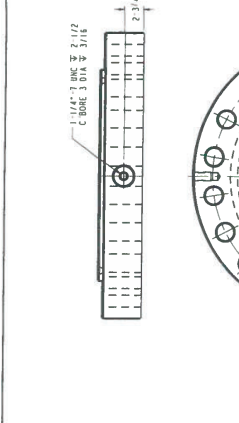
ULTRAFAB INDUSTRIES LIMITED
48" O.D. VERTICAL INLET SEPARATOR
24" MANWAY ASSEMBLY C/W DAVIT ASSEMBLY

Rev.	Description	Date	By	App'd
1	ISSUED FOR FABRICATION	12/12/12	...	...
2	...	...	...	...
3	...	...	...	...

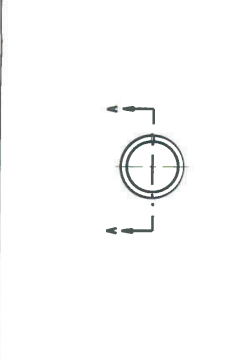
PURCHASE ORDER NUMBER: 1112

This drawing is the property of All-Weld Company Ltd. and may not be reproduced or distributed to others without permission in writing.

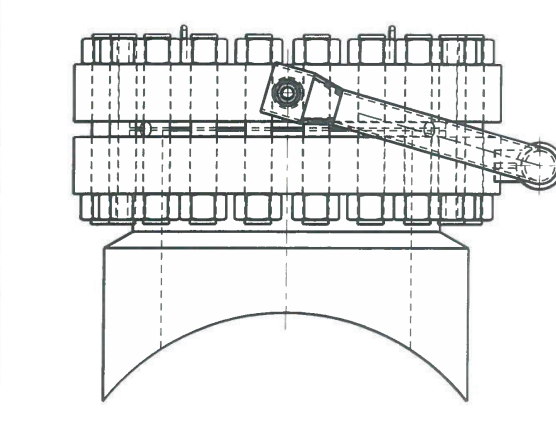
ITEM	QTY.	DESCRIPTION	SPEC.
23	1/4	1.000 1/2" DIA. 10' LONG	AS PER DWG.
24	2/4	1.000 1/2" DIA. 10' LONG	AS PER DWG.
25	2/4	1.000 1/2" DIA. 10' LONG	AS PER DWG.
26	4/4	1.000 1/2" DIA. 10' LONG	AS PER DWG.
27	6/4	1.000 1/2" DIA. 10' LONG	AS PER DWG.
28	7/4	1.000 1/2" DIA. 10' LONG	AS PER DWG.
29	8/4	1.000 1/2" DIA. 10' LONG	AS PER DWG.
30	9/4	1.000 1/2" DIA. 10' LONG	AS PER DWG.
31	10/4	1.000 1/2" DIA. 10' LONG	AS PER DWG.
32	10/4	1.000 1/2" DIA. 10' LONG	AS PER DWG.
33	10/4	1.000 1/2" DIA. 10' LONG	AS PER DWG.
26	1/4	1.000 1/2" DIA. 10' LONG	AS PER DWG.



DETAIL ITEM 5/4



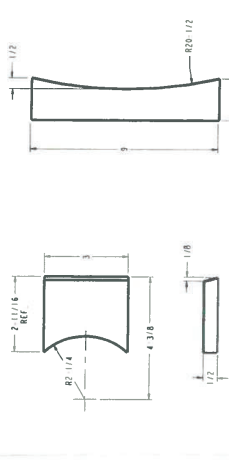
DETAIL ITEM 1/4



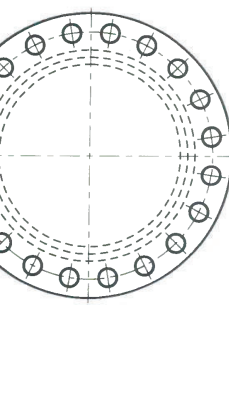
NOZZLE "MIB"

BILL OF MATERIAL

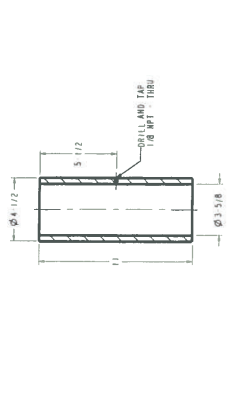
ITEM	QTY.	DESCRIPTION	SPEC.
23	1/4	1.000 1/2" DIA. 10' LONG	AS PER DWG.
24	2/4	1.000 1/2" DIA. 10' LONG	AS PER DWG.
25	2/4	1.000 1/2" DIA. 10' LONG	AS PER DWG.
26	4/4	1.000 1/2" DIA. 10' LONG	AS PER DWG.
27	6/4	1.000 1/2" DIA. 10' LONG	AS PER DWG.
28	7/4	1.000 1/2" DIA. 10' LONG	AS PER DWG.
29	8/4	1.000 1/2" DIA. 10' LONG	AS PER DWG.
30	9/4	1.000 1/2" DIA. 10' LONG	AS PER DWG.
31	10/4	1.000 1/2" DIA. 10' LONG	AS PER DWG.
32	10/4	1.000 1/2" DIA. 10' LONG	AS PER DWG.
33	10/4	1.000 1/2" DIA. 10' LONG	AS PER DWG.
26	1/4	1.000 1/2" DIA. 10' LONG	AS PER DWG.



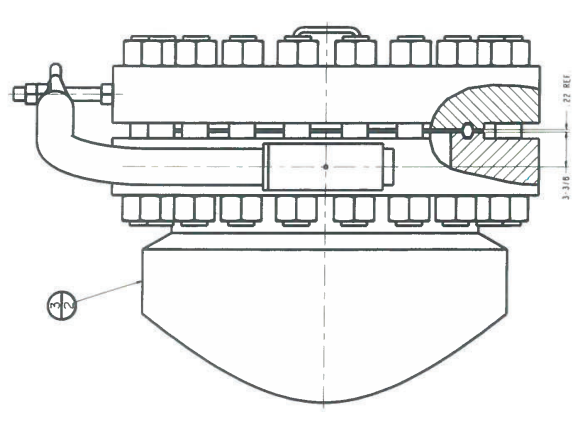
DETAIL ITEM 11/4



DETAIL ITEM 4/4



DETAIL ITEM 12/4



WELD MAP

(2) REQUIRED
PLOTTED:

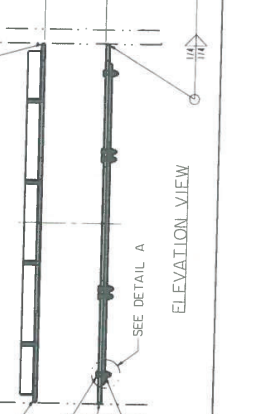
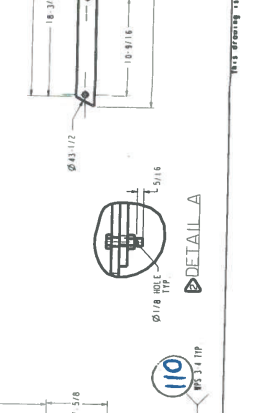
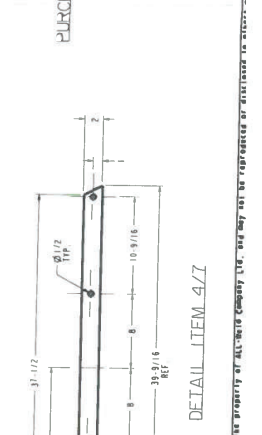
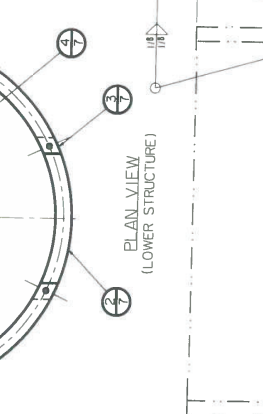
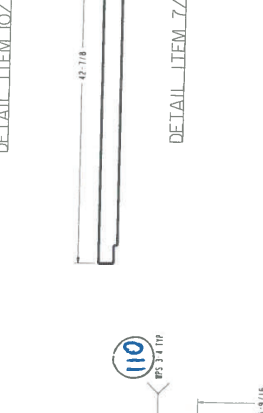
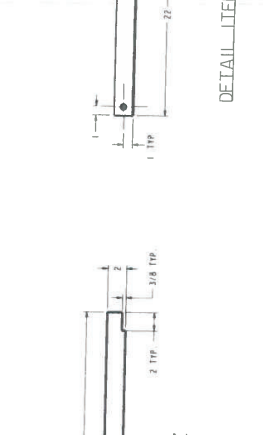
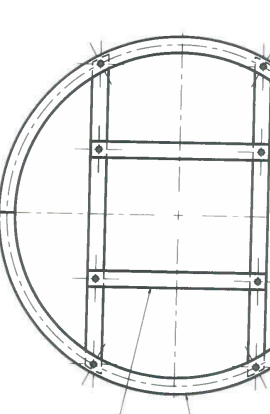
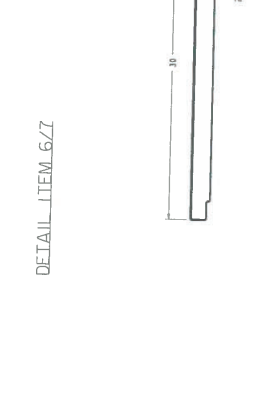
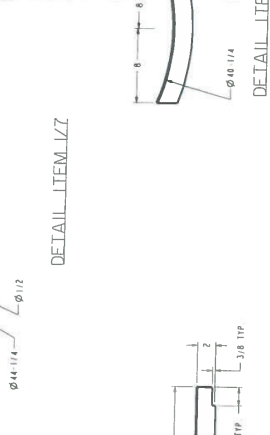
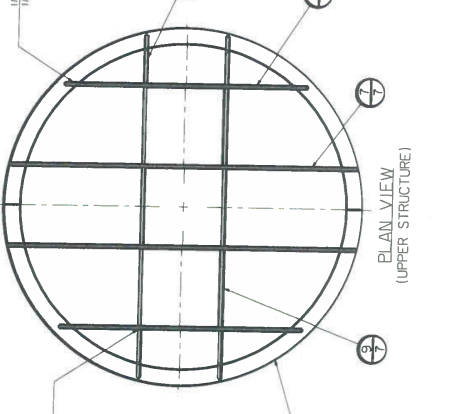
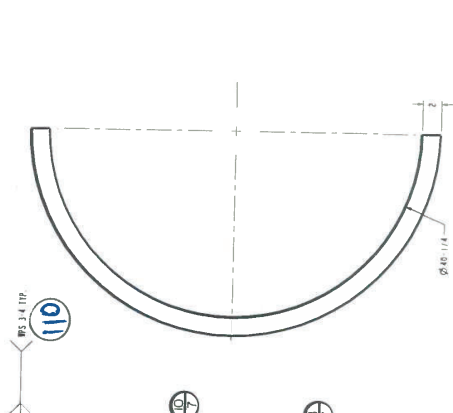
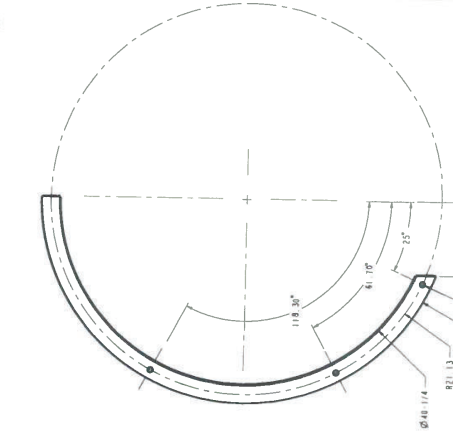
ALL-WELD
COMPANY LIMITED
Engineering Office 2005
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NOTE: DAVIT ARM ASSEMBLY IS DESIGNED TO SUPPORT TWICE THE BLIND FLANGE WEIGHT.

PURCHASE ORDER NUMBER: 1112

ULTRAFAB INDUSTRIES LIMITED
45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100

BILL OF MATERIAL			
ITEM	QTY.	DESCRIPTION	SPEC.
6.3	1/71	1/2" x 1/4" x 1/4" ANGLE 180°	304/316 SS
6.3	2/71	1/2" x 1/4" x 1/4" ANGLE 90°	304/316 SS
6.3	3/71	1/2" x 1/4" x 1/4" ANGLE 45°	304/316 SS
6.3	4/71	1/2" x 1/4" x 1/4" ANGLE 22.5°	304/316 SS
6.3	5/71	1/2" x 1/4" x 1/4" ANGLE 11.25°	304/316 SS
6.3	6/71	1/2" x 1/4" x 1/4" ANGLE 5.625°	304/316 SS
6.3	7/71	1/2" x 1/4" x 1/4" ANGLE 2.8125°	304/316 SS
6.3	8/71	1/2" x 1/4" x 1/4" ANGLE 1.40625°	304/316 SS
6.3	9/71	1/2" x 1/4" x 1/4" ANGLE 0.703125°	304/316 SS
6.3	10/71	1/2" x 1/4" x 1/4" ANGLE 0.3515625°	304/316 SS
6.3	11/71	1/2" x 1/4" x 1/4" ANGLE 0.17578125°	304/316 SS
6.3	12/71	1/2" x 1/4" x 1/4" ANGLE 0.087890625°	304/316 SS
6.3	13/71	1/2" x 1/4" x 1/4" ANGLE 0.0439453125°	304/316 SS
6.3	14/71	1/2" x 1/4" x 1/4" ANGLE 0.02197265625°	304/316 SS
6.3	15/71	1/2" x 1/4" x 1/4" ANGLE 0.010986328125°	304/316 SS
6.3	16/71	1/2" x 1/4" x 1/4" ANGLE 0.0054931640625°	304/316 SS
6.3	17/71	1/2" x 1/4" x 1/4" ANGLE 0.00274658203125°	304/316 SS
6.3	18/71	1/2" x 1/4" x 1/4" ANGLE 0.001373291015625°	304/316 SS
6.3	19/71	1/2" x 1/4" x 1/4" ANGLE 0.0006866455078125°	304/316 SS
6.3	20/71	1/2" x 1/4" x 1/4" ANGLE 0.00034332275390625°	304/316 SS



PLOTTED:

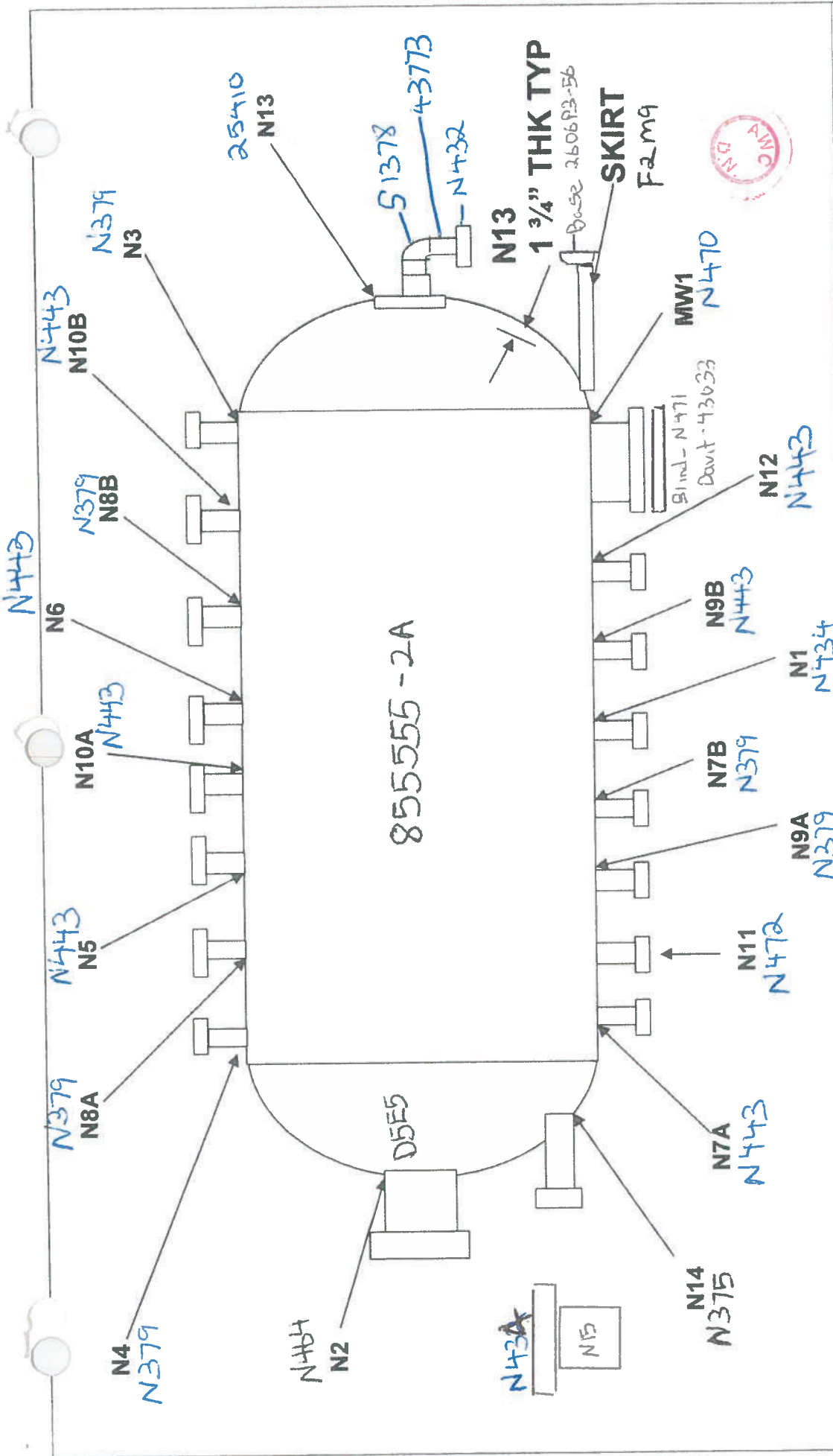
(4) REQUIRED

PURCHASE ORDER NUMBER: 1112

WELD MAP

ALL-WELD COMPANY LIMITED
 110 WINDING ROAD, WESTVALE INDUSTRIAL PARK
 WESTVALE, SOUTH AFRICA
 TEL: +27 (0) 31 944 4400
 FAX: +27 (0) 31 944 4401
 EMAIL: SALES@ALLWELD.COM

APPROD. VERTICAL INLET / OUTLET SEPARATOR
 CIVIL FABRICATION & WELDING DETAILS
 110 WINDING ROAD, WESTVALE INDUSTRIAL PARK
 WESTVALE, SOUTH AFRICA
 TEL: +27 (0) 31 944 4400
 FAX: +27 (0) 31 944 4401
 EMAIL: SALES@ALLWELD.COM



ALL-WELD CO. LTD. - HEAT NUMBER MAP

CLIENT: ULTRAFAB
 WORK ORDER #: 1173PQ SN 7472
 JOB DESCRIPTION: 48" O.D. VERTICAL INLET
 DRAWING #: 1173-1-IN
 PREPARED BY: D.NESCI
 DATE: March 25, 2013

HEAT NUMBER MAP - 1173PQ

ASME SECTION VIII. DIV. 1

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

N3, N4, N5, N6, N7A, N7B, N8A, N8B, N9A
N9B, N10A, N10B, N11, N12, N13, N14

F9x7

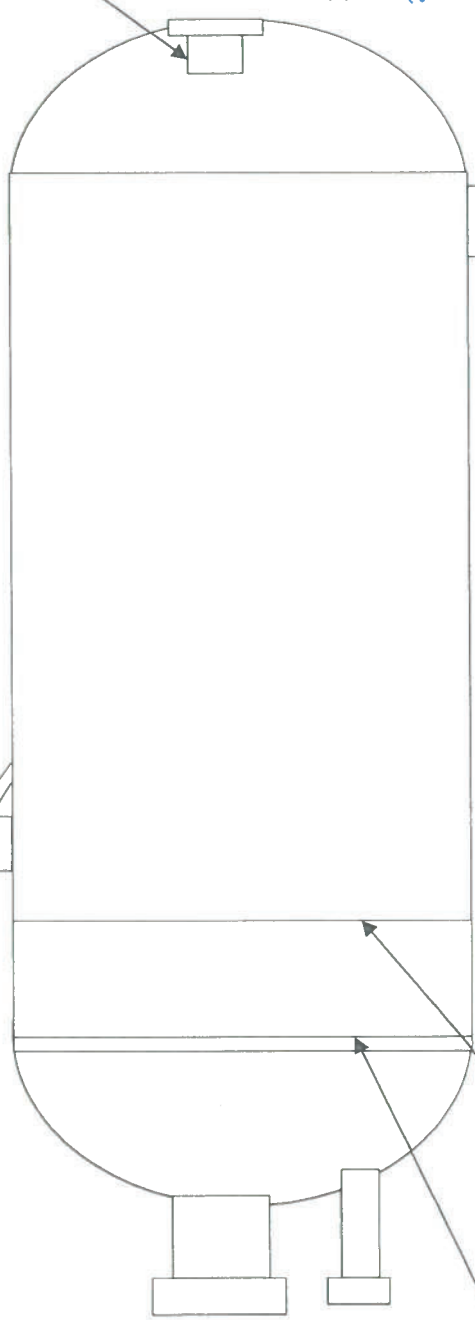
15/2- E9C1

16/2 E9W8
17/2 E9W8

12/2- E9W8
23/2- 836433-1E
25/2- 2X449
26/2- 37463
21/2 YT22057

24/2-836433-1E

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



NAME
BRACKET
E9W8

6/7
E7K6

17/2
E5K2

DAVIT BRACKET-
9IN3

**ALL-WELD COMPANY LTD. -
HEAT NUMBER MAP PARTS**

CLIENT: ULTRAFAB

WORK ORDER #: 1173PQ SN 7472

JOB DESCRIPTION: 48" O.D. VERTICAL INLET

DRAWING #: 1173-1-IN

PREPARED BY: D.NESCI

DATE: September 17, 2013

HEAT NUMBER MAP PARTS- 1173PQ

ASME SECTION VIII. DIV. 1

MATERIAL SA-240 316/316L



6870 HIGHWAY 42 EAST

METALLURGICAL TEST REPORT

NORTH AMERICAN STAINLESS
6870 HIGHWAY 42 EAST
GHENT, KY 41045

Mail To:

JACQUET MID ATLANTIC
CUSTOMER PICKUP
12273 BROWN AVENUE
RIVERSIDE, CA 92509

Ship To:

JACQUET MID ATLANTIC
CUSTOMER PICKUP
12273 BROWN AVENUE
RIVERSIDE, CA 92509

Date: 11/26/2012 Page: 1

Certificate: 789232 1

Steel: 316/316L

Finish: HRAP

Your Order: 4436

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 Compliant
Material is Free of Radioactive Contamination
NAS Steel Making Process: EAF, AOD, & Cont. Casting
Product Mfg. by a Quality Mgt. Sys. in Conf. w/ISO 9001
*Melted & Manufactured in the USA; Mat'l is DFARS Compliant

Product Id	Plate#	Skid #	Thickness	Width	Weight	Length	Mark	Pieces	Commodity Code
03D5E5 CA	03D5E5 CA		1.7575	60.0000	7,500	PLATE	240.00	1	1

CHEMICAL ANALYSIS CM(Country of Melt) ES(Spain) US(United States) ZA(South Africa) JP(Japan)

Chemical Analysis per ASTM A751/08

HEAT	CM	C %	CR %	CU %	MN %	MO %	N %	NI %	P %	S %
D5E5	US	.0226	16.5890	.4770	1.5150	2.0045	.0389	10.0350	.0345	.0010
	SI %									

MECHANICAL PROPERTIES

Product Id#	Plate#	T	UTS	.2% YS	ELONG	Hard	R of A
		KSI	KSI	%-2"	RB	%	
03D5E5 CA	03D5E5 CA	88.05	46.66	56.65	80.00	68.07	

W.O.# 11730
M.L.#
TYPE # SEE CT REPORT
P.O.# 12-1612-11730

Certification of Material Per ASME
HT# DSES
Qualifies to all requirements of
SA 240-316/316L per
Sec. II, 10 Edition 11 Addenda

Q.C.I. E.V.

HT.# DSES
MTR APPROVED
DATE 11/14/12
ISP
QUALITY CONTROL DEPT

ACCEPTED/REVIEWED/RELEASED
for and on behalf of: Velox America
SA 240-316 SA HT

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 LLC
11/26/2012

Technical
Dept. Mgr. ERIC HESS

JACQUET NO.
27162

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
QUALITY MANAGER

ACCEPTED/REVIEWED/RELEASED 036
for and on behalf of: SBM
Print Name: GIANPESIA SANTI
Signature: [Signature]
Date: MAR 26/13
Applus®
VELOSI
Velosi America LLC



FEB 05 2013



Certificate of Analysis and Tests

 * RE-CERTIFICATION *

OUR ORDER 0282469 - 01

HEAT & PIECE 855555-2A 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

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

----- ITEM DESCRIPTION -----
 HEAT & PIECE 855555 - 2A
 WEIGHT 7564
 FINISH 1
 GRADE 316L / 316 UNS-S31603 / UNS-S31600
 DIMENSIONS 1.750 X 96.000 X 154.000 EXACT

----- SPECIFICATIONS -----
 *** MFG IN NEW CASTLE, IN, USA FROM SLABS IMPORTED FROM BRITAIN
 AMS 5507F WITH EXCEPTIONS AMS 5524L WITH EXCEPTIONS
 ASTM A240-12A ASMESA240-11ED ASTM A480-12 ASMESA480 11ED
 ROLLED ALLOYS SPECS 316L/316 NAFTA CTRY ORIGIN= SLAB CTRY
 MEETS EU ELECTRICAL ROHS LIST HEAT/PCE/SIZE ON INVCE
 NACE MRO175-2009/ISO 15156 NO GRIPPER MARKS
 NO WELD REPAIRS
 ASTM A262-02A PRACTICE A ASTM A262-02A PRACTICE F

PLATES & TEST PCS SOLUTION ANNEALED @ 1900 DEGREES FAHRENHEIT MINIMUM.
 THEN WATER COOLED OR RAPIDLY COOLED BY AIR
 FREE FROM MERCURY CONTAMINATION AT CURRENT DETECTION LIMITS
 HOT ROLLED, ANNEALED & PICKLED (HRAP)

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

HARDNESS HRBW 81
 GRAIN SIZE 6
 YIELD STRENGTH (PSI) 46390
 TENSILE STRENGTH (PSI) 80510
 INTERGRANULAR CORROSION OK
 ELONGATION % IN 2" 57.9
 REDUCTION OF AREA % 59.3

W.O. # 1173Q
 M.L. # 2
 THK. # 13/16"
 P.O. # 12-1613-1173Q

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

CARBON (C) .015
 MANGANESE (MN) 1.70
 PHOSPHORUS (P) .031
 SULFUR (S) .001
 SILICON (SI) .29
 CHROMIUM (CR) 16.33
 NICKEL (NI) 10.06
 COBALT (CO) .27
 COPPER (CU) .35
 MOLY (MO) 2.04
 NITROGEN (N) .08
 COLUMBIUM (CB) .015
 TITANIUM (TI) .007
 ALUMINUM (AL) .006
 TIN (SN) .007
 TANTALUM (TA) .002

Certification of Material - Per ASME
 HT# 855555-2A
 Qualifies to all requirements of
 SA 240-316/316L per
 Sect. II 10 Edition 11a Addenda



FEB 05 2013

WE HEREBY CERTIFY THAT THE MATERIAL HEREIN HAS BEEN MADE AND TESTED IN ACCORDANCE WITH THE LISTED SPECIFICATION(S) AND THAT THE RESULTS OF ALL TESTS ARE ACCEPTABLE.

JAMES DOUBMAN, QUALITY ASSURANCE MANAGER

CERTIFICATE IN CONFORMANCE WITH EN10204-95 3.1.B/EN10204-2004 3.1

James Douman

ACCRIT (I) DIV REVIEWED/RELEASED
 for and on behalf of: *SISM OFFSHORE*
 Print Name: *James Douman*
 Signature: *[Signature]*
 Date: *11-16-12*
 Appius® VELOSI
 Velosi America LLC

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 # 7472	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

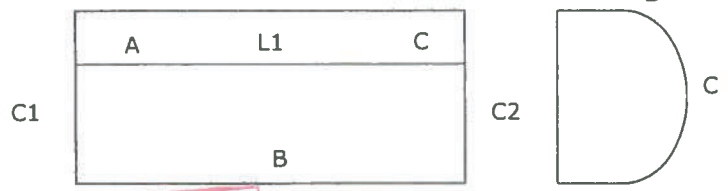
Diameter	Size	Beam Angle	Frequency	Manufacturer	Blocks
<input type="radio"/> 1/4"	<input type="radio"/> 5/8" x 5/8"	<input type="radio"/> 45°	<input type="radio"/> 1.00 MHz	<input type="radio"/> Techsonic	<input type="radio"/> IIW A2
<input type="radio"/> 3/8"	<input type="radio"/> 1/2" x 1"	<input type="radio"/> 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	1.766	1.797	1.785
B	1.786	1.740	1.732
C	1.768	1.749	1.740

All Dimensions are in inches



ACCEPTED/REVIEWED/RELEASED
for and on behalf of: SBM
Print Name: GANESH SANA
Signature: [Signature]
Date: MARCH 26/13
046
Applus[®] VELOS
Velosi America LLC
FEB 28 2013

Scanning

Test Area	Disposition	From	Length	Depth	Amplitude

Evaluation - Acceptance

<input type="radio"/> Accepted	KV Inspection Services - Technician	<u>[Signature]</u>	Date	February 26, 2013
<input type="radio"/> Rejected	CGSA No. 43.9712-2000 Reg. No.	3685	Place	Scarborough, ON.



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

REPORT NUMBER 72424

DATE 3/5/2013

FCI ORDER NUMBER 59176

Processed I.A.W. EN10204 3 1
I.A.W. NACE MR0175

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

SCARBOROUGH ONT MIV 4T1 CANADA

Item Quantity Description

1 3 24" X 900 X 26.50" LG RTJ I-2, 35" OD REINFORCEMENT ITEM 1173-4

HEAT NUMBER:
N470

MATERIAL TYPE:
SA182F316/L

Manufactured in
USA

I.A.W. ASME 2010 ED 11AD.

CHEMICAL ANALYSIS

PHYSICAL PROPERTIES

C .018 ✓
Mn 1.830 ✓
P .0260 ✓
S .0010 ✓
Si .390 ✓
Cr 16.600 ✓
Mo 2.030 ✓

Yield PSI 49,300 ✓
Tensile PSI 85,000 ✓
Elongation 50 ✓
Reduction of Area 75 ✓
Hardness 170 HBW ✓

Ni 10.170 ✓
0.0850



Certification of Material - Per ASME
HT# N470
Qualifies to all requirements of
SA182-F316/L per
Sect. II 10 Edition 11 Addenda

W.O. # 11730
M.L. # 4 (3/2)
THK. #
P.O. # 13-0074

MAR 18 2013

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



MAR 20 2013

Immediately following hot working, while at temperature above, parts were rapidly quenched.

We hereby certify that all test results and process information contained herein are correct and true as contained in the records of the company.

Prepared by

Name Rene Ordorez Title QA Representative

ACCEPTED/REVIEWED/RELEASED (05)
for and on behalf of: SIBM
Print Name: GANESH SATHI
Signature: [Signature]
Date: March 16/13
Applus® VELOSI
Velosi America LLC



14527 Smith Rd.
Humble, Texas 77396
TEL: (281) 441-4099
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 ITEM 1173-5
3	4	8" X 900 X 13.25" LG RTJ LWN	ITEM 1173-6

HEAT NUMBER:
N464

MATERIAL TYPE:
SA192F316 L

Manufactured in
USA

I.A.W. ASME 2010 ED 11AD.

CHEMICAL ANALYSIS

PHYSICAL PROPERTIES

C	.028 ✓
Mn	1.740 ✓
P	.0450 ✓
S	.0090 ✓
Si	.380 ✓
Cr	16.610 ✓
Mo	2.030 ✓
Ni	10.040 ✓
N	0.757

Yield PSI	99,100
Tensile PSI	80,300
Elongation	60.2
Reduction of Area	76.5
Hardness	149, 163 HBW

Certification of Material - Per ASME
HT# N464
Qualifies to all requirements of
SA192-F316L per
Sect. II TC Edition 11 Addenda

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

*Reviewed
Phyllis
Apr 5,
2013*

APR 03 2013
APR 05 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 RIJLWN

ITEM 1173-7

HEAT NUMBER:
N375

MATERIAL TYPE:
SA182F316/L

Manufactured in
USA

I.A.W. ASME 2010 ED 11AD.

CHEMICAL ANALYSIS

PHYSICAL PROPERTIES

C .018 ✓
Mn 1.720 ✓
P .0290 ✓
S .0280 ✓
Si .360 ✓
Cr 16.990 ✓
Mo 2.030 ✓

Yield PSI 37,000 ✓
Tensile PSI 83,000 ✓
Elongation 62 ✓
Reduction of Area 71 ✓
Hardness 158 HBW ✓

Ni 10.000 ✓
.0800

N14
Certification of Material - Per ASME
HT# **N375**
Qualifies to all requirements of
SA182-F316/B161 per
Sect. II **70** Edition **11** Addenda

W.O. # 11730
M.L. # 7 (6/2)
THK. # 1.092
P.O. # 13-0074

Q.C.I.
N.D.

Q.C.I.
E.Y.

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 Ordoñez Title QA Representative

ACCEPTED/REVIEWED/RELEASED 046
for and on behalf of: **SBM**
Print Name: **GANESH SADA**
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, 7B, 8A, 8B, 9A

Certification of Material - Per ASME
HT# N379
Qualifies to all requirements of
SA182F316L316L per
Sect. II 10 Edition 11 Addenda

W.O. # 1173Q
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 SBA 046
for and on behalf of:
Print Name: GANESH 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 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 ✓

Yield PSI 42,000 ✓
Tensile PSI 85,000 ✓
Elongation 58.9 ✓
Reduction of Area 61.4 ✓
Hardness 175 HBW ✓

Ni 10.150 ✓
.0740

N5, 6, 7A, 9B, 10A, 10B, 12

Certification of Material - Per ASME
HT# N443
Qualifies to all requirements of
SA182-F316/316L per
Sect. II 10 Edition II Addenda

W.O. # 1173
M.L. # 7(7/2)
THK. # 1.079
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

Name: Rene Ordonez

Title: QA Representative

ACCREDITED REVIEWED & RELEASED 046
for and on behalf of: CLAWSON S BH
Print Name: CLAWSON S BH
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
7	4	24" X 900 RTJ BLIND

ITEM 1173-4
ITEM 1173-9

HEAT NUMBER:
N471

MATERIAL TYPE:
SA182F316/L

Manufactured in
USA

I.A.W. ASME 2010 ED 11AD.

CHEMICAL ANALYSIS

PHYSICAL PROPERTIES

C	.019	✓
Mn	1.410	✓
P	.0230	✓
S	.0003	✓
Si	.500	✓
Cr	16.430	✓
Mo	2.050	✓

Yield PSI	49,600	✓
Tensile PSI	90,100	✓
Elongation	52.8	✓
Reduction of Area	76.1	✓
Hardness	170/179 HBW	✓

Ni	10.100	✓
	.0710	

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

Name: Rene Ordonez Title: QA Representative

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

VIRAJ PROFILES LIMITED



Regi & Mkt off: G-33 & 34, MIDC, Industrial Area, Tarapur, Thane (Dist), Maharashtra, INDIA - 401506, E-Mail: sales@viraj.com
 Works: SURVEY No- 114, 119 & 120, VILL. Mahagaon, Tal: Palgar, Dist: Thane-401501, MAHARASTRA, INDIA, 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 / FDBPX
 04/12/3124
 Overseas Branch, Mumbai-21.

ACCEPTED/REVIEWED/RELEASED
 for and on behalf of: Velosi America
 Print Name: GANI ESH SAHA
 Signature: [Signature]
 Date: 14/12
Applus
 VEL OSI
 Velosi America LLC

[Signature]
 WORKS INSPECTOR
 K R K MURTHY

File P05a37

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	E/W LR 90° ELBOW	2.0000	160		
Alloy WP316/316L Short PN 00005393			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	Elem - Content
C - .01800	MN - 1.45000	P - .02800	S - .00100
SI - .50000	CR - 16.80000	NI - 11.10000	MO - 2.10000

TEST RESULTS:

W/O#: 69333 LOAD: TEST SET: 1

Tensile Test 1

Specimen Type	Before	in	After	in
Size 1	Before	in	After	in
Size 2	Before	in	After	in
Area	Before	.0000 sq in	Red %	.00 %
Gauge Lnth	.00 in	Elong %	52.60 %	
Tensile Load	0	Tensile Strength	81,700 lb/sq in	
Yield Load	0	Yield Strength	61,800 lb/sq in	

Hardness Test

Hardness 183.00 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
 IT# S1378
 Qualifies to all requirements of
 SA403-316/316L per
 Sect. II 10 Edition 11 Addend

TED/RE
 on behalf of SIBM OFFSHORE
 name: GARY SH SAH
 signature: [Signature]
 Date: APR 15 2013
 046
 Applus VELOSI
 Velosi America LLC

Q.C.I. N.D.

HARDNESS IS ACCEPTABLE
I.A.W. NACE MRO-175/ISO 15156

W.O. # 11730
 M.L. # 13 (10/2)
 THK. # 414
 P.O. # 13-

Q.C.I. E.Y.

APR 08 2013

Material, when shipped, is free from contamination by mercury, radium, alpha source and low melting elements. Welds 100% Radiographed and acceptable to (ASME Section VIII - Para UW-51) when applicable. We Hereby Certify that the materials listed above have been manufactured in accordance with, and meet the above applicable specifications and grades.

[Signature]
 QA/QC/MTR Specialist

4/05/13
Date



TUBACEX

INSPECTION CERTIFICATE
EN 10204 3.1

Number: 519285 Rev: 00
Page: 1/3

Created on: Modified on:
Date: 09.05.2011

TTI - TUBACEX TUBOS INOXIDABLES

Registro Mercantil de Alava, Tomo 587, Folio 189, Hoja VI 2885 - N.I.F. A-01140227

Tres cruces, 8

01400 Llodio (Alava)

SPAIN

TL: +34 946719300

FAX: +34 946725062

E-MAIL: qualitytti@tubacex.es

CUSTOMER DESCRIPTION

CLIENT SOLD TO PINACLE STAINLESS STEEL INC. 455 AMBASSADOR DRIVE MISSISSAUGA, ONTARIO ON L5T 2J3 CANADA	CLIENT SHIP TO PINACLE STAINLESS STEEL INC. 455 AMBASSADOR DRIVE MISSISSAUGA, ONTARIO ON L5T 2J3 CANADA
--	--

CLIENT ORDER: 57733

SALES ORDER: 101551

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 / ISO 15156-3 : 2009

W.O. # 1173G
M.L. # 14(11/2)
THK. # .347
P.O. # 13-0243REV1

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	1050 KG	94.32 M	5791-7315 MM

RAW MATERIAL			Method	
Heat Nr:	Supplier			
37015	ACERALAVA	Electric furnace+AOD		MAR 26 2013
43773	ACERALAVA	Electric furnace+AOD		

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
279
Velosi America
MS
April 11, 2013



TUBACEX TUBOS INOXIDABLES
INGENIERIA DE CALIDAD

[Signature]



**INSPECTION CERTIFICATE
EN 10204 3.1**

Number: 519285
Page: 2 / 3

Rev: 00

Created on:
Date: 09.05.2011

Modified on:

TENSILE TEST

Prod. Order	Ins. Lot	Sample	T	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
Feb 26, 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 SÜDDEUTSCHLAND (NOTIFIED BODY 0036) TO ISSUE CERTIFICATES OF SPECIFIC PRODUCT CONTROL IN ACCORDING TO PRESSURE EQUIPMENT DIRECTIVE 97/23/EC ANNEX I POINT 4.3

MATERIAL CHARACTERISTICS COMPLY WITH POINT 7.5 OF ANNEX I TO PED BY HAVING AN ELONGATION AFTER RUPTURE AT



**TUBACEX TUBOS
INOXIDABLES**
INGENIERIA DE CALIDAD

[Signature]



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.F.P. STAINLESS STEEL, INC.
1040 BURLINGTON STREET E.
HAMILTON, ON L9B3L4

Ship To:

C.F.P. STAINLESS STEEL, INC.
1040 BURLINGTON STREET E.
HAMILTON, ON L9B3L4

Date: 1/29/2013 Page: 1

Steel: 316/316L

Finish: WRAP

Customer: 007060 001

NAS Order: IN 0161382 01

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

Your Order: C87097

PRODUCT DESCRIPTION

STAINLESS STEEL COIL, WRAP; 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 5507P/5524L X MRK;
NACE MR0175/ISO 15156-3:2003 A, MR0103/07, G09766D-A X MAG FIRM
MIN. SOLUTION ANNEAL TEMP 1900F, WATER QUENCHED

REMARKS:

Mat'l is Free of Mercury Contamination. No weld repairs.
EN 10204:2004 3.1, Rows 1 & 2 Compliant
Material is Free of Radioactive Contamination
NAS Steel Making Process: EAF, AOD, & Cast. Casting
Product Mfg. by a Quality Mgt. Sys. in Conf. w/ISO 9001
Melted & Manufactured in the USA, Mat'l is DPVMS 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	C %	CR %	CU %	NI %	MO %	SI %	P %	S %
US	.0139	16.6330	.4580	1.5125	2.0060	.0409	10.0750	.0365
HEAT T9W8								
SI % .4205								

Chemical Analysis per ASTM A751/08

W.O. # 11730
M.L. # 16 (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	47.08	49.59	94.00	97.50

ACCEPTED/REVIEWED/RELEASED
for and on behalf of: SBM OFFSHORE
Print Name: GARETH SILLIHAN
Signature: [Signature]
Date: 1/29/13
Velocity America LLC

Certification of Material - Per ASME
HT # E9038
Qualifies to all requirements of
SA 240-316/316L per
Sect. II, 10 Edition 1 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 in this report and cannot be reproduced, except in its entirety, without the written approval of NAS.

Technical Dept. Mgr. ERIC HESS
1/31/2013



METALLURGICAL TEST REPORT

NORTH AMERICAN STAINLESS
6870 HIGHWAY 42 EAST
GHENT, KY 41045

SK 34016

6870 HIGHWAY 42 EAST

Mail To: ROLARK STAINLESS STEEL, INC.
71 CONAIR PARKWAY
WOODBRIDGE, ON L4H0S4

Ship To: ROLARK STAINLESS STEEL, INC.
71 CONAIR PARKWAY
WOODBRIDGE, ON L4H0S4

Date: 2/11/2013 Page: 1

Steel: 316/316L

Finish: HRAP

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

NAS Order: DS 0002818 01

Your Order: 54026

PRODUCT DESCRIPTION:

STAINLESS STEEL PLATE, HRAP; UNS 31600/31603
ASTM A240/11b,A480/11b,A666/10;ASME SA240/11a,SA480/11a,SA666/11a
CHEM ONLY ON FOLLOWING ASTM: A276/10,A479/11,A484/11,A312/11
CHEM ONLY ON FOLLOWING ASME: SA312/11,SA479/11
AMS 5507F/5524L X MRK;
NACE MR0175/ISO 15156-3:2003 A, MR0103/07; QOS766D-A X MAG PERM
MIN. SOLUTION ANNEAL TEMP 1900F, WATER QUENCHED

REMARKS:

Mat'l is Free of Mercury Contamination. No weld repairs.
EN 10204:2004 3.1; RoHS 1 & 2 Compliant
Material is Free of Radioactive Contamination
NAS Steel Making Process: EAF, AOD, & Cont. Casting
Product Mfg.by a Quality Mgt.Sys. in Conf. w/ISO 9001
*Melted & Manufactured in the USA; Mat'l is DfARS Compliant
EN 10204 3.1.B

ACCH: (DR) (V) (W) (K) (L) (E) (A) (S) (D) 046
for and on behalf of: Velosi America
APOLUS
Signature: Mark July
Date: 2/11/13
Product Name: APOLUS
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

ES(Spain) US(United States) ZA(South Africa) JP(Japan)

HEAT	CM	C %	CR %	CU %	MN %	MO %	N %	NI %	P %	S %
F2M9	US	.0182	16.7745	.4700	1.4880	2.0480	.0297	10.0300	.0400	.0015

SI % .3000

W.O. # 11730
M.L. # 17(1/3)
THK. # 502
P.O. # 13-0203

O.C.I. N.D.

MAR 12 2013

MECHANICAL PROPERTIES

Product Id#	Plate#	UTS KSI	YIELD %	ELONG %	Hard RB	R of A %
05F2M9 AA	05F2M9 AA	85.73	39.06	56.10	72.00	75.52

Certification of Material - Per ASME
HT# F2m9
Complies to all requirements of SA312-316 per 10 Edition 11 Addenda

O.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 Dept. Mgr. Eric Hess
2/11/2013



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

000598

SO No. Item & Date: 8006515 000020 2013/01/05	Shipment No. & Date: 1000023647 2013/01/06	TC No., Date & Time: ESA-38932 2013/01/07 10:15:07
Sold to Customer Name and Address: QUALITY PLATES & PROFILES LTD NICHOLAS BEAVER ROAD RR#3 20 ABERFOYLE, Ontario, Canada N1H 6H9	Ship to Customer Name and Address: QUALITY PLATES & PROFILES LTD NICHOLAS BEAVER ROAD RR#3 20 ABERFOYLE, Ontario, Canada N1H 6H9	Customer PO NO. Item: P007755-2 BOL NO: 1000023647 Cust Part No: ROBINSON TRANSPORT LTD - 205(661) Center:

Customer Specification: HR STEEL PLATE Carbon Mils Cert ASTM A516 GR 70 (11A) Meets NACE MR G103 latest Ed. BHN < 200. D O CEO 43 max. Inclusion Supt. Control Calcium Treated Normalized Temp 1670 - F 34 min CVN. Req. 1/2" LFBF at 0 - 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 1510-837-2227

Inspection Report As Per Spec

ESSAR STEEL ALGOMA INC. HEREBY CERTIFIES THAT THE MATERIAL HEREIN DESCRIBED WAS MADE AND TESTED IN ACCORDANCE WITH THE RULES OF THE SPECIFICATION SHOWN. ALL RESULTS ARE RETAINED IN ACCORDANCE WITH THE COMPANY'S STANDARD RECORD KEEPING PRACTICES.

THIS MILL TEST REPORT MAY NOT BE REPRODUCED OR REPRINTED IN FULL WITHOUT WRITTEN APPROVAL OF ESSAR STEEL ALGOMA INC. IF YOU RECEIVE THIS DOCUMENT AND ARE NOT THE INTENDED RECEIVER PLEASE CALL (705) 945-4029 FOR INSTRUCTIONS ON METHOD OF DISPOSAL OF DOCUMENT.

MEETS EN 10204 2004 "TYPE 3.1"

SULFUR 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/OR 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 "	AB8769	2606P3-56	13 068 LB	1	1 0000 " x 120 000 " x 384 00 "	AB8770	2606P3-56	13 068 LB	1
1 0000 " x 120 000 " x 384 00 "	AB8771	2797P3-05	13 068 LB	1					

Heat No. (wt%)	CHEMICAL PROPERTIES														
	C	Mn	P	S	Si	Cr	Ni	Cu	Mo	Al	Nb	V	B	TI	DO
2606P3	0.20	1.06	0.012	0.004	0.340	0.02	0.15	0.02	0.01	0.027	0.000	0.014	0.0003	0.002	0.4000
2797P3	0.19	1.00	0.009	0.005	0.310	0.02	0.15	0.03	0.00	0.024	0.000	0.015	0.0002	0.003	0.3900

Hardness Tests	Heat No.	Batch No.	SRCE	LAB	GAUGE	COND	LOC	MTHD	HARDNESS
2606P3	AB8770	166"	ALG	1.0000	NORM B	HBW	153		
2797P3	AB8771	166"	ALG	1.0000	NORM B	HBW	150		

W.O. # 117399
M.L. # 19(43)
TRK. #
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
 QUANTITIES TO ALL REQUIREMENTS OF SA 516B PART 1
 Sect. II 10 Edition Addenda



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

SO No., Item & Date:	8006515 000020 2013/01/05	Shipment No. & Date:	1000023647 2013/01/06	TC No., Date & Time:	ESA-38932 2013/01/07 10:15:07								
Sold to Customer Name and Address:	QUALITY PLATES & PROFILES LTD NICHOLAS BEAVER ROAD RR#3 20 ABERFOYLE, Ontario, Canada N1H 6H9	Ship to Customer Name and Address:	QUALITY PLATES & PROFILES LTD NICHOLAS BEAVER ROAD RR#3 20 ABERFOYLE, Ontario, Canada N1H 6H9	Customer PO NO./Item:	P007755/2								
Customer Specification:	HR STEEL PLATE Carbon Melt 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.C.E.O. 43 max. Inclusion Size Control Calcium Treated Normalized Temp 1670 F 34 min CVN/AL Req. 15/12 FT LBF at 0-50.0 F Sid Thickness Tol PVQ Top and Bottom Standard Surface Fitness 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 1519-837-2227			Carrier:	ROBINSON TRANSPORT LTD - 205(661)								
Insp T/R:	Test Report As Per Spec			Current Use:	PVQ								
ESSAR STEEL ALGOMA INC. HEREBY CERTIFIES THAT THE MATERIAL HEREIN DESCRIBED WAS MADE AND TESTED IN ACCORDANCE WITH THE RULES OF THE SPECIFICATION SHOWN. ALL RESULTS ARE RETAINED IN ACCORDANCE WITH THE COMPANY'S STANDARD RECORD KEEPING PRACTICES. THIS MILL TEST REPORT MAY NOT BE REPRODUCED EXCEPT IN FULL, WITHOUT WRITTEN APPROVAL OF ESSAR STEEL ALGOMA INC. IF YOU RECEIVE THIS DOCUMENT AND ARE NOT THE INTENDED RECEIVER, PLEASE CALL (705) 945-4026 FOR INSTRUCTIONS ON METHOD OF DISPOSAL OF DOCUMENT.													
MELTS EN 10204 2004 TYPE 31 ISO QUALITY AND ENVIRONMENTAL CERTIFICATES AVAILABLE AT WWW.ESSARSTEELALGOMA.COM MECHANICAL PROPERTIES													
Impact Tests	Heat No.	SRCE	LAB	GAUGE	COND	METH	DIR	LOC	SIZE	TEMP(*F)	ENERGY (ft-lb)	ENERGY (J)	
	2606P3	AB8769	166"	ALG	1.0000	NORM	CVN	L	B	FULL	-50	71 69 77	72
	2606P3	AB8770	166"	ALG	1.0000	NORM	CVN	L	B	FULL	-50	59 61 73	64
	2797P3	AB8771	166"	ALG	1.0000	NORM	CVN	L	B	FULL	-50	84 86 65	79
Tensile Tests	Heat No.	SRCE	LAB	GAUGE	COND	METH	DIR	LOC	YIELD(KSI)	TENSILE(KSI)	EL SCALE	ELONG(%)	
	2606P3	AB8769	166"	ALG	1.0000	NORM	2	T	B	49.5	78.2	2" 33	
	2606P3	AB8770	166"	ALG	1.0000	NORM	2	T	B	49.0	77.1	2" 32	
	2797P3	AB8771	166"	ALG	1.0000	NORM	2	T	B	50.7	77.2	2" 31	

Velocity America
 279
 April 1, 2013

MAR 27 2013



APR 03 2013

K. UGHADPAGA

MANAGER METALLURGICAL SERVICES

WARNING THE TEST RESULTS AND VALUES REPORTED HEREIN INDICATE ONLY THAT (1) THE PARTICULAR STEEL FOR WHICH THIS CERTIFICATE IS ISSUED MEETS THE MINIMUM SPECIFIED YIELD STRENGTH AND (2) THE ANALYSIS AND PHYSICAL PROPERTIES OF SUCH STEEL ARE IN CONFORMANCE WITH THE REQUIREMENTS OF THE SPECIFICATION INDICATED. THE RESULTS OR VALUES REPORTED HEREIN CAN NOT BE USED TO QUALIFY THE STEEL FOR ANY SPECIFICATION OTHER THAN THE ONE INDICATED AND CAN NOT BE RELIED UPON FOR ANY PURPOSE (INCLUDING DESIGN OR CALCULATION) AS REPRESENTING THE ACTUAL STRENGTH OF SUCH STEEL.



ASK 55751

NORTH AMERICAN STAINLESS
6870 HIGHWAY 42 EAST
GHENT, KY 41045

METALLURGICAL TEST REPORT

6870 HIGHWAY 42 EAST

Certificate: 809666 16
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: 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 FERM
MIN. SOLUTION ANNEAL TEMP 1900F, WATER QUENCHED

REMARKS:

Mat'l is Free of Mercury Contamination. No weld repairs.
EN 10204:2004 3.1; ROHS 1 & 2 Compliant
Material is Free of Radioactive Contamination
NAS Steel Making Process: EAF, AOD, & Cont. Casting
Product Mfg. by a Quality Mgt. Sys. in Conf. w/ISO 9001
*Melted & Manufactured in the USA; Mat'l is DFARS Compliant
EN 10204 3.1.B

Product Id	Coil #	Skid #	Thickness	Width	Weight	Length	Mark	Pieces	Commodity Code
DE0841	05F3K0 B		.3748	48.0000	2,545 SHEETS	240.00	3	2	

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

HEAT	CM	C %	CR %	CU %	MN %	MO %	NI %	P %	S %
F3K0 ✓	US	.0157	16.5870	.3955	1.5420	2.0170	.0409	10.0100	.0340
	SI %								.0010

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

W.O. # 11738
M.L. # 20 (3/3, 4/3)
I.H.K. # 382
P.O. # (3-0221)

Bin David
V
279
Apr 1, 2013

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 - 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, 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

TEL: +34 946719300
FAX: +34 946725062
E-MAIL: qualitytti@tubacex.es

CUSTOMER DESCRIPTION

<p>CLIENT SOLD TO PINACLE STAINLESS STEEL INC. 455 AMBASSADOR DRIVE MISSISSAUGA, ONTARIO ON L5T 2J3 CANADA</p>	<p>CLIENT SHIP TO PINACLE STAINLESS STEEL INC. 455 AMBASSADOR DRIVE MISSISSAUGA, ONTARIO ON L5T 2J3 CANADA</p>
---	---

CLIENT ORDER: 57733
SALES ORDER: 101551

MATERIAL: SEAML. STAINL. STEEL TUBES/PIPES,
PICKLED-PASSIVATED
GRADE: TP316/316L,
STANDARD: ASTM A312M-09 / ASME SA312M ED.10
TOLERANCES: ASTM A999/A312
PLAIN ENDS,
DIMENSIONS: 4" SCH 40
HOT FINISHED
NACE MR0103-10 / MR0175 / ISO 15156-3 : 2009

W.O. # 1173
 M.L. # 21 (5/3)
 TNK. # 244
 P.O. # 13-0243-REV1

Certification of Material - Per ASME
HT# 43633
Qualifies to all requirements of
A312-316/316L per
Sect. II 10 Edition 11 Addenda

Sales Item	Client Item	Delivery Nr	Prod. Order	Insp. Lot	Heat Nr	Pieces	Weight	Tot Lgth	Un Lgth
130		8110006752	100323274	200038013	43633	15	1.718 KG	100,01 M	5791-7315 MM

RAW MATERIAL

Heat Nr:	Supplier	Method
43633	ACERIALAVA	Electric furnace+AOD

CHEMICAL COMPOSITION (%) *L: Ladle C-Products

* Heat	Seq	C	Mn	Si	P	S	Ni	Cr	Mo
L 43633	1	0.013	1.43	0.510	0.021	0.0090	11.20	16.70	2.12

Q.C.I.
E.Y.

HEAT TREATMENT
SOLUT. ANNEALED 1040 °C RAPIDLY COOLED

TENSILE TEST

Prod. Order	Ins. 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

Q.C.I.
N.D.

MAR 26 2013

Reviewed

 RJS
 Mar 11, 2013



TUBACEX TUBOS INOXIDABLES
INGENIERIA DE CALIDAD
[Signature]



**INSPECTION CERTIFICATE
EN 10204 3.1**

Number: 516293	Rev: 00
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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 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



MAR 26 2013



**TUBACEX TUBOS
INOXIDABLES**
INGENIERIA DE CALIDAD



No/Nr/N° (A03)
24546300937484

Salzgitter Mannesmann Stainless Tubes France SAS (A01)
B.P.10 - F 21501 Montbard Cedex - FRANCE
www.smsl-tubes.com
INSPECTION CERTIFICATE
Abnahmeprüfzeugnis
Certificat de réception
EN 10204: 2004 TYPE 3.1 (A02)

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Salzgitter Mannesmann Stainless Tubes France SAS - B.P.10 - F 21501 Montbard Cedex - FRANCE
SHAW ALLOY PIPING PRODUCTS
740 MARKET
71107 SHREVEPORT
Etats-Unis
Purchaser/Besteller/Acheteur

Customer order no./Kunde Auftragsnr./N° Commande client (A07)
PO#51884
SMST-Tubes order no./Auftragsnr./N° Commande (A08)
0000246463
SMST-Tubes Item
0000246463-000009

Product Description/Produkt Beschreibung/Description du produit (B01) (B02) (B04)
Seamless stainless hot finished pipe pickled and passivated / Tubes finis à chaud sans soudure, décapés et passivés
Specifications/Spezifikationen/Specifications ASME SA 312 11 a / ASME SA 376 11 a / ASTM A 312 11 / ASTM A 376 08 / NACE MR0103 2007 / NACE MR0175/ISO 15168-3 2009
Grade/Werkstoff/Nuance TP 316 / TP 316L
Tolerances/Toleranzen/Tolérances A 312

Marking of the product/Kennzeichnung des Produktes/Marquage du produit (B08-D01)
WO : 324546300901 - DMV-F - ASTM A 376 / ASTM A 312 / ASME SA 376 / ASME SA 312 - TP 316 / TP 316L - NPS 4 X SCH 120 - 23.43 FT - SML - 449090 - QL30037484 - FRANCE

Quantity/Menge/Quantité					Dimensions Abmessungen				
Heat no Schmelze Nr. N° de Coulee	Quality lot Qualitätslos Lot qualité	SMST Item	Pieces Stück Pièces (B08)	Total weight Gesamtgewicht Masse totale (B13)	Total length Gesamtlänge Longueur totale	OD (B08)	WT (B10)	Tube length Rohrlänge Longueur tube	
								min (B11)	max
449090	QL30037484	000009	7	1454.00 Kg 3208 Lbs	49.370 m 161.98 Ft	114.30 mm NPS 4	11.19 mm SCH 120	8098 mm 20.00 Ft	7316 mm 24.00 Ft

Chemical Analysis / Chemische Zusammensetzung / Analyse chimique (C71 - C92)
Heat no./Schmelzen Nr./N° de coulee 449090
Melting Process/Erschmelzungsart/Elaboration (C70) VOD
Heat Origin/Urspr. der Schmelze/Origine de la Coulee Germany
Heat Analysis / Analyse de coulée

	C	Si	Mn	P	S	Cr	Ni	Mo
Min	0.00	0.00	0.00	0.00	0.00	16.00	11.00	2.00
Max	0.030	0.75	2.00	0.045	0.0300	18.00	14.00	3.00
	0.018	0.37	1.81	0.028	0.008	16.75	11.44	2.14

Certification of Material - Per ASME
HT# 449090
Qualifies to all requirements of
SAB12-316/316L per
Sect. II 1C Edition 11 Addenda

APR 24 2013

Q.C.I.
N.D.

Q.C.I.
E.Y.

W.O. # 1173
M.L. # 23 (4, 3/4)
THK. # 443
P.O. # 13-0243-REV1

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 alteration 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 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 du nom de l'original ou 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°9284

ACCEPTED/REVIEWED/RELEASED
for and on behalf of: SAM OFFSHORE
Print Name: JANES H SAH
Signature: [Signature]
Date: 12/11/13
Applus[®] VELOSI
Velosi America LLC

046



Salzgitter Mannesmann Stainless Tubes France SAS (A01)
 B.P.10 - F 21501 Montbard Cedex - FRANCE
 www.smt-tubes.com

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INSPECTION CERTIFICATE
 Abnahmeprüfzeugnis
 Certificat de réception
 EN 10204: 2004 TYPE 3.1 (A02)

No/Nr/N° (A03)
 24548300937484

Mechanical testing

Quality Lot : QL30037484

Tensile test at room temperature/Zugversuch bei Raumtemperatur/Essai de traction à température ambiante (C10)

ASTM A 370

Test no Proben Nr. N° d'échantillon (C00)	Direction Probenricht- ung Direction (C02)	Yield strength/Dahngrenze/Limito d'élasticité (C11)			Tensile strength / Zugfestigkeit / Résistance à la traction (C12)	Elongation/Bruchdehnung/Allongement (C13)					Reduction of area Z%
		0.2 %	0.5 %	1 %		2"	50 mm	5D	6,85 √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
30128250	/	/	/	<18	<18	<18	/	/	/	/	/	/	/	/	/	/	/	/

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

ASTM A 999

Test Number	Result
30128249	OK
30128250	OK

Other testing

Quality Lot : QL30037484



APR 24 2013

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 Dieses Zeugnis bzw. diese Bescheinigung wurde mit Hilfe der EDV erstellt und ist ohne Unterschrift gültig. Von Änderungen sowie Verwendungen für andere Erzeugnisse werden als Urkundenfälschung nach Beleg 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 sujets à la juridiction pénale.

Salzgitter Mannesmann Stainless Tubes France SAS ISO9001 - LRQA N° 825479

ACCEPTED/REVIEWED/RELEASED
 for and on behalf of: S.B.M. OFFSHORE
 Print Name: GANESH SAITHI
 Signature: [Signature]
 Date: 1 May 10/13
 046
Applus
 VELOSI
 Velosi America LLC



No/Nr/N° (A03)

24546300937484

Salzgitter Mannesmann Stainless Tubes France SAS (A01)

B.P.10 - F 21501 Montbard Cedex - FRANCE

www.smst-tubes.com

INSPECTION CERTIFICATE
Abnahmeprüfzeugnis
Certificat de réception

EN 10204: 2004 TYPE 3.1

(A02)

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

MIL-P-24691/3 Feb. 1991 Ad 1 ASTM A 282 PRACTICE E

Test Number	Result
30128249	Satisfactory
30128250	Satisfactory

This certificate is issued by a computerized system and is valid without signature. In case the owner of the original would release a copy of it he must attest its conformity and will be responsible for any inaccuracy or not attested use. Any alteration or falsification will be subject to law.

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No/Nr/N° (A03)

24546300937484

Salzgitter Mannesmann Stainless Tubes France SAS (A01)
 B.P.10 - F 21501 Montbard Cedex - FRANCE
 www.smat-tubes.com

Pago/Solto
 4/4

INSPECTION CERTIFICATE
 Abnahmeprüfzeugnis
 Certificat de réception (A02)
 EN 10204: 2004 TYPE 3.1

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

QT:30037484

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

Heat Treatment / Wärmebehandlung / Traitement Thermique / Annealed: Temperature: > 1040°C 1804°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 Rohre sind frei von Quecksilberverunreinigungen und frei von radioaktiver Verunreinigung / Les tubes sont exempts de contamination par le mercure et de contamination radioactive

Confirmation with reference to Pressure Equipment Directive 97/23/EC:

The works operates a quality management system that has undergone a specific assessment for materials for pressure equipment and is certified by a competent body (TÜV-SÜD CERT.No:05/2011/MAN)

Bestätigung in Bezug auf Druckgeräterichtlinie 97/23/EC:

Das Werk wendet ein Qualitätsmanagementsystem an, das in Bezug auf Werkstoffe für Druckgeräte einer spezifischen Bewertung unterzogen wurde und von einer zuständigen Stelle (TÜV-SÜD CERT.No:05/2011/MAN) zertifiziert ist.

Confirmation concernant la Directive Equipements sous Pression 97/23/EC: L'usine applique un système de management de la qualité qui a fait l'objet d'une évaluation spécifique pour les matériaux pour équipements sous pression et qui est certifié par un organisme compétent (TÜV-SÜD CERT.No:05/2011/MAN)

SMST certify that the delivered products comply with the requirements stipulated in the order. / Die Erzeugnisse wurden bestellungsgemäß geprüft und für in Ordnung befunden. / SMST-Tubes attestent que les produits livrés sont conformes aux stipulations de la commande.

Validation by manufacturer's representative / Validierung durch Vertreter des Herstellers

Mill's Inspector
 Werksachverständiger T POMMERY
 Le contrôleur usine

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

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Ce certificat est rédigé à l'aide d'un traitement électronique et est valide sans signature. Tout changement ou application pour d'autres produits seront considérés comme falsification de documents et seront sujets à la justice pénale.



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

<p>CLIENT SOLD TO PINACLE STAINLESS STEEL INC. 455 AMBASSADOR DRIVE MISSISSAUGA, ONTARIO ON L5T 2J3 CANADA</p>	<p>CLIENT SHIP TO PINACLE STAINLESS STEEL INC. 455 AMBASSADOR DRIVE MISSISSAUGA, ONTARIO ON L5T 2J3 CANADA</p>
---	---

CLIENT ORDER: 57733
SALES ORDER: 101551

MATERIAL: SEAML. STAINL. STEEL TUBES/PIPES,
PICKLED-PASSIVATED
GRADE: TP316/316L
STANDARD: ASTM A312M-09 / ASME SA312M ED.10
TOLERANCES: ASTM A999/A312
PLAIN ENDS,
DIMENSIONS: 3" SCH 160
HOT FINISHED
NACE MR0103-10 / MR0175 / ISO 15156-3 : 2009

Q.C.I.
E.Y.
Q.C.I.
N.D.
MAR 26 2013

W.O. # 11730
M.S. # 24 (2/14)
THK. # 436
P.O. # 130243-REV 1

Certification of Material - Per ASME
HT# 43633
Qualifies to all requirements of
SA312-316/316L per
Sect. II 10 Edition 11 Addenda

Sales Item	Client Item	Delivery Nr	Prod. Order	Insp. Lot	Heat Nr	Pieces	Weight	Tot Lgth	Un Lgth
180		8110006752	100323250	200037778	43633	8	1091 KG	47,95 M	5791-7315 MM

RAW MATERIAL		
Heat Nr: 43633	Supplier ACERALAVA	Method Electric furnacc+AOD

CHEMICAL COMPOSITION (%)										
* Heat	Seq	C	Mn	Si	P	S	Ni	Cr	Mo	
L 43633	1	0,013	1,43	0,510	0,021	0,0090	11,20	16,70	2,12	

HEAT TREATMENT
SOLUT. ANNEALED 1040 °C RAPIDLY COOLED

TENSILE TEST									
Prod. Order	Insp. Lot	Sample	T	Rp0.2	Rp1.0	Rm	A2"	A5	
			°C	N/mm2	N/mm2	N/mm2	%	%	
100323250	200037778	1	20	432	472	625	54	48	

Review
 RJS
 April 11 2013

Q.C.I.
N.D.



TUBACEX TUBOS INOXIDABLES
INGENIERIA DE CALIDAD

[Signature]



TUBACEX

**INSPECTION CERTIFICATE
EN 10204 3.1**

Number: 516297
Page: 2 / 2

Rev: 00

Created on:
Date: 01.04.2011

Modified on:

HARDNESS TEST

Prod. Order	Ins. Lot	Sample	HRB1	HRB2
100323250	200037778	1	88	89

METALURGICAL TESTS

INTERGRANULAR CORROSION TEST ACC. TO ASTM A262 PRACT."E": SATISFACTORY

NON-DESTRUCTIVE TESTS

100 % HYDROSTATIC PRESSURE TESTED AT 2500 PSI, DURING 5 SEC, GOOD.

POSITIVE MATERIAL IDENTIFICATION TEST ON EACH TUBE/PIPE BY
"X-RAY-FLUORESCENCE-ANALYZER": SATISFACTORY

VISUAL INSPECTION ON EACH TUBE: SATISFACTORY

DIMENSIONAL CHECKING ON EACH TUBE: SATISFACTORY

TECHNOLOGICAL TESTS

FLATTENING TEST: SATISFACTORY



Renewed
April 1, 2011

MARKING

TUBACEX 3" SCH 160 ASME SA312 ASTM A312 TP316 TP316L HF SMLS HEAT/
PMI LOT NO/ SPAIN TX3 TX1

REMARKS

NO MERCURY, MERCURY COMPOUNDS OR MERCURY BEARING INSTRUMENTS AND/OR EQUIPMENT HAVE BEEN USED ALONG MANUFACTURING AND INSPECTION PROCESS.

NO WELD REPAIR WAS PERFORMED

MATERIAL MANUFACTURER APPROVED WITH CERTIFICATE NR. 07/2001/MUC BY TÜV SÜDDEUTSCHLAND (NOTIFIED BODY 0036) TO ISSUE CERTIFICATES OF SPECIFIC PRODUCT CONTROL IN ACCORDING TO PRESSURE EQUIPMENT DIRECTIVE 97/23/EC ANNEX I POINT 4.3

MATERIAL CHARACTERISTICS COMPLY WITH POINT 7.5 OF ANNEX I TO PED BY HAVING AN ELONGATION AFTER RUPTURE AT TENSILE TEST NO LESS THAN 14% AND A BENDING RUPTURE ENERGY AT IMPACT TEST NO LESS THAN 27J AT 20°C

MATERIAL IS FREE OF RADIATION CONTAMINATION



**TUBACEX TUBOS
INOXIDABLES**
INGENIERIA DE CALIDAD



METALLURGICAL TEST REPORT

NORTH AMERICAN STAINLESS
801 TWIN RAIL DRIVE
MINOOKA, IL 60447

Date: 3/21/2006 Page: 1
Steel: 316/316L
Finish: HAAP
Corrosion: ASTM A262/02a2; 1808end-OK

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

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

Customer: 002830 001
Your Order: T56490
NAS Order: IM 0006185 01

REMARKS:

Material free from mercury contamination. No weld repairs.
EN 10204 3.1 PED 97/23/EC Annex1, Para. 4.3 Q987637 Cond A
Material is ROHS-Compliant
EN 10204 3.1.B
NACE MR0 175 EN 10204 3.1.B
Melted & Manufactured in the USA

PRODUCT DESCRIPTION:

STAINLESS STEEL PLATE, HOT ROLLED, ANNEALED AND PICKLED.
ASTM A240/05a, 480/05, 666/03, ASME SA240/04-A05, 480/06-A05, SA666/04
ASTM A240/05a, 480/05, 666/03, ASME SA240/04-A05, 480/06-A05, SA666/04
(X GRAIN), Q98766D-A X NG PERM, AMS5507/AMS524K X MKK
ASME SA312/SA479, ASME SA312/SA479, ASME SA312/SA479
Chem only for following: ASTM A276/A312/3A79, ASME SA312/SA479

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

ACCEPTED/REVISED/RELEASED
for and on behalf of: SPAM OFFSHORE
Print Name: JAMES SAHA
Signature: [Signature]
Date: 4/11/13
Appplus® VELOSI
Velocity America LLC

CHEMICAL ANALYSIS

Heat	CM	C	CR	CU	MIN	MO	H	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 #	Id	Coil	CF	UTS	KSI	.2% Y8	ELONG	Hard
0991N3 HC	0991N3 HC	FT	FT	FT	80.82	37.73	58.95	76.50	RB

Certification of Material - Per ASMB

HT# 91N3
Qualifies to all requirements of
SA240-316/316L per
Sect. II 10 Edition II Addenda

Q.C.I.
N.D.

W.O. # 117388119
M.L. # 2644114
TIK. # 503
P.O. # CA6570500

ROLLED ALLOYS QUALITY ASSURANCE
APPROVED [Signature]
DATE 3-27-06

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 (INCH)	SHAPE	TOLERANCE	LENGTH (FT)	PIECES	WEIGHT (LBS)
1/2	ROUND	ASTM A484	12' - 14'	225	1850

CHEMICAL ANALYSIS

HEAT NO.	C	Mn	Si	S	P	NI	Cr	Mo	Cu	N	Co
67824	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	81	47	75	187	8

Specification:

MATERIAL CONFORMS TO ASTM A276-00a, A 479-01, A484-00, A282-00 PRACTICE E, RMS 80, ASTM A182-01b BSM CL1, A308-00ED, A182-01a AMS 8040/5053E, ASME SA-192-00ED, SA479-00ED, SA-193-00 BSM C L1, QQ-S-783F, MILL-S-7720A AMZ, NACE-MR-01-75-00, UNS#S316 03/S31603, ASTM E 112-00(GRAIN SIZE), CERTIFICATION AS PER EN 10204-3.1B

Remarks :

MATERIAL IS FREE MERCURY CONTAMINATION, FREE FROM WELD OR WELD REPAIRS, MICRO-FREE FROM CONTINUOUS CARBIDE NETWORK ON GRAIN BOUNDARIES, MACRO-GOOD, MINIMUM SOLUTION ANNEALING TEMPERATURE 1050C, 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# 67824
 Qualifies to all requirements of
SA479-316/316L 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® 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
2 4 8" X 900 X RTJ BLIND

ITEM# 1173-40
ITEM# 1173-41

HEAT NUMBER:
N434

MATERIAL TYPE:
SA182F316/L

Manufactured in
USA

I.A.W. ASME 2010 ED 11AD.

CHEMICAL ANALYSIS

PHYSICAL PROPERTIES

C .027 ✓
Mn 1.160 ✓
P .0290 ✓
S .0250 ✓
Si .350 ✓
Cr 17.450 ✓
Mo 2.030 ✓

Yield PSI 47,000 ✓
Tensile PSI 86,000 ✓
Elongation 77.1 ✓
Reduction of Area 79.6 ✓
Hardness 176 HBW



10.310 ✓
N .0980

Certification of Material - Per ASME
HT# N 434
Qualifies to all requirements of
SA182F316/L per
Sect. II 10 Edition 11 Addenda

W.O. # 1173Q
M.L. # 40(5/2)41C(11)
THK. # 1.963
P.O. # 13-0266

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

ACCEPTED/REVIEWED/RELEASED 046
for and on behalf of: SBM Off Shore
Print Name: G.A. Fielder SAH MAY 27 2013
Signature: [Signature] **Applus[®]**
Date: July 19 13 **VELOSI**
Velosi America LLC

Immediately following hot working, while at temperature above, parts were rapidly quenched.

We hereby certify that all test results and process information contained herein are correct and true as contained in the records of the company.

Prepared by [Signature]

Name Helen Fielder Title: QA Representative



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

REPORT NUMBER 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
SOLD/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. # 1.104
P.O. # 13-0294

N11
Certification of Material - Per ASME
HT# N472
Qualifies to all requirements of
SA182-F316/316L per
Sect. II 10 Edition 11 Addenda

ACCEPTED/REVIEWED/RELEASED
for and on behalf of: SBM OFF SHORE
Print Name: GANESH SAHNI
Signature: [Signature]
Date: July 14 2013
046
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 Ordenez

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. # 1173G
M.L. # 46 (3/2)
THK. # 3/4 160-407
P.O. # 13-0279

N13

Certification of Material - Per ASME
HT# N432
Qualifies to all requirements of
SA182-F316/L per
Sect. II Edition II Addenda



MAY 27 2013

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

Immediately following hot working, while at temperature above, parts were rapidly quenched.

We hereby certify that all test results and process information contained herein are correct and true as contained in the records of the company.

Prepared by

Name: Helen Fielder Title: QA Representative

ACCEPTED/REVIEWED/RELEASED 046
for and on behalf of: SIMON OFF SHOOTER
Print Name: GANESH SAHA
Signature: [Signature]
Date: July 10, 2013
Applus® VELOSI
Velosi America LLC

L PALACE PIPE CO., LTD

FEST CERTIFICATE

W.O. # **11730**
 M.L. # **49012, 2, 1/2**
 THK. # **150**
 P.O. # **13-0707**

CRYS

DATE OF ISSUE: 2013/7/17

CERTIFICATE (No.: QAC0021058/A)

CERTIFICATE NO.: 2013-05-021-1-17

ORDER NO.: 2013-05-021-1

GRADE: ASTM A312-12 TP316/316L

HEAT NO.: YT22057

COMMODITY: STAINLESS STEEL SEAMLESS PIPE.

CONDITION: COLD FINISH / SOLUTION TREATED / PICKLED / PLAIN END

CHEMICAL CONTENTS (WT%)

ELEMENTS	C	Mn	P	S	Si	Ni	Cr	Mo
SPECIFICATION	≤ 0.035	≤ 2.00	≤ 0.045	≤ 0.030	≤ 1.00	11.0~14.0	16.0~18.0	2.00~3.00
RESULTS (LADLE)	0.024	1.06	0.039	0.004	0.34	11.07	16.71	2.07

PHYSICAL PROPERTIES

NPS	Dimensions		Bundle No.	Pieces	Weight (kg)	T S (Mpa)	EL (%)	FLATTENING TEST	HARDNESS HRB	EDDY CURRENT TEST (100%)
	W.T (SCH)	Length (feet)								
2"	40S	20	Z13-5-295	250	8428	575	58.0	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
Dingpin Guo
 MANAGER OF QUALITY ASSURANCE DEPARTMENT / DING WEI-GUO

ACCEPTED/REVIEWED/RELEASED
 for and on behalf of
 Signature: *[Signature]*
 Date: *2013/7/17*
 APPLIED VERIFIED STAINLESS
 PIMA VERIFIED STAINLESS
 Weld America LLC



METALLURGICAL TEST REPORT

6970 HIGHWAY 42 EAST
CERTIFICATE: 728066 15
CUSTOMER: 007050 001

SHIP TO:

DATE: 4/12/2012 PAGE: 1

STEEL: 316/316L

FINISH: BRAP

CORRECTION: AFTER 2262/0208/1900HEAD-02

YOUR ORDER: 59966

NAS ORDER: DE 0000209 02

PRODUCT DESCRIPTION

FLATNESS SPEC. CORR. HTZ, PLATE, BRAP; UNS 31690/31693
AFTER 2268/115, 2269/115, 2266/10/ASME SA240/116, SA600/116, SA666/116
CHEM. CORR. OR FOLLOWS ASTM: A276/10, A279/11, SA666/11, A312/11
CHEM. CORR. OR FOLLOWS ASTM: SA312/11, SA479/11
UNS 31679/55246, X UNS
PLATE MS0178/150 15156-3:2003 A, MS0103/07; Q37600-A X UNS FORM
HTZ. SOLUTION ANNEAL, TEMP 1900F, WATER QUENCHED

REMARKS

Mat'l is Free of Mercury Contamination. No weld repairs.
UN 10204:2004 3.2, Q37637 Cond A, NPS Compliant
Material is Free of Radiocative Contamination
NAS Steel Making Process: BRAP, AOD, & Cont. Casting
Product Mfg. by a Quality Mgt. Sys. in Conf. w/ISO 9001
Annealed & Manufactured in the USA; Mat'l is UNS Compliant
UN 10204 3.2.B

Product ID	Coil #	ODIA @ Thickness	Width	Weight	Length	Mark	Pieces	Commodity Code
DA9060	080679 1	.2400	60.0000	3.000	600000	144.00	9	B

CHEMICAL ANALYSIS

Element	C	CR	CU	NI	MO	MN	NO	NI	P	S
Wt%	0.0206	16.0325	0.0025	1.0335	2.0004	0.426	10.0300	0.0300		0.0017
Max	0.030									
Min										

W.O. # 11730
M.L. # 502721
THK. # 248
P.O. # 12-1767-1029

Q.C.I.
N.D.

MECHANICAL PROPERTIES

Product ID	Coil #	UTS	YTS	ELONG	RED	HAZ	TALL
DA9060	080679	73	64.23	43.69	46.97	84.00	83.00

Certification of Material - Per ASME
HT# B934
Qualifies to all requirements of
SA 240-216316L per
Sect. II 10 Edition I Addenda
AUG 16 2013

ACCEPTED/REVIEWED/RELEASED
for and on behalf of: SIM OFF SHORE
Print Name: G. W. S. V. S. H. A.
Signature: [Signature]
APPLICS® VELOSI

Technical Dept. Mgr. ERIC HESS
2/2012

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

Outokumpu Stainless Plate, Inc.



Certificate of Analysis and Tests

OUR ORDER 0252379 - 13

HEAT & PIECE 836433-1E 06/23/06

SOLD TO: INTEGRIS METALS LTD. - Etobicoke SHIP TO: INTEGRIS METALS LTD. - Etobicoke
 161 THE WEST HALL 161 THE WEST HALL
 ETOBICOKE, ON M9C 4V8 ETOBICOKE, ON M9C 4V8

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 BRT

SPECIFICATIONS
 FROM SLABS IMPORTED FROM BRITAIN
 ASTM A240-06
 ASTM A262-02A PRACTICE A
 NO GRIPPER MARKS
 *** MFG 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
 Certification of Material - Per ASME
 HT# 836433-1E
 Qualifies to all requirements of
 SA 240-316L per
 Sect. II 10 Edition II Addenda

CHEMICAL COMPOSITION

CARBON	(C)	.018
MANGANESE	(MN)	1.69
PHOSPHORUS	(P)	.027
SULFUR	(S)	.001
SILICON	(SI)	.38
CHROMIUM	(CR)	16.27
NICKEL	(NI)	10.11
COBALT	(CO)	.38
COPPER	(CU)	.36
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, 26/2)
 61 (8/3)

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

ACCEPTED FOR REVIEW (PLEASE) for and on behalf of: SPM OFF STORES
 Print Name: (AARON H. SPAIN)
 Signature: [Signature]
 Date: Sept 3/13
 Appius® VELOSI
 Velosi America LLC

WE HEREBY CERTIFY THAT THE MATERIAL HEREIN HAS BEEN MADE AND TESTED IN ACCORDANCE WITH THE LISTED SPECIFICATION(S) AND THAT THE RESULTS OF ALL TESTS ARE ACCEPTABLE.

JAMES DOUBMAN, QUALITY ASSURANCE MANAGER

CERTIFICATE IN CONFORMANCE WITH EN10204-95 3.1.B/EN10204-2004 3.1

James Douberman

ACCEPTED/REVIEWED/RELEASED
for and on behalf of: SAM OF FSHHS

Print Name: GARY SAHA
Signature: *[Signature]*
Date: 08/13/13

046
Applus®
VELOSI
Velos America LLC

Q.C.I.
E.Y.

AUG 16 2013

Q.C.I.
N.D.

WALSIN WALSIN LIHWA CORPORATION YENSHUI PLANT
ISO-9001, ISO-14001 CERTIFIED

MILL TEST / INSPECTION CERTIFICATE

Customer		ENERGY STEEL PRODUCTS, INC.		Date	2008/06/27	File	2108070025										
Steel Grade	AISI	JIS	Commodity	Order No.	289681	P.O. NO.	22804										
Item	Heat No.	Shape	Size	Quantity (PCS)	Weight (lbs)	Condition	Workmanship										
1	2X469	R	1.905	129	2323	PL	Material is free from mercury contamination										
2	2X919	R	31.75	61	2048	PL	No welding repair										
3	2X471	R	38.10	32	2292	PL	Solution treatment at 1040°C · 1-2 hour · water quenched Grain size test by ASTM E112-96e1 : 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										
Chemical Composition (WT%)																	
Kind of Test	C	Si	Mn	P	S	NI	Cr	Mo	Cu	N	Co	Hardness (HB)	Tensile Strength (N/mm2)	Yield Strength (N/mm2)	Elongation (%)	Reduction of Area (%)	
Spec.	0.03	1.00	1.25	0.040	0.02	10.00	16.00	2.00	0.75	0.10	0.75						
1	MAX 0.02	0.38	1.69	MAX 0.029	0.028	10.00	16.70	2.03	MAX 0.57	0.06	MAX 0.20	149	560.0	242.0	55.0	74.0	
2	0.02	0.42	1.68	0.028	0.028	10.02	16.93	2.04	0.57	0.06	0.19	140	565.0	264.0	59.0	72.0	
3	0.02	0.37	1.80	0.030	0.028	10.02	16.70	2.02	0.60	0.05	0.20	142	520.0	242.0	62.0	75.0	
Mechanical Properties																	
Condition :												Shape :					
S-Solution Treated												R : Round					
H-Hot Rolled												H : Hexagonal					
C-Cold Drawn												S : Square					
ST-Smooth Turned												SR : Square-Round					
CC-Charterless Grinding												R : Ellipse					
												FL : Rectangular					
Invoice No. 06JUN-L19626TOR												L/C No.					
A-Annealed												Att. To ASTM A193-94b B8M Class1, A276-04a cond.A, A479-04 cond.A					
P-Polished												ASTM A314-97 (REAPPROVED 2003), A182-02a, A484-02a, A720-01 B8M Class1					
PL-Peeling												ASTM A202-02 Practice B, ASME SA479-601 cond.A, SA182-501 A03					
												SA193-E01 A02 B8M Class1, SA320-01a B8M Class1					
												NACE MR 0175, MIL 7280, SAE-AMS QQ8-763P cond.A, AMS 5648K, 5653F					
												UNS S31603/1603 For 316/316L					

Certification of Material - Per ASMB
HT# 2X469
Qualifies to all requirements of SA 479-316/316L per Sect. II, Edition 4 Addenda

W.O. # 11730
M.L. # 53 (25-2-1)
THK. # 750 (27-2-0)
P.O. # H10-8451Q

MANAGER OF QUALITY ASSURANCE DEPARTMENT

INSPECTION CERTIFICATE AND MILL TEST REPORT

According to
DIN 50049 3. 1. B / EN 10204

Customer:
PINACLE STAINLESS STEEL INC.
455 AMBASSADOR DRIVE
MISSISSAUGA, ONTARIO
L5T 2J3

Manufacturer's Symbol
SCDN

Order No. 31054

SC MFG PO No. SC-1524

THIRD DIVISION
/ DBA OF SC MFG. GROUP INC.
No. 80 Dali Road, Heping District, Tianjin, China
Tel.: 86-22-27319741 Fax.: 86-22-27319749

ACCEPTED/REVIEWED/RELEASED
for and on behalf of: SBM OFFICE
Print Name: LIANG BIL SAHAI
Signature: [Signature]
Date: Sept 2/13
Applus
VELCOST
Velocid America, LLC

MTR No.	SC-1524
Date of issue:	30-Dec-2005
Grade:	316 / 316L
Made From:	Pipe A/SA 312 - 01a
Material Specification:	ASTM A403 WPS - 00a ASME A403 WPS - 98
Dimensional Specification:	ASME B16.9 - 01 MSS-SP43-91

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-OA8868.56 NFLD 0A8868.50
ALB	OA8868.52 NS 0A8868.56
BC	OA8868.51 PEI 0A8868.59
SASK	CSA-OA8868.56 NWT 0A8868.5T
MAN	CSA-OA8868.56 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. # 11730
M.L. # 540612-19/2-0
THK. # -532
P.O. # 13-0707

Certification of Material - Per ASMB
HT# 37463
Qualifies to all requirements of SA403-316/316L per Sect. II, D, Edition 11 Addenda



AUG 12 2013

ACCEPTED/REVIEWED/RELEASED
 for and on behalf of: SUNGKWANG BEND CO., LTD.
 Print Name: GARY W. SAHIN
 Signature: [Signature]
 Date: 3/13/2007

APPIUS®
 VELOSI
 America LLC

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

MATERIAL TEST & INSPECTION CERTIFICATE

CUSTOMER: SOUTHWEST STAINLESS, INC.
 PROJECT NAME: N/A
 According to DIN 50049 3.1 / EN 10204 3.1 / ISO 10474-3.1

PURCHASE ORDER NO.	173882	SPEC. FOR MATERIAL	ASTM/ASME A36/A36W/P3-63-16-N 0400-ED	CERTIFICATE NO.	QCLJ2007090114
PJT JOB NO.	N/A	SPEC. FOR INSPECTION	ASME B16.9	DATE OF ISSUE	2007.08.23
STARTING MATERIAL	STEEL PLATE	SKB JOB NO.	2007051119	VISUAL & DIMENSION	SATISFACTORY
NO.	841	DESCRIPTION	10" B/W WELDED SUS	MILL MAKER	POR/CODE/TAS NO
				DAEKYUNG CORP.	

HEAT NO.	TEST TEMP.	IMPACT TEST	SIZE OF SPECIMEN(mm)	ABSORBED ENERGY		LATERAL EXPANSION		PERCENT SHEAR		HARDNESS		HEAT TREATMENT		TENSILE TEST				
				STD./	VALUE	STD./	VALUE	STD./	VALUE	MIN	MAX	MIN	MAX	YS	T.S	EL	RA	
E7172																		

SPEX.	C	SI	Mn	P	S	Ni	Cr	Mo	Cu	V	Nb	N	Al	B	W	Sn	Ti	C.E	SPEC.	TENSILE TEST		
																				MIN	MAX	
MIN	0.030	1.00	2.00	0.045	0.030	10.00	16.00	2.00											30.0	75.0	23.0	
MAX	0.010	0.44	0.53	0.025	0.001	10.22	16.21	2.10											40.5	85.4	80.0	
L																						
P																						

SOLUTION TREATED: 1060 °C, 40Min, Water

W.O. # 11739
 M.S. # 54026-2
 THK. # 5789-2
 P.O. # 13-0707

Q.C.I. N.D.

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.

Certification of Material - Per ASMB
 HT# E7172
 Quantities to and the requirements of SA403.316.16L per Addenda II/c Edition II

REVIEWED BY : [Signature]
 WITNESSED BY : [Signature]

Q.M. DIV. SENIOR MANAGING DIRECTOR

SKE-9903



Jeppop Speciality Products
500 Green Street
Washington, PA 15301

Ship To
316/316L STAINLESS
FRANKIE HUGHES
LAVAL QC CANADA

CERTIFIED MATERIAL
TEST REPORT

INTERIS METAIS
161 THE WEST MALL
ETWATERLOO ON CANADA

OUR ORDER NO. 104230
YOUR ORDER NO. 435898
MEMO NO. 274337-00
DATE 08/20/2013
SALESMAN NO. 1384

P.M. Claitor
P.M. Claitor - Product Quality Engineer

HZ1 545000 HST 215400

ALC 316/316L STAINLESS HRAP
ASTM A240-04c ASME SA 240-04c

Heat Slip Lot No
820113 70691 A 153806
FROM 5110 17281 PART# 7581-2546
820237 70822 A 154596
FROM 5110 19218 PART# 7581-2542

Heat C MN P R BI NT CR NI
820113 .016 ✓ 1.43 0.08 0.002 ✓ .34 16.10 16.20 2.06 ✓
820237 .022 1.42 0.08 0.004 .37 16.13 16.25 2.05 ✓
Gauge .7500
153806 .7500
154596 .7500

Yield Tensile Mod. of
Strength Elong. Area Hardness
45.2 KSI 87.0 KSI 56.0 74.0 BHN170
40.2 KSI 84.5 KSI 58.0 78.0 BHN140

MATERIAL WAS NOT WELD REPAIRED
MATERIAL WAS PRODUCED WITHOUT KNOWN CONTACT WITH MERCURY
MATERIAL IS OF USA MILI AND MANUFACTURE
MATERIAL WAS SOLUTION ANNEALED (HEAT TREATED) ABOVE 1900F AND WATER QUENCHED
DIR 50049 3.1-B AND EN 10204 3.1-B CERTIFICATE

Certification of Material - Per ASME
RTV 820113
Qualifies to all specifications
SA 240-316/316L per
Part II of ASME II
Addenda

W.O. # 1173
M.L. # 55
THK. # -771
P.O. # D545-110411

AUG 19 2013

046
ACCEPTED BY VAL WELLS
for and on behalf of: ANANESH SAHA
Print Name: Val Wells
Signature: Val Wells
Date: Sept 3 2013
Applus
VELOSI
Velosi America LLC





6870 HIGHWAY 42 EAST

METALLURGICAL TEST REPORT

NORTH AMERICAN STAINLESS
6870 HIGHWAY 42 EAST
GHENT, KY 41045

✓ NDK P54189

Certificate: 824674 3 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

Customer: 007050 001

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; QOS766D-A X MAG PERM
MIN. SOLUTION ANNEAL TEMP 1900F, WATER QUENCHED

REMARKS:

Mat'l is Free of Mercury Contamination. No weld repairs.
EN 10204:2004 3.1; ROHS 1 & 2 Compliant
Material is Free of Radioactive Contamination
NAS Steel Making Process: EAF, AOD, & Cont. Casting
Product Mfg. by a Quality Mgt. Sys. in Conf. w/ISO 9001
*Melted & Manufactured in the USA; Mat'l is DFARS Compliant
EN 10204 3.1.B

Product Id	Coil #	Skid #	Thickness	Width	Weight	Length	Mark	Pieces	Commodity Code
DE6858	02F9X7 D		.2460	48.0000	4,890 SHEETS	240.00	20	6	

CHEMICAL ANALYSIS 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
for use on behalf of: IBM OFFSHORE

Print Name: LIAMESH SMITH **Applus[®] VELOSI**
Signature: [Signature]
Date: 8/13/13 **Velosi America LLC**

MECHANICAL PROPERTIES

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

Certification of Material - Per ASME
HT# F9X7
Qualifies to all requirements of
SA240-316 13066
Sect. II Edition VI Addenda

W.O. # 11730
M.L. # 58(30/21/30/12)
P.O. # 13-0713

Q.C.I. N.D.

AUG 13 2013

Q.C.I. E.Y.

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

Technical Mgr. [Signature]
ERIC HERSH



9195311 (1) DATE 16/12/2011

MILL TEST REPORT

IN ACCORDANCE TO EN 10204 3.1

KANZEN TETSU SDN BHD

Kanzen Tetsu Sdn Bhd

Company No: 16287746
No. 2, Jalan 4 Perumahan Perumahan
Mestampin, 14, 40708 Seremban, Negeri Sembilan, Malaysia
Tel: +603-5943 0260 Fax: +603-5943 9777
http://www.kanzen-tetsu.com/ email: info@kanzen-tetsu.com

PINNACLE STAINLESS STEEL INC.

STAINLESS STEEL BUTT WELDING
FITTINGS ASTM A403/ASME SA403H-07g

SIZE	QTY	TOTAL LENGTH	WEIGHT	HEAT NO.	W.O. #	M.L. #	THK. #	P.O. #	DATE
NP316/316L N X B X SCH10S X 45 LR ELBOW	20	-	100	63V9605	292 598	59 81	-	-	2.2 43 83 30 1
NP316/316L N X B X SCH40S X 45 LR ELBOW	20	-	7	63U8605	292 598	59 81	-	-	2.2 43 83 30 1
NP304/304L N X B X 4 X SCH10S X ECC REDUCER	20	-	51	43X7401	312 665	52 86	-	-	3 0 52 96 36 6

CHEMICAL COMPOSITION (%)									
C	Mn	P	S	Si	Cr	Ni	Mo	Cu	AP ₀
0.025	0.030	0.010	0.005	0.030	19.00	10.00	0.010	0.010	0.010
0.025	0.030	0.010	0.005	0.030	19.00	10.00	0.010	0.010	0.010

W.O. # 117304
M.L. # 59 (24/12/2012)
THK. # 147
P.O. # 13-0707

Q.C.I. N.D.

Q.C.I. E.Y.

AUG 12 2013

Certification of Material - Per ASMB
HT# 63U8605
Qualifies to all requirements of
SA403-316/316L per
Sect. II 10 Edition II Addenda

ACCEPTED/REVIEWED/RELEASED
for and on behalf of: SAM OFFSHORE
APPLUS[®] VELOSI
Print Name: SAM
Signature: [Signature]
Date: 18 Sept 13
Velosi America LLC

1650 BLAKE CIRCLE, GREENWOOD, AL 36060

FOR REVIEW ONLY
DATE: 16/12/2011

Hardness use in accordance to NACE MR 0175 / ISO 15156-3 and NACE MR 0103 (Latest Edition)

A subsidiary of P&L Industries Incorporated (Ireland)

MEMBER/CLAS-22-R5



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:	13651-STK / 1 1000012968
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 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			Cust. Part No.:	TRIPLE K TRANSPORT LTD - 35099 (250)
Carrier:					

Supplementary Instructions : Test Cert 1: drafting@canadianplate.com Test Cert 2: 905-206-1370

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 (+) MADE IN CANADA WITH DOMESTIC AND NORTH AMERICAN MATERIALS.

Dimensions (T x W x L)	Batch No.	Heat No-MS	Quantity	No. of Pcs	Dimensions (T x W x L)	Batch No.	Heat No-MS	Quantity	No. of Pcs
1,0000" x 120,000" x 480,00"	AB0907	0811P3-02	16,335 LB	1	1,0000" x 120,000" x 480,00"	AB0908	0811P3-54	16,335 LB	1

Heat No. (wt%)	C	Mn	P	S	Si	Cr	Ni	Mo	Al	Nb	TI	DO
0811P3*	0.19	1.08	0.009	0.004	0.330	0.05	0.16	0.04	0.030	0.000	0.015	0.4000

MECHANICAL PROPERTIES

Heat No.	SRCE	LAB	GAUGE	COND	LOC	MTHD	HARDNESS
0811P3	166"	ALG	1.0000	N	B	HBW	153
0811P3	166"	ALG	1.0000	N	B	HBW	150

LIMITS OF UNSPECIFIED ELEMENTS PER ASME SECTION II (SA-20)
CU + Ni + CR + MO = .26
CR + MO = .06

Certification of Material - Per ASME
 HT# 0811P3-02
 Qualifies to all requirements of SA516-GR70 per Sect. II, Edition 11 Addenda

W.O. # 11739
 M.L. # 60 (713)
 THK. # 1"
 P.O. # 13-0720

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

ACCEPTED BY: WEDYK
 for and on behalf of: SMM OFF SHORE
 Print Name: W.A. WEST
 Signature: [Signature]
 Date: 2013-07-13

Appius VELOSI
 Velosi America LLC

K. UGHADPAGA
 MANAGER METALLURGICAL SERVICES
 AUG 20 2013

****WARNING**** THE TEST RESULTS AND VALUES REPORTED HEREIN INDICATE ONLY THAT (1) THE PARTICULAR STEEL FOR WHICH THIS CERTIFICATE IS ISSUED MEETS THE MINIMUM SPECIFIED YIELD STRENGTH AND (2) THE ANALYSIS AND PHYSICAL PROPERTIES OF SUCH STEEL ARE IN CONFORMANCE WITH THE REQUIREMENTS OF THE SPECIFICATION INDICATED. THE RESULTS OR VALUES REPORTED HEREIN CAN NOT BE USED TO QUALIFY THE STEEL FOR ANY SPECIFICATION OTHER THAN THE ONE INDICATED AND CAN NOT BE RELIED UPON FOR ANY PURPOSE (INCLUDING DESIGN OR CALCULATIONS) AS REPRESENTING THE ACTUAL STRENGTH OF SUCH STEEL.



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.: TRIPLE K TRANSPORT LTD - 35099 (250 Carrier :								
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 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												
***** MECHANICAL PROPERTIES *****												
Impact Tests												
Heat No.	Batch No.	SRCE	LAB	GAUGE	COND	METH	DIR	LOC	SIZE	TEMP(°F)	FULLENERGY(ft-lbf)	FULL AVG(ft-lbf)
0811P3	AB0907	166"	ALG	1.0000	N	CVN	L	B	FULL	-50	101 74 89	86
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/REVIEWED/RELEASED 046
 for and on behalf of: S P M OFF SHORE
 Print Name: GIRISH SAHAI **APPLIUS®**
 Signature: [Signature] **VELOSI**
 Date: Sept 3/13 **Velosi America LLC**



AUG 20 2013

K. UGHADPAGA
 MANAGER METALLURGICAL SERVICES

****WARNING**** THE TEST RESULTS AND VALUES REPORTED HEREIN INDICATE ONLY THAT (1) THE PARTICULAR STEEL FOR WHICH THIS CERTIFICATE IS ISSUED MEETS THE MINIMUM SPECIFIED YIELD STRENGTH AND (2) THE ANALYSIS AND PHYSICAL PROPERTIES OF SUCH STEEL ARE IN CONFORMANCE WITH THE REQUIREMENTS OF THE SPECIFICATION INDICATED. THE RESULTS OR VALUES REPORTED HEREIN CAN NOT BE USED TO QUALIFY THE STEEL FOR ANY SPECIFICATION OTHER THAN THE ONE INDICATED AND CAN NOT BE RELIED UPON FOR ANY PURPOSE INCLUDING DESIGN OR CALCULATIONS AS REPRESENTING THE ACTUAL STRENGTH OF SUCH STEEL.



METALLURGICAL TEST REPORT

NORTH AMERICAN STAINLESS
6870 HIGHWAY 42 EAST
GHENT, KY 41045

1/10 055430
L

6870 HIGHWAY 42 EAST

Certificate: 806076 1
Customer: 007050 001

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

Date: 1/30/2013 Page: 1

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

Steel: 316/316L

Finish: HRAP

Your Order: 53930

NAS Order: IN 0161281 01

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

PRODUCT DESCRIPTION:

STAINLESS STEEL PLATE, HRAP; UNS 31600/31603
ASTM A240/11b,A480/11b,A666/10;ASME SA240/11a,SA480/11a,SA666/11a
CHEM ONLY ON FOLLOWING ASTM: A276/10,A479/11,A484/11,A312/11
CHEM ONLY ON FOLLOWING ASME: SA312/11,SA479/11
AMS 5507F/5524L X MRK;
NACE MR0175/ISO 15156-3:2003 A, MR0103/07; QQS766D-A X MAG PERM
MIN. SOLUTION ANNEAL TEMP 1900F, WATER QUENCHED

REMARKS:

Mat'l is Free of Mercury Contamination. No weld repairs.
EN 10204:2004 3.1; ROHS 1 & 2 Compliant
Material is Free of Radioactive Contamination
NAS Steel Making Process: EAF, AOD, & Cont. Casting
Product Mfg. by a Quality Mgt. Sys. in Conf. w/ISO 9001
*Melted & Manufactured in the USA; Mat'l is DFARS Compliant

Product Id	Plate#	Skid #	Thickness	Width	Weight	Length	Mark	Pieces	Commodity Code
05E9C1 AA	05E9C1 AA		1.5075	60.0000	6,275	PLATE	240.00	1	1

CHEMICAL ANALYSIS

Chemical Analysis per ASTM A751/08

HEAT	CM	C %	CR %	CU %	MN %	MO %	N %	NI %	P %	S %
E9C1	US	.0193	16.5860	.4350	1.5900	2.1020	.0498	10.0400	.0340	.0010

APPLUS[®] VELOCITY
 for and on behalf of: SPM OFFSHORE
 Print Name: LIAN HUI SAH OF
 D to: SEA 13/13
 W.O. # (1730)
 M.L. # 02(9/13)
 P.O. # 13-0713

MECHANICAL PROPERTIES

Product Id#	Plate#	UTS KSI	.2% YS KSI	ELONG %	Hard RB	R of A %
05E9C1 AA	05E9C1 AA	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
Dept. Mgr.

ERIC HESS
1/30/2013



6870 HIGHWAY 42 EAST

Certificate: 791192 7
Customer: 007050 001

METALLURGICAL TEST REPORT

NORTH AMERICAN STAINLESS
6870 HIGHWAY 42 EAST
GHENT, KY 41045

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, A480/11a, 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; QCS766D-A X MAG PERM
MIN. SOLUTION ANNEAL TEMP 1900F, WATER QUENCHED

REMARKS:

Mat'l is Free of Mercury Contamination. No weld repairs.
EN 10204:2004 3.1; RoHS 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
DD2371	06E5K2 B		.3748	48.0000	2,545 SHEETS	240.00	16	2	

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

HEAT	CM	C %	CR %	CU %	MN %	MO %	N %	NI %	P %	S %
E5K2	US	.0154	16.5720	.4135	1.4470	2.0650	.0461	10.0450	.0310	.0192

ACCEPTED/REVIEWED/RELEASED
for use on behalf of: ARMCO/SSA/DAK
Print Name: G. ANDRESA SAH-A **Appius®**
Signature: [Signature] **VELOSI**
Date: Sept 13/12 **Velosi America LLC**

W.O. # 11730
M.C. # 63(17 to 10/17)
P.O. # 13-0713

MECHANICAL PROPERTIES

Product Id#	Coil #	UTS	2% YS	ELONG	Hard	Hard	Tail
		KSI	%-2"	RB	RB	RB	
DD2371	06E5K2	FT 85.68	48.52	51.53	87.00	89.00	

Certification of Material - Per ASME
IT# E5K2
Qualifies to all requirements of SA 240-316 B1C per
Sect. II LC Edition 11 Addenda

Q.C.I.
N.D.

AUG 16 2013

Q.C.I.
E.Y.

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

Technical Dept. Mgr. [Signature] ERIC HESS 12/03/2012



METALLURGICAL TEST REPORT

NORTH AMERICAN STEEL
6870 HIGHWAY 42 EAST
GHENT, KY 41045

6870 HIGHWAY 42 EAST

Certificate: 794815 1
Customer: 007050 001

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

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

Date: 12/14/2012 Page: 1

Steel: 316/316L

Finish: HRAP

Corrosion: ASTM A262/02a2;180Bend-OK

x Order: 53315

NAS Order: DS 0002247 05

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; 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
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

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% YG	ELONG	Hard	Tail
		KSI	KSI	%-2"	RB	Hard
DD4383	02E7K6	88.88	55.61	50.97	87.00	89.00

Q.C.I.
N.D.

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

Technical Dept. Mgr. ERIC HESS 12/14/2012

Certification of Material - Per ASME
HT# E7K6
Qualifies to all requirements of
SA240-316/316L per
Sect. II 10 Edition 11 Addenda

W.O. # 11730
M.L. # 63 (1/16/10)
THK. # 376
P.O. # 13-0713

Q.C.I.
E.Y.

AUG 16 2013

ACCEPTED/REVIEWED/RELEASED
for and on behalf of: SIBM OFFSHORE
Print Name: L. A. NESH SAH H
Signature: [Signature]
Date: Sept 2/13
Applus® VELOSI
Velosi America LLC



METALLURGICAL TEST REPORT

NORTH AMERICAN STAINLESS
6870 HIGHWAY 42 EAST
GHENT, KY 41045

6870 HIGHWAY 42 EAST

Mail To: **ROLARK STAINLESS STEEL, INC.**

Ship To: **ROLARK STAINLESS STEEL, INC.**

Date: 1/04/2013 Page: 1

Certificate: 798933 1

Steel: 316/316L

Customer: 007050 012

Finish: BRAP

Your Order: 53412 NAS Order: DS 0002333 01

Corrosion: ASTM A262/02a5;180Bend-OK

PRODUCT DESCRIPTION:

STAINLESS STEEL COIL, BRAP; UNS 31600/31603
ASTM A740/11b, 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/S526L X HRK;
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 1 & 2 Compliant
Material is Free of Radioactive Contamination
NAS Steel Making Process: EAF, AOD, & Cast. Casting
Product Mfg. by a Quality Mgt. Sys. in Conf. w/ISO 9001
Welded & Manufactured in the USA; Mat'l is DPARS Compliant

Product ID	Coil #	Skid #	Thickness	Width	Weight	Length	Mark	Pieces	Commodity Code
05E9B3 C	05E9B3 C		.3748	60.0000	22,730 COIL			1	1

CHEMICAL ANALYSIS

CM(Country of Melt) ES(Spain) US(United States) ZA(South Africa) JP(Japan)
Chemical Analysis per ASTM A731/08

HEAT	CN %	C %	CR %	CU %	MN %	N %	NI %	P %	S %
5933 ✓	.0207	16.8085	.4240	1.4520	2.0375	.0412	10.0055	.0330	.0010

SI %
.3575

MECHANICAL PROPERTIES

Product Id#	Coil #	UTS	YS	ELONG	Hard	Tail
		%	%	%-2"	RB	Hard
05E9B3 C	05E9B3 C	87.49	54.04	49.86	87.00	90.50

Certification of Material - Per ASME
HT# **E9 B3**
Qualifies to all requirements of
SA 240-316/316L or
Sec. 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 represented herein and do not constitute a general statement of approval of the material without the written approval of NAS.

Technical Dept. Mgr. **ERIC HESS**

1/06/2013

APPLUS®
VELOSI
Velosi America LLC

Print Name: **Eric Hess**
Signature: *Eric Hess*
Date: **8/16/13**

ACCEPTED/REVISED/RELEASED
for and on behalf of: **SA 240-316/316L**
SA 240-316/316L

PHOENIX TUBE COMPANY, INC.
 Manufacturer of Stainless Ornamental and Structural Tubing
CERTIFICATION OF TEST

Sold To: RYERSON CANADA
 161 THE WEST MALL
 PAUL MASSE@416-620-3865 FOR APPT
 ETOBICOKE ON M9C
 CAN

Shlp To: RYERSON CANADA
 161 THE WEST MALL
 PAUL MASSE@416-620-3865 FOR APPT
 ETOBICOKE ON M9C
 CAN

CUSTOMER ORDER#: 739299
 CUST REF NBR: 7136671
 DATE SHIPPED: 07/10/13

Phone# 6223100 Ext:
 ORDER#: 311820
 QTY SHIPPED: 555.0
 GRADE: 316L NO WELD: BAR
 HEAT#: D5F9

SIZE: 2" X 3/8" HRAP
 SOURCE: USA D
 W.O. # 11730
 M.L. # 66 (1/10/13)
 T.I.K. # -375
 VENDOR: NAS
 P.O. # 13-0889

TEST REPORT#: TR010548
 Report Date: 08/27/12

Specification:

CHEMISTRY THIS COLUMN:
 ASTMA276-13
 ASME SA276-08 COND. A
 ASTMA479-13
 ASME SA479-13, S2.1
 QQ-S-766D, COND. A

ASTMA262, PRACTICE E
 CORROSION OK, HRAP
 ASTMA484-13
 ASME SA484-13
 NO WELD REPAIR
 EN 10204 2.2

ASTM A240-13
 ASME SA240-13
 MILS 5059D AMEND 3
 AMS 5648L & AMS 5653G
 ASTM A480-13
 ASME SA480-13

TYPE 316L/316 DUAL CERTIFIED
 UNS# 31600 / 31603
 ASTM A666-10
 NACE MR0175/01 / MR0103



SEP 19 2013



Certification of Material - Per ASME
 HT# D5F9
 Qualifies to all requirements of
SA 479-316/316L per
 Sect. II 10 Edition II Addenda

MERCURY IS NOT USED BY US AS AN ALLOYING MATERIAL NOR IS METALLIC MERCURY HANDLED IN THE VICINITY OF OUR PROCESSING LINES. WE ARE NOT PRESENTLY AWARE OF ANY MERCURY CONTAMINATION. MATERIAL HAS BEEN HEATED TO A MINIMUM OF 1900 DEG. F AND IS SUBSEQUENTLY COOLED RAPIDLY TO PREVENT CARBIDE PRECIPITATION

Chemical Analysis

C ✓	MN ✓	P ✓	S ✓	SI ✓	CR ✓	NI ✓	MO ✓	CU	CO	N2	TI
.023	1.57	.037	.001	.38	16.58	10.08	2.11	56	0	.04	0

Physical Analysis

Hardness	YIELD		TENSILE		OTHER	
	PSI	MPA	PSI	MPA	Percent EL	Percent RA
RB 87	53510	0	88630	0	52 ✓	69

THE CHEMICAL ANALYSES ARE CORRECT AS CONTAINED IN OUR CORPORATE RECORDS.
 PHYSICAL PROPERTIES ARE DETERMINED WHILE MATERIAL IS IN STRIP FORM

Melted & Manufactured In the USA FAR BAA complies, DFARS BAA complies, FAR TAA complies

CERTIFIED BY Quality Control Dept.

Neilson Uguiza

1185 WIN DR, BETHLEHEM, PA, 18017 - (610) 865-5337
 FAX NUMBER: 610-865-4073

046

APPROVED/REVIEWED/RELEASED
 for and on behalf of: SIM OF FSH016

Print Name: GARIBASH SAHA
 Signature: [Signature]
 Date: SEP 26 2013

Applus®
 VELOSI
 Velosi America LLC

ALL-WELD COMPANY LIMITED

49 Passmore Avenue,

Toronto, Ontario,

Canada M1V 4T1

www.allweld.ca



COMPRESS Pressure Vessel Design Calculations

Item: 48" OD Vertical Stainless Steel Inlet Separator
Vessel No: 772-VESE-101/201
Customer: Ultrafab Industries Limited
Designer: Todd Clark, P. Eng.
Date: Tuesday, July 16, 2013



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Nozzle Schedule

Nozzle mark	Service	Size	Materials		Impact Tested	Normalized	Fine Grain	Flange	Blind
<u>MW1</u>	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
<u>N1</u>	Inlet	11.75 OD x 1.875	Nozzle	SA-182 F316 <= 5	No	No	No	NPS 8 Class 900 LWN A182 F316	No
<u>N10A</u>	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
<u>N10B</u>	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
<u>N11</u>	Spare	4.12 OD x 1.06	Nozzle	SA-182 F316 <= 5	No	No	No	NPS 2 Class 900 LWN A182 F316	No
<u>N12</u>	Purge	4.12 OD x 1.06	Nozzle	SA-182 F316 <= 5	No	No	No	NPS 2 Class 900 LWN A182 F316	No
<u>N13</u>	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
<u>N14</u>	Vent	4.12 OD x 1.06	Nozzle	SA-182 F316 <= 5	No	No	No	NPS 2 Class 900 LWN A182 F316	No
<u>N15</u>	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
<u>N2</u>	Gas Outlet	11.75 OD x 1.875	Nozzle	SA-182 F316 <= 5	No	No	No	NPS 8 Class 900 LWN A182 F316	No
<u>N3</u>	Liquid Outlet	4.12 OD x 1.06	Nozzle	SA-182 F316 <= 5	No	No	No	NPS 2 Class 900 LWN A182 F316	No
<u>N4</u>	PSV	4.12 OD x 1.06	Nozzle	SA-182 F316 <= 5	No	No	No	NPS 2 Class 900 LWN A182 F316	No
<u>N5</u>	Pressure Indicator	4.12 OD x 1.06	Nozzle	SA-182 F316 <= 5	No	No	No	NPS 2 Class 900 LWN A182 F316	No
<u>N6</u>	Temperature Indicator	4.12 OD x 1.06	Nozzle	SA-182 F316 <= 5	No	No	No	NPS 2 Class 900 LWN A182 F316	No
<u>N7A</u>	PDI High	4.12 OD x 1.06	Nozzle	SA-182 F316 <= 5	No	No	No	NPS 2 Class 900 LWN A182 F316	No
<u>N7B</u>	PDI Low	4.12 OD x 1.06	Nozzle	SA-182 F316 <= 5	No	No	No	NPS 2 Class 900 LWN A182 F316	No

<u>N8A</u>	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
<u>N8B</u>	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
<u>N9A</u>	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
<u>N9B</u>	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 _n (In)	Req t _n (In)	A ₁ ?	A ₂ ?	Shell			Reinforcement Pad		Corr (In)	A _a /A _r (%)
						Nom t (In)	Design t (In)	User t (In)	Width (in)	t _{pad} (in)		
<u>MW1</u>	35	5.5	1.1622	Yes	Yes	1.75	1.6094		N/A	N/A	0	111.5
<u>N1</u>	11.75	1.875	0.3983	Yes	Yes	1.75	1.6093		N/A	N/A	0	141.4
<u>N10A</u>	4.12	1.06	0.2074	Yes	Yes	1.75	N/A		N/A	N/A	0	Exempt
<u>N10B</u>	4.12	1.06	0.2074	Yes	Yes	1.75	N/A		N/A	N/A	0	Exempt
<u>N11</u>	4.12	1.06	0.2074	Yes	Yes	1.75	N/A		N/A	N/A	0	Exempt
<u>N12</u>	4.12	1.06	0.2074	Yes	Yes	1.75	N/A		N/A	N/A	0	Exempt
<u>N13</u>	2.375	0.344	0.154	Yes	Yes	1.73*	N/A		N/A	N/A	0	Exempt
<u>N14</u>	4.12	1.06	0.2074	Yes	Yes	1.73*	N/A		N/A	N/A	0	Exempt
<u>N15</u>	11.75	1.875	0.3983	Yes	Yes	1.75	1.6093		N/A	N/A	0	141.4
<u>N2</u>	11.75	1.875	0.3634	Yes	Yes	1.73*	1.4483		N/A	N/A	0	139.2
<u>N3</u>	4.12	1.06	0.2074	Yes	Yes	1.75	N/A		N/A	N/A	0	Exempt
<u>N4</u>	4.12	1.06	0.2074	Yes	Yes	1.75	N/A		N/A	N/A	0	Exempt
<u>N5</u>	4.12	1.06	0.2074	Yes	Yes	1.75	N/A		N/A	N/A	0	Exempt
<u>N6</u>	4.12	1.06	0.2074	Yes	Yes	1.75	N/A		N/A	N/A	0	Exempt
<u>N7A</u>	4.12	1.06	0.2074	Yes	Yes	1.75	N/A		N/A	N/A	0	Exempt
<u>N7B</u>	4.12	1.06	0.2074	Yes	Yes	1.75	N/A		N/A	N/A	0	Exempt
<u>N8A</u>	4.12	1.06	0.2074	Yes	Yes	1.75	N/A		N/A	N/A	0	Exempt
<u>N8B</u>	4.12	1.06	0.2074	Yes	Yes	1.75	N/A		N/A	N/A	0	Exempt
<u>N9A</u>	4.12	1.06	0.2074	Yes	Yes	1.75	N/A		N/A	N/A	0	Exempt
<u>N9B</u>	4.12	1.06	0.2074	Yes	Yes	1.75	N/A		N/A	N/A	0	Exempt

- t_n: Nozzle thickness
- Req t_n: Nozzle thickness required per UG-45/UG-16
- Nom t: Vessel wall thickness
- Design t: Required vessel wall thickness due to pressure + corrosion allowance per UG-37
- User t: Local vessel wall thickness (near opening)
- A_a: Area available per UG-37, governing condition
- A_r: Area required per UG-37, governing condition
- Corr: Corrosion allowance on nozzle wall
- * 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 _e external (°F)	MDMT (°F)	MDMT Exemption	Impact Tested
<u>48 OD TOP SE HEAD</u>	1,378	140	1,541.68	566.01	140	-320	Note 1	No
<u>Straight Flange on 48 OD TOP SE HEAD</u>	1,378	140	1,519.84	630.75	140	-320	Note 2	No
<u>48 OD SHELL</u>	1,378	140	1,501.51	622.51	140	-320	Note 2	No
<u>Straight Flange on 48 OD BOTTOM SE HEAD</u>	1,378	140	1,519.12	630.75	140	-320	Note 2	No
<u>48 OD BOTTOM SE HEAD</u>	1,378	140	1,540.53	566.01	140	-320	Note 3	No
<u>Manway c/w Blind Flange (MW1)</u>	1,378	140	1,378	622.51	140	-55	Note 4	No
<u>Inlet (N1)</u>	1,378	140	1,378	622.51	140	-55	Note 4	No
<u>Level Gauge High (N10A)</u>	1,378	140	1,378	622.51	140	-55	Note 4	No
<u>Level Gauge Low (N10B)</u>	1,378	140	1,378	622.51	140	-55	Note 4	No
<u>Spare (N11)</u>	1,378	140	1,378	622.51	140	-55	Note 4	No
<u>Purge (N12)</u>	1,378	140	1,378	622.51	140	-55	Note 4	No
<u>Bottom Drain (N13)</u>	1,378	140	1,378	566.01	140	-55	Note 4	No
<u>Vent (N14)</u>	1,378	140	1,378	566.01	140	-55	Note 4	No
<u>Inspection c/w Blind Flange (N15)</u>	1,378	140	1,378	622.51	140	-55	Note 4	No
<u>Gas Outlet (N2)</u>	1,378	140	1,378	566.01	140	-55	Note 4	No
<u>Liquid Outlet (N3)</u>	1,378	140	1,378	622.51	140	-55	Note 4	No
<u>PSV (N4)</u>	1,378	140	1,378	622.51	140	-55	Note 4	No
<u>Pressure Indicator (N5)</u>	1,378	140	1,378	622.51	140	-55	Note 4	No
<u>Temperature Indicator (N6)</u>	1,378	140	1,378	622.51	140	-55	Note 4	No
<u>PDI High (N7A)</u>	1,378	140	1,378	622.51	140	-55	Note 4	No
<u>PDI Low (N7B)</u>	1,378	140	1,378	622.51	140	-55	Note 4	No
<u>Level Bridle - (Process) High (N8A)</u>	1,378	140	1,378	622.51	140	-55	Note 4	No
<u>Level Bridle - (Process) Low (N8B)</u>	1,378	140	1,378	622.51	140	-55	Note 4	No
<u>Level Bridle - (Safety) High (N9A)</u>	1,378	140	1,378	622.51	140	-55	Note 4	No
<u>Level Bridle - (Safety) Low (N9B)</u>	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.	<u>Straight Flange</u> governs MDMT	
2.	Rated MDMT per UHA-51(d)(1)(a) = -320 °F	
3.	<u>Straight Flange</u> 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
<u>48 OD TOP SE HEAD</u>	SA-240 316	48 OD	12.865	1.73*	1.5571	0	1.00	Internal
<u>Straight Flange on 48 OD TOP SE HEAD</u>	SA-240 316	48 OD	2	1.77	1.6093	0	1.00	Internal
<u>48 OD SHELL</u>	SA-240 316	48 OD	96	1.75	1.61	0	1.00	Internal
<u>Straight Flange on 48 OD BOTTOM SE HEAD</u>	SA-240 316	48 OD	2	1.77	1.6101	0	1.00	Internal
<u>48 OD BOTTOM SE HEAD</u>	SA-240 316	48 OD	12.865	1.73*	1.5583	0	1.00	Internal
<u>46-3 4" OD Skirt</u>	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 ²
	Metal New*	Metal Corroded*	Insulation	Insulation Supports	Lining	Piping + Liquid	Operating Liquid		Test Liquid		
							New	Corroded	New	Corroded	
48 OD TOP SE HEAD	1,349.3	1,349.3	0	0	0	0	0	0	542.8	542.8	21
48 OD SHELL	6,385.9	6,385.9	0	0	0	0	1,019.6	1,019.6	5,518.3	5,518.3	91
48 OD BOTTOM SE HEAD	1,408.1	1,408.1	0	0	0	0	582.9	582.9	529.9	529.9	21
46-3/4" OD Skirt	400.3	400.3	0	0	0	0	0	0	0	0	41
Skirt Base Ring	318	318	0	0	0	0	0	0	0	0	20
TOTAL:	9,861.6	9,861.6	0	0	0	0	1,602.5	1,602.5	6,590.9	6,590.9	194

* Shells with attached nozzles have weight reduced by material cut out for opening.

Component	Weight (lb) Contributed by Attachments										Surface Area ft ²
	Body Flanges		Nozzles & Flanges		Packed Beds	Ladders & Platforms	Trays	Tray Supports	Rings & Clips	Vertical Loads	
	New	Corroded	New	Corroded							
48 OD TOP SE HEAD	0	0	378.5	378.5	0	0	0	0	31.9	0	6
48 OD SHELL	0	0	7,893.4	7,893.4	0	0	0	0	0	0	57
48 OD BOTTOM SE HEAD	0	0	28.7	28.7	0	0	0	0	0	0	1
46-3/4" OD Skirt	0	0	60	60	0	0	0	0	16.2	0	1
TOTAL:	0	0	8,360.7	8,360.7	0	0	0	0	48.1	0	65

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 ft²

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.

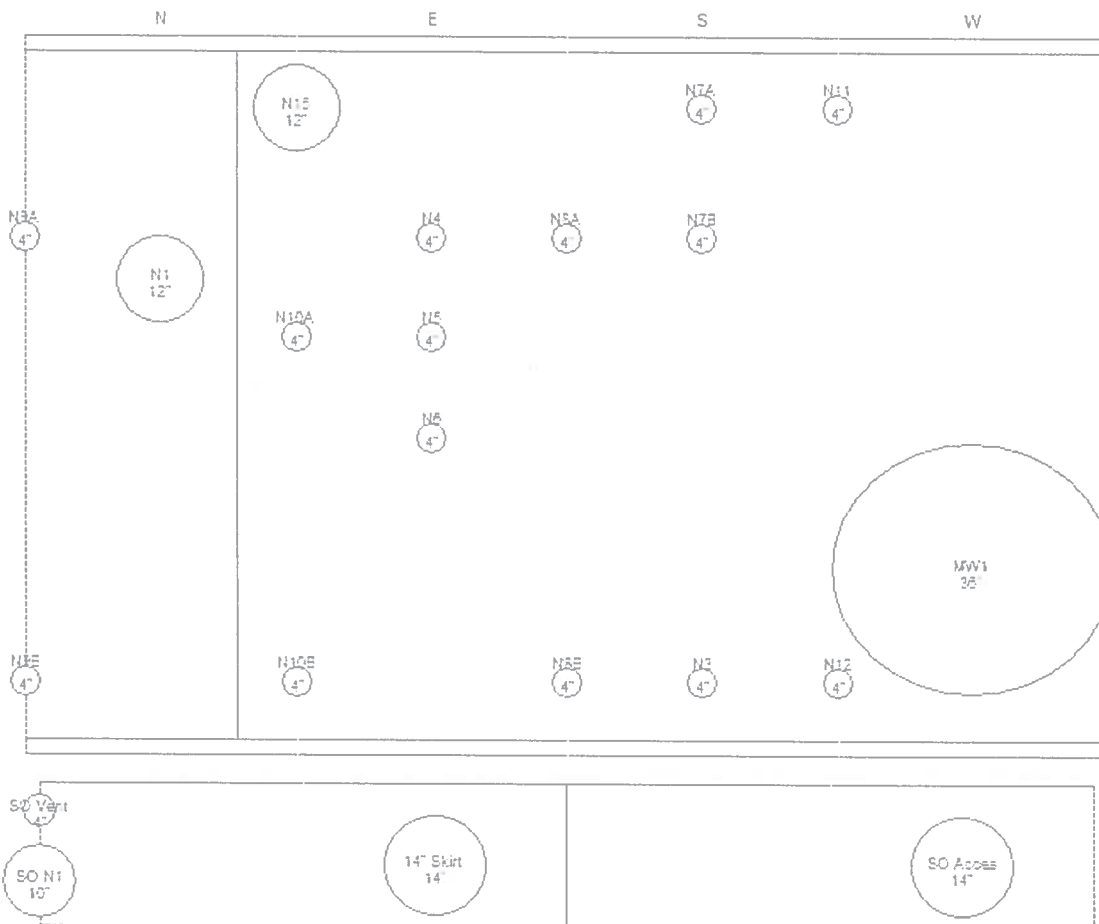
Long Seam Summary

Shell Long Seam Angles	
Component	Seam 1
<u>48 OD SHELL</u>	25°
<u>46-3/4" OD Skirt</u>	135°

Shell Plate Lengths		
Component	Starting Angle	Plate 1
<u>48 OD SHELL</u>	25°	145.2987"
<u>46-3/4" OD Skirt</u>	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)
<u>48 OD TOP SE HEAD</u>	-	-14.865	N/A
-	<u>1.3 depth of 48 OD TOP SE HEAD</u>	-5.7117	N/A
<u>Straight Flange on 48 OD TOP SE HEAD Top</u>	-	-2	107.4233
<u>Straight Flange on 48 OD TOP SE HEAD Bottom</u>	-	0	107.4233
<u>48 OD SHELL Top</u>	-	0	107.4233
<u>48 OD SHELL Bottom</u>	-	96	107.4233
<u>Straight Flange on 48 OD BOTTOM SE HEAD Top</u>	-	96	107.4233
<u>Straight Flange on 48 OD BOTTOM SE HEAD Bottom</u>	-	98	107.4233
-	<u>1.3 depth of 48 OD BOTTOM SE HEAD</u>	101.7117	N/A
<u>48 OD BOTTOM SE HEAD</u>	-	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

Method of seismic analysis: User-defined

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^{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 ⁶ psi)	Inertia I (ft ⁴)	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 ⁶ psi)	Inertia I (ft ⁴)	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 ⁶ psi)	Inertia I (ft ⁴)	Seismic shear at Bottom (lbf)	Bending Moment at Bottom (lbf-ft)
48 OD TOP SE HEAD	121.88	27.9	*	2,376	2,187
48 OD SHELL	25.88	27.9	3.2834	9,365	69,180
48 OD BOTTOM SE HEAD (top)	20	27.9	*	9,518	73,808
46-3/4" OD Skirt	0	27.9	0.9369	9,936	90,304

*Moment of Inertia I varies over the length of the component

Vertical Acceleration Term, V_{Accel}

Factor is applied to dead load.

Compressive Side: = $1.0 + V_{Accel}$

V_{Accel} 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)	$\frac{\text{Force Mult} * \text{Shear}}{\text{Weight}}$	V_{Accel}
Operating, Corroded	9,936	19,872.9	0.7369	1
Operating, New	9,936	19,872.9	0.7369	1
Empty, Corroded	9,135	18,270.4	0.7369	1
Empty, New	9,135	18,270.4	0.7369	1
Vacuum, Corroded	9,936	19,872.9	0.7369	1

Base Shear Calculations

Operating, Corroded

Empty, Corroded

Vacuum, Corroded

Base Shear Calculations: Operating, Corroded

$$\begin{aligned} V &= \text{Base Shear Multiplier} * W \\ &= 0.5000 * 19,872.8789 \\ &= 9,936.44 \text{ lb} \end{aligned}$$

Base Shear Calculations: Empty, Corroded

$$\begin{aligned} V &= \text{Base Shear Multiplier} * W \\ &= 0.5000 * 18,270.3887 \\ &= 9,135.19 \text{ lb} \end{aligned}$$

Base Shear Calculations: Vacuum, Corroded

$$\begin{aligned} V &= \text{Base Shear Multiplier} * W \\ &= 0.5000 * 19,872.8789 \\ &= 9,936.44 \text{ lb} \end{aligned}$$

Wind Code

Building Code: **User Defined**
 Elevation of base above grade: 0.0000 ft
 Increase effective outer diameter by: 0.0000 ft
 Wind Force Coefficient Cf: 0.8000

Vessel Characteristics

Vessel height, h: 11.3954 ft
 Vessel Minimum Diameter
 Operating, Corroded: 4.0000 ft
 Empty, Corroded: 4.0000 ft
 Fundamental Frequency, n_1
 Operating, Corroded: 52.0264 Hz
 Empty, Corroded: 52.5492 Hz
 Damping coefficient, β
 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 ⁶ psi)	Inertia I (ft ⁴)	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 ⁶ psi)	Inertia I (ft ⁴)	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 ⁶ psi)	Inertia I (ft ⁴)	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, 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:

$P_s = 0$ psi (SG=1.1, $H_s=0$ " Operating head)
 $P_{th} = 2.03$ psi (SG=1, $H_s=56.27$ " Horizontal test head)

Corrosion allowance: Inner C = 0" Outer C = 0"

Design MDMT = -20°F 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 = 1,349.3 lb corr = 1,349.3 lb
Capacity*: new = 63.5 US gal corr = 63.5 US gal
* includes straight flange

Outer diameter = 48"
Minimum head thickness = 1.73"
Head ratio D/2h = 2 (new)
Head ratio D/2h = 2 (corroded)
Straight flange length L_{sf} = 2"
Nominal straight flange thickness t_{sf} = 1.77"

Results Summary

The governing condition is internal pressure.
Minimum thickness per UG-16 = $0.0625 + 0 = 0.0625$ "
Design thickness due to internal pressure (t) = 1.5571"
Design thickness due to external pressure (t_e) = 0.1193"
Maximum allowable working pressure (MAWP) = 1,541.68 psi
Maximum allowable external pressure (MAEP) = 566.01 psi

K (Corroded)

$$K = (1/6) * [2 + (D / (2*h))^2] = (1/6) * [2 + (44.54 / (2*11.135))^2] = 1$$

K (New)

$$K = (1/6) * [2 + (D / (2*h))^2] = (1/6) * [2 + (44.54 / (2*11.135))^2] = 1$$

Design thickness for internal pressure, (Corroded at 140 °F) Appendix 1-4(c)

$$\begin{aligned}t &= P \cdot D_o \cdot K / (2 \cdot S \cdot E + 2 \cdot P \cdot (K - 0.1)) + \text{Corrosion} \\&= 1,378 \cdot 48 \cdot 1 / (2 \cdot 20,000 \cdot 1 + 2 \cdot 1,378 \cdot (1 - 0.1)) + 0 \\&= 1.557''\end{aligned}$$

The head internal pressure design thickness is 1.5571".

Maximum allowable working pressure, (Corroded at 140 °F) Appendix 1-4(c)

$$\begin{aligned}P &= 2 \cdot S \cdot E \cdot t / (K \cdot D_o - 2 \cdot t \cdot (K - 0.1)) - P_s \\&= 2 \cdot 20,000 \cdot 1 \cdot 1.73 / (1 \cdot 48 - 2 \cdot 1.73 \cdot (1 - 0.1)) - 0 \\&= 1,541.68 \text{ psi}\end{aligned}$$

The maximum allowable working pressure (MAWP) is 1,541.68 psi.

Design thickness for external pressure, (Corroded at 140 °F) UG-33(d)

Equivalent outside spherical radius (R_o)

$$\begin{aligned}R_o &= K_o \cdot D_o \\&= 0.8395 \cdot 48 \\&= 40.2954 \text{ in}\end{aligned}$$

$$\begin{aligned}A &= 0.125 / (R_o / t) \\&= 0.125 / (40.2954 / 0.119274) \\&= 0.00037\end{aligned}$$

From Table HA-2: $B = 5,067.5892$ psi

$$\begin{aligned}P_a &= B / (R_o / t) \\&= 5,067.5892 / (40.2954 / 0.1193) \\&= 15 \text{ psi}\end{aligned}$$

$$t = 0.1193'' + \text{Corrosion} = 0.1193'' + 0'' = 0.1193''$$

Check the external pressure per UG-33(a)(1) Appendix 1-4(c)

$$\begin{aligned}t &= 1.67 \cdot P_e \cdot D_o \cdot K / (2 \cdot S \cdot E + 2 \cdot 1.67 \cdot P_e \cdot (K - 0.1)) + \text{Corrosion} \\&= 1.67 \cdot 15 \cdot 48 \cdot 1 / (2 \cdot 20,000 \cdot 1 + 2 \cdot 1.67 \cdot 15 \cdot (1 - 0.1)) + 0 \\&= 0.03''\end{aligned}$$

The head external pressure design thickness (t_e) is 0.1193".

Maximum Allowable External Pressure, (Corroded at 140 °F) UG-33(d)

Equivalent outside spherical radius (R_o)

$$\begin{aligned}R_o &= K_o \cdot D_o \\&= 0.8395 \cdot 48 \\&= 40.2954 \text{ in}\end{aligned}$$

$$\begin{aligned}A &= 0.125 / (R_o / t) \\&= 0.125 / (40.2954 / 1.73) \\&= 0.005367\end{aligned}$$

From Table HA-2: $B = 13,183.56$ psi

$$\begin{aligned}
 P_a &= B / (R_o / t) \\
 &= 13,183.56 / (40.2954 / 1.73) \\
 &= 566.0093 \text{ psi}
 \end{aligned}$$

Check the Maximum External Pressure, UG-33(a)(1) Appendix 1-4(c)

$$\begin{aligned}
 P &= 2 * S * E * t / ((K * D_o - 2 * t * (K - 0.1)) * 1.67) - P_{s2} \\
 &= 2 * 20,000 * 1 * 1.73 / ((1 * 48 - 2 * 1.73 * (1 - 0.1)) * 1.67) - 0 \\
 &= 923.16 \text{ psi}
 \end{aligned}$$

The maximum allowable external pressure (MAEP) is 566.01 psi.

% Forming strain - UHA-44(a)(2)(b)

$$\begin{aligned}
 EFE &= (75 * t / R_t) * (1 - R_t / R_o) \\
 &= (75 * 1.77 / 8.4568) * (1 - 8.4568 / \infty) \\
 &= 15.6974\%
 \end{aligned}$$

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

$$\begin{aligned} t &= P R_o / (S E + 0.40 P) + \text{Corrosion} \\ &= 1,378 * 24 / (20,000 * 1.00 + 0.40 * 1,378) + 0 \\ &= 1.6093" \end{aligned}$$

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

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

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

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

$$= 15 \text{ psi}$$

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)

$$L / D_o = 107.4233 / 48 = 2.2380$$

$$D_o / t = 48 / 1.77 = 27.1186$$

$$\text{From table G: } A = 0.004031$$

$$\text{From table HA-2: } B = 12,828.9038 \text{ psi}$$

$$\begin{aligned} P_a &= 4*B / (3*(D_o / t)) \\ &= 4*12,828.9 / (3*(48 / 1.77)) \\ &= 630.75 \text{ psi} \end{aligned}$$

% Forming strain - UHA-44(a)(2)(a)

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

Design thickness = 1.6093''

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 _t	S _c					
Operating, Hot & Corroded	1,378	20,000	13,729	140	0	Wind	0.6305	0.6304
						Seismic	0.6311	0.6293
Operating, Hot & New	1,378	20,000	13,729	140	0	Wind	0.6305	0.6304
						Seismic	0.6311	0.6293
Hot Shut Down, Corroded	0	20,000	13,729	140	0	Wind	0.0007	0.0008
						Seismic	0.0001	0.0024
Hot Shut Down, New	0	20,000	13,729	140	0	Wind	0.0007	0.0008
						Seismic	0.0001	0.0024
Empty, Corroded	0	20,000	13,908	70	0	Wind	0.0007	0.0008
						Seismic	0.0001	0.0023
Empty, New	0	20,000	13,908	70	0	Wind	0.0007	0.0008
						Seismic	0.0001	0.0023
Vacuum	-15	20,000	13,729	140	0	Wind	0.0108	0.0109
						Seismic	0.0099	0.0125
Hot Shut Down, Corroded, Weight & Eccentric Moments Only	0	20,000	13,729	140	0	Weight	0.0008	0.0009

Allowable Compressive Stress, Hot and Corroded- S_{CHC}, (table HA-2)

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (24 / 1.77) \\
 &= 0.009219 \\
 B &= 13,729 \text{ psi} \\
 S &= 20,000 / 1.00 = 20,000 \text{ psi} \\
 S_{CHC} &= \min(B, S) = 13,729 \text{ psi}
 \end{aligned}$$

Allowable Compressive Stress, Hot and New- S_{CHN}

$$\begin{aligned}
 S_{CHN} &= S_{CHC} \\
 &= 13,729 \text{ psi}
 \end{aligned}$$

Allowable Compressive Stress, Cold and New- S_{CCN}, (table HA-2)

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (24 / 1.77) \\
 &= 0.009219 \\
 B &= 13,908 \text{ psi} \\
 S &= 20,000 / 1.00 = 20,000 \text{ psi} \\
 S_{CCN} &= \min(B, S) = 13,908 \text{ psi}
 \end{aligned}$$

Allowable Compressive Stress, Cold and Corroded- S_{CCC}

$$\begin{aligned}
 S_{CCC} &= S_{CCN} \\
 &= 13,908 \text{ psi}
 \end{aligned}$$

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

$$t_p = 0'' \quad \text{(Pressure)}$$

$$\begin{aligned}
t_m &= M / (\pi R_m^2 S_c K_s) && \text{(bending)} \\
&= 1,145 / (\pi 23.115^2 13,907.75 1.20) \\
&= 0'' \\
t_w &= W / (2 \pi R_m S_c K_s) && \text{(Weight)} \\
&= 1,759.7 / (2 \pi 23.115 13,907.75 1.20) \\
&= 0.0007'' \\
t_t &= |t_p + t_m - t_w| && \text{(total, net compressive)} \\
&= |0 + 0 - (0.0007)| \\
&= \underline{0.0007''} \\
t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\
&= 0 + (0.0007) - (0) \\
&= \underline{0.0008''}
\end{aligned}$$

Empty. New. Wind. Bottom Seam

$$\begin{aligned}
t_p &= 0'' && \text{(Pressure)} \\
t_m &= M / (\pi R_m^2 S_c K_s) && \text{(bending)} \\
&= 1,145 / (\pi 23.115^2 13,907.75 1.20) \\
&= 0'' \\
t_w &= W / (2 \pi R_m S_c K_s) && \text{(Weight)} \\
&= 1,759.7 / (2 \pi 23.115 13,907.75 1.20) \\
&= 0.0007'' \\
t_t &= |t_p + t_m - t_w| && \text{(total, net compressive)} \\
&= |0 + 0 - (0.0007)| \\
&= \underline{0.0007''} \\
t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\
&= 0 + (0.0007) - (0) \\
&= \underline{0.0008''}
\end{aligned}$$

Vacuum. Wind. Bottom Seam

$$\begin{aligned}
t_p &= P R / (2 S_c K_s + 0.40 |P|) && \text{(Pressure)} \\
&= -15 22.23 / (2 13,728.59 1.20 + 0.40 |15|) \\
&= -0.0101'' \\
t_m &= M / (\pi R_m^2 S_c K_s) && \text{(bending)} \\
&= 1,145 / (\pi 23.115^2 13,728.59 1.20) \\
&= 0'' \\
t_w &= W / (2 \pi R_m S_c K_s) && \text{(Weight)} \\
&= 1,759.7 / (2 \pi 23.115 13,728.59 1.20) \\
&= 0.0007'' \\
t_t &= |t_p + t_m - t_w| && \text{(total, net compressive)} \\
&= |-0.0101 + 0 - (0.0007)| \\
&= \underline{0.0108''} \\
t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\
&= 0 + (0.0007) - (-0.0101) \\
&= \underline{0.0109''}
\end{aligned}$$

Maximum Allowable External Pressure, Longitudinal Stress

$$\begin{aligned} P &= 2*S_c*K_s*(t - t_{mc} - t_{wc}) / (R - 0.40*(t - t_{mc} - t_{wc})) \\ &= 2*13,728.59*1.20*(1.77 - 0 - 0.0007) / (22.23 - 0.40*(1.77 - 0 - 0.0007)) \\ &= 2,708.51 \text{ psi} \end{aligned}$$

Hot Shut Down, Corroded, Weight & Eccentric Moments Only, Bottom Seam

$$\begin{aligned} t_p &= 0'' && \text{(Pressure)} \\ t_m &= M / (\pi*R_m^2*S_c*K_s) && \text{(bending)} \\ &= 826 / (\pi*23.115^2*13,728.59*1.00) \\ &= 0'' \\ t_w &= W / (2*\pi*R_m*S_c*K_s) && \text{(Weight)} \\ &= 1,759.7 / (2*\pi*23.115*13,728.59*1.00) \\ &= 0.0009'' \\ t_t &= |t_p + t_m - t_w| && \text{(total, net compressive)} \\ &= |0 + 0 - (0.0009)| \\ &= \underline{0.0008''} \\ t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\ &= 0 + (0.0009) - (0) \\ &= \underline{0.0009''} \end{aligned}$$

Operating, Hot & Corroded, Seismic, Bottom Seam

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

Maximum allowable working pressure, Longitudinal Stress

$$\begin{aligned} P &= 2*S_t*K_s*E_c*(t - t_m + t_w) / (R - 0.40*(t - t_m + t_w)) \\ &= 2*20,000*1.20*1.00*(1.77 - 0.0007 + (0.0005)) / (22.23 - 0.40*(1.77 - 0.0007 + (0.0005))) \\ &= 3,947.25 \text{ psi} \end{aligned}$$

Operating, Hot & New, Seismic, Bottom Seam

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

Maximum allowable working pressure, Longitudinal Stress

$$\begin{aligned}P &= 2 \cdot S_t \cdot K_s \cdot E_c \cdot (t - t_m + t_w) / (R - 0.40 \cdot (t - t_m + t_w)) \\ &= 2 \cdot 20,000 \cdot 1.20 \cdot 1.00 \cdot (1.77 - 0.0007 + (0.0005)) / (22.23 - 0.40 \cdot (1.77 - 0.0007 + (0.0005))) \\ &= 3,947.25 \text{ psi}\end{aligned}$$

Hot Shut Down, Corroded, Seismic, Bottom Seam

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

$$= 0.0024''$$

Hot Shut Down, New, Seismic, Bottom Seam

$$\begin{aligned}t_p &= 0'' && \text{(Pressure)} \\t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\&= 26,243 / (\pi * 23.115^2 * 20,000 * 1.20 * 1.00) \\&= 0.0007'' \\t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\&= 1,759.7 / (2 * \pi * 23.115 * 20,000 * 1.20 * 1.00) \\&= 0.0005'' \\t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\&= 0 + 0.0007 - (0.0005) \\&= 0.0001'' \\t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\&= 26,243 / (\pi * 23.115^2 * 13,728.59 * 1.20) \\&= 0.0009'' \\t_{wc} &= (1 + VAccel) * W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\&= 2.00 * 1,759.7 / (2 * \pi * 23.115 * 13,728.59 * 1.20) \\&= 0.0015'' \\t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\&= 0.0009 + (0.0015) - (0) \\&= 0.0024''\end{aligned}$$

Empty, Corroded, Seismic, Bottom Seam

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

Empty, New, Seismic, Bottom Seam

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

Vacuum, Seismic, Bottom Seam

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

Maximum Allowable External Pressure, Longitudinal Stress

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

= 2,705.92 psi

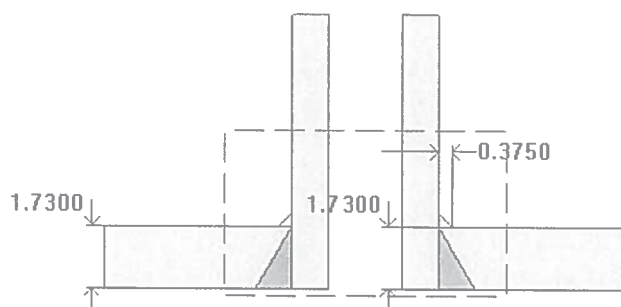


Vent (N14)

ASME Section VIII Division 1, 2010 Edition, A11 Addenda

$$t_{w(\text{lower})} = 1.73 \text{ in}$$

$$Leg_{41} = 0.375 \text{ in}$$



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, ln. 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 _{pr} :	5.2776 in
Projection available outside vessel to flange face, L _f :	7.0276 in
Local vessel minimum thickness:	1.73 in
Liquid static head included:	0 psi
Longitudinal joint efficiency:	1

ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 LWN A182 F316
Bolt Material:	SA-193 B7 Bolt $\leq 2 \frac{1}{2}$ (II-D p. 334, ln. 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:
MAP rating:
Hydrotest rating:
PWHT performed:

2,040 psi @ 140°F
2,160 psi @ 50°F
3,250 psi @ 50°F
No



Reinforcement Calculations for Chamber MAWP

UG-37 Area Calculation Summary (in ²) For P = 1,378 psi @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2074	1.06

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

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

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)

$$\begin{aligned}
 t_{rn} &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

Required thickness t_r 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

UG-37 Area Calculation Summary (in ²) For Pe = 566.01 psl @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2074	1.06

UG-41 Weld Failure Path Analysis Summary
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 ₄₁)	0.25	0.2625	weld size is adequate

Calculations for external pressure 566.01 psi @ 140 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.2205, 1.1103 + (1.06 - 0) + (1.73 - 0)) \\
 &= 3.9003 \text{ in}
 \end{aligned}$$

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 $t_{rn} = 0.1383 \text{ in}$

From UG-37(d)(1) required thickness $t_r = 1.73 \text{ in}$

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

UW-16(c) Weld Check

Fillet weld: $t_{min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$
 $t_{c(min)} = \text{lesser of } 0.25 \text{ or } 0.7*t_{min} = 0.25 \text{ in}$
 $t_{c(actual)} = 0.7*Leg = 0.7*0.375 = 0.2625 \text{ in}$

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

Interpretation VIII-1-83-66 has been applied.

$$t_{a \text{ UG-28}} = 0.1383 \text{ in}$$

$$\begin{aligned} t_a &= \max[t_{a \text{ UG-28}}, t_{a \text{ UG-22}}] \\ &= \max[0.1383, 0] \\ &= 0.1383 \text{ in} \end{aligned}$$

$$t_{b2} = 0.6623 \text{ in}$$

$$\begin{aligned} t_{b2} &= \max[t_{b2}, t_{b \text{ UG16}}] \\ &= \max[0.6623, 0.0625] \\ &= 0.6623 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[t_{b3}, t_{b2}] \\ &= \min[0.2074, 0.6623] \\ &= 0.2074 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[t_a, t_b] \\ &= \max[0.1383, 0.2074] \\ &= 0.2074 \text{ in} \end{aligned}$$

Available nozzle wall thickness new, $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

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

$$L / D_o = 9.0272 / 4.12 = 2.1911$$

$$D_o / t = 4.12 / 0.1383 = 29.7856$$

From table G: $A = 0.003548$

From table
HA-2: $B = 12,644.1965 \text{ psi}$

$$\begin{aligned} P_a &= 4*B / (3*(D_o / t)) \\ &= 4*12,644.2 / (3*(4.12 / 0.1383)) \\ &= 566.01 \text{ psi} \end{aligned}$$

Design thickness for external pressure $P_a = 566.01 \text{ psi}$

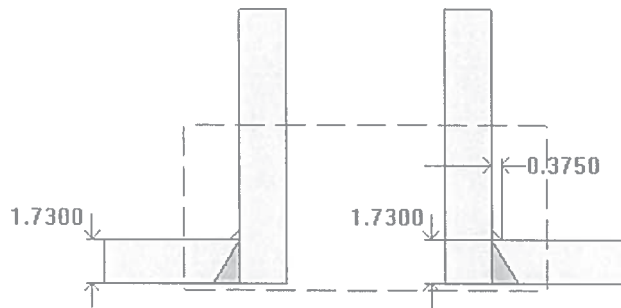
$$t_a = t + \text{Corrosion} = 0.1383 + 0 = 0.1383''$$

Gas Outlet (N2)

ASME Section VIII Division 1, 2010 Edition, A11 Addenda

$$t_{w(\text{lower})} = 1.73 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

Location and Orientation

Located on:	48 OD TOP SE HEAD
Orientation:	0°
End of nozzle to datum line:	-24.5 in
Calculated as hillside:	No
Distance to head center, R:	0 in
Passes through a Category A joint:	No

Nozzle

Access opening:	No
Material specification:	SA-182 F316 ≤ 5 (II-D p. 70, In. 22)
Inside diameter, new:	8 in
Nominal wall thickness:	1.875 in
Corrosion allowance:	0 in
Projection available outside vessel, Lpr:	7.2764 in
Projection available outside vessel to flange face, Lf:	10.0264 in
Local vessel minimum thickness:	1.73 in
Liquid static head included:	0 psi
Longitudinal joint efficiency:	1

ASME B16.5-2009 Flange

Description:	NPS 8 Class 900 LWN A182 F316
Bolt Material:	SA-193 B7 Bolt $\leq 2 \frac{1}{2}$ (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:
Hydrotest rating:
PWHT performed:

2,160 psi @ 50°F
3,250 psi @ 50°F
No



Reinforcement Calculations for Chamber MAWP

UG-37 Area Calculation Summary (in²) For P = 1,378 psi @ 140 °F The opening is adequately reinforced							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
11.5866	16.1259	2.2534	13.7319	--	--	0.1406	0.3281	1.875

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

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.25	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)

$$\begin{aligned}
 t_n &= P * R_n / (S_n * E - 0.6 * P) \\
 &= 1,378 * 4 / (20,000 * 1 - 0.6 * 1,378) \\
 &= 0.2875 \text{ in}
 \end{aligned}$$

Required thickness t_r from UG-37(a)(c)

$$\begin{aligned}
 t_r &= P * K_1 * D_o / (2 * S * E + 0.8 * P) \\
 &= 1,378 * 0.9 * 48 / (2 * 20,000 * 1 + 0.8 * 1,378) \\
 &= 1.4483 \text{ in}
 \end{aligned}$$

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

$A_1 = \text{larger of the following} = \underline{2.2534} \text{ in}^2$

$$\begin{aligned} &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 8 \cdot (1 \cdot 1.73 - 1 \cdot 1.4483) - 2 \cdot 1.875 \cdot (1 \cdot 1.73 - 1 \cdot 1.4483) \cdot (1 - 1) \\ &= 2.2534 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2 \cdot (1.73 + 1.875) \cdot (1 \cdot 1.73 - 1 \cdot 1.4483) - 2 \cdot 1.875 \cdot (1 \cdot 1.73 - 1 \cdot 1.4483) \cdot (1 - 1) \\ &= 2.0309 \text{ in}^2 \end{aligned}$$

$A_2 = \text{smaller of the following} = \underline{13.7319} \text{ in}^2$

$$\begin{aligned} &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t \\ &= 5 \cdot (1.875 - 0.2875) \cdot 1 \cdot 1.73 \\ &= 13.7319 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (1.875 - 0.2875) \cdot 1 \cdot 1.875 \\ &= 14.8828 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} A_{41} &= \text{Leg}^2 \cdot f_{r2} \\ &= 0.375^2 \cdot 1 \\ &= \underline{0.1406} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_{41} \\ &= 2.2534 + 13.7319 + 0.1406 \\ &= \underline{16.1259} \text{ in}^2 \end{aligned}$$

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

UG-37 Area Calculation Summary (in ²) For Pe = 566.01 psi @ 140 °F The opening is adequately reinforced							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
6.92	13.2159	--	13.0753	--	--	0.1406	0.3634	1.875

UG-41 Weld Failure Path Analysis Summary
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 ₄₁)	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 $t_{rn} = 0.3634 \text{ in}$

From UG-37(d)(1) required thickness $t_r = 1.73 \text{ in}$

Area required per UG-37(d)(1)

Allowable stresses: $S_n = 20,000$, $S_v = 20,000 \text{ psi}$

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$\begin{aligned}
 A &= 0.5*(d*t_r*F + 2*t_n*t_r*F*(1 - f_{r1})) \\
 &= 0.5*(8*1.73*1 + 2*1.875*1.73*1*(1 - 1))
 \end{aligned}$$

$$= \underline{6.92} \text{ in}^2$$

Area available from FIG. UG-37.1

$$A_1 = \text{larger of the following} = \underline{0} \text{ in}^2$$

$$\begin{aligned} &= d(E_1 t - F t_r) - 2 t_n (E_1 t - F t_r) (1 - f_{r1}) \\ &= 8(1 \cdot 1.73 - 1 \cdot 1.73) - 2 \cdot 1.875(1 \cdot 1.73 - 1 \cdot 1.73)(1 - 1) \\ &= 0 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 2(t + t_n)(E_1 t - F t_r) - 2 t_n (E_1 t - F t_r) (1 - f_{r1}) \\ &= 2(1.73 + 1.875)(1 \cdot 1.73 - 1 \cdot 1.73) - 2 \cdot 1.875(1 \cdot 1.73 - 1 \cdot 1.73)(1 - 1) \\ &= 0 \text{ in}^2 \end{aligned}$$

$$A_2 = \text{smaller of the following} = \underline{13.0753} \text{ in}^2$$

$$\begin{aligned} &= 5(t_n - t_m) f_{r2} t \\ &= 5(1.875 - 0.3634) \cdot 1 \cdot 1.73 \\ &= 13.0753 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 5(t_n - t_m) f_{r2} t_n \\ &= 5(1.875 - 0.3634) \cdot 1 \cdot 1.875 \\ &= 14.1712 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} A_{41} &= \text{Leg}^2 f_{r2} \\ &= 0.375^2 \cdot 1 \\ &= \underline{0.1406} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_{41} \\ &= 0 + 13.0753 + 0.1406 \\ &= \underline{13.2159} \text{ in}^2 \end{aligned}$$

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 $0.7 t_{\min} = \underline{0.25}$ in

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

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

UG-45 Nozzle Neck Thickness Check

Interpretation VIII-1-83-66 has been applied.

$$t_{a \text{ UG-28}} = 0.3634 \text{ in}$$

$$\begin{aligned} t_a &= \max[t_{a \text{ UG-28}}, t_{a \text{ UG-22}}] \\ &= \max[0.3634, 0] \\ &= 0.3634 \text{ in} \end{aligned}$$

$$t_{b2} = 0.6623 \text{ in}$$

$$\begin{aligned} t_{b2} &= \max[t_{b2}, t_{b \text{ UG16}}] \\ &= \max[0.6623, 0.0625] \\ &= 0.6623 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[t_{b3}, t_{b2}] \\ &= \min[0.3281, 0.6623] \\ &= 0.3281 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[t_a, t_b] \\ &= \max[0.3634, 0.3281] \\ &= 0.3634 \text{ in} \end{aligned}$$

Available nozzle wall thickness new, $t_n = 1.875 \text{ in}$

The nozzle neck thickness is adequate.

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

$$L / D_o = 10.0264 / 11.75 = 0.8533$$

$$D_o / t = 11.75 / 0.3634 = 32.3334$$

$$\text{From table G: } A = 0.009195$$

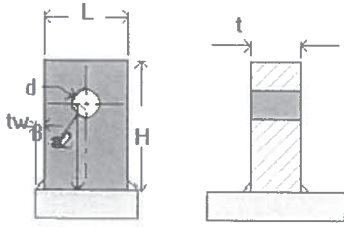
$$\begin{aligned} \text{From table HA-2: } B &= 13,725.7301 \text{ psi} \end{aligned}$$

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

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, D _p	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, β	145.3411 °
Load Angle from Vertical, φ	110.7073 °

Intermediate Values

Load Factor	1.5000
Vessel Weight (new, incl. Load Factor), W	27406 lb
Lug Weight (new), W_{lug}	16 lb
Distance from Center of Gravity to Top Lug, l_1	70.4868"
Distance from Center of Gravity to Tail Lug, l_2	61.8933"
Distance from Vessel Center Line to Tail Lug, l_3	28.375"
Allowable Stress, Tensile, σ_t	19980 psi
Allowable Stress, Shear, σ_s	13320 psi
Allowable Stress, Bearing, σ_p	29970 psi
Allowable Stress, Bending, σ_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

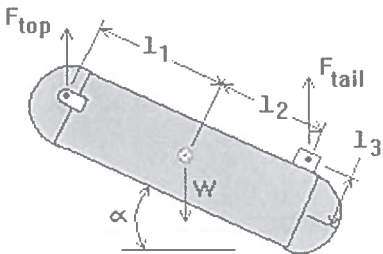
Required Lift Pin Diameter, d_{regd}	0.8093"
Required Lug Thickness, t_{regd}	0.3048"
Lug Stress Ratio, σ_{ratio}	0.21
Weld Shear Stress Ratio, τ_{ratio}	0.36
Lug Design	Acceptable
Local Stresses	Acceptable

Lift Forces

Lift force on lugs during rotational lift ($0^\circ \leq \alpha \leq 90^\circ$):

$$2 * F_{top} = W * (l_2 * \cos(\alpha) + l_3 * \sin(\alpha)) / (l_1 * \cos(\alpha) + l_2 * \cos(\alpha) + l_3 * \sin(\alpha))$$

$$F_{tail} = W - (2 * F)$$



α [°]	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 ¹	13,703	0
90 ²	13,703	0
¹ Lift angle at maximum lug stress.		
² Lift angle at maximum weld stress.		
Shell angle at lift lug	235.37°	

Lug Pin Diameter - Shear stress

$$d_{reqd} = (2 \cdot F_r / (\pi \cdot \sigma_s))^{0.5}$$

$$= (2 \cdot 13,703 / (\pi \cdot 13,320))^{0.5} = \underline{0.8093"}$$

$$d_{reqd} / D_p = 0.8093 / 1.5 = 0.54 \quad \text{Acceptable}$$

$$\sigma = F_r / A$$

$$= F_r / (2 \cdot (0.25 \cdot \pi \cdot D_p^2))$$

$$= 13,703 / (2 \cdot (0.25 \cdot \pi \cdot 1.5^2)) = 3,877 \text{ psi}$$

$$\sigma / \sigma_s = 3,877 / 13,320 = 0.29 \quad \text{Acceptable}$$

Lug Thickness - Tensile stress

$$t_{reqd} = F_r / ((L - d) \cdot \sigma_t)$$

$$= 13,703 / ((5 - 1.5625) \cdot 19,980) = 0.1995"$$

$$t_{reqd} / t = 0.1995 / 1.5 = 0.13 \quad \text{Acceptable}$$

$$\sigma = F_r / A$$

$$= F_r / ((L - d) \cdot t)$$

$$= 13,703 / ((5 - 1.5625) \cdot 1.5) = 2,658 \text{ psi}$$

$$\sigma / \sigma_t = 2,658 / 19,980 = 0.13 \quad \text{Acceptable}$$

Lug Thickness - Bearing stress

$$t_{reqd} = F_v / (D_p \cdot \sigma_p)$$

$$= 13,703 / (1.5 \cdot 29,970) = \underline{0.3048"}$$

$$t_{\text{reqd}} / t = 0.3048 / 1.5 = 0.20 \quad \text{Acceptable}$$

$$\begin{aligned} \sigma &= F_v / A_{\text{bearing}} \\ &= F_v / (D_p * t) \\ &= 13,703 / (1.5 * (1.5)) = 6,090 \text{ psi} \end{aligned}$$

$$\sigma / \sigma_p = 6,090 / 29,970 = 0.2 \quad \text{Acceptable}$$

Lug Thickness - Shear stress

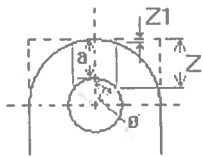
$$\begin{aligned} t_{\text{reqd}} &= [F_v / \sigma_s] / (2 * L_{\text{shear}}) \\ &= (13,703 / 13,320) / (2 * 2.0153) = \underline{0.2552"} \end{aligned}$$

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

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

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

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



$$\begin{aligned} \phi &= 55 * D_p / d \\ &= 55 * 1.5 / 1.5625 \\ &= 52.8^\circ \end{aligned}$$

$$\begin{aligned} L_{\text{shear}} &= (H - a_2 - 0.5 * d) + 0.5 * D_p * (1 - \cos(\phi)) \\ &= (7.5 - 5 - 0.5 * 1.5625) + 0.5 * 1.5 * (1 - \cos(52.8)) \\ &= 2.0153" \end{aligned}$$

Lug Plate Stress

Lug stress tensile + bending during lift:

$$\begin{aligned} \sigma_{\text{ratio}} &= [F_{\text{ten}} / (A_{\text{ten}} * \sigma_t)] + [M_{\text{bend}} / (Z_{\text{bend}} * \sigma_b)] \leq 1 \\ &= [(F_r * \cos(\alpha)) / (t * L * \sigma_t)] + [(6 * \text{abs}(F_r * \sin(\alpha) * \text{Hght} - F_r * \cos(\alpha) * a_1)) / (t * L^2 * \sigma_b)] \leq 1 \\ &= (13,703 * \cos(145.4)) / (1.5 * 5 * 19,980) + 6 * \text{abs}(13,703 * \sin(145.4) * 5 - 13,703 * \cos(145.4) * 0) / (1.5 * 5^2 * 22,201) \\ &= \underline{0.21} \quad \text{Acceptable} \end{aligned}$$

Weld Stress

Weld stress, tensile, bending and shear during lift:

Direct shear:

Shear stress at lift angle 145.34°; lift force = 13,703 lbf

$$A_{\text{weld}} = 2 \cdot (0.707) \cdot t_w \cdot (L + t)$$

$$= 2 \cdot (0.707) \cdot 0.5 \cdot (5 + 1.5) = 4.5955 \text{ in}^2$$

$$\tau_t = F_r \cdot \cos(\alpha) / A_{\text{weld}}$$

$$= 13,703 \cdot \cos(145.3) / 4.5955 = -2,453 \text{ psi}$$

$$\tau_s = F_r \cdot \sin(\alpha) / A_{\text{weld}}$$

$$= 13,703 \cdot \sin(145.3) / 4.5955 = 1,696 \text{ psi}$$

$$\tau_b = \frac{M \cdot c}{I}$$

$$= \frac{3 \cdot (F_r \cdot \sin(\alpha) \cdot \text{Hght} - F_r \cdot \cos(\alpha) \cdot a_1)}{(0.707 \cdot h \cdot L \cdot (3 \cdot t + L))}$$

$$= \frac{3 \cdot \text{abs}(13,703 \cdot \sin(145.3) \cdot 5 - 13,703 \cdot \cos(145.3) \cdot (0))}{(16.7912)}$$

$$= 6,961 \text{ psi}$$

$$\tau_{\text{ratio}} = \text{sqr}((\tau_t + \tau_b)^2 + \tau_s^2) / \tau_{\text{allowable}} \leq 1$$

$$= \text{sqr}((-2,453 + 6,961)^2 + (1,696)^2) / 13,320$$

$$= \underline{0.36}$$

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_{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	13.703 lbf
Maximum Allowable Load, F_{Rmax}	68.941 lbf
Load Acceptance Ratio, F_R / F_{Rmax}	0.1988
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

$$F_r = \text{force on vessel at lug}$$

$$F_r = [W / \cos(\phi_1)] \cdot (1 - x_1 / (x_1 + x_2))$$

$$= (27,405.6) / \cos(110.7073) \cdot (1 - 0 / (0 + 0))$$

$$= 13.703 \text{ lbf}$$

where 'x₁' is the distance between this lug and the center of gravity
 'x₂' 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

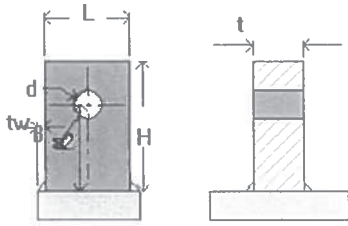
$$\begin{aligned} K_1 &= (1 - v_2^2) / ((1/3 + v_1 * v_2) + \text{sqr}((1/3 + v_1 * v_2)^2 + (1 - v_2^2) * v_1^2)) \\ &= (1 - 0^2) / ((1/3 + 0.0554 * 0) + \text{sqr}((1/3 + 0.0554 * 0)^2 + (1 - 0^2) * 0.0554^2)) \\ &= 1.4898 \end{aligned}$$

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

Maximum Allowable Load

$$\begin{aligned} F_{Rmax} &= \sigma_b * e_n^2 / (K_{13} * |\cos(\beta)| + K_{14} * |a_2 * \sin(\beta) - a_1 * \cos(\beta)| / b_1) \\ &= 37,244 * (1.73)^2 / (0.8216 * |\cos(145.3411)| + 1.6548 * |5 * \sin(145.3411) - 0 * \cos(145.3411)| / 5) \\ &= \underline{68,941 \text{ lbf}} \end{aligned}$$

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 _p	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, 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, σ_t	19980 psi
Allowable Stress, Shear, σ_s	13320 psi
Allowable Stress, Bearing, σ_p	29970 psi
Allowable Stress, Bending, σ_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

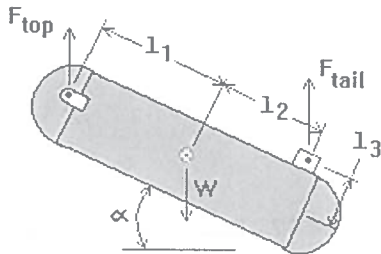
Required Lift Pin Diameter, d_{reqd}	<u>0.8093"</u>
Required Lug Thickness, t_{reqd}	<u>0.3048"</u>
Lug Stress Ratio, σ_{ratio}	<u>0.22</u>
Weld Shear Stress Ratio, τ_{ratio}	<u>0.39</u>
Lug Design	Acceptable
Local Stresses	Acceptable

Lift Forces

Lift force on lugs during rotational lift ($0^\circ \leq \alpha \leq 90^\circ$):

$$2 * F_{top} = W * (l_2 * \cos(\alpha) + l_3 * \sin(\alpha)) / (l_1 * \cos(\alpha) + l_2 * \cos(\alpha) + l_3 * \sin(\alpha))$$

$$F_{tail} = W - (2 * F)$$



α [°]	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 ¹	13,703	0
90 ²	13,703	0
¹ Lift angle at maximum lug stress.		
² Lift angle at maximum weld stress.		
Shell angle at lift lug	233.22°	

Lug Pin Diameter - Shear stress

$$d_{reqd} = (2F_r / (\pi\sigma_s))^{0.5}$$

$$= (2 \cdot 13,703 / (\pi \cdot 13,320))^{0.5} = \underline{0.8093"}$$

$$d_{reqd} / D_p = 0.8093 / 1.5 = 0.54 \quad \text{Acceptable}$$

$$\sigma = F_r / A$$

$$= F_r / (2 \cdot (0.25 \cdot \pi \cdot D_p^2))$$

$$= 13,703 / (2 \cdot (0.25 \cdot \pi \cdot 1.5^2)) = 3,877 \text{ psi}$$

$$\sigma / \sigma_s = 3,877 / 13,320 = 0.29 \quad \text{Acceptable}$$

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

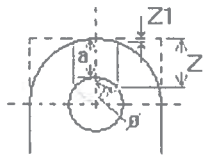
$$\begin{aligned} t_{\text{reqd}} &= [F_v / \sigma_s] / (2 * L_{\text{shear}}) \\ &= (13,703 / 13,320) / (2 * 2.0153) = \underline{0.2552"} \end{aligned}$$

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

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

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

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



$$\begin{aligned} \phi &= 55 * D_p / d \\ &= 55 * 1.5 / 1.5625 \\ &= 52.8^\circ \end{aligned}$$

$$\begin{aligned} L_{\text{shear}} &= (H - a_2 - 0.5 * d) + 0.5 * D_p * (1 - \cos(\phi)) \\ &= (7.5 - 5 - 0.5 * 1.5625) + 0.5 * 1.5 * (1 - \cos(52.8)) \\ &= 2.0153" \end{aligned}$$

Lug Plate Stress

Lug stress tensile + bending during lift:

$$\begin{aligned} \sigma_{\text{ratio}} &= [F_{\text{ten}} / (A_{\text{ten}} * \sigma_t)] + [M_{\text{bend}} / (Z_{\text{bend}} * \sigma_b)] \leq 1 \\ &= [(F_r * \cos(\alpha)) / (t * L * \sigma_t)] + [(6 * \text{abs}(F_r * \sin(\alpha) * \text{Hght} - F_r * \cos(\alpha) * a_1)) / (t * L^2 * \sigma_b)] \leq 1 \\ &= (13,703 * \cos(143.2)) / (1.5 * 5 * 19,980) + (6 * \text{abs}(13,703 * \sin(143.2) * 5 - 13,703 * \cos(143.2) * 0)) / (1.5 * 5^2 * 22,201) \\ &= \underline{0.22} \quad \text{Acceptable} \end{aligned}$$

Weld Stress

Weld stress, tensile, bending and shear during lift:

Direct shear:

Shear stress at lift angle 143.19°; lift force = 13,703 lbf

$$A_{\text{weld}} = 2 \cdot (0.707) \cdot t_w \cdot (L + t)$$

$$= 2 \cdot (0.707) \cdot 0.5 \cdot (5 + 1.5) = 4.5955 \text{ in}^2$$

$$\tau_t = F_r \cdot \cos(\alpha) / A_{\text{weld}}$$

$$= 13,703 \cdot \cos(143.2) / 4.5955 = -2,387 \text{ psi}$$

$$\tau_s = F_r \cdot \sin(\alpha) / A_{\text{weld}}$$

$$= 13,703 \cdot \sin(143.2) / 4.5955 = 1,786 \text{ psi}$$

$$\tau_b = \frac{M \cdot c}{I}$$

$$= \frac{3 \cdot (F_r \cdot \sin(\alpha) \cdot \text{Hght} - F_r \cdot \cos(\alpha) \cdot a_1)}{(0.707 \cdot h \cdot L \cdot (3 \cdot t + L))}$$

$$= \frac{3 \cdot \text{abs}(13,703 \cdot \sin(143.2) \cdot 5 - 13,703 \cdot \cos(143.2) \cdot (0))}{(16.7912)}$$

$$= 7,334 \text{ psi}$$

$$\tau_{\text{ratio}} = \frac{\text{sqr}((\tau_t + \tau_b)^2 + \tau_s^2)}{\tau_{\text{allowable}}} \leq 1$$

$$= \frac{\text{sqr}((-2,387 + 7,334)^2 + (1,786)^2)}{13,320}$$

$$= 0.39 \quad \text{Acceptable}$$

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_{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	13.703 lbf
Maximum Allowable Load, F_{Rmax}	67.596 lbf
Load Acceptance Ratio, F_r / F_{Rmax}	0.2027
Lug Design	Acceptable

Equivalent Inner Diameter

$$ID_{eq} = D_i \sqrt{1 - 3(x / D_i)^2}$$

$$ID_{eq} = 44.54 \sqrt{1 - 3(19.5044 / 44.54)^2}$$

$$ID_{eq} = 29.0267''$$

where 'x' is the distance between the axis of semi-ellipsoidal head and the center of the lug

Applied Force

$$F_r = \text{force on vessel at lug}$$

$$F_r = [W / \cos(\phi_1)] * (1 - x_1 / (x_1 + x_2))$$

$$= (27,405.6) / \cos(106.4106) * (1 - 0 / (0 + 0))$$

$$= 13.703 \text{ lbf}$$

where 'x₁' is the distance between this lug and the center of gravity
 'x₂' is the distance between the second lift lug and the center of gravity

Lug factors

$$\lambda = \text{line load factor}$$

$$\lambda = b / \sqrt{ID_{eq} * e_n}$$

$$= 5 / \sqrt{29.0267 * 1.73}$$

$$= 0.706$$

$$v_1 = \text{ratio between local membrane stress and local bending stress}$$

$$v_1 = \min(0.08 * \lambda, 0.2)$$

$$= 0.056$$

$$\sigma_m = \text{global membrane stress}$$

$$\sigma_m = P * ID_{eq} / (2 * e_n)$$

$$= 0 * 29.0267 / (2 * 1.73)$$

$$= 0.0000 \text{ psi}$$

$$v_2 = \text{ratio between global membrane stress and allowable stress}$$

$$v_2 = \sigma_m / (K_2 * f)$$

$$= 0 / (1.25 * 20,000)$$

$$= 0$$

$$K_{13} = 1 / (1.2 * \sqrt{1 + 0.06 * \lambda^2})$$

$$= 1 / (1.2 * \sqrt{1 + 0.06 * 0.7056^2})$$

$$= 0.8212$$

$$\begin{aligned} K_{14} &= 1 / (0.6 * \text{sqr}(1 + 0.03 * \lambda^2)) \\ &= 1 / (0.6 * \text{sqr}(1 + 0.03 * 0.7056^2)) \\ &= 1.6544 \end{aligned}$$

Bending Limit Stress

$$\begin{aligned} K_1 &= (1 - \nu_2^2) / ((1/3 + \nu_1 * \nu_2) + \text{sqr}((1/3 + \nu_1 * \nu_2)^2 + (1 - \nu_2^2) * \nu_1^2)) \\ &= (1 - 0^2) / ((1/3 + 0.0564 * 0) + \text{sqr}((1/3 + 0.0564 * 0)^2 + (1 - 0^2) * 0.0564^2)) \\ &= 1.4894 \end{aligned}$$

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

Maximum Allowable Load

$$\begin{aligned} F_{Rmax} &= \sigma_b * e_n^2 / (K_{13} * |\cos(\beta)| + K_{14} * |a_2 * \sin(\beta) - a_1 * \cos(\beta)| / b_1) \\ &= 37,235 * (1.73)^2 / (0.8212 * |\cos(143.1925)| + 1.6544 * |5 * \sin(143.1925) - 0 * \cos(143.1925)| / 5) \\ &= \underline{67.596 \text{ lbf}} \end{aligned}$$

48 OD SHELL

ASME Section VIII Division 1, 2010 Edition, A11 Addenda

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

Internal design pressure: $P = 1,378$ psi @ 140 °F
External design pressure: $P_e = 15$ psi @ 140 °F

Static liquid head:

$P_s = 0.64$ psi (SG = 1.1, $H_s = 16$ ", Operating head)
 $P_{th} = 2.03$ psi (SG = 1, $H_s = 56.25$ ", Horizontal test head)

Corrosion allowance Inner C = 0" Outer C = 0"

Design MDMT = -20 °F No impact test performed
Rated MDMT = -320 °F Material is not normalized
Material is not produced to Fine Grain Practice
PWHT is not performed

Radiography: Longitudinal joint - Full UW-11(a) Type 1
Top circumferential joint - Full UW-11(a) Type 1
Bottom circumferential joint - Full UW-11(a) Type 1

Estimated weight New = 6,385.9 lb corr = 6,385.9 lb
Capacity New = 646.35 US gal corr = 646.35 US gal

OD = 48"
Length = 96"
 L_c
t = 1.75"

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

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"

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

P = $S \cdot E \cdot t / (R_o - 0.40 \cdot t) - P_s$
= $20,000 \cdot 1.00 \cdot 1.75 / (24 - 0.40 \cdot 1.75) - 0.64$
= 1,501.51 psi

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

$L / D_o = 107.4233 / 48 = 2.2380$
 $D_o / t = 48 / 0.2194 = 218.7532$
From table G: A = 0.000180
From table HA-2: B = 2,460.9773 psi

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

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

$$= 15 \text{ psi}$$

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)

$$L / D_o = 107.4233 / 48 = 2.2380$$

$$D_o / t = 48 / 1.75 = 27.4286$$

$$\text{From table G: } A = 0.003965$$

$$\text{From table HA-2: } B = 12,805.8347 \text{ psi}$$

$$P_a = 4 * B / (3 * (D_o / t))$$

$$= 4 * 12,805.83 / (3 * (48 / 1.75))$$

$$= 622.51 \text{ psi}$$

% Forming strain - UHA-44(a)(2)(a)

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

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

$$= 3.7838\%$$

External Pressure + Weight + Wind Loading Check (Bergman, ASME paper 54-A-104)

$$P_v = W / (2 * \pi * R_m) + M / (\pi * R_m^2)$$

$$= 16,039 / (2 * \pi * 23.125) + 270,826 / (\pi * 23.125^2)$$

$$= 271.5912 \text{ lb/in}$$

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

$$= 271.5912 / (15 * 48)$$

$$= 0.3772$$

$$n = 3$$

$$m = 1.23 / (L / D_o)^2$$

$$= 1.23 / (107.4233 / 48)^2$$

$$= 0.2456$$

$$\text{Ratio } P_e = (n^2 - 1 + m + m * \alpha) / (n^2 - 1 + m)$$

$$= (3^2 - 1 + 0.2456 + 0.2456 * 0.3772) / (3^2 - 1 + 0.2456)$$

$$= 1.0112$$

Ratio $P_e * P_e \leq$ MAEP design cylinder thickness is satisfactory.

External Pressure + Weight + Seismic Loading Check (Bergman, ASME paper 54-A-104)

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

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

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

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

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

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

Ratio $P_e * P_e \leq$ MAEP design cylinder thickness is satisfactory.

Design thickness = 1.61"

The governing condition is due to internal pressure.

The cylinder thickness of 1.75" is adequate.

Thickness Required Due to Pressure + External Loads

Condition	Pressure P (psi)	Allowable Stress Before UG-23 Stress Increase (psi)		Temperature (°F)	Corrosion C (In)	Load	Req'd Thk Due to Tension (In)	Req'd Thk Due to Compression (In)
		S _t	S _c					
<u>Operating, Hot & Corroded</u>	1,378	20,000	<u>13,716</u>	140	0	Wind	<u>0.6336</u>	<u>0.6202</u>
						Seismic	<u>0.6475</u>	<u>0.6017</u>
<u>Operating, Hot & New</u>	1,378	20,000	<u>13,716</u>	140	0	Wind	<u>0.6336</u>	<u>0.6202</u>
						Seismic	<u>0.6475</u>	<u>0.6017</u>
<u>Hot Shut Down, Corroded</u>	0	20,000	<u>13,716</u>	140	0	Wind	<u>0.0021</u>	<u>0.0165</u>
						Seismic	<u>0.016</u>	<u>0.0434</u>
<u>Hot Shut Down, New</u>	0	20,000	<u>13,716</u>	140	0	Wind	<u>0.0021</u>	<u>0.0165</u>
						Seismic	<u>0.016</u>	<u>0.0434</u>
<u>Empty, Corroded</u>	0	20,000	<u>13,895</u>	70	0	Wind	<u>0.0021</u>	<u>0.0163</u>
						Seismic	<u>0.0152</u>	<u>0.0418</u>
<u>Empty, New</u>	0	20,000	<u>13,895</u>	70	0	Wind	<u>0.0021</u>	<u>0.0163</u>
						Seismic	<u>0.0152</u>	<u>0.0418</u>
<u>Vacuum</u>	-15	20,000	<u>13,716</u>	140	0	Wind	<u>0.007</u>	<u>0.0266</u>
						Seismic	<u>0.009</u>	<u>0.0536</u>
<u>Hot Shut Down, Corroded, Weight & Eccentric Moments Only</u>	0	20,000	<u>13,716</u>	140	0	Weight	<u>0.0018</u>	<u>0.0188</u>

Allowable Compressive Stress, Hot and Corroded- S_{CHC}, (table HA-2)

A = 0.125 / (R_o / t)
 = 0.125 / (24 / 1.75)
 = 0.009115
 B = 13,716 psi
 S = 20,000 / 1.00 = 20,000 psi
 S_{CHC} = min(B, S) = 13,716 psi

Allowable Compressive Stress, Hot and New- S_{CHN}

S_{CHN} = S_{CHC}
 = 13,716 psi

Allowable Compressive Stress, Cold and New- S_{CCN}, (table HA-2)

A = 0.125 / (R_o / t)
 = 0.125 / (24 / 1.75)
 = 0.009115
 B = 13,895 psi
 S = 20,000 / 1.00 = 20,000 psi
 S_{CCN} = min(B, S) = 13,895 psi

Allowable Compressive Stress, Cold and Corroded- S_{CCC}

S_{CCC} = S_{CCN}
 = 13,895 psi

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

$$\begin{aligned}
 t_p &= 0" && \text{(Pressure)} \\
 t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\
 &= 270,826 / (\pi * 23.125^2 * 20,000 * 1.20 * 1.00) \\
 &= 0.0067" \\
 t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\
 &= 16,039 / (2 * \pi * 23.125 * 20,000 * 1.20 * 1.00) \\
 &= 0.0046" \\
 t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\
 &= 0 + 0.0067 - (0.0046) \\
 &= \underline{0.0021"} \\
 t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\
 &= 270,826 / (\pi * 23.125^2 * 13,894.91 * 1.20)
 \end{aligned}$$

$$= 0.0097''$$

$$\begin{aligned} t_{wc} &= W / (2 \cdot \pi \cdot R_m \cdot S_c \cdot K_s) && \text{(Weight)} \\ &= 16,039 / (2 \cdot \pi \cdot 23.125 \cdot 13,894.91 \cdot 1.20) \\ &= 0.0066'' \end{aligned}$$

$$\begin{aligned} t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\ &= 0.0097 + (0.0066) - (0) \\ &= \underline{0.0163''} \end{aligned}$$

Vacuum, Wind, Bottom Seam

$$\begin{aligned} t_p &= P \cdot R / (2 \cdot S_c \cdot K_s + 0.40 \cdot |P|) && \text{(Pressure)} \\ &= -15 \cdot 22.25 / (2 \cdot 13,715.98 \cdot 1.20 + 0.40 \cdot |15|) \\ &= -0.0101'' \end{aligned}$$

$$\begin{aligned} t_m &= M / (\pi \cdot R_m^2 \cdot S_c \cdot K_s) && \text{(bending)} \\ &= 270,826 / (\pi \cdot 23.125^2 \cdot 13,715.98 \cdot 1.20) \\ &= 0.0098'' \end{aligned}$$

$$\begin{aligned} t_w &= W / (2 \cdot \pi \cdot R_m \cdot S_c \cdot K_s) && \text{(Weight)} \\ &= 16,039 / (2 \cdot \pi \cdot 23.125 \cdot 13,715.98 \cdot 1.20) \\ &= 0.0067'' \end{aligned}$$

$$\begin{aligned} t_t &= |t_p + t_m - t_w| && \text{(total, net compressive)} \\ &= |-0.0101 + 0.0098 - (0.0067)| \\ &= \underline{0.007''} \end{aligned}$$

$$\begin{aligned} t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\ &= 0.0098 + (0.0067) - (-0.0101) \\ &= \underline{0.0266''} \end{aligned}$$

Maximum Allowable External Pressure, Longitudinal Stress

$$\begin{aligned} P &= 2 \cdot S_c \cdot K_s \cdot (t - t_{mc} - t_{wc}) / (R - 0.40 \cdot (t - t_{mc} - t_{wc})) \\ &= 2 \cdot 13,715.98 \cdot 1.20 \cdot (1.75 - 0.0098 - 0.0067) / (22.25 - 0.40 \cdot (1.75 - 0.0098 - 0.0067)) \\ &= 2,647.17 \text{ psi} \end{aligned}$$

Hot Shut Down, Corroded, Weight & Eccentric Moments Only, Bottom Seam

$$\begin{aligned} t_p &= 0'' && \text{(Pressure)} \\ t_m &= M / (\pi \cdot R_m^2 \cdot S_t \cdot K_s \cdot E_c) && \text{(bending)} \\ &= 246,659 / (\pi \cdot 23.125^2 \cdot 20,000 \cdot 1.00 \cdot 1.00) \\ &= 0.0073'' \end{aligned}$$

$$\begin{aligned} t_w &= W / (2 \cdot \pi \cdot R_m \cdot S_t \cdot K_s \cdot E_c) && \text{(Weight)} \\ &= 16,039 / (2 \cdot \pi \cdot 23.125 \cdot 20,000 \cdot 1.00 \cdot 1.00) \\ &= 0.0055'' \end{aligned}$$

$$\begin{aligned} t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\ &= 0 + 0.0073 - (0.0055) \\ &= \underline{0.0018''} \end{aligned}$$

$$\begin{aligned} t_{mc} &= M / (\pi \cdot R_m^2 \cdot S_c \cdot K_s) && \text{(bending)} \\ &= 246,659 / (\pi \cdot 23.125^2 \cdot 13,715.98 \cdot 1.00) \\ &= 0.0107'' \end{aligned}$$

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

$$= 16,039 / (2\pi * 23.125 * 13,715.98 * 1.00)$$

$$= 0.008"$$

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

$$= 0.0107 + (0.008) - (0)$$

$$= \underline{0.0188}"$$

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

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

$$= 1,378 * 22.25 / (2 * 20,000 * 1.20 * 1.00 + 0.40 * |1,378|)$$

$$= 0.6315"$$

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

$$= 830,156 / (\pi * 23.125^2 * 20,000 * 1.20 * 1.00)$$

$$= 0.0206"$$

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

$$= 16,039 / (2\pi * 23.125 * 20,000 * 1.20 * 1.00)$$

$$= 0.0046"$$

$$t_t = t_p + t_m - t_w \quad (\text{total required, tensile})$$

$$= 0.6315 + 0.0206 - (0.0046)$$

$$= 0.6475''$$

$$\begin{aligned} t_{wc} &= (1 + V_{Accel}) * W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\ &= 2.00 * 16,039 / (2 * \pi * 23.125 * 20,000 * 1.20 * 1.00) \\ &= 0.0092'' \end{aligned}$$

$$\begin{aligned} t_c &= |t_{mc} + t_{wc} - t_{pc}| && \text{(total, net tensile)} \\ &= |0.0206 + (0.0092) - (0.6315)| \\ &= 0.6017'' \end{aligned}$$

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

$$t_p = 0'' \quad \text{(Pressure)}$$

$$\begin{aligned} t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\ &= 830,156 / (\pi * 23.125^2 * 20,000 * 1.20 * 1.00) \\ &= 0.0206'' \end{aligned}$$

$$\begin{aligned} t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\ &= 16,039 / (2 * \pi * 23.125 * 20,000 * 1.20 * 1.00) \\ &= 0.0046'' \end{aligned}$$

$$\begin{aligned} t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\ &= 0 + 0.0206 - (0.0046) \\ &= 0.016'' \end{aligned}$$

$$\begin{aligned} t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\ &= 830,156 / (\pi * 23.125^2 * 13,715.98 * 1.20) \\ &= 0.03'' \end{aligned}$$

$$\begin{aligned} t_{wc} &= (1 + V_{Accel}) * W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\ &= 2.00 * 16,039 / (2 * \pi * 23.125 * 13,715.98 * 1.20) \\ &= 0.0134'' \end{aligned}$$

$$\begin{aligned} t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\ &= 0.03 + (0.0134) - (0) \\ &= 0.0434'' \end{aligned}$$

Hot Shut Down, New, Seismic, Bottom Seam

$$t_p = 0'' \quad \text{(Pressure)}$$

$$\begin{aligned} t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\ &= 830,156 / (\pi * 23.125^2 * 20,000 * 1.20 * 1.00) \\ &= 0.0206'' \end{aligned}$$

$$\begin{aligned} t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\ &= 16,039 / (2 * \pi * 23.125 * 20,000 * 1.20 * 1.00) \\ &= 0.0046'' \end{aligned}$$

$$\begin{aligned} t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\ &= 0 + 0.0206 - (0.0046) \end{aligned}$$

$$= 0.016''$$

$$\begin{aligned} t_{mc} &= M / (\pi R_m^2 S_c K_s) && \text{(bending)} \\ &= 830,156 / (\pi 23.125^2 13,715.98 1.20) \\ &= 0.03'' \end{aligned}$$

$$\begin{aligned} t_{wc} &= (1 + V_{\text{Accel}}) W / (2 \pi R_m S_c K_s) && \text{(Weight)} \\ &= 2.00 16,039 / (2 \pi 23.125 13,715.98 1.20) \\ &= 0.0134'' \end{aligned}$$

$$\begin{aligned} t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\ &= 0.03 + (0.0134) - (0) \\ &= 0.0434'' \end{aligned}$$

Empty, Corroded, Seismic, Bottom Seam

$$t_p = 0'' \quad \text{(Pressure)}$$

$$\begin{aligned} t_m &= M / (\pi R_m^2 S_t K_s E_c) && \text{(bending)} \\ &= 799,344 / (\pi 23.125^2 20,000 1.20 1.00) \\ &= 0.0198'' \end{aligned}$$

$$\begin{aligned} t_w &= W / (2 \pi R_m S_t K_s E_c) && \text{(Weight)} \\ &= 16,039 / (2 \pi 23.125 20,000 1.20 1.00) \\ &= 0.0046'' \end{aligned}$$

$$\begin{aligned} t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\ &= 0 + 0.0198 - (0.0046) \\ &= 0.0152'' \end{aligned}$$

$$\begin{aligned} t_{mc} &= M / (\pi R_m^2 S_c K_s) && \text{(bending)} \\ &= 799,344 / (\pi 23.125^2 13,894.91 1.20) \\ &= 0.0285'' \end{aligned}$$

$$\begin{aligned} t_{wc} &= (1 + V_{\text{Accel}}) W / (2 \pi R_m S_c K_s) && \text{(Weight)} \\ &= 2.00 16,039 / (2 \pi 23.125 13,894.91 1.20) \\ &= 0.0132'' \end{aligned}$$

$$\begin{aligned} t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\ &= 0.0285 + (0.0132) - (0) \\ &= 0.0418'' \end{aligned}$$

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

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

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

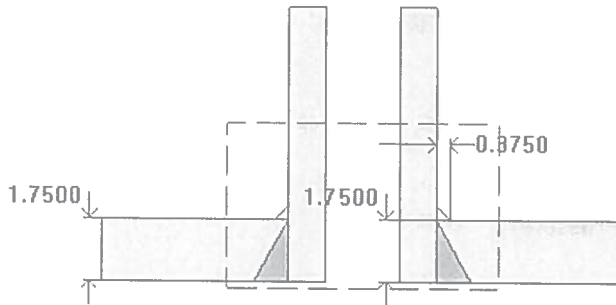
$$= 2,604.73 \text{ psi}$$

Level Gauge High (N10A)

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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:	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, 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 $\leq 2 \frac{1}{2}$ (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

UG-37 Area Calculation Summary (in ²) For P = 1,378 psi @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2074	1.06

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

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

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)

$$\begin{aligned}
 t_{rn} &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

Required thickness t_r 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)

$$\text{Local circumferential pressure stress} = I * P * R_i / t = 18,519 \text{ psi}$$

$$\text{Local longitudinal pressure stress} = I * P * R_i / (2 * t) = 9,260 \text{ psi}$$

$$\text{Maximum combined stress } (P_L + P_b + Q) = 18,780 \text{ psi}$$

$$\text{Allowable combined stress } (P_L + P_b + Q) = \pm 3 * S = \pm 60,000 \text{ psi}$$

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.

$$\text{Maximum local primary membrane stress } (P_L) = 18,524 \text{ psi}$$

$$\text{Allowable local primary membrane stress } (P_L) = \pm 1.5 * S = \pm 30,000 \text{ psi}$$

The maximum local primary membrane stress (P_L) is within allowable limits.

Stresses at the nozzle OD per WRC Bulletin 107										
Figure	value	β	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
Pressure stress*			18,519	18,519	18,519	18,519	17,520	17,520	17,520	17,520
Total circumferential stress			18,162	18,778	18,614	18,434	17,018	17,966	17,716	17,296
Primary membrane circumferential stress*			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
Pressure stress*			8,760	8,760	8,760	8,760	9,260	9,260	9,260	9,260
Total longitudinal stress			8,283	9,181	8,929	8,563	8,921	9,537	9,345	9,149
Primary membrane longitudinal stress*			8,732	8,732	8,746	8,746	9,229	9,229	9,247	9,247
Shear from M_l			89	89	89	89	89	89	89	89
Circ shear from V_c			36	36	-36	-36	0	0	0	0
Long shear from V_L			0	0	0	0	0	0	0	0
Total Shear stress			125	125	53	53	53	53	125	125
Combined stress (P_L+P_b+Q)			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

$$\begin{aligned} \sigma_{\text{shear}} &= (V_L^2 + V_c^2)^{0.5} / (\pi \cdot R_i \cdot t_n) \\ &= (409^2 + 409^2)^{0.5} / (\pi \cdot 1 \cdot 1.06) \\ &= 174 \text{ psi} \end{aligned}$$

$$\begin{aligned} \sigma_{\text{torsion}} &= M_l / (2 \cdot \pi \cdot R_i^2 \cdot t_n) \\ &= 4,160 / (2 \cdot \pi \cdot 1^2 \cdot 1.06) \end{aligned}$$

= 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

UG-37 Area Calculation Summary (in ²) For Pe = 622.51 psl @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2074	1.06

UG-41 Weld Failure Path Analysis Summary
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 ₄₁)	0.25	0.2625	weld size is adequate

Calculations for external pressure 622.51 psi @ 140 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

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 $t_n = 0.1482$ 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

$$\begin{aligned}
 \text{Fillet weld: } t_{\min} &= \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in} \\
 t_{c(\min)} &= \text{lesser of } 0.25 \text{ or } 0.7*t_{\min} = 0.25 \text{ in} \\
 t_{c(\text{actual})} &= 0.7*\text{Leg} = 0.7*0.375 = 0.2625 \text{ in}
 \end{aligned}$$

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

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

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

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

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

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

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

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

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 $P_a = 622.51 \text{ psi}$

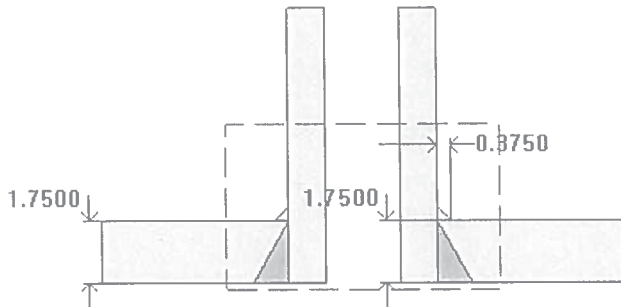
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482 \text{ in}$$

Liquid Outlet (N3)

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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:	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 _{pr} :	6.25 in
Projection available outside vessel to flange face, L _f :	8 in
Local vessel minimum thickness:	1.75 in
Liquid static head included:	0.3574 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

UG-37 Area Calculation Summary (in ²) For P = 1,378.36 psi @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2074	1.06

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

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

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)

$$\begin{aligned}
 t_{rn} &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378.3574 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378.3574) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

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

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

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

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

UG-37 Area Calculation Summary (in ²) For Pe = 622.51 psi @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2074	1.06

UG-41 Weld Failure Path Analysis Summary
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 ₄₁)	0.25	0.2625	weld size is adequate

Calculations for external pressure 622.51 psi @ 140 °F

Parallel Limit of reinforcement per UG-40

$$L_R = \text{MAX}(d, R_n + (t_n - C_n) + (t - C))$$

$$= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0))$$

$$= 3.81 \text{ in}$$

Outer Normal Limit of reinforcement per UG-40

$$L_H = \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e)$$

$$= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0)$$

$$= 2.65 \text{ in}$$

Nozzle required thickness per UG-28 $t_{rn} = 0.1482 \text{ in}$

From UG-37(d)(1) required thickness $t_r = 1.75 \text{ in}$

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

UW-16(c) Weld Check

Fillet weld: $t_{min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$
 $t_{c(min)} = \text{lesser of } 0.25 \text{ or } 0.7*t_{min} = 0.25 \text{ in}$
 $t_{c(actual)} = 0.7*Leg = 0.7*0.375 = 0.2625 \text{ in}$

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 psi

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

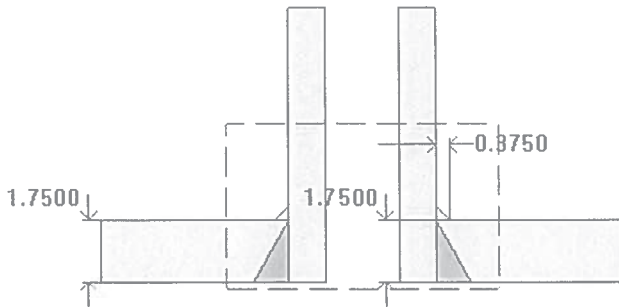
Design thickness for external pressure $P_a = 622.51 \text{ psi}$

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

PSV (N4)

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$t_{w(lower)} = 1.75 \text{ in}$
 $Leg_{41} = 0.375 \text{ in}$



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 <= 5 (II-D p. 70, ln. 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, ln. 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

UG-37 Area Calculation Summary (in ²) For P = 1,378 psi @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45		
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2074	1.06	

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

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

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)

$$\begin{aligned}
 t_{rn} &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

Required thickness t_r 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

UG-37 Area Calculation Summary (in ²) For Pe = 622.51 psi @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2074	1.06

UG-41 Weld Failure Path Analysis Summary 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 ₄₁)	0.25	0.2625	weld size is adequate

Calculations for external pressure 622.51 psi @ 140 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

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 $t_n = 0.1482$ 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

$$\begin{aligned}
 \text{Fillet weld: } t_{\min} &= \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in} \\
 t_{c(\min)} &= \text{lesser of } 0.25 \text{ or } 0.7*t_{\min} = 0.25 \text{ in} \\
 t_{c(\text{actual})} &= 0.7*\text{Leg} = 0.7*0.375 = 0.2625 \text{ in}
 \end{aligned}$$

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

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

$$\begin{aligned} t_a &= \max[t_{a \text{ UG-28}}, t_{a \text{ UG-22}}] \\ &= \max[0.1482, 0] \\ &= 0.1482 \text{ in} \end{aligned}$$

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

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

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

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

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 $P_a = 622.51 \text{ psi}$

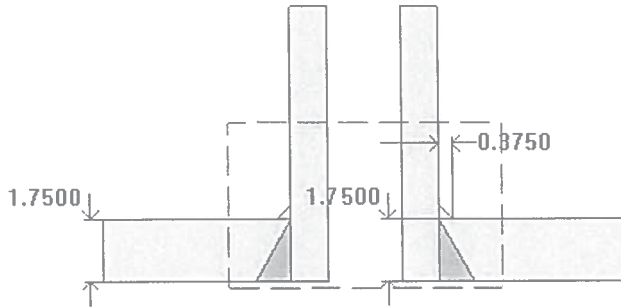
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

Pressure Indicator (N5)

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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:	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, 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

UG-37 Area Calculation Summary (in ²) For P = 1,378 psl @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2074	1.06

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

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

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_r 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

UG-37 Area Calculation Summary (in ²) For Pe = 622.51 psi @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45		
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2074	1.06	

UG-41 Weld Failure Path Analysis Summary
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 ₄₁)	0.25	0.2625	weld size is adequate

Calculations for external pressure 622.51 psi @ 140 °F

Parallel Limit of reinforcement per UG-40

$$L_R = \text{MAX}(d, R_n + (t_n - C_n) + (t - C))$$

$$= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0))$$

$$= 3.81 \text{ in}$$

Outer Normal Limit of reinforcement per UG-40

$$L_H = \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e)$$

$$= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0)$$

$$= 2.65 \text{ in}$$

Nozzle required thickness per UG-28 $t_{rn} = 0.1482 \text{ in}$

From UG-37(d)(1) required thickness $t_r = 1.75 \text{ in}$

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

UW-16(c) Weld Check

Fillet weld: $t_{min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$
 $t_{c(min)} = \text{lesser of } 0.25 \text{ or } 0.7*t_{min} = 0.25 \text{ in}$
 $t_{c(actual)} = 0.7*Leg = 0.7*0.375 = 0.2625 \text{ in}$

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 $P_a = 622.51 \text{ psi}$

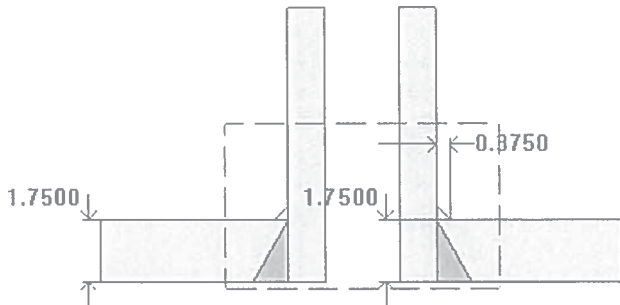
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

Temperature Indicator (N6)

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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:	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 _{pr} :	6.25 in
Projection available outside vessel to flange face, L _f :	8 in
Local vessel minimum thickness:	1.75 in
Liquid static head included:	0 psi
Longitudinal joint efficiency:	1

ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 LWN A182 F316
Bolt Material:	SA-193 B7 Bolt ≤ 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

UG-37 Area Calculation Summary (in ²) For P = 1,378 psi @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2074	1.06

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

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

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)

$$\begin{aligned}
 t_{rn} &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

Required thickness t_r 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

UG-37 Area Calculation Summary (in²) For Pe = 622.51 psl @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A _{required}	A _{available}	A ₁	A ₂	A ₃	A ₅	A _{welds}	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2074	1.06

UG-41 Weld Failure Path Analysis Summary
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 ₄₁)	0.25	0.2625	weld size is adequate

Calculations for external pressure 622.51 psi @ 140 °F

Parallel Limit of reinforcement per UG-40

$$L_R = \text{MAX}(d, R_n + (t_n - C_n) + (t - C))$$

$$= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0))$$

$$= 3.81 \text{ in}$$

Outer Normal Limit of reinforcement per UG-40

$$L_H = \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e)$$

$$= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0)$$

$$= 2.65 \text{ in}$$

Nozzle required thickness per UG-28 $t_{rn} = 0.1482 \text{ in}$

From UG-37(d)(1) required thickness $t_r = 1.75 \text{ in}$

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

UW-16(c) Weld Check

Fillet weld: $t_{min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$
 $t_{c(min)} = \text{lesser of } 0.25 \text{ or } 0.7*t_{min} = 0.25 \text{ in}$
 $t_{c(actual)} = 0.7*Leg = 0.7*0.375 = 0.2625 \text{ in}$

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)

$$\begin{aligned} L / D_o &= 8.0886 / 4.12 = 1.9632 \\ D_o / t &= 4.12 / 0.1482 = 27.7945 \\ \text{From table G: } A &= 0.004502 \\ \text{From table HA-2: } B &= 12,976.6933 \text{ psi} \end{aligned}$$

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

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

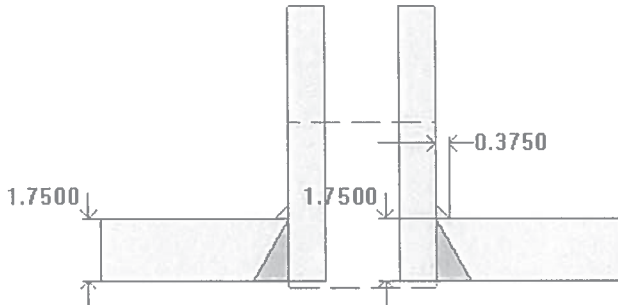
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

Level Bridle - (Safety) High (N9A)

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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:	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 <= 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
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 <= 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:
Hydrotest rating:
PWHT performed:

2,160 psi @ 50°F
3,250 psi @ 50°F
No



Reinforcement Calculations for Chamber MAWP

UG-37 Area Calculation Summary (in ²) For P = 1,378 psi @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2074	1.06

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

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (In)	Actual weld throat size (In)	Status
Nozzle to shell fillet (Leg41)	0.25	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)

$$\begin{aligned}
 t_{rn} &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

Required thickness t_r 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

UG-37 Area Calculation Summary (in ²) For Pe = 622.51 psi @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2074	1.06

UG-41 Weld Failure Path Analysis Summary
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 ₄₁)	0.25	0.2625	weld size is adequate

Calculations for external pressure 622.51 psi @ 140 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28 $t_{rn} = 0.1482 \text{ in}$

From UG-37(d)(1) required thickness $t_r = 1.75 \text{ in}$

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

UW-16(c) Weld Check

Fillet weld: $t_{min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$
 $t_{c(min)} = \text{lesser of } 0.25 \text{ or } 0.7*t_{min} = 0.25 \text{ in}$
 $t_{c(actual)} = 0.7*Leg = 0.7*0.375 = 0.2625 \text{ in}$

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)

$$\begin{aligned} L / D_o &= 8.0886 / 4.12 = 1.9632 \\ D_o / t &= 4.12 / 0.1482 = 27.7945 \\ \text{From table G: } A &= 0.004502 \\ \text{From table HA-2: } B &= 12,976.6933 \text{ psi} \end{aligned}$$

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

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

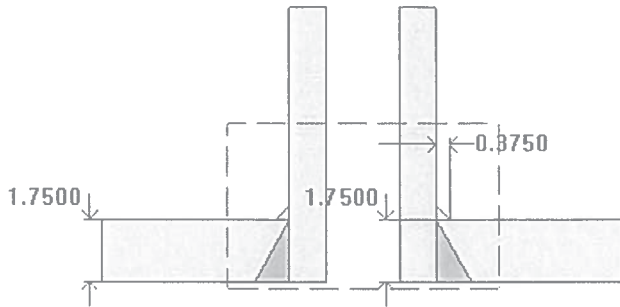
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

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 <= 5 (II-D p. 70, ln. 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, ln. 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

UG-37 Area Calculation Summary (in ²) For P = 1,378 psi @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45		
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2074	1.06	

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

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

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)

$$\begin{aligned}
 t_{rn} &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

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

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

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

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

UG-37 Area Calculation Summary (in ²) For $P_e = 622.51$ psi @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45		
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2074	1.06	

UG-41 Weld Failure Path Analysis Summary
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 ₄₁)	0.25	0.2625	weld size is adequate

Calculations for external pressure 622.51 psi @ 140 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28 $t_{rn} = 0.1482$ in

From UG-37(d)(1) required thickness $t_r = 1.75$ in

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

UW-16(c) Weld Check

$$\begin{aligned}
 \text{Fillet weld: } t_{\min} &= \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in} \\
 t_{c(\min)} &= \text{lesser of } 0.25 \text{ or } 0.7*t_{\min} = 0.25 \text{ in} \\
 t_{c(\text{actual})} &= 0.7*\text{Leg} = 0.7*0.375 = 0.2625 \text{ in}
 \end{aligned}$$

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

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

$$\begin{aligned} t_a &= \max[t_{a \text{ UG-28}}, t_{a \text{ UG-22}}] \\ &= \max[0.1482, 0] \\ &= 0.1482 \text{ in} \end{aligned}$$

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

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

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

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

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 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 $P_a = 622.51 \text{ psi}$

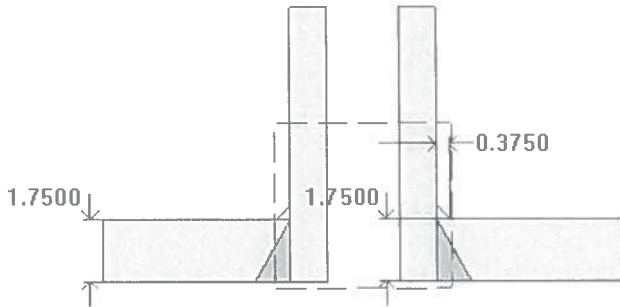
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

Purge (N12)

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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(e)

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 <= 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
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 <= 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:
Hydrotest rating:
PWHT performed:

2,160 psi @ 50°F
3,250 psi @ 50°F
No



Reinforcement Calculations for Chamber MAWP

UG-37 Area Calculation Summary (in ²) For P = 1,378.36 psi @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2074	1.06

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

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

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)

$$\begin{aligned}
 t_n &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378.3574 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378.3574) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

Required thickness t_r 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 -in
Circumferential shear:	$V_c = 409$	lb _f
Longitudinal moment:	$M_L = 2,965$	lb _f -in
Longitudinal shear:	$V_L = 409$	lb _f
Torsion moment:	$M_t = 4,160$	lb _f -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	β	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
Pressure stress*			18,524	18,524	18,524	18,524	17,525	17,525	17,525	17,525
Total circumferential stress			18,167	18,783	18,619	18,439	17,023	17,971	17,721	17,301
Primary membrane circumferential stress*			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
Pressure stress*			8,762	8,762	8,762	8,762	9,262	9,262	9,262	9,262
Total longitudinal stress			8,285	9,183	8,931	8,565	8,923	9,539	9,347	9,151
Primary membrane longitudinal stress*			8,734	8,734	8,748	8,748	9,231	9,231	9,249	9,249
Shear from M_t			89	89	89	89	89	89	89	89
Circ shear from V_c			36	36	-36	-36	0	0	0	0
Long shear from V_L			0	0	0	0	-36	-36	36	36
Total Shear stress			125	125	53	53	53	53	125	125
Combined stress (P_L+P_b+Q)			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

$$\begin{aligned}\sigma_{n(P_m)} &= P \cdot R_i / (2 \cdot t_n) - P_r / (\pi \cdot (R_o^2 - R_i^2)) + M \cdot R_o / I \\ &= 1,378.36 \cdot 1 / (2 \cdot 1.06) - 334 / (\pi \cdot (2.06^2 - 1^2)) + 4,193.1 \cdot 2.06 / 13.3582 \\ &= 1,264 \text{ psi}\end{aligned}$$

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

UG-37 Area Calculation Summary (in ²) For Pe = 622.51 psi @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45		
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2074	1.06	

UG-41 Weld Failure Path Analysis Summary
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 ₄₁)	0.25	0.2625	weld size is adequate

Calculations for external pressure 622.51 psi @ 140 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28 $t_{rn} = 0.1482$ in

From UG-37(d)(1) required thickness $t_r = 1.75$ in

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

UW-16(c) Weld Check

Fillet weld: $t_{min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$
 $t_{c(min)} = \text{lesser of } 0.25 \text{ or } 0.7*t_{min} = 0.25 \text{ in}$
 $t_{c(actual)} = 0.7*Leg = 0.7*0.375 = 0.2625 \text{ in}$

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 psi

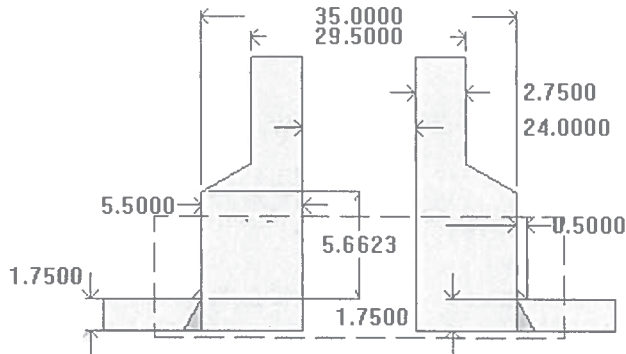
$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 12,976.69 / (3 \cdot (4.12 / 0.1482)) \\ &= 622.51 \text{ psi} \end{aligned}$$

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

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

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 $r_1 = \min [1'4"t, 0.125 \text{ in}] = 0.125 \text{ in}$

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:
MAWP rating:
MAP rating:
Hydrotest rating:
PWHT performed:

0 psi
2,040 psi @ 140°F
2,160 psi @ 50°F
3,250 psi @ 50°F
No

Reinforcement Calculations for Chamber MAWP

UG-37 Area Calculation Summary (in²) For P = 1,378.16 psi @ 140 °F The opening is adequately reinforced							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
38.6263	43.0763	2.2491	40.5772	--	--	0.25	0.8626	2.75

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

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.25	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 in²

$$\begin{aligned}&= (2 \cdot \text{limits} - d) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= (2 \cdot 20 - 24) \cdot (1 \cdot 1.75 - 1 \cdot 1.6094) - 2 \cdot 5.5 \cdot (1 \cdot 1.75 - 1 \cdot 1.6094) \cdot (1 - 1) \\ &= \underline{2.2491} \text{ in}^2\end{aligned}$$

A_2 = smaller of the following = 40.5772 in²

$$\begin{aligned}&= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t \\ &= 5 \cdot (5.5 - 0.8626) \cdot 1 \cdot 1.75 \\ &= 40.5772 \text{ in}^2 \\ &= 2 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot L_{pr} - [(t_n - t_p)^2 \cdot \tan(30) + 2 \cdot (\text{LIMIT} - L_{hb} - L_{slope}) \cdot (t_n - t_p)] \cdot f_{r2} \\ &= 2 \cdot (5.5 - 0.8626) \cdot 1 \cdot 10 - [(5.5 - 2.75)^2 \cdot \tan(30) + 2 \cdot (10 - 5.6623 - 1.5877) \cdot (5.5 - 2.75)] \cdot 1 \\ &= 73.2568 \text{ in}^2\end{aligned}$$

$$\begin{aligned}A_{41} &= \text{Leg}^2 \cdot f_{r2} \\ &= 0.5^2 \cdot 1 \\ &= \underline{0.25} \text{ in}^2\end{aligned}$$

$$\begin{aligned}\text{Area} &= A_1 + A_2 + A_{41} \\ &= 2.2491 + 40.5772 + 0.25 \\ &= \underline{43.0763} \text{ in}^2\end{aligned}$$

As Area \geq A the reinforcement is adequate.

UW-16(c) Weld Check

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

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

$t_{c(\text{actual})} = 0.7*\text{Leg} = 0.7*0.5 = 0.35 \text{ in}$

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
 $= 2 / 3*A = (2 / 3)*38.6263 = \underline{25.7509} \text{ in}^2$

Area that is within 75 percent of the limits of reinforcement is:

$A_1 = \text{larger of } 2.0383 \text{ or}$

$$\begin{aligned}&= (2*\text{limits} - d)*(E_1*t - F*t_r) - 2*t_n*(E_1*t - F*t_r)*(1 - f_{r1}) \\ &= (2*18 - 24)*(1*1.75 - 1*1.6094) - 2*5.5*(1*1.75 - 1*1.6094)*(1 - 1) \\ &= 1.6868 \text{ in}^2\end{aligned}$$

$$\begin{aligned}\text{Area} &= A_1 + A_2 + A_3 + A_{41} + A_{42} + A_{43} + A_5 \\ &= 2.0383 + 40.5772 + 0 + 0.25 + 0 + 0 + 0 \\ &= \underline{42.8655} \text{ in}^2\end{aligned}$$

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

UG-37 Area Calculation Summary (in²) For Pe = 622.51 psi @ 140 °F The opening is adequately reinforced							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
21	38.206	--	37.956	--	--	0.25	1.1622	2.75

UG-41 Weld Failure Path Analysis Summary
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 ₄₁)	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_m = 1.1622 in

From UG-37(d)(1) required thickness t_r = 1.75 in

Area required per UG-37(d)(1)

Allowable stresses: S_n = 20,000, S_v = 20,000 psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$\begin{aligned}
 A &= 0.5(d_t F + 2t_n t_r F(1 - f_{r1})) \\
 &= 0.5(24 \cdot 1.75 \cdot 1 + 2 \cdot 5.5 \cdot 1.75 \cdot 1 \cdot (1 - 1)) \\
 &= \underline{21} \text{ in}^2
 \end{aligned}$$

Area available from FIG. UG-37.1

$$A_1 = \text{larger of the following} = \underline{0} \text{ in}^2$$

$$\begin{aligned}
 &= d(E_1 t - F t_r) - 2t_n(E_1 t - F t_r)(1 - f_{r1}) \\
 &= 24(1 \cdot 1.75 - 1 \cdot 1.75) - 2 \cdot 5.5(1 \cdot 1.75 - 1 \cdot 1.75)(1 - 1) \\
 &= 0 \text{ in}^2 \\
 &= 2(t + t_n)(E_1 t - F t_r) - 2t_n(E_1 t - F t_r)(1 - f_{r1}) \\
 &= 2(1.75 + 5.5)(1 \cdot 1.75 - 1 \cdot 1.75) - 2 \cdot 5.5(1 \cdot 1.75 - 1 \cdot 1.75)(1 - 1) \\
 &= 0 \text{ in}^2
 \end{aligned}$$

$$A_2 = \text{smaller of the following} = \underline{37.956} \text{ in}^2$$

$$\begin{aligned}
 &= 5(t_n - t_m) f_{r2} t \\
 &= 5(5.5 - 1.1622) \cdot 1 \cdot 1.75 \\
 &= 37.956 \text{ in}^2 \\
 &= 2(t_n - t_m) f_{r2} L_{pr} - [(t_n - t_p)^2 \tan(30) + 2(\text{LIMIT} - L_{hb} - L_{slope}) (t_n - t_p)] f_{r2} \\
 &= 2(5.5 - 1.1622) \cdot 1 \cdot 10 - [(5.5 - 2.75)^2 \tan(30) + 2(10 - 5.6623 - 1.5877) (5.5 - 2.75)] \cdot 1 \\
 &= 67.2653 \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 A_{41} &= \text{Leg}^2 f_{r2} \\
 &= 0.5^2 \cdot 1 \\
 &= \underline{0.25} \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 \text{Area} &= A_1 + A_2 + A_{41} \\
 &= 0 + 37.956 + 0.25 \\
 &= \underline{38.206} \text{ in}^2
 \end{aligned}$$

As Area \geq A the reinforcement is adequate.

UW-16(c) Weld Check

$$\begin{aligned}
 \text{Fillet weld: } t_{\min} &= \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in} \\
 t_{c(\min)} &= \text{lesser of } 0.25 \text{ or } 0.7 \cdot t_{\min} = \underline{0.25} \text{ in} \\
 t_{c(\text{actual})} &= 0.7 \cdot \text{Leg} = 0.7 \cdot 0.5 = 0.35 \text{ in}
 \end{aligned}$$

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
 $= 2 / 3 * A = (2 / 3) * 21 = \underline{14} \text{ in}^2$

Area that is within 75 percent of the limits of reinforcement is:

$A_1 =$ larger of 0 or

$$\begin{aligned} &= (2 * \text{limits} - d) * (E_1 * t - F * t_r) - 2 * t_n * (E_1 * t - F * t_r) * (1 - f_{r1}) \\ &= (2 * 18 - 24) * (1 * 1.75 - 1 * 1.75) - 2 * 5.5 * (1 * 1.75 - 1 * 1.75) * (1 - 1) \\ &= 0 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_3 + A_{41} + A_{42} + A_{43} + A_5 \\ &= 0 + 37.956 + 0 + 0.25 + 0 + 0 + 0 \\ &= \underline{38.206} \text{ in}^2 \end{aligned}$$

The area replacement requirements of Appendix 1-7(a) are satisfied.

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

$$\begin{aligned} L / D_o &= 23.3259 / 35 = 0.6665 \\ D_o / t &= 35 / 1.1622 = 30.1160 \\ \text{From table G: } A &= 0.013249 \\ \text{From table HA-2: } B &= 14,060.5232 \text{ psi} \end{aligned}$$

$$\begin{aligned} P_a &= 4 * B / (3 * (D_o / t)) \\ &= 4 * 14,060.52 / (3 * (35 / 1.1622)) \\ &= 622.51 \text{ psi} \end{aligned}$$

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

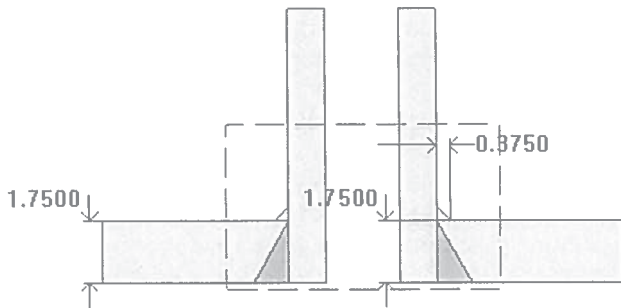
$$t_a = t + \text{Corrosion} = 1.1622 + 0 = 1.1622''$$

PDI High (N7A)

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$$t_{w(\text{lower})} = 1.75 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



Note: round inside edges per UG 76(c)

Location and Orientation

Located on: 48 OD SHELL
 Orientation: 180°
 Nozzle center line offset to datum line: 8 in
 End of nozzle to shell center: 32 in
 Passes through a Category A joint: No

Nozzle

Access opening: No
 Material specification: SA-182 F316 ≤ 5 (II-D p. 70, In. 22)
 Inside diameter, new: 2 in
 Nominal wall thickness: 1.06 in
 Corrosion allowance: 0 in
 Projection available outside vessel, Lpr: 6.25 in
 Projection available outside vessel to flange face, Lf: 8 in
 Local vessel minimum thickness: 1.75 in
 Liquid static head included: 0 psi
 Longitudinal joint efficiency: 1

ASME B16.5-2009 Flange

Description: NPS 2 Class 900 LWN A182 F316
 Bolt Material: SA-193 B7 Bolt ≤ 2 1/2 (II-D p. 334, In. 32)
 Blind included: No
 Rated MDMT: -55°F
 (Per UHA-51(d)(1)(a))
 (Flange rated MDMT = -320 °F)
 Bolts rated MDMT per Fig UCS-66 note (c) = -55 °F
 Liquid static head: 0 psi
 MAWP rating: 2,040 psi @ 140°F
 MAP rating: 2,160 psi @ 50°F

Hydrotest rating:
PWHT performed:

3,250 psi @ 50°F
No

Reinforcement Calculations for Chamber MAWP

UG-37 Area Calculation Summary (in ²) For P = 1,378 psi @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45		
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<u>0.2074</u>	1.06	

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

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	<u>0.25</u>	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)

$$\begin{aligned}
 t_{rn} &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

Required thickness t_r 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

UG-37 Area Calculation Summary (in ²) For Pe = 622.51 psl @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2074	1.06

UG-41 Weld Failure Path Analysis Summary
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 ₄₁)	0.25	0.2625	weld size is adequate

Calculations for external pressure 622.51 psi @ 140 °F

Parallel Limit of reinforcement per UG-40

$$L_R = \text{MAX}(d, R_n + (t_n - C_n) + (t - C))$$

$$= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0))$$

$$= 3.81 \text{ in}$$

Outer Normal Limit of reinforcement per UG-40

$$L_H = \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e)$$

$$= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0)$$

$$= 2.65 \text{ in}$$

Nozzle required thickness per UG-28 t_{rn} = 0.1482 in

From UG-37(d)(1) required thickness t_r = 1.75 in

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

UW-16(c) Weld Check

Fillet weld: t_{min} = lesser of 0.75 or t_n or t = 0.75 in

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

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

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

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

$$\begin{aligned} t_a &= \max[t_{a \text{ UG-28}}, t_{a \text{ UG-22}}] \\ &= \max[0.1482, 0] \\ &= 0.1482 \text{ in} \end{aligned}$$

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

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

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

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

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)

$$\begin{aligned} L / D_o &= 8.0886 / 4.12 = 1.9632 \\ D_o / t &= 4.12 / 0.1482 = 27.7945 \\ \text{From table G: } A &= 0.004502 \\ \text{From table HA-2: } B &= 12,976.6933 \text{ psi} \end{aligned}$$

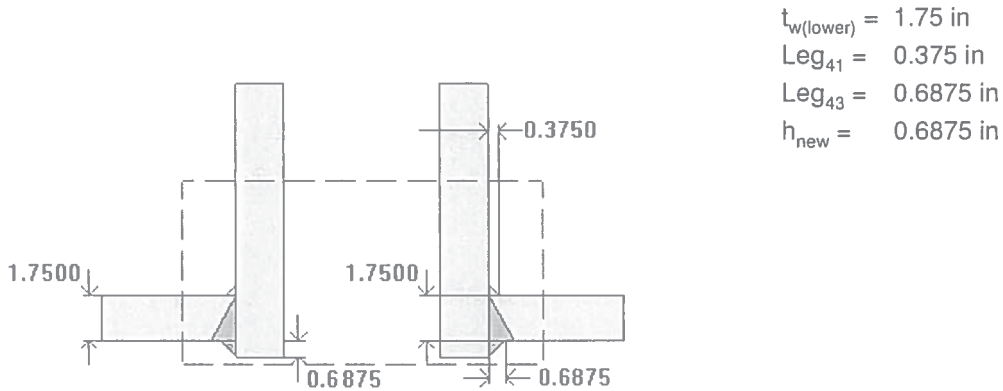
$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 12,976.69 / (3 \cdot (4.12 / 0.1482)) \\ &= 622.51 \text{ psi} \end{aligned}$$

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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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 <= 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 _{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 <= 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:
Hydrotest rating:
PWHT performed:

2,160 psi @ 50°F
3,250 psi @ 50°F
No

Reinforcement Calculations for Chamber MAWP

UG-37 Area Calculation Summary (in ²) For P = 1,378 psi @ 140 °F The opening is adequately reinforced							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
12.874	18.208	1.126	13.8906	2.5781	--	0.6133	0.3281	1.875

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

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.25	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)

$$\begin{aligned}
 t_m &= P*R_n / (S_n*E - 0.6*P) \\
 &= 1,378*4 / (20,000*1 - 0.6*1,378) \\
 &= 0.2875 \text{ in}
 \end{aligned}$$

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P*R_o / (S*E + 0.4*P) \\
 &= 1,378*24 / (20,000*1 + 0.4*1,378)
 \end{aligned}$$

$$= 1.6092 \text{ in}$$

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

$$A_1 = \text{larger of the following} = \underline{1.126} \text{ in}^2$$

$$\begin{aligned} &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 8 \cdot (1 \cdot 1.75 - 1 \cdot 1.6093) - 2 \cdot 1.875 \cdot (1 \cdot 1.75 - 1 \cdot 1.6093) \cdot (1 - 1) \\ &= 1.126 \text{ in}^2 \\ &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2 \cdot (1.75 + 1.875) \cdot (1 \cdot 1.75 - 1 \cdot 1.6093) - 2 \cdot 1.875 \cdot (1 \cdot 1.75 - 1 \cdot 1.6093) \cdot (1 - 1) \\ &= 1.0204 \text{ in}^2 \end{aligned}$$

$$A_2 = \text{smaller of the following} = \underline{13.8906} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t \\ &= 5 \cdot (1.875 - 0.2875) \cdot 1 \cdot 1.75 \\ &= 13.8906 \text{ in}^2 \\ &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (1.875 - 0.2875) \cdot 1 \cdot 1.875 \\ &= 14.8828 \text{ in}^2 \end{aligned}$$

$$A_3 = \text{smaller of the following} = \underline{2.5781} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot t_i \cdot f_{r2} \\ &= 5 \cdot 1.75 \cdot 1.875 \cdot 1 \\ &= \underline{16.4063} \text{ in}^2 \\ &= 5 \cdot t_i \cdot t_i \cdot f_{r2} \\ &= 5 \cdot 1.875 \cdot 1.875 \cdot 1 \\ &= \underline{17.5781} \text{ in}^2 \\ &= 2 \cdot h \cdot t_i \cdot f_{r2} \\ &= 2 \cdot 0.6875 \cdot 1.875 \cdot 1 \end{aligned}$$

$$= \underline{2.5781} \text{ in}^2$$

$$\begin{aligned} A_{41} &= \text{Leg}^2 \cdot f_{r2} \\ &= 0.375^2 \cdot 1 \\ &= \underline{0.1406} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} A_{43} &= \text{Leg}^2 \cdot f_{r2} \\ &= 0.6875^2 \cdot 1 \\ &= \underline{0.4727} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_3 + A_{41} + A_{43} \\ &= 1.126 + 13.8906 + 2.5781 + 0.1406 + 0.4727 \\ &= \underline{18.208} \text{ in}^2 \end{aligned}$$

As Area \geq A the reinforcement is adequate.

UW-16(c) Weld Check

$$\begin{aligned} \text{Fillet weld: } t_{\min} &= \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in} \\ t_{c(\min)} &= \text{lesser of } 0.25 \text{ or } 0.7 \cdot t_{\min} = \underline{0.25} \text{ in} \\ t_{c(\text{actual})} &= 0.7 \cdot \text{Leg} = 0.7 \cdot 0.375 = 0.2625 \text{ in} \end{aligned}$$

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

$$\begin{aligned} t_{a \text{ UG-27}} &= P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion} \\ &= 1,378 \cdot 4 / (20,000 \cdot 1 - 0.6 \cdot 1,378) + 0 \\ &= 0.2875 \text{ in} \end{aligned}$$

$$t_{a \text{ UG-22}} = 0.2543 \text{ in}$$

$$\begin{aligned} t_a &= \max[t_{a \text{ UG-27}}, t_{a \text{ UG-22}}] \\ &= \max[0.2875, 0.2543] \\ &= 0.2875 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion} \\ &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378) + 0 \\ &= 1.6092 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= \max[t_{b1}, t_{b \text{ UG16}}] \\ &= \max[1.6092, 0.0625] \\ &= 1.6092 \text{ in} \end{aligned}$$

$$t_b = \min[t_{b3}, t_{b1}]$$

$$\begin{aligned} &= \min[0.3281 , 1.6092] \\ &= 0.3281 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{UG-45} &= \max[t_a , t_b] \\ &= \max[0.2875 , 0.3281] \\ &= 0.3281 \text{ in} \end{aligned}$$

Available nozzle wall thickness new, $t_n = 1.875$ in

The nozzle neck thickness is adequate.

Applied Loads

Radial load: $P_r = 2,720 \text{ lb}_f$
Circumferential moment: $M_c = 92,535 \text{ lb}_f\text{-in}$
Circumferential shear: $V_c = 3,332 \text{ lb}_f$
Longitudinal moment: $M_L = 92,535 \text{ lb}_f\text{-in}$
Longitudinal shear: $V_L = 3,332 \text{ lb}_f$
Torsion moment: $M_t = 130,858 \text{ lb}_f\text{-in}$
Internal pressure: $P = 1,378 \text{ psi}$
Mean shell radius: $R_m = 23.125 \text{ in}$
Local shell thickness: $t = 1.75 \text{ in}$
Shell yield stress: $S_y = 27,900 \text{ psi}$

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)

$$\text{Local circumferential pressure stress} = I * P * R_i / t = 19,526 \text{ psi}$$

$$\text{Local longitudinal pressure stress} = I * P * R_i / (2 * t) = 9,763 \text{ psi}$$

$$\begin{aligned} \text{Maximum combined stress } (P_L + P_b + Q) &= 21,128 \text{ psi} \\ \text{Allowable combined stress } (P_L + P_b + Q) &= +3 * S = +60,000 \text{ psi} \end{aligned}$$

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.

$$\begin{aligned} \text{Maximum local primary membrane stress } (P_L) &= 20,047 \text{ psi} \\ \text{Allowable local primary membrane stress } (P_L) &= +1.5 * S = +30,000 \text{ psi} \end{aligned}$$

The maximum local primary membrane stress (P_L) is within allowable limits.

Stresses at the nozzle OD per WRC Bulletin 107										
Figure	value	β	A_u	A_l	B_u	B_l	C_u	C_l	D_u	D_l
3C*	1.7827	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
Pressure stress*			19,526	19,526	19,526	19,526	17,520	17,520	17,520	17,520
Total circumferential stress			16,950	20,472	21,122	18,972	13,443	20,919	20,335	14,903
Primary membrane circumferential stress*			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
Pressure stress*			8,760	8,760	8,760	8,760	9,763	9,763	9,763	9,763
Total longitudinal stress			5,634	11,214	10,616	7,096	7,109	11,391	11,439	8,525
Primary membrane longitudinal stress*			8,424	8,424	8,856	8,856	9,250	9,250	9,982	9,982
Shear from M_t			345	345	345	345	345	345	345	345
Circ shear from V_c			103	103	-103	-103	0	0	0	0
Long shear from V_L			0	0	0	0	-103	-103	103	103
Total Shear stress			448	448	242	242	242	242	448	448
Combined stress (P_L+P_b+Q)			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

$$\begin{aligned} \sigma_{n(P_m)} &= P \cdot R_i / (2 \cdot t_n) - P_r / (\pi \cdot (R_o^2 - R_i^2)) + M \cdot R_o / I \\ &= 1,378 \cdot 4 / (2 \cdot 1.875) - 2,720 / (\pi \cdot (5.875^2 - 4^2)) + 130,864 \cdot 3 \cdot 5.875 / 734.6052 \\ &= 2,470 \text{ psi} \end{aligned}$$

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

UG-37 Area Calculation Summary (in²) For $P_e = 622.51 \text{ psi @ } 140 \text{ }^\circ\text{F}$ The opening is adequately reinforced							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
7	16.1125	--	12.9211	2.5781	--	0.6133	0.3983	1.875

UG-41 Weld Failure Path Analysis Summary
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 ₄₁)	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 $t_m = 0.3983 \text{ in}$

From UG-37(d)(1) required thickness $t_r = 1.75 \text{ in}$

Area required per UG-37(d)(1)

Allowable stresses: $S_n = 20,000, S_v = 20,000 \text{ psi}$

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$\begin{aligned} A &= 0.5(d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1})) \\ &= 0.5(8 \cdot 1.75 \cdot 1 + 2 \cdot 1.875 \cdot 1.75 \cdot 1 \cdot (1 - 1)) \\ &= \underline{7} \text{ in}^2 \end{aligned}$$

Area available from FIG. UG-37.1

$$A_1 = \text{larger of the following} = \underline{0} \text{ in}^2$$

$$\begin{aligned} &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 8 \cdot (1 \cdot 1.75 - 1 \cdot 1.75) - 2 \cdot 1.875 \cdot (1 \cdot 1.75 - 1 \cdot 1.75) \cdot (1 - 1) \\ &= 0 \text{ in}^2 \\ &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2 \cdot (1.75 + 1.875) \cdot (1 \cdot 1.75 - 1 \cdot 1.75) - 2 \cdot 1.875 \cdot (1 \cdot 1.75 - 1 \cdot 1.75) \cdot (1 - 1) \\ &= 0 \text{ in}^2 \end{aligned}$$

$$A_2 = \text{smaller of the following} = \underline{12.9211} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t \\ &= 5 \cdot (1.875 - 0.3983) \cdot 1 \cdot 1.75 \\ &= 12.9211 \text{ in}^2 \\ &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (1.875 - 0.3983) \cdot 1 \cdot 1.875 \\ &= 13.844 \text{ in}^2 \end{aligned}$$

$$A_3 = \text{smaller of the following} = \underline{2.5781} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot t_i \cdot f_{r2} \\ &= 5 \cdot 1.75 \cdot 1.875 \cdot 1 \\ &= \underline{16.4063} \text{ in}^2 \\ &= 5 \cdot t_i \cdot t_i \cdot f_{r2} \\ &= 5 \cdot 1.875 \cdot 1.875 \cdot 1 \\ &= \underline{17.5781} \text{ in}^2 \\ &= 2 \cdot h \cdot t_i \cdot f_{r2} \\ &= 2 \cdot 0.6875 \cdot 1.875 \cdot 1 \\ &= \underline{2.5781} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} A_{41} &= \text{Leg}^2 \cdot f_{r2} \\ &= 0.375^2 \cdot 1 \\ &= \underline{0.1406} \text{ in}^2 \end{aligned}$$

$$A_{43} = \text{Leg}^2 \cdot f_{r2}$$

$$= 0.6875^2 \cdot 1$$

$$= \underline{0.4727 \text{ in}^2}$$

$$\text{Area} = A_1 + A_2 + A_3 + A_{41} + A_{43}$$

$$= 0 + 12.9211 + 2.5781 + 0.1406 + 0.4727$$

$$= \underline{16.1125 \text{ in}^2}$$

As Area \geq A the reinforcement is adequate.

UW-16(c) Weld Check

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

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

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

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

$$t_{a \text{ UG-28}} = 0.3983 \text{ in}$$

$$t_{a \text{ UG-22}} = 0.1555 \text{ in}$$

$$t_a = \max[t_{a \text{ UG-28}}, t_{a \text{ UG-22}}]$$

$$= \max[0.3983, 0.1555]$$

$$= 0.3983 \text{ in}$$

$$t_{b2} = P \cdot R_o / (S \cdot E + 0.4 \cdot P) + \text{Corrosion}$$

$$= 622.5059 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 622.5059) + 0$$

$$= 0.7378 \text{ in}$$

$$t_{b2} = \max[t_{b2}, t_{b \text{ UG16}}]$$

$$= \max[0.7378, 0.0625]$$

$$= 0.7378 \text{ in}$$

$$t_b = \min[t_{b3}, t_{b2}]$$

$$= \min[0.3281, 0.7378]$$

$$= 0.3281 \text{ in}$$

$$t_{\text{UG-45}} = \max[t_a, t_b]$$

$$= \max[0.3983, 0.3281]$$

$$= 0.3983 \text{ in}$$

Available nozzle wall thickness new, $t_n = 1.875 \text{ in}$

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

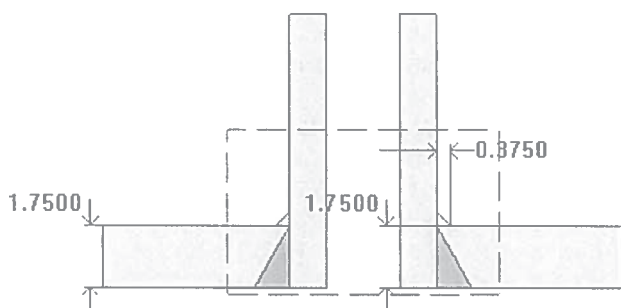
$$t_a = t + \text{Corrosion} = 0.3983 + 0 = 0.3983''$$

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, ln. 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, ln. 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

UG-37 Area Calculation Summary (in ²) For P = 1,378 psi @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2074	1.06

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

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

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_r 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

UG-37 Area Calculation Summary (in ²) For Pe = 622.51 psi @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45		
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<u>0.2074</u>	1.06	

UG-41 Weld Failure Path Analysis Summary
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 ₄₁)	<u>0.25</u>	0.2625	weld size is adequate

Calculations for external pressure 622.51 psi @ 140 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28 $t_{rn} = 0.1482$ in

From UG-37(d)(1) required thickness $t_r = 1.75$ in

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

UW-16(c) Weld Check

Fillet weld: $t_{min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$
 $t_{c(min)} = \text{lesser of } 0.25 \text{ or } 0.7*t_{min} = \underline{0.25} \text{ in}$
 $t_{c(actual)} = 0.7*Leg = 0.7*0.375 = 0.2625 \text{ in}$

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

UG-45 Nozzle Neck Thickness Check

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

$$\begin{aligned} t_a &= \max[t_{a \text{ UG-28}}, t_{a \text{ UG-22}}] \\ &= \max[0.1482, 0] \\ &= 0.1482 \text{ in} \end{aligned}$$

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

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

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

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

Available nozzle wall thickness new, $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

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

$$L / D_o = 8.0886 / 4.12 = 1.9632$$

$$D_o / t = 4.12 / 0.1482 = 27.7945$$

From table G: $A = 0.004502$

From table
HA-2: $B = 12,976.6933 \text{ psi}$

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

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

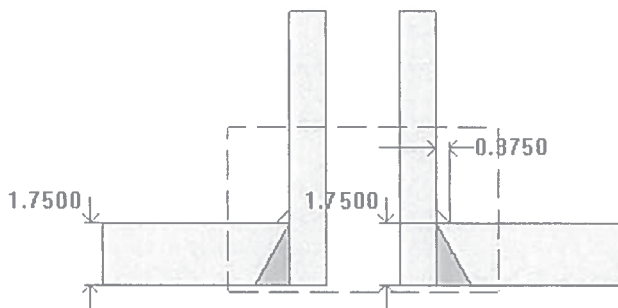
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

Level Bridle - (Process) High (N8A)

ASME Section VIII Division 1, 2010 Edition, A11 Addenda

$$t_{w(\text{lower})} = 1.75 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

Location and Orientation

Located on:	48 OD SHELL
Orientation:	135°
Nozzle center line offset to datum line:	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, ln. 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 $\leq 2 \frac{1}{2}$ (II-D p. 334, ln. 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

UG-37 Area Calculation Summary (in ²) For P = 1,378 psi @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45		
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2074	1.06	

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

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

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)

$$\begin{aligned}
 t_n &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

Required thickness t_r 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

UG-37 Area Calculation Summary (in ²) For Pe = 622.51 psi @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<u>0.2074</u>	1.06

UG-41 Weld Failure Path Analysis Summary
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 ₄₁)	<u>0.25</u>	0.2625	weld size is adequate

Calculations for external pressure 622.51 psi @ 140 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28 $t_{rn} = 0.1482$ in

From UG-37(d)(1) required thickness $t_r = 1.75$ in

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

UW-16(c) Weld Check

Fillet weld: $t_{min} =$ lesser of 0.75 or t_n or $t = 0.75$ in
 $t_{c(min)} =$ lesser of 0.25 or $0.7*t_{min} = 0.25$ 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 $P_a = 622.51 \text{ psi}$

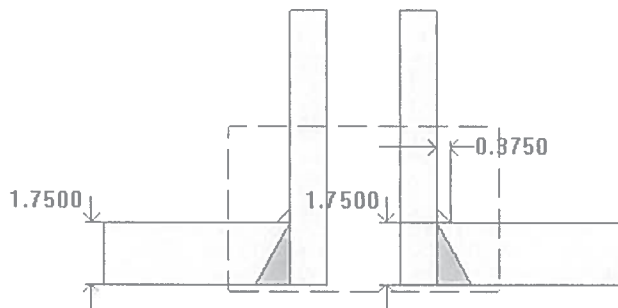
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482 \text{ in}$$

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 ≤ 5 (II-D p. 70, ln. 22)
Inside diameter, new:	2 in
Nominal wall thickness:	1.06 in
Corrosion allowance:	0 in
Projection available outside vessel, L _{pr} :	6.25 in
Projection available outside vessel to flange face, L _f :	8 in
Local vessel minimum thickness:	1.75 in
Liquid static head included:	0.3574 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, ln. 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

UG-37 Area Calculation Summary (in ²) For P = 1,378.36 psi @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<u>0.2074</u>	1.06

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

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg41)	<u>0.25</u>	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)

$$\begin{aligned}
 t_{rn} &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378.3574 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378.3574) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

Required thickness t_r 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

UG-37 Area Calculation Summary (in ²) For Pe = 622.51 psi @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<u>0.2074</u>	1.06

UG-41 Weld Failure Path Analysis Summary
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 ₄₁)	<u>0.25</u>	0.2625	weld size is adequate

Calculations for external pressure 622.51 psi @ 140 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28 $t_{rn} = 0.1482 \text{ in}$

From UG-37(d)(1) required thickness $t_r = 1.75 \text{ in}$

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

UW-16(c) Weld Check

$$\begin{aligned}
 \text{Fillet weld: } t_{min} &= \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in} \\
 t_{c(min)} &= \text{lesser of } 0.25 \text{ or } 0.7*t_{min} = \underline{0.25} \text{ in} \\
 t_{c(actual)} &= 0.7*Leg = 0.7*0.375 = 0.2625 \text{ in}
 \end{aligned}$$

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

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

$$\begin{aligned} t_a &= \max[t_{a \text{ UG-28}}, t_{a \text{ UG-22}}] \\ &= \max[0.1482, 0] \\ &= 0.1482 \text{ in} \end{aligned}$$

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

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

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

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

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 $P_a = 622.51 \text{ psi}$

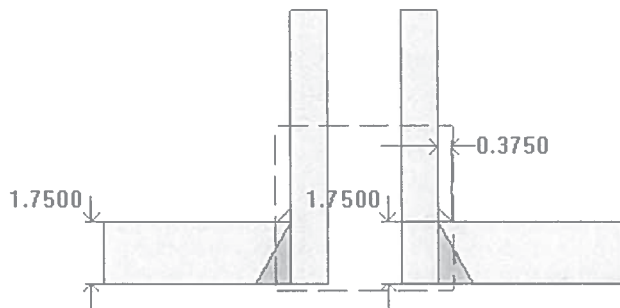
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482 \text{ in}$$

Level Bridle - (Safety) Low (N9B)

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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:	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 ≤ 5 (II-D p. 70, ln. 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
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, ln. 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:
Hydrotest rating:
PWHT performed:

2,160 psi @ 50°F
3,250 psi @ 50°F
No



Reinforcement Calculations for Chamber MAWP

UG-37 Area Calculation Summary (in ²) For P = 1,378.36 psi @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45		
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2074	1.06	

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

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

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_r 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

UG-37 Area Calculation Summary (in ²) For Pe = 622.51 psi @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<u>0.2074</u>	1.06

UG-41 Weld Failure Path Analysis Summary
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 ₄₁)	<u>0.25</u>	0.2625	weld size is adequate

Calculations for external pressure 622.51 psi @ 140 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28 $t_{rn} = 0.1482 \text{ in}$

From UG-37(d)(1) required thickness $t_r = 1.75 \text{ in}$

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

UW-16(c) Weld Check

Fillet weld: $t_{min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$
 $t_{c(min)} = \text{lesser of } 0.25 \text{ or } 0.7*t_{min} = \underline{0.25} \text{ in}$
 $t_{c(actual)} = 0.7*Leg = 0.7*0.375 = 0.2625 \text{ in}$

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

UG-45 Nozzle Neck Thickness Check

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

$$\begin{aligned} t_a &= \max[t_{a \text{ UG-28}}, t_{a \text{ UG-22}}] \\ &= \max[0.1482, 0] \\ &= 0.1482 \text{ in} \end{aligned}$$

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

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

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

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

Available nozzle wall thickness new, $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

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

$$L / D_o = 8.0886 / 4.12 = 1.9632$$

$$D_o / t = 4.12 / 0.1482 = 27.7945$$

From table G: $A = 0.004502$

From table HA-2: $B = 12,976.6933 \text{ psi}$

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

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

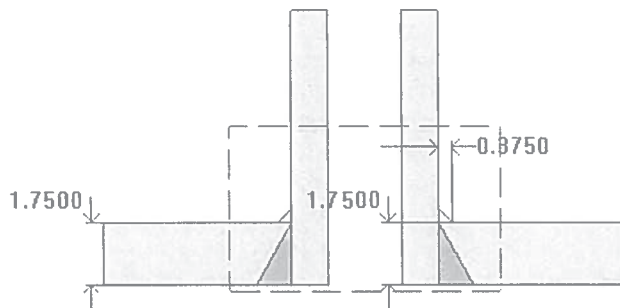
$$t_a = t + \text{Corrosion} = 0.1482 + 0 = 0.1482''$$

Level Gauge Low (N10B)

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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:	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, 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:	0.3574 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

UG-37 Area Calculation Summary (in ²) For P = 1,378.36 psi @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45		
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2074	1.06	

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

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

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)

$$\begin{aligned}
 t_{rn} &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378.3574 \cdot 1 / (20,000 \cdot 1 - 0.6 \cdot 1,378.3574) \\
 &= 0.0719 \text{ in}
 \end{aligned}$$

Required thickness t_r 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 -in
Circumferential shear:	$V_c = 409$	lb _f
Longitudinal moment:	$M_L = 2,965$	lb _f -in
Longitudinal shear:	$V_L = 409$	lb _f
Torsion moment:	$M_t = 4,160$	lb _f -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	β	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
Pressure stress*			18,524	18,524	18,524	18,524	17,525	17,525	17,525	17,525
Total circumferential stress			18,167	18,783	18,619	18,439	17,023	17,971	17,721	17,301
Primary membrane circumferential stress*			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
Pressure stress*			8,762	8,762	8,762	8,762	9,262	9,262	9,262	9,262
Total longitudinal stress			8,285	9,183	8,931	8,565	8,923	9,539	9,347	9,151
Primary membrane longitudinal stress*			8,734	8,734	8,748	8,748	9,231	9,231	9,249	9,249
Shear from M_l			89	89	89	89	89	89	89	89
Circ shear from V_c			36	36	-36	-36	0	0	0	0
Long shear from V_l			0	0	0	0	-36	-36	36	36
Total Shear stress			125	125	53	53	53	53	125	125
Comblned stress (P_L+P_b+Q)			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

$$\begin{aligned} \sigma_{n(P_m)} &= P \cdot R_i / (2 \cdot t_n) - P_r / (\pi \cdot (R_o^2 - R_i^2)) + M \cdot R_o / I \\ &= 1,378.36 \cdot 1 / (2 \cdot 1.06) - 334 / (\pi \cdot (2.06^2 - 1^2)) + 4,193.1 \cdot 2.06 / 13.3582 \\ &= 1,264 \text{ psi} \end{aligned}$$

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

$$\begin{aligned} \sigma_{\text{shear}} &= (V_L^2 + V_c^2)^{0.5} / (\pi \cdot R_i \cdot t_n) \\ &= (409^2 + 409^2)^{0.5} / (\pi \cdot 1 \cdot 1.06) \\ &= 174 \text{ psi} \end{aligned}$$

$$\begin{aligned} \sigma_{\text{torsion}} &= M_l / (2 \cdot \pi \cdot R_i^2 \cdot t_n) \\ &= 4,160 / (2 \cdot \pi \cdot 1^2 \cdot 1.06) \end{aligned}$$

= 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

UG-37 Area Calculation Summary (in ²) For Pe = 622.51 psi @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							<u>0.2074</u>	1.06

UG-41 Weld Failure Path Analysis Summary
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 ₄₁)	<u>0.25</u>	0.2625	weld size is adequate

Calculations for external pressure 622.51 psi @ 140 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2, 1 + (1.06 - 0) + (1.75 - 0)) \\
 &= 3.81 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(1.75 - 0), 2.5*(1.06 - 0) + 0) \\
 &= 2.65 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28 t_{rn} = 0.1482 in

From UG-37(d)(1) required thickness t_r = 1.75 in

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

UW-16(c) Weld Check

Fillet weld: t_{min} = lesser of 0.75 or t_n or t = 0.75 in
 t_{c(min)} = lesser of 0.25 or 0.7*t_{min} = 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: $B = 12,976.6933 \text{ psi}$

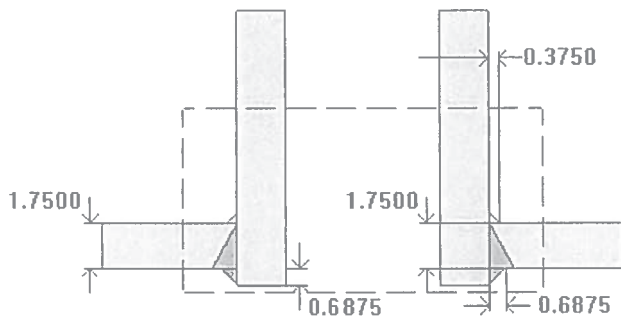
$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 12,976.69 / (3 \cdot (4.12 / 0.1482)) \\ &= 622.51 \text{ psi} \end{aligned}$$

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

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

Inspection c/w Blind Flange (N15)

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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:	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 ≤ 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:	7.25 in
Internal projection, h_{new} :	0.6875 in
Projection available outside vessel to flange face, Lf:	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:
Hydrotest rating:
PWHT performed:

2,160 psi @ 50°F
3,250 psi @ 50°F
No

Reinforcement Calculations for Chamber MAWP

UG-37 Area Calculation Summary (in ²)							UG-45 Nozzle Wall Thickness Summary (in)	
For P = 1,378 psi @ 140 °F The opening is adequately reinforced							The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	-A welds	t _{req}	t _{min}
12.874	18.208	1.126	13.8906	2.5781	--	0.6133	0.3281	1.875

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

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg ₄₁)	0.25	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)

$$\begin{aligned}
 t_{rn} &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 4 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.2875 \text{ in}
 \end{aligned}$$

Required thickness t_r from UG-37(a)

$$\begin{aligned}
 t_r &= P \cdot R_o / (S \cdot E + 0.4 \cdot P) \\
 &= 1,378 \cdot 24 / (20,000 \cdot 1 + 0.4 \cdot 1,378)
 \end{aligned}$$

$$= 1.6092 \text{ in}$$

Area required per UG-37(c)

Allowable stresses: $S_n = 20,000$, $S_v = 20,000$ psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$\begin{aligned} A &= d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1}) \\ &= 8 \cdot 1.6093 \cdot 1 + 2 \cdot 1.875 \cdot 1.6093 \cdot 1 \cdot (1 - 1) \\ &= \underline{12.874} \text{ in}^2 \end{aligned}$$

Area available from FIG. UG-37.1

$A_1 = \text{larger of the following} = \underline{1.126} \text{ in}^2$

$$\begin{aligned} &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 8 \cdot (1 \cdot 1.75 - 1 \cdot 1.6093) - 2 \cdot 1.875 \cdot (1 \cdot 1.75 - 1 \cdot 1.6093) \cdot (1 - 1) \\ &= 1.126 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2 \cdot (1.75 + 1.875) \cdot (1 \cdot 1.75 - 1 \cdot 1.6093) - 2 \cdot 1.875 \cdot (1 \cdot 1.75 - 1 \cdot 1.6093) \cdot (1 - 1) \\ &= 1.0204 \text{ in}^2 \end{aligned}$$

$A_2 = \text{smaller of the following} = \underline{13.8906} \text{ in}^2$

$$\begin{aligned} &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t \\ &= 5 \cdot (1.875 - 0.2875) \cdot 1 \cdot 1.75 \\ &= 13.8906 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (1.875 - 0.2875) \cdot 1 \cdot 1.875 \\ &= 14.8828 \text{ in}^2 \end{aligned}$$

$A_3 = \text{smaller of the following} = \underline{2.5781} \text{ in}^2$

$$\begin{aligned} &= 5 \cdot t_i \cdot f_{r2} \\ &= 5 \cdot 1.75 \cdot 1.875 \cdot 1 \\ &= \underline{16.4063} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 5 \cdot t_i \cdot f_{r2} \\ &= 5 \cdot 1.875 \cdot 1.875 \cdot 1 \\ &= \underline{17.5781} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 2 \cdot h \cdot t_i \cdot f_{r2} \\ &= 2 \cdot 0.6875 \cdot 1.875 \cdot 1 \end{aligned}$$

$$= \underline{2.5781 \text{ in}^2}$$

$$\begin{aligned} A_{41} &= \text{Leg}^2 f_{r2} \\ &= 0.375^2 * 1 \\ &= \underline{0.1406 \text{ in}^2} \end{aligned}$$

$$\begin{aligned} A_{43} &= \text{Leg}^2 f_{r2} \\ &= 0.6875^2 * 1 \\ &= \underline{0.4727 \text{ in}^2} \end{aligned}$$

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_3 + A_{41} + A_{43} \\ &= 1.126 + 13.8906 + 2.5781 + 0.1406 + 0.4727 \\ &= \underline{18.208 \text{ in}^2} \end{aligned}$$

As Area \geq A the reinforcement is adequate.

UW-16(c) Weld Check

Fillet weld: t_{\min} = lesser of 0.75 or t_n or $t = 0.75$ in

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

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

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

UG-45 Nozzle Neck Thickness Check

$$\begin{aligned} t_{a \text{ UG-27}} &= P * R / (S * E - 0.6 * P) + \text{Corrosion} \\ &= 1,378 * 4 / (20,000 * 1 - 0.6 * 1,378) + 0 \\ &= 0.2875 \text{ in} \end{aligned}$$

$$\begin{aligned} t_a &= \max[t_{a \text{ UG-27}}, t_{a \text{ UG-22}}] \\ &= \max[0.2875, 0] \\ &= 0.2875 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= P * R_o / (S * E + 0.4 * P) + \text{Corrosion} \\ &= 1,378 * 24 / (20,000 * 1 + 0.4 * 1,378) + 0 \\ &= 1.6092 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= \max[t_{b1}, t_{b \text{ UG16}}] \\ &= \max[1.6092, 0.0625] \\ &= 1.6092 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[t_{b3}, t_{b1}] \\ &= \min[0.3281, 1.6092] \\ &= 0.3281 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{UG-45} &= \max[t_a, t_b] \\ &= \max[0.2875, 0.3281] \\ &= 0.3281 \text{ in} \end{aligned}$$

Available nozzle wall thickness new, $t_n = 1.875$ in

The nozzle neck thickness is adequate.

Reinforcement Calculations for MAEP

UG-37 Area Calculation Summary (in²) For $P_e = 622.51 \text{ psi @ } 140 \text{ }^\circ\text{F}$ The opening is adequately reinforced							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}
7	16.1125	--	12.9211	2.5781	--	0.6133	0.3983	1.875

UG-41 Weld Failure Path Analysis Summary
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 ₄₁)	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: $S_n = 20,000$, $S_v = 20,000 \text{ psi}$

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$\begin{aligned} A &= 0.5(d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1})) \\ &= 0.5(8 \cdot 1.75 \cdot 1 + 2 \cdot 1.875 \cdot 1.75 \cdot 1 \cdot (1 - 1)) \\ &= \underline{7} \text{ in}^2 \end{aligned}$$

Area available from FIG. UG-37.1

$$A_1 = \text{larger of the following} = \underline{0} \text{ in}^2$$

$$\begin{aligned} &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 8 \cdot (1 \cdot 1.75 - 1 \cdot 1.75) - 2 \cdot 1.875 \cdot (1 \cdot 1.75 - 1 \cdot 1.75) \cdot (1 - 1) \\ &= 0 \text{ in}^2 \\ &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2 \cdot (1.75 + 1.875) \cdot (1 \cdot 1.75 - 1 \cdot 1.75) - 2 \cdot 1.875 \cdot (1 \cdot 1.75 - 1 \cdot 1.75) \cdot (1 - 1) \\ &= 0 \text{ in}^2 \end{aligned}$$

$$A_2 = \text{smaller of the following} = \underline{12.9211} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t \\ &= 5 \cdot (1.875 - 0.3983) \cdot 1 \cdot 1.75 \\ &= 12.9211 \text{ in}^2 \\ &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (1.875 - 0.3983) \cdot 1 \cdot 1.875 \\ &= 13.844 \text{ in}^2 \end{aligned}$$

$$A_3 = \text{smaller of the following} = \underline{2.5781} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot t_i \cdot t_i \cdot f_{r2} \\ &= 5 \cdot 1.75 \cdot 1.875 \cdot 1 \\ &= \underline{16.4063} \text{ in}^2 \\ &= 5 \cdot t_i \cdot t_i \cdot f_{r2} \\ &= 5 \cdot 1.875 \cdot 1.875 \cdot 1 \\ &= \underline{17.5781} \text{ in}^2 \\ &= 2 \cdot h \cdot t_i \cdot f_{r2} \\ &= 2 \cdot 0.6875 \cdot 1.875 \cdot 1 \\ &= \underline{2.5781} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} A_{41} &= \text{Leg}^2 \cdot f_{r2} \\ &= 0.375^2 \cdot 1 \\ &= \underline{0.1406} \text{ in}^2 \end{aligned}$$

$$A_{43} = \text{Leg}^2 \cdot f_{r2}$$

$$= 0.6875^2 * 1$$

$$= \underline{0.4727} \text{ in}^2$$

$$\text{Area} = A_1 + A_2 + A_3 + A_{41} + A_{43}$$

$$= 0 + 12.9211 + 2.5781 + 0.1406 + 0.4727$$

$$= \underline{16.1125} \text{ in}^2$$

As Area \geq A the reinforcement is adequate.

UW-16(c) Weld Check

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

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

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

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

$$t_{a \text{ UG-28}} = 0.3983 \text{ in}$$

$$t_a = \max[t_{a \text{ UG-28}}, t_{a \text{ UG-22}}]$$

$$= \max[0.3983, 0]$$

$$= 0.3983 \text{ in}$$

$$t_{b2} = P * R_o / (S * E + 0.4 * P) + \text{Corrosion}$$

$$= 622.5059 * 24 / (20,000 * 1 + 0.4 * 622.5059) + 0$$

$$= 0.7378 \text{ in}$$

$$t_{b2} = \max[t_{b2}, t_{b \text{ UG16}}]$$

$$= \max[0.7378, 0.0625]$$

$$= 0.7378 \text{ in}$$

$$t_b = \min[t_{b3}, t_{b2}]$$

$$= \min[0.3281, 0.7378]$$

$$= 0.3281 \text{ in}$$

$$t_{\text{UG-45}} = \max[t_a, t_b]$$

$$= \max[0.3983, 0.3281]$$

$$= 0.3983 \text{ in}$$

Available nozzle wall thickness new, $t_n = 1.875 \text{ in}$

The nozzle neck thickness is adequate.

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

$$\begin{aligned}L / D_o &= 10.7302 / 11.75 = 0.9132 \\D_o / t &= 11.75 / 0.3983 = 29.4998 \\ \text{From table G: } A &= 0.009593 \\ \text{From table} & \\ \text{HA-2: } B &= 13,772.846 \text{ psi}\end{aligned}$$

$$\begin{aligned}P_a &= 4*B / (3*(D_o / t)) \\ &= 4*13,772.85 / (3*(11.75 / 0.3983)) \\ &= 622.51 \text{ psi}\end{aligned}$$

Design thickness for external pressure $P_a = 622.51$ psi

$$t_a = t + \text{Corrosion} = 0.3983 + 0 = 0.3983''$$

Straight Flange on 48 OD BOTTOM SE HEAD

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Component: Straight Flange
 Material specification: SA-240 316 (II-D p. 70, In. 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:

$$P_s = 0.71 \text{ psi (SG} = 1.1, H_s = 18\text{"}, \text{Operating head)}$$

$$P_{th} = 2.03 \text{ psi (SG} = 1, H_s = 56.23\text{"}, \text{Horizontal test head)}$$

Corrosion allowance Inner C = 0" Outer C = 0"

Design MDMT = -20 °F No impact test performed
 Rated MDMT = -320 °F Material is not normalized
 Material is not produced to Fine Grain Practice
 PWHT is not performed

Radiography: Longitudinal joint - Seamless No RT
 Circumferential joint - Full UW-11(a) Type 1

Estimated weight New = 149.1 lb corr = 149.1 lb
 Capacity New = 13.44 US gal corr = 13.44 US gal

OD = 48"
 Length = 2"
 L_c
 t = 1.77"

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

$$t = P \cdot R_o / (S \cdot E + 0.40 \cdot P) + \text{Corrosion}$$

$$= 1,378.71 \cdot 24 / (20,000 \cdot 1.00 + 0.40 \cdot 1,378.71) + 0$$

$$= 1.6101"$$

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

$$P = S \cdot E \cdot t / (R_o - 0.40 \cdot t) - P_s$$

$$= 20,000 \cdot 1.00 \cdot 1.77 / (24 - 0.40 \cdot 1.77) - 0.71$$

$$= 1,519.12 \text{ psi}$$

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

$L / D_o = 107.4233 / 48 = 2.2380$
 $D_o / t = 48 / 0.2194 = 218.7532$
 From table G: A = 0.000180
 From table HA-2: B = 2,460.9773 psi

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

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

$$= 15 \text{ psi}$$

Design thickness for external pressure $P_a = 15 \text{ psi}$

$$t_a = t + \text{Corrosion} = 0.2194 + 0 = 0.2194''$$

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

$$L / D_o = 107.4233 / 48 = 2.2380$$

$$D_o / t = 48 / 1.77 = 27.1186$$

$$\text{From table G: } A = 0.004031$$

$$\text{From table HA-2: } B = 12,828.9038 \text{ psi}$$

$$\begin{aligned} P_a &= 4 * B / (3 * (D_o / t)) \\ &= 4 * 12,828.9 / (3 * (48 / 1.77)) \\ &= 630.75 \text{ psi} \end{aligned}$$

% Forming strain - UHA-44(a)(2)(a)

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

Design thickness = 1.6101''

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 _t	S _c					
<u>Operating, Hot & Corroded</u>	1,378	20,000	<u>13,729</u>	140	0	Wind	<u>0.633</u>	<u>0.6196</u>
						Seismic	<u>0.6474</u>	<u>0.6006</u>
<u>Operating, Hot & New</u>	1,378	20,000	<u>13,729</u>	140	0	Wind	<u>0.633</u>	<u>0.6196</u>
						Seismic	<u>0.6474</u>	<u>0.6006</u>
<u>Hot Shut Down, Corroded</u>	0	20,000	<u>13,729</u>	140	0	Wind	<u>0.0021</u>	<u>0.0166</u>
						Seismic	<u>0.0165</u>	<u>0.0443</u>
<u>Hot Shut Down, New</u>	0	20,000	<u>13,729</u>	140	0	Wind	<u>0.0021</u>	<u>0.0166</u>
						Seismic	<u>0.0165</u>	<u>0.0443</u>
<u>Empty, Corroded</u>	0	20,000	<u>13,908</u>	70	0	Wind	<u>0.0021</u>	<u>0.0164</u>
						Seismic	<u>0.0157</u>	<u>0.0425</u>
<u>Empty, New</u>	0	20,000	<u>13,908</u>	70	0	Wind	<u>0.0021</u>	<u>0.0164</u>
						Seismic	<u>0.0157</u>	<u>0.0425</u>
<u>Vacuum</u>	-15	20,000	<u>13,729</u>	140	0	Wind	<u>0.0071</u>	<u>0.0267</u>
						Seismic	<u>0.0095</u>	<u>0.0544</u>
<u>Hot Shut Down, Corroded, Weight & Eccentric Moments Only</u>	0	20,000	<u>13,729</u>	140	0	Weight	<u>0.0018</u>	<u>0.0188</u>

Allowable Compressive Stress, Hot and Corroded- S_{CHC} (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_{CHN}

$$\begin{aligned}
 S_{CHN} &= S_{CHC} \\
 &= \underline{13,729 \text{ psi}}
 \end{aligned}$$

Allowable Compressive Stress, Cold and New- S_{CCN} (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_{CCC}

$$\begin{aligned}
 S_{CCC} &= S_{CCN} \\
 &= \underline{13,908 \text{ psi}}
 \end{aligned}$$

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

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

$$= 1,378 * 22.23 / (2 * 20,000 * 1.20 * 1.00 + 0.40 * |1,378|)$$

$$= 0.6309"$$

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

$$= 849,942 / (\pi * 23.115^2 * 20,000 * 1.20 * 1.00)$$

$$= 0.0211"$$

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

$$= 16,188.1 / (2\pi * 23.115 * 20,000 * 1.20 * 1.00)$$

$$= 0.0046"$$

$$t_t = t_p + t_m - t_w \quad (\text{total required, tensile})$$

$$= 0.6309 + 0.0211 - (0.0046)$$

$$= 0.6474''$$

$$\begin{aligned} t_{wc} &= (1 + V_{Accel}) * W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\ &= 2.00 * 16,188.1 / (2 * \pi * 23.115 * 20,000 * 1.20 * 1.00) \\ &= 0.0093'' \end{aligned}$$

$$\begin{aligned} t_c &= |t_{mc} + t_{wc} - t_{pc}| && \text{(total, net tensile)} \\ &= |0.0211 + (0.0093) - (0.6309)| \\ &= 0.6006'' \end{aligned}$$

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

$$t_p = 0'' \quad \text{(Pressure)}$$

$$\begin{aligned} t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\ &= 849,942 / (\pi * 23.115^2 * 20,000 * 1.20 * 1.00) \\ &= 0.0211'' \end{aligned}$$

$$\begin{aligned} t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\ &= 16,188.1 / (2 * \pi * 23.115 * 20,000 * 1.20 * 1.00) \\ &= 0.0046'' \end{aligned}$$

$$\begin{aligned} t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\ &= 0 + 0.0211 - (0.0046) \\ &= 0.0165'' \end{aligned}$$

$$\begin{aligned} t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\ &= 849,942 / (\pi * 23.115^2 * 13,728.59 * 1.20) \\ &= 0.0307'' \end{aligned}$$

$$\begin{aligned} t_{wc} &= (1 + V_{Accel}) * W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\ &= 2.00 * 16,188.1 / (2 * \pi * 23.115 * 13,728.59 * 1.20) \\ &= 0.0135'' \end{aligned}$$

$$\begin{aligned} t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\ &= 0.0307 + (0.0135) - (0) \\ &= 0.0443'' \end{aligned}$$

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

$$\begin{aligned} t_p &= 0'' && \text{(Pressure)} \\ t_m &= M / (\pi R_m^2 S_t K_s E_c) && \text{(bending)} \\ &= 817,665 / (\pi 23.115^2 20,000 1.20 1.00) \\ &= 0.0203'' \end{aligned}$$

$$\begin{aligned} t_w &= W / (2 \pi R_m S_t K_s E_c) && \text{(Weight)} \\ &= 16,188.1 / (2 \pi 23.115 20,000 1.20 1.00) \\ &= 0.0046'' \end{aligned}$$

$$\begin{aligned} t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\ &= 0 + 0.0203 - (0.0046) \\ &= 0.0157'' \end{aligned}$$

$$\begin{aligned} t_{mc} &= M / (\pi R_m^2 S_c K_s) && \text{(bending)} \\ &= 817,665 / (\pi 23.115^2 13,907.75 1.20) \\ &= 0.0292'' \end{aligned}$$

$$\begin{aligned} t_{wc} &= (1 + V_{\text{Accel}}) W / (2 \pi R_m S_c K_s) && \text{(Weight)} \\ &= 2.00 16,188.1 / (2 \pi 23.115 13,907.75 1.20) \\ &= 0.0134'' \end{aligned}$$

$$\begin{aligned} t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\ &= 0.0292 + (0.0134) - (0) \\ &= 0.0425'' \end{aligned}$$

Empty, New, Seismic, Bottom Seam

$$\begin{aligned} t_p &= 0'' && \text{(Pressure)} \\ t_m &= M / (\pi R_m^2 S_t K_s E_c) && \text{(bending)} \\ &= 817,665 / (\pi 23.115^2 20,000 1.20 1.00) \\ &= 0.0203'' \end{aligned}$$

$$\begin{aligned} t_w &= W / (2 \pi R_m S_t K_s E_c) && \text{(Weight)} \\ &= 16,188.1 / (2 \pi 23.115 20,000 1.20 1.00) \\ &= 0.0046'' \end{aligned}$$

$$\begin{aligned} t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\ &= 0 + 0.0203 - (0.0046) \\ &= 0.0157'' \end{aligned}$$

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

$$= 817,665 / (\pi * 23.115^2 * 13,907.75 * 1.20)$$

$$= 0.0292"$$

$$t_{wc} = (1 + V_{Accel}) * W / (2 * \pi * R_m * S_c * K_s) \quad (\text{Weight})$$

$$= 2.00 * 16,188.1 / (2 * \pi * 23.115 * 13,907.75 * 1.20)$$

$$= 0.0134"$$

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

$$= 0.0292 + (0.0134) - (0)$$

$$= \underline{0.0425}"$$

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

Rated MDMT = -320 °F

No impact test performed

Material is not normalized

Material is not produced to fine grain practice

PWHT is not performed

Do not Optimize MDMT / Find MAWP

Radiography: Category A joints - Seamless No RT
Head to shell seam - Full UW-11(a) Type 1

Estimated weight*: new = 1,408.1 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)

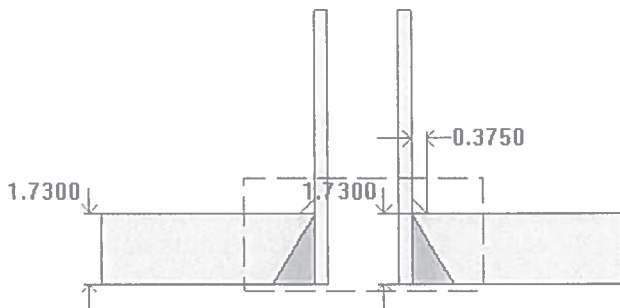
$$\begin{aligned}
 EFE &= (75 * t / R_f) * (1 - R_f / R_o) \\
 &= (75 * 1.77 / 8.4568) * (1 - 8.4568 / \infty) \\
 &= 15.6974\%
 \end{aligned}$$

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, Lpr:	4.01 in
Projection available outside vessel to flange face, Lf:	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

UG-37 Area Calculation Summary (in ²) For P = 1,379.48 psi @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45		
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.301	

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

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (In)	Actual weld throat size (In)	Status
Nozzle to shell fillet (Leg ₄₁)	0.2408	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)

$$\begin{aligned}
 t_{rn} &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,379.4842 \cdot 0.8435 / (15,700 \cdot 1 - 0.6 \cdot 1,379.4842) \\
 &= 0.0782 \text{ in}
 \end{aligned}$$

Required thickness t_r 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

UG-37 Area Calculation Summary (in²) For Pe = 566.01 psi @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45		
A required	A available	A ₁	A ₂	A ₃	A ₅	A welds	t _{req}	t _{min}	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.1348	0.301	

UG-41 Weld Failure Path Analysis Summary
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 ₄₁)	0.2408	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

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_o) \\
 &= \text{MIN}(2.5*(1.73 - 0), 2.5*(0.344 - 0) + 0) \\
 &= 0.86 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28 $t_{rn} = 0.0949 \text{ in}$

From UG-37(d)(1) required thickness $t_r = 1.73 \text{ in}$

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

UW-16(c) Weld Check

Fillet weld: $t_{min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.344 \text{ in}$
 $t_{c(min)} = \text{lesser of } 0.25 \text{ or } 0.7*t_{min} = 0.2408 \text{ in}$
 $t_{c(actual)} = 0.7*Leg = 0.7*0.375 = 0.2625 \text{ in}$

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

Interpretation VIII-1-83-66 has been applied.

$$t_{a \text{ UG-28}} = 0.0949 \text{ in}$$

$$\begin{aligned} t_a &= \max[t_{a \text{ UG-28}}, t_{a \text{ UG-22}}] \\ &= \max[0.0949, 0] \\ &= 0.0949 \text{ in} \end{aligned}$$

$$t_{b2} = 0.6623 \text{ in}$$

$$\begin{aligned} t_{b2} &= \max[t_{b2}, t_{b \text{ UG16}}] \\ &= \max[0.6623, 0.0625] \\ &= 0.6623 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[t_{b3}, t_{b2}] \\ &= \min[0.1348, 0.6623] \\ &= 0.1348 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[t_a, t_b] \\ &= \max[0.0949, 0.1348] \\ &= 0.1348 \text{ in} \end{aligned}$$

Available nozzle wall thickness new, $t_n = 0.875 \cdot 0.344 = 0.301 \text{ in}$

The nozzle neck thickness is adequate.

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

$$\begin{aligned} L / D_o &= 8.26 / 2.375 = 3.4779 \\ D_o / t &= 2.375 / 0.0949 = 25.0382 \\ \text{From table G: } A &= 0.002711 \\ \text{From table HA-4: } B &= 10,628.92 \text{ psi} \end{aligned}$$

$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 10,628.92 / (3 \cdot (2.375 / 0.0949)) \\ &= 566.01 \text{ psi} \end{aligned}$$

Design thickness for external pressure $P_a = 566.01 \text{ psi}$

$$t_a = t + \text{Corrosion} = 0.0949 + 0 = 0.0949''$$

46-3/4" OD Skirt

Material: SA-240 316 (II-D p. 70, In. 26)
 Design temperature, operating: 140 °F
 Design temperature, vacuum: 140 °F
 Inner diameter at top, new: 45.75 in
 Inner diameter at bottom, new: 45.75 in
 Overall length (includes base ring thickness): 20 in
 Corrosion allowance inside: 0 in
 Corrosion allowance outside: 0 in
 Weld joint efficiency top: 0.55
 Weld joint efficiency bottom: 0.8
 Nominal thickness, new: 0.5 in
 Skirt is attached to: 48 OD BOTTOM SE HEAD
 Skirt attachment offset: 5.88 in down from the top seam

Skirt design thickness, largest of the following + corrosion = 0.0579 in

The governing condition is due to earthquake, compressive stress at the base, operating & corroded.

The skirt thickness of 0.5 in is adequate.

Loading	Vessel Condition (Stress)	Governing Skirt Location	Temperature (°F)	Allowable Stress (psi)	Calculated Stress/E (psi)	Required thickness (In)
Wind	operating, corroded (+)	top	140	26,000	114.57	<u>0.0022</u>
Wind	operating, corroded (-)	bottom	140	15,798.24	606.74	<u>0.0192</u>
Wind	empty, corroded (+)	top	50	26,000	154.67	<u>0.003</u>
Wind	empty, corroded (-)	bottom	50	16,049.74	584.68	<u>0.0182</u>
Wind	vacuum, corroded (+)	top	140	26,000	114.57	<u>0.0022</u>
Wind	vacuum, corroded (-)	bottom	140	15,798.24	606.74	<u>0.0192</u>
Seismic	operating, corroded (+)	top	140	26,000	1,437.7	<u>0.0276</u>
Seismic	operating, corroded (-)	bottom	140	15,798.24	1,827.93	<u>0.0579</u>
Seismic	empty, corroded (+)	top	50	26,000	1,402.29	<u>0.027</u>
Seismic	empty, corroded (-)	bottom	50	16,049.74	1,723.22	<u>0.0537</u>
Seismic	vacuum, corroded (+)	top	140	26,000	1,437.7	<u>0.0276</u>
Seismic	vacuum, corroded (-)	bottom	140	15,798.24	1,827.93	<u>0.0579</u>

Loading due to wind, operating & corroded

Windward side (tensile)

Required thickness, tensile stress at base:

$$\begin{aligned}
 t &= -W / (\pi \cdot D \cdot S_t \cdot E) + 48 \cdot M / (\pi \cdot D^2 \cdot S_t \cdot E) \\
 &= -19,538.66 / (\pi \cdot 46.25 \cdot 26,000 \cdot 0.8) + 48 \cdot 23,645.6 / (\pi \cdot 46.25^2 \cdot 26,000 \cdot 0.8) \\
 &= \underline{0.0017} \text{ in}
 \end{aligned}$$

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 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:

$$\begin{aligned}t &= -W / (\pi * D_t * S_t * E) + 48 * M / (\pi * D_t^2 * S_t * E) \\&= -19,538.66 / (\pi * 46.25 * 26,000 * 0.8) + 48 * 23,645.6 / (\pi * 46.25^2 * 26,000 * 0.8) \\&= \underline{0.0017} \text{ in}\end{aligned}$$

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:

$$\begin{aligned}t &= W / (\pi * D_c * S_c * E_c) + 48 * M / (\pi * D_c^2 * S_c * E_c) \\&= 19,538.66 / (\pi * 46.25 * 15,798 * 1) + 48 * 23,645.6 / (\pi * 46.25^2 * 15,798 * 1) \\&= \underline{0.0192} \text{ in}\end{aligned}$$

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

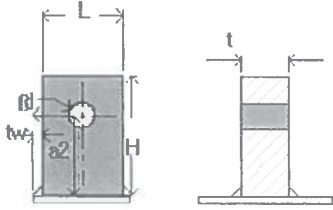
Required thickness, compressive stress at base:

$$\begin{aligned}t &= (1 + V_{\text{Accel}}) * W / (\pi * D_t * S_c * E_c) + 48 * M / (\pi * D_t^2 * S_c * E_c) \\&= (1 + 1) * 19,538.66 / (\pi * 46.25 * 15,798 * 1) + 48 * 90,303.6 / (\pi * 46.25^2 * 15,798 * 1) \\&= \underline{0.0579} \text{ in}\end{aligned}$$

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 ₁	0"
Distance from Load to Shell or Pad, a ₂	5"
Weld Size, t _w	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, σ_t	19980 psi
Allowable Stress, Shear, σ_s	13320 psi
Allowable Stress, Bearing, σ_p	29970 psi
Allowable Stress, Bending, σ_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

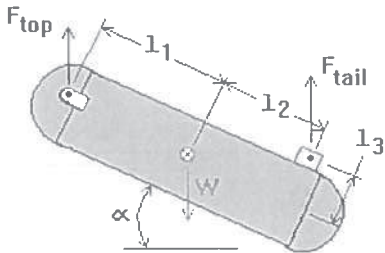
Required Lift Pin Diameter, d_{reqd}	0.8351"
Required Lug Thickness, t_{reqd}	0.3246"
Lug Stress Ratio, σ_{ratio}	0.37
Weld Shear Stress Ratio, τ_{ratio}	0.23
Lug Design	Acceptable
Local Stresses	Acceptable
Base ring loading	Acceptable

Lift Forces

Lift force on lugs during rotational lift ($0^\circ \leq \alpha \leq 90^\circ$):

$$2 \cdot F_{top} = W \cdot (l_2 \cdot \cos(\alpha) + l_3 \cdot \sin(\alpha)) / (l_1 \cdot \cos(\alpha) + l_2 \cdot \cos(\alpha) + l_3 \cdot \sin(\alpha))$$

$$F_{tail} = W - (2 \cdot F)$$



α [°]	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 ¹	8,069	11,268
0 ²	6,407	14,592
¹ Lift angle at maximum lug stress.		
² 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

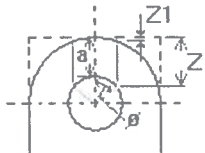
$$\begin{aligned} t_{\text{reqd}} &= [F_v / \sigma_s] / (2 * L_{\text{shear}}) \\ &= (14,592 / 13,320) / (2 * 2.0153) = \underline{0.2718"} \end{aligned}$$

$$t_{\text{reqd}} / t = 0.2718 / 1.5 = 0.18 \quad \text{Acceptable}$$

$$\begin{aligned} \tau &= F_v / A_{\text{shear}} \\ &= F_v / (2 * t * L_{\text{shear}}) \\ &= 14,592 / (2 * 1.5 * 2.0153) = 2,414 \text{ psi} \end{aligned}$$

$$\tau / \sigma_s = 2,414 / 13,320 = 0.18 \quad \text{Acceptable}$$

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



$$\begin{aligned} \phi &= 55 * D_p / d \\ &= 55 * 1.5 / 1.5625 \\ &= 52.8^\circ \end{aligned}$$

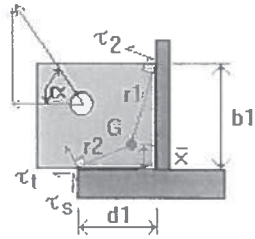
$$\begin{aligned} L_{\text{shear}} &= (H - a - 0.5 * d) + 0.5 * D_p * (1 - \cos(\phi)) \\ &= (7.5 - 5 - 0.5 * 1.5625) + 0.5 * 1.5 * (1 - \cos(52.8)) \\ &= 2.0153" \end{aligned}$$

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° ; 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

$$\begin{aligned} A_1 &= 0.707*t_w*L_1 \\ A_1 &= 0.707*0.625*4.625 = 2.0437 \text{ in}^2 \\ A_2 &= 0.707*0.625*5 = 2.2094 \text{ in}^2 \\ A_{\text{weld torsion}} &= \Sigma A_i = 4.253 \text{ in}^2 \end{aligned}$$

Weld centroid locations

$$\begin{aligned} x_1 &= 0" \\ y_1 &= 2.3125" \\ x_2 &= 2.5" \\ y_2 &= 0" \\ X_{\text{bar}} &= \Sigma (A_i*x_i) / \Sigma A_i \\ Y_{\text{bar}} &= \Sigma (A_i*y_i) / \Sigma A_i \\ X_{\text{bar}} &= (2.0437*0 + 2.2094*2.5) / 4.253 = 1.2987" \\ Y_{\text{bar}} &= (2.0437*2.3125 + 2.2094*0) / 4.253 = 1.1112" \end{aligned}$$

Radius to centroid locations

$$\begin{aligned} r_i &= \text{sqr}((X_{\text{bar}} - x_i)^2 + (Y_{\text{bar}} - y_i)^2) \\ r_1 &= \text{sqr}((1.2987 - 0)^2 + (1.1112 - 2.3125)^2) = 1.7691" \\ r_2 &= \text{sqr}((1.2987 - 2.5)^2 + (1.1112 - 0)^2) = 1.6364" \end{aligned}$$

Radial distance from centroid to weld:

$$r = \text{sqr}(\Delta X^2 + \Delta Y^2) \\ = \text{sqr}(3.7013^2 + 1.1112^2) = 3.8645''$$

$$\theta_r = \text{arctan}(\Delta Y / \Delta X) \\ = \text{arctan}(1.1112 / 3.7013) = 16.71^\circ$$

Polar Moment of Area

$$J_i = 0.707 \cdot t_w \cdot (L_i^3) / 12$$

$$J_1 = 0.707 \cdot 0.625 \cdot (4.625^3) / 12 = 3.643 \text{ in}^4$$

$$J_2 = 0.707 \cdot 0.625 \cdot (5^3) / 12 = 4.6029 \text{ in}^4$$

$$J = 2 \cdot \Sigma (J_i + A_i \cdot r_i^2) \quad \text{Parallel axis theorem (weld on both sides of lug)}$$

$$J = 2 \cdot [3.6430 + 2.0437 \cdot (1.7691)^2 + 4.6029 + 2.2094 \cdot (1.6364)^2] = 41.12 \text{ in}^4$$

Secondary shear

$$\tau_2 = M \cdot r / J \\ = [F(\alpha) \cdot \cos(\alpha) \cdot (X - X_{\text{bar}}) - F(\alpha) \cdot \sin(\alpha) \cdot (Y - Y_{\text{bar}})] \cdot r / J \\ = (14,592 \cdot \cos(0.0) \cdot (2.5 - 1.2987) - 14,592 \cdot \sin(0.0) \cdot (5 - 1.1112)) \cdot 3.8645 / 41.1169 \\ = 1,648 \text{ psi}$$

$$\tau_{\text{ratio}} = \text{sqr}(\tau_t + \tau_2 \cdot \cos(\theta_r))^2 + (\tau_s + \tau_2 \cdot \sin(\theta_r))^2 / \tau_{\text{allowable}} \leq 1 \\ = \text{sqr}((1,484 + 1,648 \cdot \cos(16.71))^2 + (0 + 1,648 \cdot \sin(16.71))^2) / 13,320 \\ = \underline{0.23} \quad \text{Acceptable}$$

WRC 107 Analysis

Geometry

Height(radial):	7.5"
Width (circumferential):	1.5"
Length	5"
Fillet Weld Size:	0.625"
Located on:	46-3/4" OD Skirt (1" from bottom end)
Location Angle:	225.00°

Applied Loads

Maximum stress ratio occurs at lift angle = 29.00° with lift force = 13,043 lbf

Radial load:	$P_r = -11,407.38 \text{ lb}_f$
Circumferential moment:	$M_c = 0 \text{ lb}_f\text{-in}$
Circumferential shear:	$V_c = 0 \text{ lb}_f$
Longitudinal moment:	$M_L = 31,616.06 \text{ lb}_f\text{-in}$
Longitudinal shear:	$V_L = 6,323.21 \text{ lb}_f$
Torsion moment:	$M_t = 0 \text{ lb}_f\text{-in}$
Internal pressure:	$P = 0 \text{ psi}$

Mean shell radius: $R_m = 23.125$ in
Shell yield stress: $S_y = 30,000$ psi

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

$$R_m / t = 23.125 / 0.5 = 46.25$$

$$C_1 = 1.375, C_2 = 3.125 \text{ in}$$

$$\text{Local circumferential pressure stress} = P \cdot R_i / t = 0 \text{ psi}$$

$$\text{Local longitudinal pressure stress} = P \cdot R_i / (2 \cdot t) = 0 \text{ psi}$$

$$\text{Maximum combined stress } (P_L + P_b + Q) = 58,761 \text{ psi}$$

$$\text{Allowable combined stress } (P_L + P_b + Q) = \pm 3 \cdot S = \pm 60,000 \text{ psi}$$

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

$$\text{Maximum local primary membrane stress } (P_L) = 12,675 \text{ psi}$$

$$\text{Allowable local primary membrane stress } (P_L) = \pm 1.5 \cdot S = \pm 30,000 \text{ psi}$$

The maximum local primary membrane stress (P_L) is within allowable limits.

Stresses at the lug edge per WRC Bulletin 107

Figure	value	β	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_l			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:

$$R_m = (D_i + t_1) \cdot 0.5$$

$$= (45.75 + 0.5) \cdot 0.5 = 23.125"$$

$$L_1 = \text{Min}(0.78 \cdot \text{sqr}(R_m \cdot t_1), 16 \cdot t_1)$$

$$= 0.78 \cdot \text{sqr}(23.125 \cdot 0.5) = 2.6523"$$

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 $k_1 = k_2 = 1$

$$\text{Change in vertical diameter, } D_v = (-W) * R^3 * (\pi * k_1 / 8 - k_2^2 / \pi) / (E * I)$$

$$\text{Internal Moment, } M_A = W * R * (k_2 - 0.5) / (2 * \pi)$$

$$\text{Internal Force, } N_A = 0.75 * W / \pi$$

$$\text{Internal Shear Force, } V_A = 0$$

$$\text{Ring loading, } W_r = 14,592 \text{ lbf}$$

$$D_{v_r} = -14,592 * 24.281^3 * (\pi * 1 / 8 - 1^2 / \pi) / (29,000,000 * 30.7189) = -0.0174''$$

$$M_{A_r} = 14,592 * 24.281 * (1 - 0.5) / (2 * \pi) = 28195.5728 \text{ lbf-in}$$

$$N_{A_r} = 0.75 * 14,592 / \pi = 3,484 \text{ lbf}$$

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 ²
Diameter of anchor bolt holes, d_b :	1.625 in

Load	Vessel condition	Base M (lb-ft)	W (lb)	Required bolt area (In ²)	t_r Base (In)	Foundation bearing stress (psi)
Wind	operating, corroded	23,645.6	19,872.9	0.0142	0.3457	42.81
Wind	operating, new	23,645.6	19,872.9	0.0142	0.3457	42.81
Wind	empty, corroded	23,645.6	18,270.4	0.0242	0.3395	41.3
Wind	empty, new	23,645.6	18,270.4	0.0242	0.3395	41.3
Wind	vacuum, corroded	23,645.6	19,872.9	0.0142	0.3457	42.81
Seismic	operating, corroded	90,303.6	19,872.9	0.4044	0.7867	221.69
Seismic	operating, new	90,303.6	19,872.9	0.4044	0.7867	221.69
Seismic	empty, corroded	86,062.1	18,270.4	0.3896	0.7649	209.58
Seismic	empty, new	86,062.1	18,270.4	0.3896	0.7649	209.58
Seismic	vacuum, corroded	90,303.6	19,872.9	0.4044	0.7867	221.69

Anchor bolt load (operating, corroded + Wind)

$$\begin{aligned}
 P &= -W / N + 48 * M / (N * BC) \\
 &= -19,872.88 / 8 + 48 * 23,645.6 / (8 * 51.25) \\
 &= 284.16 \text{ lb}_f
 \end{aligned}$$

$$\text{Required area per bolt} = P / S_b = 0.0142 \text{ in}^2$$

The area provided (0.929 in²) by the specified anchor bolt is adequate.

Foundation bearing stress (operating, corroded + Wind)

$$A_c = \pi(D_o^2 - D_i^2) / 4 - N\pi d_b^2 / 4$$

$$= \pi(56^2 - 42^2) / 4 - 8\pi(1.625)^2 / 4$$

$$= 1,060.9747 \text{ in}^2$$

$$I_c = \pi(D_o^4 - D_i^4) / 64$$

$$= \pi(56^4 - 42^4) / 64$$

$$= 330,004.7 \text{ in}^4$$

$$f_c = N A_b \text{Preload} / A_c + W / A_c + 6 M D_o / I_c$$

$$= 8 \times 0.929 \times 0 / 1,060.9747 + 19,872.88 / 1,060.9747 + 6 \times 23,645.6 \times 56 / 330,004.7$$

$$= 43 \text{ psi}$$

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

Base plate required thickness (operating, corroded + Wind)

From Brownell & Young, Table 10.3: $l/b = 0.3008$

$$M_x = 0.007 \times 43 \times 15.3758^2 = 71.2 \text{ lb}_f$$

$$M_y = -0.435 \times 43 \times 4.625^2 = -398.3 \text{ lb}_f$$

$$t_r = (6 M_{\max} / S_p)^{0.5}$$

$$= (6 \times 398.33 / 20,000)^{0.5}$$

$$= 0.3457 \text{ in}$$

The base plate thickness is satisfactory.

Base plate bolt load (Jawad & Farr eq. 12.13, operating, corroded + Wind)

$$\text{Bolt load} = A_b f_s = 0.929 \times 306 = 284.16 \text{ lb}_f$$

$$t_r = (3.91 F / (S_y (2b / w + w / (2l) - d_b (2 / w + 1 / (2l))))))^{0.5}$$

$$= (3.91 \times 284.16 / (36,000 (2 \times 4.625 / 4 + 4 / (2 \times 2.25) - 1.625 (2 / 4 + 1 / (2 \times 2.25))))))^{0.5}$$

$$= 0.1234 \text{ in}$$

The base plate thickness is satisfactory.

Check skirt for gusset reaction (Jawad & Farr eq. 12.14)

$$S_r = 1.5 F b / (\text{gussets} \pi t_{sk}^2 h)$$

$$= 1.5 \times 284.16 \times 4.625 / (2 \pi \times 0.5^2 \times 4.625)$$

$$= 271.35 \text{ psi}$$

As $S_r \leq 30,000 \text{ psi}$ the skirt thickness is adequate to resist the gusset reaction.

Anchor bolt load (operating, new + Wind)

$$P = -W / N + 48 M / (N \times BC)$$

$$= -19,872.88 / 8 + 48 \times 23,645.6 / (8 \times 51.25)$$

$$= 284.16 \text{ lb}_f$$

$$\text{Required area per bolt} = P / S_b = 0.0142 \text{ in}^2$$

The area provided (0.929 in²) by the specified anchor bolt is adequate.

Foundation bearing stress (operating, new + Wind)

$$\begin{aligned}
 A_c &= \pi(D_o^2 - D_i^2) / 4 - N\pi d_b^2 / 4 \\
 &= \pi(56^2 - 42^2) / 4 - 8\pi(1.625)^2 / 4 \\
 &= 1,060.9747 \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 I_c &= \pi(D_o^4 - D_i^4) / 64 \\
 &= \pi(56^4 - 42^4) / 64 \\
 &= 330,004.7 \text{ in}^4
 \end{aligned}$$

$$\begin{aligned}
 f_c &= N A_b \text{Preload} / A_c + W / A_c + 6 M D_o / I_c \\
 &= 8 \cdot 0.929 \cdot 0 / 1,060.9747 + 19,872.88 / 1,060.9747 + 6 \cdot 23,645.6 \cdot 56 / 330,004.7 \\
 &= \underline{43} \text{ psi}
 \end{aligned}$$

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., $l / b = 0.3008$

$$M_x = 0.007 \cdot 43 \cdot 15.3758^2 = 71.2 \text{ lb}_f$$

$$M_y = -0.435 \cdot 43 \cdot 4.625^2 = -398.3 \text{ lb}_f$$

$$\begin{aligned}
 t_r &= (6 M_{\max} / S_p)^{0.5} \\
 &= (6 \cdot 398.33 / 20,000)^{0.5} \\
 &= \underline{0.3457} \text{ in}
 \end{aligned}$$

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)

$$\begin{aligned}
 P &= -W / N + 48 \cdot M / (N \cdot BC) \\
 &= -18,270.39 / 8 + 48 \cdot 23,645.6 / (8 \cdot 51.25) \\
 &= 484.47 \text{ lb}_f
 \end{aligned}$$

$$\text{Required area per bolt} = P / S_b = \underline{0.0242} \text{ in}^2$$

The area provided (0.929 in²) by the specified anchor bolt is adequate.

Foundation bearing stress (empty, corroded + Wind)

$$\begin{aligned} A_c &= \pi(D_o^2 - D_i^2) / 4 - N\pi d_b^2 / 4 \\ &= \pi(56^2 - 42^2) / 4 - 8\pi(1.625)^2 / 4 \\ &= 1,060.9747 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} I_c &= \pi(D_o^4 - D_i^4) / 64 \\ &= \pi(56^4 - 42^4) / 64 \\ &= 330,004.7 \text{ in}^4 \end{aligned}$$

$$\begin{aligned} f_c &= N A_b \text{Preload} / A_c + W / A_c + 6 M D_o / I_c \\ &= 8(0.929)(0) / 1,060.9747 + 18,270.39 / 1,060.9747 + 6(23,645.6)(56) / 330,004.7 \\ &= 41 \text{ psi} \end{aligned}$$

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., $l / b = 0.3008$

$$M_x = 0.007(41)(15.3758)^2 = 68.7 \text{ lb}_f$$

$$M_y = -0.435(41)(4.625)^2 = -384.3 \text{ lb}_f$$

$$\begin{aligned} t_r &= (6 M_{\max} / S_p)^{0.5} \\ &= (6(384.28) / 20,000)^{0.5} \\ &= 0.3395 \text{ in} \end{aligned}$$

The base plate thickness is satisfactory.

Base plate bolt load (Jawad & Farr eq. 12.13, empty, corroded + Wind)

$$\text{Bolt load} = A_b f_s = 0.929(521) = 484.47 \text{ lb}_f$$

$$\begin{aligned} t_r &= (3.91 F / (S_y (2b / w + w / (2l) - d_b (2 / w + 1 / (2l))))))^{0.5} \\ &= (3.91(484.47) / (36,000(2(4.625) / 4 + 4 / (2(2.25)) - 1.625(2 / 4 + 1 / (2(2.25))))))^{0.5} \\ &= 0.1611 \text{ in} \end{aligned}$$

The base plate thickness is satisfactory.

Check skirt for gusset reaction (Jawad & Farr eq. 12.14)

$$\begin{aligned} S_r &= 1.5 F b / (\text{gussets} \pi t_{sk}^2 h) \\ &= 1.5(484.47)(4.625) / (2 \pi (0.5)^2 (4.625)) \\ &= 462.63 \text{ psi} \end{aligned}$$

As $S_r \leq 30,000$ psi the skirt thickness is adequate to resist the gusset reaction.

Anchor bolt load (empty, new + Wind)

$$\begin{aligned} P &= -W / N + 48 M / (N BC) \\ &= -18,270.39 / 8 + 48(23,645.6) / (8(51.25)) \\ &= 484.47 \text{ lb}_f \end{aligned}$$

$$\text{Required area per bolt} = P / S_b = 0.0242 \text{ in}^2$$

The area provided (0.929 in²) by the specified anchor bolt is adequate.

Foundation bearing stress (empty, new + Wind)

$$\begin{aligned}A_c &= \pi(D_o^2 - D_i^2) / 4 - N\pi d_b^2 / 4 \\&= \pi(56^2 - 42^2) / 4 - 8\pi(1.625)^2 / 4 \\&= 1,060.9747 \text{ in}^2\end{aligned}$$

$$\begin{aligned}I_c &= \pi(D_o^4 - D_i^4) / 64 \\&= \pi(56^4 - 42^4) / 64 \\&= 330,004.7 \text{ in}^4\end{aligned}$$

$$\begin{aligned}f_c &= N A_b \text{Preload} / A_c + W / A_c + 6 M D_o / I_c \\&= 8 \cdot 0.929 \cdot 0 / 1,060.9747 + 18,270.39 / 1,060.9747 + 6 \cdot 23,645.6 \cdot 56 / 330,004.7 \\&= \underline{41} \text{ psi}\end{aligned}$$

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.: $l / b = 0.3008$

$$M_x = 0.007 \cdot 41 \cdot 15.3758^2 = 68.7 \text{ lb}_f$$

$$M_y = -0.435 \cdot 41 \cdot 4.625^2 = -384.3 \text{ lb}_f$$

$$\begin{aligned}t_r &= (6 M_{\max} / S_p)^{0.5} \\&= (6 \cdot 384.28 / 20,000)^{0.5} \\&= \underline{0.3395} \text{ in}\end{aligned}$$

The base plate thickness is satisfactory.

Base plate bolt load (Jawad & Farr eq. 12.13, empty, new + Wind)

$$\text{Bolt load} = A_b \cdot f_s = 0.929 \cdot 521 = 484.47 \text{ lb}_f$$

$$\begin{aligned}t_r &= (3.91 \cdot F / (S_y \cdot (2 \cdot b / w + w / (2 \cdot l) - d_b \cdot (2 / w + 1 / (2 \cdot l))))))^{0.5} \\&= (3.91 \cdot 484.47 / (36,000 \cdot (2 \cdot 4.625 / 4 + 4 / (2 \cdot 2.25) - 1.625 \cdot (2 / 4 + 1 / (2 \cdot 2.25))))))^{0.5} \\&= 0.1611 \text{ in}\end{aligned}$$

The base plate thickness is satisfactory.

Check skirt for gusset reaction (Jawad & Farr eq. 12.14)

$$\begin{aligned}S_r &= 1.5 \cdot F \cdot b / (\text{gussets} \cdot \pi \cdot t_{sk}^2 \cdot h) \\&= 1.5 \cdot 484.47 \cdot 4.625 / (2 \cdot \pi \cdot 0.5^2 \cdot 4.625) \\&= 462.63 \text{ psi}\end{aligned}$$

As $S_r \leq 30,000$ psi the skirt thickness is adequate to resist the gusset reaction.

Anchor bolt load (vacuum, corroded + Wind)

$$\begin{aligned}P &= -W / N + 48 \cdot M / (N \cdot BC) \\&= -19,872.88 / 8 + 48 \cdot 23,645.6 / (8 \cdot 51.25) \\&= 284.16 \text{ lb}_f\end{aligned}$$

$$\text{Required area per bolt} = P / S_b = \underline{0.0142} \text{ in}^2$$

The area provided (0.929 in²) by the specified anchor bolt is adequate.

Foundation bearing stress (vacuum, corroded + Wind)

$$\begin{aligned} A_c &= \pi(D_o^2 - D_i^2) / 4 - N\pi d_b^2 / 4 \\ &= \pi(56^2 - 42^2) / 4 - 8\pi(1.625)^2 / 4 \\ &= 1,060.9747 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} I_c &= \pi(D_o^4 - D_i^4) / 64 \\ &= \pi(56^4 - 42^4) / 64 \\ &= 330,004.7 \text{ in}^4 \end{aligned}$$

$$\begin{aligned} f_c &= N A_b \text{Preload} / A_c + W / A_c + 6 M D_o / I_c \\ &= 8 \cdot 0.929 \cdot 0 / 1,060.9747 + 19,872.88 / 1,060.9747 + 6 \cdot 23,645.6 \cdot 56 / 330,004.7 \\ &= \underline{43} \text{ psi} \end{aligned}$$

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.: $l / b = 0.3008$

$$M_x = 0.007 \cdot 43 \cdot 15.3758^2 = 71.2 \text{ lb}_f$$

$$M_y = -0.435 \cdot 43 \cdot 4.625^2 = -398.3 \text{ lb}_f$$

$$\begin{aligned} t_r &= (6 M_{\max} / S_p)^{0.5} \\ &= (6 \cdot 398.33 / 20,000)^{0.5} \\ &= \underline{0.3457} \text{ in} \end{aligned}$$

The base plate thickness is satisfactory.

Base plate bolt load (Jawad & Farr eq. 12.13, vacuum, corroded + Wind)

$$\text{Bolt load} = A_b \cdot f_s = 0.929 \cdot 306 = 284.16 \text{ lb}_f$$

$$\begin{aligned} t_r &= (3.91 \cdot F / (S_y \cdot (2 \cdot b / w + w / (2 \cdot l) - d_b \cdot (2 / w + 1 / (2 \cdot l))))))^{0.5} \\ &= (3.91 \cdot 284.16 / (36,000 \cdot (2 \cdot 4.625 / 4 + 4 / (2 \cdot 2.25) - 1.625 \cdot (2 / 4 + 1 / (2 \cdot 2.25))))))^{0.5} \\ &= 0.1234 \text{ in} \end{aligned}$$

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, corroded + Seismic)

$$\begin{aligned} P &= -W / N + 48 \cdot M / (N \cdot BC) \\ &= -19,872.88 / 8 + 48 \cdot 90,303.6 / (8 \cdot 51.25) \\ &= 8,088.01 \text{ lb}_f \end{aligned}$$

$$\text{Required area per bolt} = P / S_b = \underline{0.4044} \text{ in}^2$$

The area provided (0.929 in²) by the specified anchor bolt is adequate.

Support calculations (Jawad & Farr chapter 12, operating, corroded + Seismic)

Base plate width, t_c : 7 in
Average base plate diameter, d : 49 in
Base plate elastic modulus, E_s : 29.0E+06 psi
Base plate yield stress, S_y : 36,000 psi

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

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

$$\begin{aligned} t_s &= (N * A_b) / (\pi * d) \\ &= (8 * 0.929) / (\pi * 49) \\ &= 0.0483 \text{ in} \end{aligned}$$

From table 12.4 for $k = 0.264922$:

$$\begin{aligned} K_1 &= 2.5185, \quad K_2 = 1.4124 \\ L_1 &= 11.5204, \quad L_2 = 27.899, \quad L_3 = 10.2954 \end{aligned}$$

Total tensile force on bolting

$$\begin{aligned} T &= (12 * M - W * (L_1 + L_3)) / (L_2 + L_3) \\ &= (12 * 90,303.6 - 19,872.88 * (11.5204 + 10.2954)) / (27.899 + 10.2954) \\ &= 17,020.84 \text{ lb}_f \end{aligned}$$

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

$$\begin{aligned} f_s &= T / (t_s * (d / 2) * K_1) \\ &= 17,020.84 / (0.0483 * (49 / 2) * 2.5185) \\ &= 5,714 \text{ psi} \end{aligned}$$

Total compressive load on foundation

$$\begin{aligned} C_c &= T + (1 + V_{\text{Accel}}) * W + \text{Bolt Preload} \\ &= 17,020.84 + (1 + 1) * 19,872.88 + 0 \\ &= 56,766.59 \text{ lb}_f \end{aligned}$$

Foundation bearing stress

$$\begin{aligned} f_c &= C_c / (((t_c - t_s) + n * t_s) * (d / 2) * K_2) \\ &= 56,766.59 / (((7 - 0.0483) + 9.2889 * 0.0483) * (49 / 2) * 1.4124) \\ &= \underline{222} \text{ psi} \end{aligned}$$

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, corroded + Seismic)

From Brownell & Young, Table 10.3.; $l / b = 0.3008$

$$M_x = 0.007 * 222 * 15.3758^2 = 369 \text{ lb}_f$$

$$M_y = -0.435 * 222 * 4.625^2 = -2,062.9 \text{ lb}_f$$

$$t_r = (6 * M_{\max} / S_p)^{0.5}$$

$$= (6 * 2,062.91 / 20,000)^{0.5}$$

$$= \underline{0.7867} \text{ in}$$

The base plate thickness is satisfactory.

Base plate bolt load (Jawad & Farr eq. 12.13, operating, corroded + Seismic)

$$\text{Bolt load} = A_b * f_s = 0.929 * 5,714 = 5,308.02 \text{ lb}_f$$

$$t_r = (3.91 * F / (S_y * (2 * b / w + w / (2 * l) - d_b * (2 / w + 1 / (2 * l))))^{0.5}$$

$$= (3.91 * 5,308.02 / (36,000 * (2 * 4.625 / 4 + 4 / (2 * 2.25) - 1.625 * (2 / 4 + 1 / (2 * 2.25))))^{0.5}$$

$$= 0.5332 \text{ in}$$

The base plate thickness is satisfactory.

Check skirt for gusset reaction (Jawad & Farr eq. 12.14)

$$S_r = 1.5 * F * b / (\text{gussets} * \pi * t_{sk}^2 * h)$$

$$= 1.5 * 5,308.02 * 4.625 / (2 * \pi * 0.5^2 * 4.625)$$

$$= 5,068.78 \text{ psi}$$

As $S_r \leq 30,000$ psi the skirt thickness is adequate to resist the gusset reaction.

Anchor bolt load (operating, new + Seismic)

$$P = -W / N + 48 * M / (N * BC)$$

$$= -19,872.88 / 8 + 48 * 90,303.6 / (8 * 51.25)$$

$$= 8,088.01 \text{ lb}_f$$

$$\text{Required area per bolt} = P / S_b = \underline{0.4044} \text{ in}^2$$

The area provided (0.929 in²) 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

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

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

$$t_s = (N * A_b) / (\pi * d)$$

$$= (8 * 0.929) / (\pi * 49)$$

$$= 0.0483 \text{ in}$$

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

$$\begin{aligned} T &= (12 * M - W * (L_1 + L_3)) / (L_2 + L_3) \\ &= (12 * 90,303.6 - 19,872.88 * (11.5204 + 10.2954)) / (27.899 + 10.2954) \\ &= 17,020.84 \text{ lb}_f \end{aligned}$$

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)

$$S_r = 1.5 * F * b / (\text{gussets} * \pi * t_{sk}^2 * h)$$

$$= 1.5 * 5,308.02 * 4.625 / (2 * \pi * 0.5^2 * 4.625)$$

$$= 5,068.78 \text{ psi}$$

As $S_r \leq 30,000$ psi the skirt thickness is adequate to resist the gusset reaction.

Anchor bolt load (empty, corroded + 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 in²) 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

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

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

$$t_s = (N * A_b) / (\pi * d)$$

$$= (8 * 0.929) / (\pi * 49)$$

$$= 0.0483 \text{ in}$$

From table 12.4 for $k = 0.259917$:

$$K_1 = 2.5294, \quad K_2 = 1.3981$$

$$L_1 = 11.7657, \quad L_2 = 28.0786, \quad L_3 = 10.1027$$

Total tensile force on bolting

$$T = (12 * M - W * (L_1 + L_3)) / (L_2 + L_3)$$

$$= (12 * 86,062.1 - 18,270.39 * (11.7657 + 10.1027)) / (28.0786 + 10.1027)$$

$$= 16,584.11 \text{ lb}_f$$

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

$$f_s = T / (t_s * (d / 2) * K_1)$$

$$= 16,584.11 / (0.0483 * (49 / 2) * 2.5294)$$

$$= 5,543 \text{ psi}$$

Total compressive load on foundation

$$C_c = T + (1 + V_{\text{Accel}}) * W + \text{Bolt Preload}$$

$$= 16,584.11 + (1 + 1) * 18,270.39 + 0$$

$$= 53,124.89 \text{ lb}_f$$

Foundation bearing stress

$$f_c = C_c / (((t_c - t_s) + n * t_s) * (d / 2) * K_2)$$

$$= 53,124.89 / (((7 - 0.0483) + 9.2889 * 0.0483) * (49 / 2) * 1.3981)$$

$$= \underline{210} \text{ psi}$$

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., $l / b = 0.3008$

$$M_x = 0.007 * 210 * 15.3758^2 = 348.8 \text{ lb}_f$$

$$M_y = -0.435 * 210 * 4.625^2 = -1,950.2 \text{ lb}_f$$

$$t_r = (6 * M_{\max} / S_p)^{0.5}$$

$$= (6 * 1,950.22 / 20,000)^{0.5}$$

$$= \underline{0.7649} \text{ in}$$

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)

$$P = -W / N + 48 * M / (N * BC)$$

$$= -18,270.39 / 8 + 48 * 86,062.1 / (8 * 51.25)$$

$$= 7,791.77 \text{ lb}_f$$

$$\text{Required area per bolt} = P / S_b = \underline{0.3896} \text{ in}^2$$

The area provided (0.929 in²) 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)

$$\text{Bolt load} = A_b \cdot f_s = 0.929 \cdot 5,543 = 5,149.51 \text{ lb}_f$$

$$\begin{aligned} t_r &= (3.91 \cdot F / (S_y \cdot (2 \cdot b / w + w / (2 \cdot l) - d_b \cdot (2 / w + 1 / (2 \cdot l))))))^{0.5} \\ &= (3.91 \cdot 5,149.51 / (36,000 \cdot (2 \cdot 4.625 / 4 + 4 / (2 \cdot 2.25) - 1.625 \cdot (2 / 4 + 1 / (2 \cdot 2.25))))))^{0.5} \\ &= 0.5252 \text{ in} \end{aligned}$$

The base plate thickness is satisfactory.

Check skirt for gusset reaction (Jawad & Farr eq. 12.14)

$$\begin{aligned} S_r &= 1.5 \cdot F \cdot b / (\text{gussets} \cdot \pi \cdot t_{sk}^2 \cdot h) \\ &= 1.5 \cdot 5,149.51 \cdot 4.625 / (2 \cdot \pi \cdot 0.5^2 \cdot 4.625) \\ &= 4,917.42 \text{ psi} \end{aligned}$$

As $S_r \leq 30,000$ psi the skirt thickness is adequate to resist the gusset reaction.

Anchor bolt load (vacuum, corroded + Seismic)

$$\begin{aligned} P &= -W / N + 48 \cdot M / (N \cdot BC) \\ &= -19,872.88 / 8 + 48 \cdot 90,303.6 / (8 \cdot 51.25) \\ &= 8,088.01 \text{ lb}_f \end{aligned}$$

$$\text{Required area per bolt} = P / S_b = 0.4044 \text{ in}^2$$

The area provided (0.929 in²) 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

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

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

$$\begin{aligned} t_s &= (N \cdot A_b) / (\pi \cdot d) \\ &= (8 \cdot 0.929) / (\pi \cdot 49) \\ &= 0.0483 \text{ in} \end{aligned}$$

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

$$\begin{aligned} T &= (12 \cdot M - W \cdot (L_1 + L_3)) / (L_2 + L_3) \\ &= (12 \cdot 90,303.6 - 19,872.88 \cdot (11.5204 + 10.2954)) / (27.899 + 10.2954) \\ &= 17,020.84 \text{ lb}_f \end{aligned}$$

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 (vacuum, corroded + Seismic)

From Brownell & Young, Table 10.3.; $l / b = 0.3008$

$$M_x = 0.007 * 222 * 15.3758^2 = 369 \text{ lb}_f$$

$$M_y = -0.435 * 222 * 4.625^2 = -2,062.9 \text{ lb}_f$$

$$\begin{aligned}
 t_r &= (6 * M_{\text{max}} / S_p)^{0.5} \\
 &= (6 * 2,062.91 / 20,000)^{0.5} \\
 &= \underline{0.7867} \text{ in}
 \end{aligned}$$

The base plate thickness is satisfactory.

Base plate bolt load (Jawad & Farr eq. 12.13, vacuum, corroded + Seismic)

$$\text{Bolt load} = A_b * f_s = 0.929 * 5,714 = 5,308.02 \text{ lb}_f$$

$$\begin{aligned}
 t_r &= (3.91 * F / (S_y * (2 * b / w + w / (2 * l) - d_b * (2 / w + 1 / (2 * l))))))^{0.5} \\
 &= (3.91 * 5,308.02 / (36,000 * (2 * 4.625 / 4 + 4 / (2 * 2.25) - 1.625 * (2 / 4 + 1 / (2 * 2.25))))))^{0.5} \\
 &= 0.5332 \text{ in}
 \end{aligned}$$

The base plate thickness is satisfactory.

Check skirt for gusset reaction (Jawad & Farr eq. 12.14)

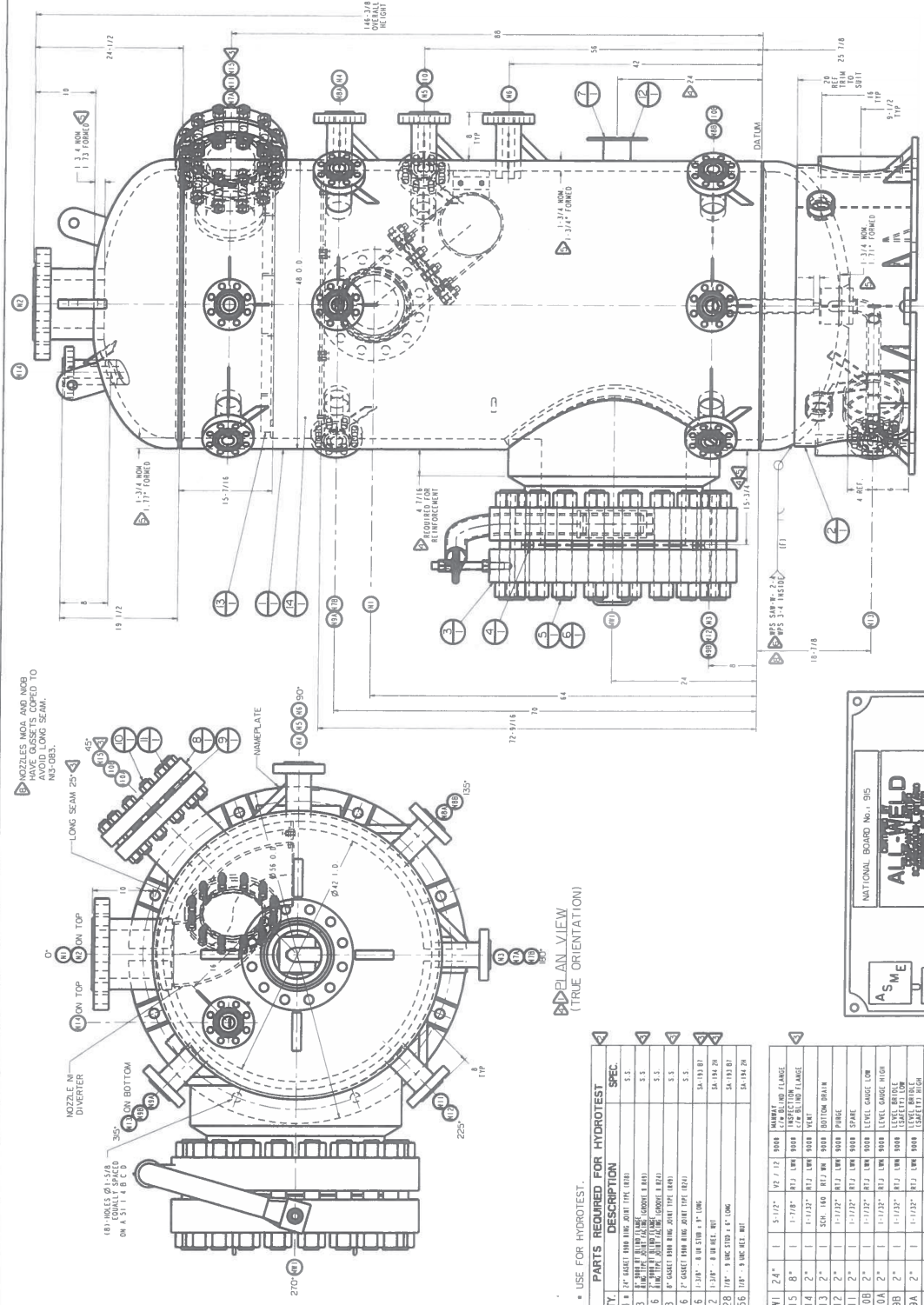
$$\begin{aligned}
 S_r &= 1.5 * F * b / (\text{gussets} * \pi * t_{\text{sk}}^2 * h) \\
 &= 1.5 * 5,308.02 * 4.625 / (2 * \pi * 0.5^2 * 4.625) \\
 &= 5,068.78 \text{ psi}
 \end{aligned}$$

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



ITEM	QTY.	DESCRIPTION	SPEC.
1/1	1	1/4" SCH. 40S PIPE	ASTM A106
2/1	1	1/4" SCH. 40S PIPE	ASTM A106
3/1	1	1/4" SCH. 40S PIPE	ASTM A106
4/1	24	24" GASKET FLANGING JOINT TYPE (A)	ASME VIII
5/1	20	1/4" SCH. 40S PIPE	ASTM A106
6/1	40	1/4" SCH. 40S PIPE	ASTM A106
7/1	4	1/4" SCH. 40S PIPE	ASTM A106
8/1	24	1/4" SCH. 40S PIPE	ASTM A106
9/1	12	1/4" SCH. 40S PIPE	ASTM A106
10/1	24	1/4" SCH. 40S PIPE	ASTM A106
11/1	24	1/4" SCH. 40S PIPE	ASTM A106
12/1	24	1/4" SCH. 40S PIPE	ASTM A106
13/1	24	1/4" SCH. 40S PIPE	ASTM A106
14/1	24	1/4" SCH. 40S PIPE	ASTM A106
15/1	24	1/4" SCH. 40S PIPE	ASTM A106
16/1	24	1/4" SCH. 40S PIPE	ASTM A106
17/1	24	1/4" SCH. 40S PIPE	ASTM A106
18/1	24	1/4" SCH. 40S PIPE	ASTM A106
19/1	24	1/4" SCH. 40S PIPE	ASTM A106
20/1	24	1/4" SCH. 40S PIPE	ASTM A106
21/1	24	1/4" SCH. 40S PIPE	ASTM A106
22/1	24	1/4" SCH. 40S PIPE	ASTM A106
23/1	24	1/4" SCH. 40S PIPE	ASTM A106
24/1	24	1/4" SCH. 40S PIPE	ASTM A106
25/1	24	1/4" SCH. 40S PIPE	ASTM A106
26/1	24	1/4" SCH. 40S PIPE	ASTM A106
27/1	24	1/4" SCH. 40S PIPE	ASTM A106
28/1	24	1/4" SCH. 40S PIPE	ASTM A106
29/1	24	1/4" SCH. 40S PIPE	ASTM A106
30/1	24	1/4" SCH. 40S PIPE	ASTM A106
31/1	24	1/4" SCH. 40S PIPE	ASTM A106
32/1	24	1/4" SCH. 40S PIPE	ASTM A106
33/1	24	1/4" SCH. 40S PIPE	ASTM A106
34/1	24	1/4" SCH. 40S PIPE	ASTM A106
35/1	24	1/4" SCH. 40S PIPE	ASTM A106

GENERAL NOTES:

- MATERIALS OF CONSTRUCTION: SA 240 316/316L
- SA-82 316/316L AND SA-307 TP304/316L (SEAMLESS)
- WELDING SHALL BE DONE OUT OF FLUX & SPATTER REMOVED
- SURFACE FINISH: EXTERNAL - AS FABRICATED
- INTERNAL - AS FABRICATED
- HEAT STAIN REMOVED, INTERNAL AND EXTERNAL
- ALL BOLT HEADS TO STAGRA EITHER MAJOR OR RADIAL CENTERLINES, WHERE APPLICABLE.
- BLANK ALL OPENINGS FOR SHIPMENT WITH GASKET AND NOZZLE FILED BLEND SMOOTHLY WITHOUT NOTCH, SHARP CORNERS OR UNDERCUT.
- GASKET HARDNESS MUST BE LESS THAN THAT OF THE FLANGE
- VESSELS TO BE SHIPPED WITH THE HYDROTEST GASKETS INSTALLED WHERE REQUIRED AND SERVICE GASKETS ARE TO BE SHIPPED LOOSE.
- LIFTING LUGS DESIGN FOR VERTICAL LIFT ONLY.

QUALITY ASSURANCE NOTES:

- ASME DATA REPORT AND NAMEPLATE RUBBING.
- HYDROTEST INSPECTION: WPS, POR, ADE, AND DIMENSIONAL INSPECTION VERIFIED ON AS BUILT DRAWINGS.
- WATER TO BE LESS THAN 50 ppm OF CHLORIDE.
- ONLY SEAMLESS PIPE.
- ALL PRESSURE PARTS AND ANY MATERIAL ATTACHED TO PRESURE PARTS TO BE HARD STAMPED THE HEAT NUMBERS.
- NOZZLE WELDS: WELDS TO BE QUALIFIED IN ACCORDANCE WITH ASME SECTION VIII, DIV. 1 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 HYDRO-200 EDITION, 2001 ADDENDA AND CSA B58-2008. REGISTERED WITH NATIONAL BOARD.

DESIGN TEMPERATURE: 1378 PSIG
140 °F @ 1378 PSIG
1378 PSIG @ 140 °F

MA.E.W.P. ALLOWANCES: 15 PSIG @ 140 °F
SNIP HYDROTEST PRESSURE: 1026 PSIG @ 50 °F

FULL 100% (RT-I) RADIOGRAPHY, AS PER UG-99(b)(4) (NIPR 34)

PHW TEST TESTING: FULL 100% (RT-I) NOT REQUIRED AS PER UG-91 OFF OF THE COAST OF ANGOLA

SERIAL NO. 5: 472
NATIONAL BOARD NO.: B58-355.5
VOLUME: 73 U.S. GALLONS (EMPTY)
WEIGHT: 29,000 LB. (FULL WITH WATER)

ALL-WELD COMPANY LIMITED
 48° 0' ULTRAFAB INDUSTRIES LIMITED
 48° 0' GENERAL ASSEMBLY
 166 AS, 172 VECE 101

DESIGNED BY: B.O. 11/29/01
 DRAWN BY: B.O. 11/29/01

(2) REQUIRED
 PURCHASE ORDER NUMBER: 11112

STANDARD TOLERANCES
 ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE NOTED
 ANGULAR
 L ± .00" ± .016
 R ± .00" ± .016
 40° ± .1" ± .160" ± 1/8
 160° ± .1" ± .400" ± 5/16

ALL-WELD COMPANY LIMITED
 CERTIFIED AS-BUILT
 BY: OCM DATE: MAY 07 2013

ITEM	SIZE	REQD	NECK	FACE	DATE	SERVICE
NW1	2 1/4"	1	5-132"	RT / 12	8000	MARBY
N15	8"	1	1-118"	RT / LN	8000	TOP WELD FLANGE
N14	2"	1	1-132"	RT / LN	8000	TOP WELD FLANGE
N13	2"	1	5-168"	RT / LN	8000	FEET
N12	2"	1	1-132"	RT / LN	8000	PHONE
N11	2"	1	1-132"	RT / LN	8000	PHONE
N10	2"	1	1-132"	RT / LN	8000	PHONE
N9	2"	1	1-132"	RT / LN	8000	PHONE
N8	2"	1	1-132"	RT / LN	8000	PHONE
N7	2"	1	1-132"	RT / LN	8000	PHONE
N6	2"	1	1-132"	RT / LN	8000	PHONE
N5	2"	1	1-132"	RT / LN	8000	PHONE
N4	2"	1	1-132"	RT / LN	8000	PHONE
N3	2"	1	1-132"	RT / LN	8000	PHONE
N2	8"	1	1-132"	RT / LN	8000	PHONE
N1	8"	1	1-132"	RT / LN	8000	PHONE

ASME
 RT-1
 NATIONAL BOARD NO. 915
 TAG 772-VECE-01

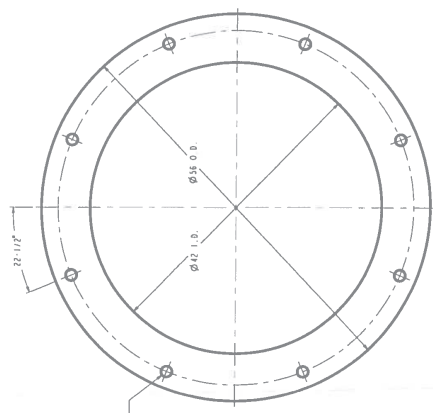
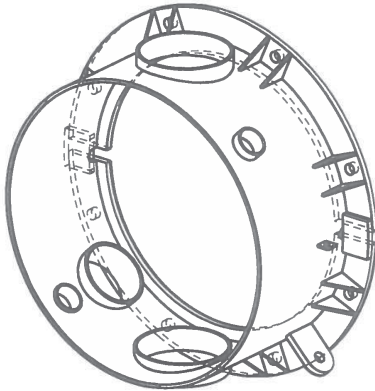
NAMEPLATE STAMPING DETAIL
 (SEE DRAWING 873-B FOR ALL NAMEPLATE STAMPING)

NOZZLES MOD. AND INOB HAVE GASKETS COPIED TO THIS DRAWING

NOZZLE SCHEDULE

ITEM	SIZE	REQD	NECK	FACE	DATE	SERVICE
NW1	2 1/4"	1	5-132"	RT / 12	8000	MARBY
N15	8"	1	1-118"	RT / LN	8000	TOP WELD FLANGE
N14	2"	1	1-132"	RT / LN	8000	TOP WELD FLANGE
N13	2"	1	5-168"	RT / LN	8000	FEET
N12	2"	1	1-132"	RT / LN	8000	PHONE
N11	2"	1	1-132"	RT / LN	8000	PHONE
N10	2"	1	1-132"	RT / LN	8000	PHONE
N9	2"	1	1-132"	RT / LN	8000	PHONE
N8	2"	1	1-132"	RT / LN	8000	PHONE
N7	2"	1	1-132"	RT / LN	8000	PHONE
N6	2"	1	1-132"	RT / LN	8000	PHONE
N5	2"	1	1-132"	RT / LN	8000	PHONE
N4	2"	1	1-132"	RT / LN	8000	PHONE
N3	2"	1	1-132"	RT / LN	8000	PHONE
N2	8"	1	1-132"	RT / LN	8000	PHONE
N1	8"	1	1-132"	RT / LN	8000	PHONE

ITEM QTY	DESCRIPTION	SPEC.
18 1/2	1 1/2" PLATE, 1/4" THICK, 10' DIA. (10' 0" DIA. NET)	SA-516 GR. 60
20 3/4	1 1/2" PLATE, 1/4" THICK, 8' 6" DIA. (8' 0" DIA. NET)	SA-516 GR. 60
20 3/4	1 1/2" PLATE, 1/4" THICK, 8' 6" DIA. (8' 0" DIA. NET)	SA-516 GR. 60
20 3/4	1 1/2" PLATE, 1/4" THICK, 8' 6" DIA. (8' 0" DIA. NET)	SA-516 GR. 60
21 5/8	2 1/2" PLATE, 1/4" THICK, 10' 0" DIA. (9' 6" DIA. NET)	SA-516 GR. 60
16 5/8	2 1/2" PLATE, 1/4" THICK, 10' 0" DIA. (9' 6" DIA. NET)	SA-516 GR. 60
60 7/8	2 1/2" PLATE, 1/4" THICK, 10' 0" DIA. (9' 6" DIA. NET)	SA-516 GR. 60
61 8/8	2 1/2" PLATE, 1/4" THICK, 10' 0" DIA. (9' 6" DIA. NET)	SA-516 GR. 60
62 9/8	2 1/2" PLATE, 1/4" THICK, 10' 0" DIA. (9' 6" DIA. NET)	SA-516 GR. 60



DETAIL ITEM 2/3

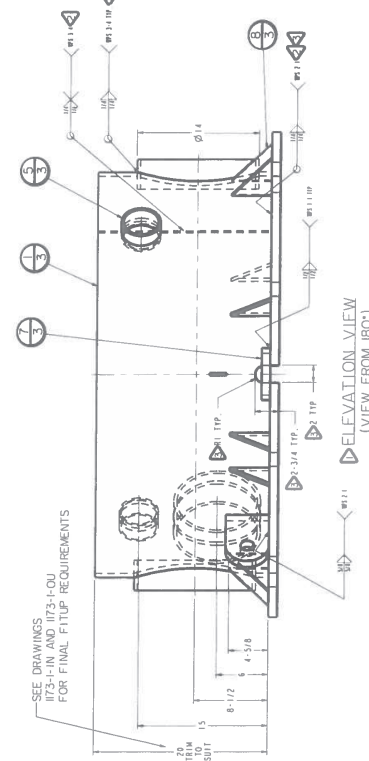
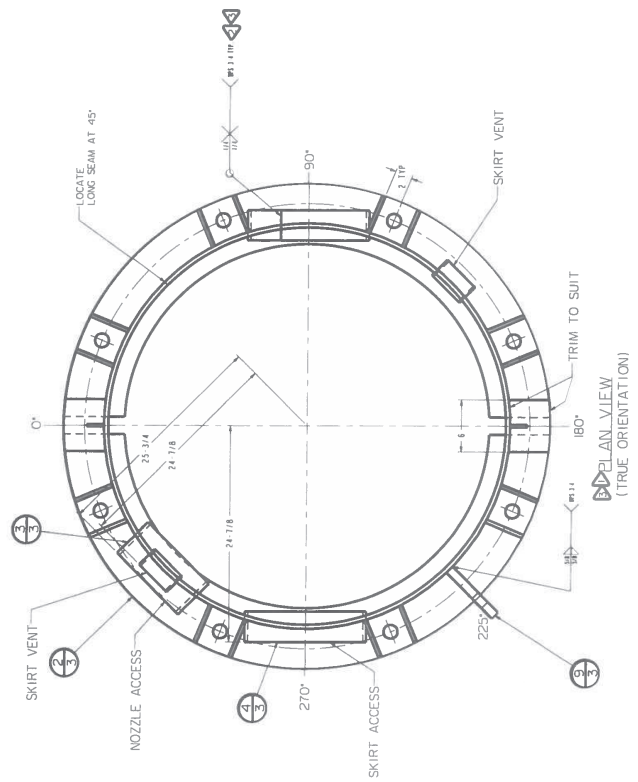
PURCHASE ORDER NUMBER: IIIJ2

(4) REQUIRED

ALL-WELD COMPANY LIMITED
 CERTIFIED AS-BUILT
 BY OCM DATE NOV 07 2003

ALL-WELD COMPANY LIMITED
 WELD MAP DRAWING
 48" O.D. VERTICAL SEPARATOR
 50' TALL 100' DIA. STEEL SKELETAL DETAILS

NO.	DESCRIPTION	DATE
5	REV. 1.0	11/13/03
4	REV. 1.0	11/13/03
3	REV. 1.0	11/13/03
2	REV. 1.0	11/13/03
1	REV. 1.0	11/13/03



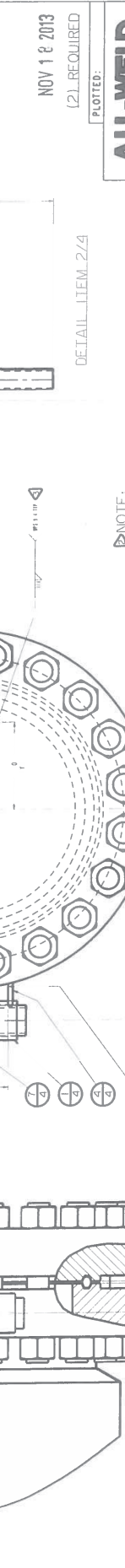
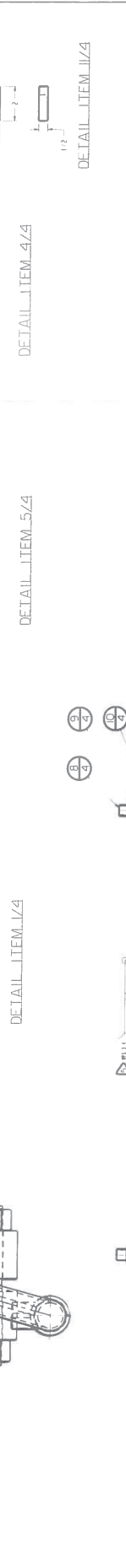
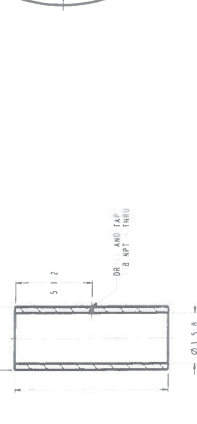
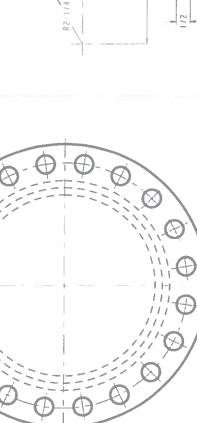
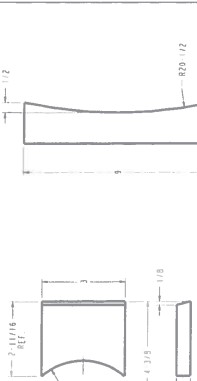
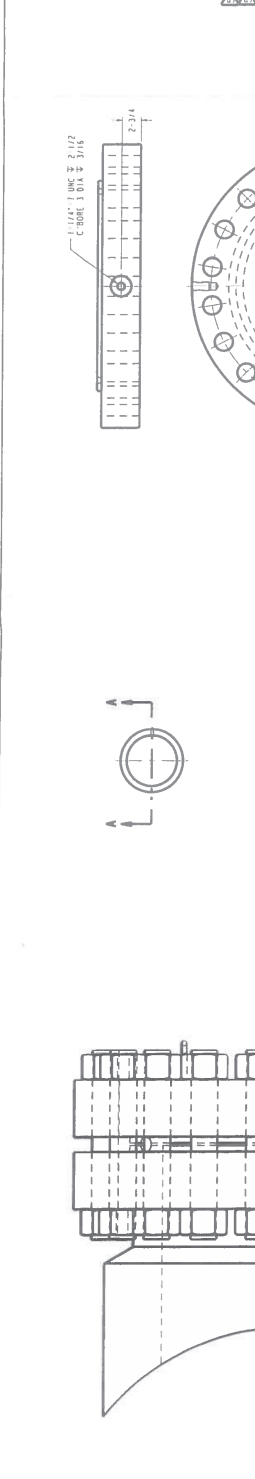
DETAIL ITEM 8/3

DETAIL ITEM 6/3

DETAIL ITEM 9/3

NOT DRAWING IS THE PROPERTY OF ALL-WELD COMPANY LTD. AND MAY BE REPRODUCED OR DISTRIBUTED IN WHOLE OR IN PART WITHOUT PERMISSION IN WRITING.

ITEM	QTY	DESCRIPTION	SPEC.
2.3	1/4	1.500" O.D. X 3.500" L	1.1006
2.3	2/4	1.500" O.D. X 3.500" L	1.1006
2.3	3/4	1.500" O.D. X 3.500" L	1.1006
2.6	4/4	2.000" O.D. X 4.000" L	1.1006
9	5/4	1.500" O.D. X 3.500" L	1.1006
27	6/4	1.500" O.D. X 3.500" L	1.1006
28	7/4	1.500" O.D. X 3.500" L	1.1006
31	8/4	1.500" O.D. X 3.500" L	1.1006
32	9/4	1.500" O.D. X 3.500" L	1.1006
33	10/4	1.500" O.D. X 3.500" L	1.1006
36	11/4	1.500" O.D. X 3.500" L	1.1006
70	12/4	1.500" O.D. X 3.500" L	1.1006
71	13/4	1.500" O.D. X 3.500" L	1.1006



ITEM	QTY	DESCRIPTION	SPEC.
2.3	1/4	1.500" O.D. X 3.500" L	1.1006
2.3	2/4	1.500" O.D. X 3.500" L	1.1006
2.3	3/4	1.500" O.D. X 3.500" L	1.1006
2.6	4/4	2.000" O.D. X 4.000" L	1.1006
9	5/4	1.500" O.D. X 3.500" L	1.1006
27	6/4	1.500" O.D. X 3.500" L	1.1006
28	7/4	1.500" O.D. X 3.500" L	1.1006
31	8/4	1.500" O.D. X 3.500" L	1.1006
32	9/4	1.500" O.D. X 3.500" L	1.1006
33	10/4	1.500" O.D. X 3.500" L	1.1006
36	11/4	1.500" O.D. X 3.500" L	1.1006
70	12/4	1.500" O.D. X 3.500" L	1.1006
71	13/4	1.500" O.D. X 3.500" L	1.1006

ALL-WELD COMPANY LIMITED
 CERTIFIED AS-BUILT
 BY GCM
 DATE NOV 2 1 2013

NOV 1 2 2013

(2) REQUIRED

PLOTTED:

ALL-WELD COMPANY LIMITED
 485° 00' VERTICAL INLET SEPAR. R
 25" HORIZONTAL ASSEMBLY 21" DIA 145 LWB

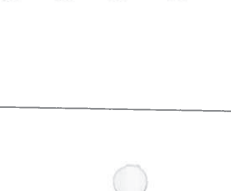
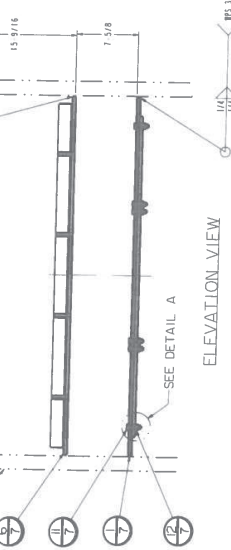
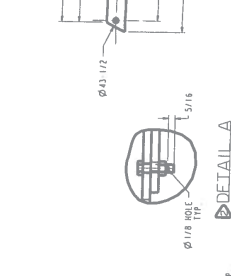
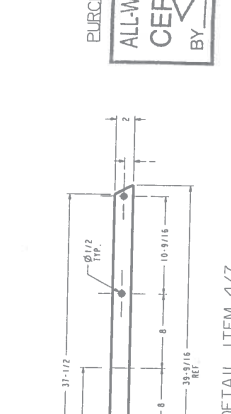
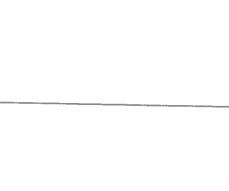
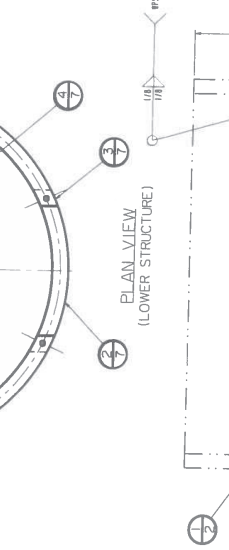
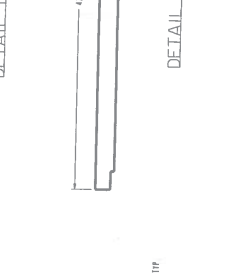
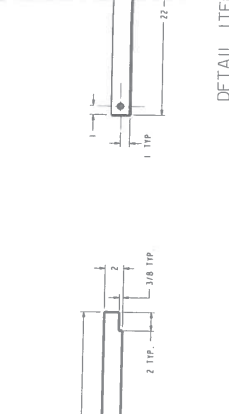
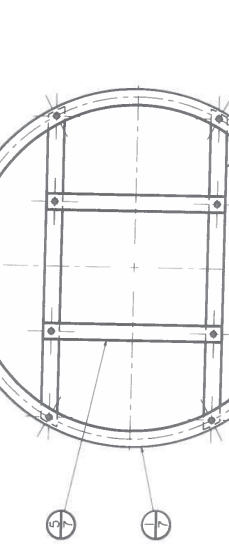
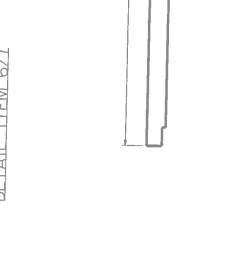
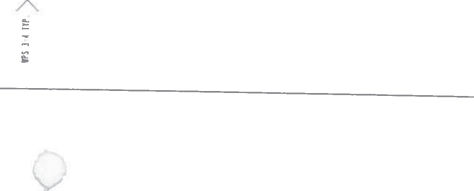
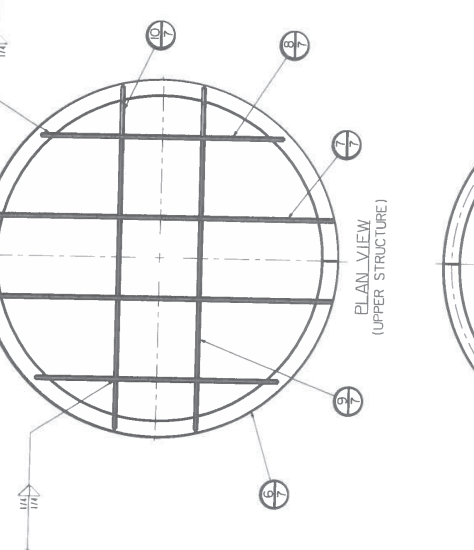
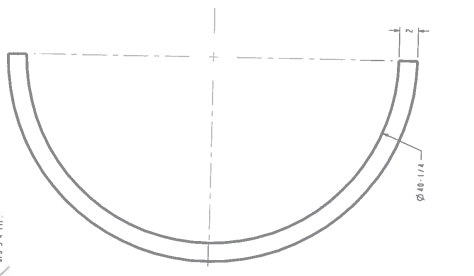
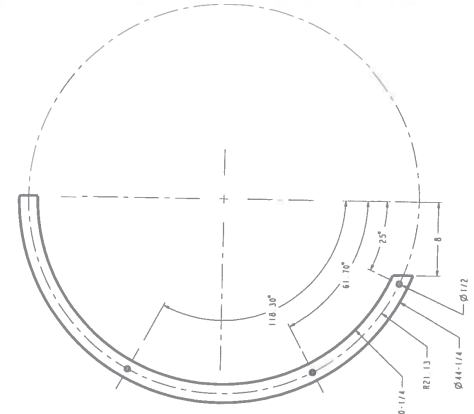
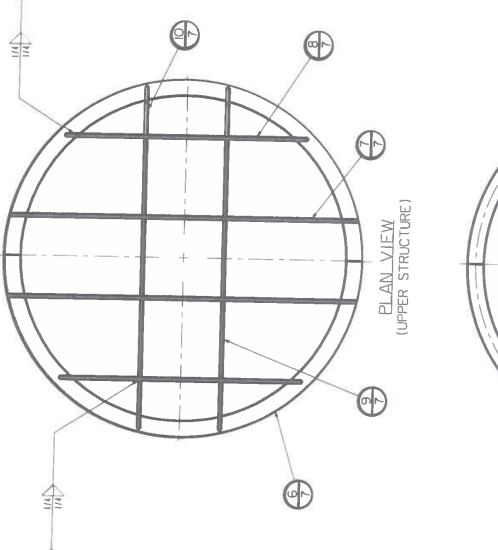
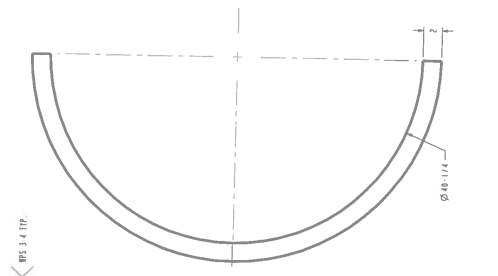
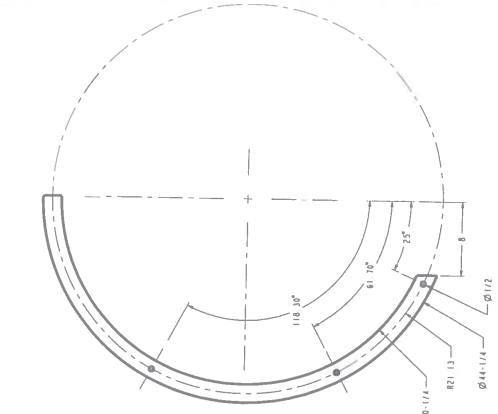
REV.	DATE	BY	APP'D.	DESCRIPTION
1				INITIAL DESIGN
2				REVISED DESIGN
3				REVISED DESIGN

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

PURCHASE ORDER NUMBER: 1112

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BILL OF MATERIAL			SPEC.
ITEM	QTY.	DESCRIPTION	
63	1/71	2	SEPERATOR
63	2/71	1	
63	3/71	1	
63	4/71	2	
63	5/71	2	
63	6/71	2	
63	7/71	2	
63	8/71	2	
63	9/71	6	
63	10/71	4	
63	11/71	10	
64	12/71	10	



PLOTTED: (4) REQUIRED

PURCHASE ORDER NUMBER: 1112
ALL-WELD COMPANY LIMITED
CERTIFIED AS-BUILT
 BY: QCM DATE: 07/2015

ALL-WELD COMPANY LIMITED
 2000 NORTH BRIDGE ROAD
 SINGAPORE 15000

ULTRAFAB INDUSTRIES LIMITED
 150-0 VERTICAL INLET / OUTLET SEPARATOR
 FOR FABRICATION & WELDING DETAILS

Rev. 1 Date: 03/28/13
 Rev. 2 Date: 11/30/13
 Rev. 3 Date: 11/30/13

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