

## HISTORY DOCKET

**CUSTOMER** : ULTRAFAB INDUSTRIES LTD.,  
**WO. NO.** : 1176PQ  
**A.W.C. SERIAL NO.** : 7468  
**ITEM** : 60" I.D. VERTICAL H2S CONTACTOR TAG # 772-VECO-102

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- 3) TRAVELLER SHEETS 1&2
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REPORT
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- 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.:** 1176 PQ  
**SERIAL NO'S:** 7468  
**ITEM:** 60" I.D. VERTICAL H2S CONTACTOR TAG # 772-VECO-102

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 2011ADDDENDA

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 7468 M10137.5 1176-1 REV. 6 914 2013  
(Horizontal or vertical tank) (Manufacturer's serial number) (CRN) (Drawing number) (National Board number) (Year built)

5. The chemical and physical properties of all parts meet the requirements of material specifications of the ASME BOILER AND PRESSURE VESSEL CODE. The design, construction, and workmanship conform to ASME Rules, Section VIII, Division 1.  
 to 2011a N/A 2010  
[Addenda, if applicable (date)] (Code Case numbers) (Year)

LETHAL UW-2(a)  
[Special service per UG-120(d)]

6. Shell: SA-516 70N 2.5" 0.125" 5'-0" 8'-0"  
(Material spec. number, grade) (Nominal thickness) (Corr. allow.) (Inner diameter) [Length (overall)]

7. Seams: TYPE 1 FULL 100% 1100°F 2.25 TYPE 1 FULL 100% 1  
[Long (welded, dbl. snl., lap, butt)] [R T (spot or full)] (Eff. %) (H T temp.) (Time, hr) [Girth (welded, dbl. snl., lap, butt)] [R T (spot or full)] (Eff. %) (No. of courses)]

8. Heads: (a) Material SA-516-70N (b) Material SA-516-70N  
(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	2.491"	0.125"	--	--	2:1	--	--	--	CONCAVE
(b)	BOTTOM	2.491"	0.125"	--	--	2:1	--	--	--	CONCAVE

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

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

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

Proof test N/A

10. Nozzles, inspection and safety valve openings:

Purpose (Inlet, Outlet, Drain etc.)	No.	Diameter or Size	Type	Material		Nominal Thickness		Reinforcement Material	Attachment Details		Location (Insp. Open.)
				Nozzle	Flange	Nom.	Corr.		Nozzle	Flange	
VENT (N7)	1	2" ID	Cl.900 LWN	SA-350-LF2	SA-350-LF2	1.06"	0.125"	N/A	UW-16.1 (e)	N/A	N/A
OUTLET (N10)	1	8" ID	Cl.900 LWN	SA-350-LF2	SA-350-LF2	1.875"	0.125"	N/A	UW-16.1 (e)	N/A	N/A
CORR. (N9)	1	2" ID	Cl.900 LWN	SA-350-LF2	SA-350-LF2	1.06"	0.125"	N/A	UW-16.1 (e)	N/A	N/A
PURGE (N2)	1	2" ID	Cl.900 LWN	SA-350-LF2	SA-350-LF2	1.06"	0.125"	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 PER UG-20 (f) (3) SEE ATTACHED U-4 FORM  
(Name of part, item number, Manufacturer's name and identifying stamp)

CERTIFICATE OF SHOP/FIELD COMPLIANCE

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

Date 7 NOV 2013 Co. name ALL-WELD COMPANY LIMITED. Signed [Signature]  
(Manufacturer) (Representative)

CERTIFICATE OF SHOP/FIELD INSPECTION

Vessel constructed by ALL-WELD COMPANY LIMITED at 49 PASSMORE AVE. TORONTO, ONT.

I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and/or the State or Province of ONTARIO and employed by T.S.S.A. OF ONTARIO

have inspected the component described in this Manufacturer's Data Report on OCT 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 NB3106A ONT915  
(Authorized Inspector) (National Board [incl. endorsements], State, Province and number)

FORM U-4 MANUFACTURER'S DATA REPORT SUPPLEMENTARY SHEET

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

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

2. Manufactured for ULTRA FAB INDUSTRIES LTD., 261068 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 7468  
(Horizontal, vertical, or sphere) (Tank, separator, heat exch., etc.) (Manufacturer's serial number)

M10137.5 1176-1 REV. 6 914 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	
LEVEL BRIDAL LOW (N3)	1	2" ID	Cl.900 LWN	SA-350 LF2	SA-350 LF2	1.06"	0.125"	N/A	UW.16 1(e)	N/A	N/A
DIFF PRESS HIGH (N4)	1	2" ID	Cl.900 LWN	SA-350 LF2	SA-350 LF2	1.06"	0.125"	N/A	UW.16 1(e)	N/A	N/A
LEVEL BRIDAL HIGH (N5)	1	2" ID	Cl.900 LWN	SA-350 LF2	SA-350 LF2	1.06"	0.125"	N/A	UW.16 1(e)	N/A	N/A
FILL/WATER FLUSH (N6)	1	2" ID	Cl.900 LWN	SA-350 LF2	SA-350 LF2	1.06"	0.125"	N/A	UW.16 1(e)	N/A	N/A
DIFF PRESS LOW (N8)	1	2" ID	Cl.900 LWN	SA-350 LF2	SA-350 LF2	1.06"	0.125"	N/A	UW.16 1(e)	N/A	N/A
INSPECTION NOZZLE (N11)	1	8" ID	Cl.900 LWN	SA-350 LF2	SA-350 LF2	1.875"	0.125"	N/A	UW.16 1(e)	N/A	SHELL
INLET NOZZLE (N12)	1	8" ID	Cl.900 LWN	SA-350 LF2	SA-350 LF2	1.875"	0.125"	N/A	UW.16 1(e)	N/A	N/A
MANWAY (N13)	1	24" ID	Cl.900 V2/12	SA-350 LF2	SA-350 LF2	5.5"	0.125"	N/A	UW.16 1(e)	N/A	SHELL
BOTTOM DRAIN (N1)	1	NPS 2"	Cl.900 WN	SA-333 6	SA-350 LF2	0.344"	0.125"	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: R Bault  
(Manufacturer) (Representative)

Date: NOV 07, 2013 Name: [Signature] Commission: NB3106A, ONT 915  
(Authorized Inspector) (National Board (incl. endorsements), State, Province, and number)

DATE 2013-02-06	WORK ORDER 1176Q	CUSTOMER PO 11112	REVIEWED <i>[Signature]</i>	BY A.I. <i>[Signature]</i>
SERIAL NO. 7468	C.R.N. M10137.5	DATE 2013-02-06		SIGN FEB 20 9.13
NATIONAL BOARD NO. 914				
CUSTOMER ULTRAFAB	ULTIMATE OWNER			
FOR DRAWINGS & DOCUMENTS/REV./DATE ISSUED TO Q.C.	ASME CODE 2010			
SEE Q.C. DOCUMENT CONTROL FORM	SECTION VIII DIV 1			
VESSEL TYPE/JOB DESCRIPTION 60" ID VERTICAL H2S CONTRACTOR	ADD 2011		H = HOLD R = REVIEW	
<b>OPERATIONS, INSPECTIONS &amp; TEST POINTS</b>	H	H	H	H
	R	R	R	R
	AWC QC	CUSTOMER	AI	
REVIEW APPVD DRWGS, CALCS,	H		R	4 SEP 11.13
REVIEW TRAVELLER AND REVIEW INSPECTION AND TEST PLAN	H		R	4 MAR 15.13
REVIEW MATERIAL LIST	H		R	2 JUL 23.13
REVIEW W.P.S., P.Q.R SAW-w-4, 52-2	H		R	2 MAR 15.13
INCOMING MATERIAL INSPECTION REPORT	H		R	2 JUL 23.13
CHECK ROUNDNESS OF VESSEL	H			
FIT-UP INSPECTION	H			
PRODUCTION IMPACT TEST	H			
MAG PARTICLE / LIQUID PEN TEST	H			
APPROVAL OF RADIOGRAPH MAP BY AI	H		R	2 MAR 15.13
RADIOGRAPHIC TESTS - FULL	H		R	2 OCT 10.13
ULTRASONIC TEST	H			
HARDNESS TESTS	H			
REVIEW WELDERS QUALIFICATION	H		R	2 OCT 10.13
WELD MAP REPORT	H		R	2 OCT 10.13
FINAL INTERNAL INSPECTION	H		H	2 SEP 26.13
POST WELD HEAT TREATMENT	H		R	2 OCT 10.13
FINAL (ALL NCR'S HAVE BEEN CLEARED)	H		R	2 OCT 24.13
FINAL COMPLETED VESSEL INSPECTION	H		H	2 OCT 24.13
FINAL HYDROSTATIC TEST	H		H	2 OCT 10.13
FINAL HYDROSTATIC TEST JACKET	N/A			
FINAL HYDROSTATIC TEST TUBE SIDE	N/A			
APPLICATION OF CODE STAMP + ATTACH NAMEPLATE	H		H	2 OCT 24.13
DATA REPORT SIGN OFF	H		H	2 NOV 07.13
GLASS BEAD BLASTING	N/A			
DATA PACKAGE SENT TO CUSTOMER	H			





# ALL-WELD HYDROSTATIC TEST REPORT

<b>JOB NUMBER</b> 1176PQ	<b>DATE</b> 10 OCTOBER , 2013
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<b>CUSTOMER</b> ULTRA FAB INDUSTRIES LTD	<b>SERIAL NO.</b> 7468
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<b>VESSEL DESCRIPTION</b> 60 " OD VERTICAL H2S CONTACTOR TAG # 772 - VECO - 102
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<b>TEST PRESSURE</b>	<b>VESSEL</b> 1792 PSIG	<b>TUBE</b>	<b>JACKET</b>
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<b>TEST METAL TEMPERATURE</b> 50 F	<b>HOLDING TIME</b> 1 HOUR MIN.
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<b>GAUGE #</b> 122 & 123	<b>LAST CALI. DATE</b> 12 - Jun - 13
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**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.

MIKE KAMYAB  
 REVIEWED   
 WITNESSED   
 FOR: ULTRAFAB13 DATE: 10/10/13

*M. H. Kamyab*

*Forward on behalf of SBM off shore*

**COMMENTS: ACCEPTED**

*WITNESSED BY MS*

*DATE: 10/06/2013*

*10/10/2013*

*12/05/13*

<b>Q.A. SIGNATURE</b> <i>R Bentley</i>
<b>DATE:</b> 10 OCTOBER , 2013







We're There

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

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

# CALIBRATION TEST CERTIFICATE

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

Expiration: JUNE 27, 2014

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

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

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

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

Technician: [Signature] Approved: [Signature]

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

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

GCM  
JUL 03 2013





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

**Laboratory #:** 608636-12

**Report Date:** May 14, 2012

**Received Date:** May 9, 2012

**Customer P.O. #:** N860-9764Q

**Specimen:** Water Sample

**TEST REPORT**

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

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

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

HALOGEN RADICALS	CONCENTRATION (ppm)
Fluoride (F)	0.5
Chloride (Cl)	47.4
Bromide (Br)	<0.5

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

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

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

**Cambridge Materials Testing Limited**

Per Steve Brown

QUALITY ASSURANCE

Per Rupinder Singh

TECHNICIAN

N 914

CERTIFIED BY  
**ALL-WELD**  
COMPANY LIMITED  
SCARBOROUGH, ONTARIO  
ENGINEERS SINCE 1920



W-1  
RT 1  
HT

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.	7468	YEAR BUILT	2013		

CRN M10157.5

ITAG 772-NECO-102

CERTIFIED BY  
**ALL-WELD**

COMPANY LIMITED  
SCARBOROUGH, ONTARIO  
ENGINEERS SINCE 1920

W-L  
RT 1  
HT  
  
A3

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.	7468	YEAR BUILT	2013	

C.R.N.

M 10 137 5

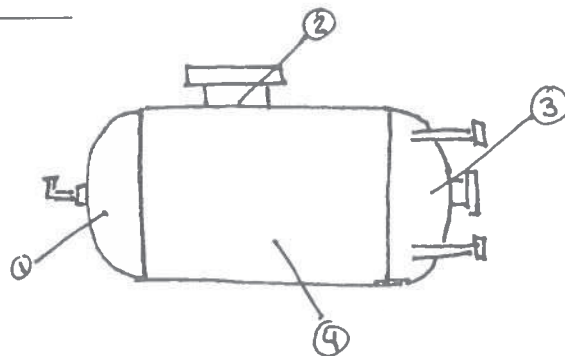
10-296008

TAG# 772-VECO-102

CONREX STEEL LIMITED  
 50 TABER ROAD  
 REXDALE, ONTARIO M9W 3A9  
 HEAT TRACING RECORD

CSL WO#	QTY	DESCRIPTION	CUSTOMER	CUST PO#
75355	1	vessel 60" dia x 155 1/16" lg	All Weld Company	13-0781
		(2 <sup>nd</sup> of 2) job # 1176-36		
		Serial # 7468		

HEAT TREATMENT SPECIFICATION: All Weld PWHT Proc No PWHT-PI rev No 0  
 HEAT AT max 160°F PER HOUR FROM 800°F  
 HOLD 125 to 150 MINUTES AT 175°F +/- 25°F  
 COOL AT max 200°F PER HOUR TO 800°F



THERMOCOUPLES: # 1, 2, 3, 4

NOTES:

All temperatures in degees Fahrenheit unless noted

SIGNED FOR CSL

DATE Sept 30/13



OCT 01 2013

TIME	STEP	SETPT	CHART TEMPERATURES					
			TC#1	TC#2	TC#3	TC#4	TC#5	TC#6
17:08	1	109	114	114	115	114	0	0
17:18	1	161	175	175	175	173	0	0
17:28	1	235	254	255	254	251	0	0
17:38	1	310	330	334	334	331	0	0
17:48	1	384	407	410	407	404	0	0
17:58	1	459	482	486	482	479	0	0
18:08	1	533	555	562	559	557	0	0
18:18	2	603	626	630	626	623	0	0
18:28	2	637	657	661	657	655	0	0
18:38	2	670	688	694	691	690	0	0
18:48	2	707	724	728	725	723	0	0
18:58	2	737	755	759	755	753	0	0



CHART TEMPERATURES

TIME	STEP	SETPT	TC#1	TC#2	TC#3	TC#4	TC#5	TC#6
19:08	2	773	789	796	793	791	0	0
19:18	3	803	821	826	821	820	0	0
19:28	3	820	836	841	837	835	0	0
19:38	3	837	851	857	854	854	0	0
19:48	3	853	866	870	866	865	0	0
19:58	3	870	883	887	883	882	0	0
20:08	3	887	898	903	901	900	0	0
20:18	3	903	914	918	914	914	0	0
20:28	3	920	930	934	930	929	0	0
20:38	3	937	945	950	947	947	0	0
20:48	3	953	963	967	963	962	0	0
20:58	3	970	979	981	979	978	0	0
21:08	3	987	993	997	995	995	0	0
21:18	3	1003	1011	1014	1011	1011	0	0
21:28	3	1020	1022	1025	1023	1023	0	0
21:38	3	1037	1039	1043	1041	1042	0	0
21:48	3	1053	1058	1062	1058	1059	0	0
21:58	3	1070	1075	1078	1075	1076	0	0
22:08	3	1087	1091	1095	1093	1093	0	0
22:18	3	1103	1107	1111	1108	1108	0	0
22:28	3	1120	1123	1126	1124	1124	0	0
22:38	3	1137	1141	1145	1142	1143	0	0
22:48	3	1153	1161	1164	1161	1161	0	0
22:58	3	1170	1174	1178	1174	1175	0	0
23:08	4	1175	1174	1177	1174	1175	0	0
23:19	4	1175	1174	1177	1175	1175	0	0
23:29	4	1175	1172	1174	1172	1173	0	0
23:39	4	1175	1175	1177	1176	1176	0	0
23:49	4	1175	1175	1178	1175	1176	0	0
23:59	4	1175	1172	1176	1173	1175	0	0
00:09	4	1175	1169	1171	1169	1170	0	0
00:19	4	1175	1171	1173	1172	1173	0	0
00:29	4	1175	1173	1176	1173	1175	0	0
00:39	4	1175	1172	1174	1173	1173	0	0
00:49	4	1175	1173	1175	1174	1174	0	0
00:59	4	1175	1173	1174	1173	1174	0	0
01:09	4	1175	1171	1173	1171	1172	0	0
01:19	4	1175	1173	1175	1173	1174	0	0
01:29	4	1175	1170	1172	1171	1171	0	0
01:39	5	1163	1158	1157	1156	1157	0	0
01:49	5	1147	1135	1133	1135	1138	0	0
01:59	5	1130	1119	1118	1119	1122	0	0
02:09	5	1113	1102	1098	1098	1101	0	0
02:19	5	1097	1084	1082	1084	1088	0	0
02:29	5	1080	1067	1066	1067	1071	0	0
02:39	5	1063	1052	1049	1048	1051	0	0
02:49	5	1047	1036	1035	1036	1039	0	0
02:59	5	1030	1021	1020	1020	1023	0	0
03:09	5	1013	1006	1005	1003	1005	0	0
03:19	5	997	991	992	990	992	0	0
03:29	5	980	976	977	975	977	0	0
03:39	5	963	961	962	959	961	0	0
03:49	5	947	947	949	946	947	0	0

2 hrs / 20 minutes

QCM

CHART TEMPERATURES

TIME	STEP	SETPT	TC#1	TC#2	TC#3	TC#4	TC#5	TC#6
03:59	5	930	931	934	931	931	0	0
04:09	5	913	916	921	917	917	0	0
04:19	5	897	903	907	902	902	0	0
04:29	5	880	888	894	888	886	0	0
04:39	5	863	872	881	876	874	0	0
04:49	5	847	860	866	860	857	0	0
04:59	5	830	845	853	845	842	0	0
05:09	5	813	829	841	834	831	0	0
05:19	5	797	816	825	816	812	0	0
05:29	5	781	800	809	800	796	0	0
05:39	5	765	781	796	788	784	0	0
05:49	5	749	768	777	768	764	0	0
05:59	5	733	752	761	752	748	0	0
06:09	5	717	733	748	741	736	0	0
06:19	5	701	720	729	720	716	0	0
06:29	5	685	703	713	704	700	0	0
06:39	5	669	685	700	693	688	0	0
06:49	5	653	671	681	672	668	0	0
06:59	5	637	655	666	656	652	0	0
07:09	5	621	637	652	645	640	0	0
07:19	5	605	623	634	625	620	0	0
07:29	5	589	607	618	609	604	0	0
07:39	5	573	589	605	597	592	0	0
07:49	5	557	575	589	581	578	0	0

REF#1617

QCM

ACCEPTED/REVIEWED/RELEASED 046  
 for and on behalf of: SBM OFFSHORE  
 Print Name: GANESH SAHA  
 Signature: [Signature]  
 Date: Oct 2/13  
**Applus<sup>®</sup>**  
**VELOSI**  
 Velosi America LLC

# CONREX STEEL LTD.

50 Taber Road. Rexdale. Ontario, M9W 3A9 Phone (416)-747-4665 Fax (416)-747-4667

## CALIBRATION CERTIFICATE

INSTRUMENT: STRESS RELIEF FURNACE # 2  
 MANUFACTURER: NORTH AMERICAN  
 SERIAL NUMBER: CONREX # 2

Standard	As Found	Calibrated	Standard	As Found	Calibrated
LOAD#1			ADDITIONAL TEMPERATURE CONTROLS		
1125°F	1127°F	Aug 19, 2013	1#: 1125°F	1127°F	— " —
1650°F	1652°F	— " —	1650°F	1652°F	— " —
			2#: 1125°F	1126°F	— " —
LOAD#2			1650°F	1651°F	— " —
1125°F	1127°F	— " —	3#: 1125°F	1126°F	— " —
1650°F	1652°F	— " —	1650°F	1651°F	— " —
			4#: 1125°F	1127°F	— " —
LOAD#3			1650°F	1651°F	— " —
1125°F	1128°F	— " —	5#: 1125°F	1127°F	— " —
1650°F	1652°F	— " —	1650°F	1651°F	— " —
			6#: 1125°F	1127°F	— " —
			1650°F	1652°F	— " —
			7#: 1125°F	1126°F	— " —
			1650°F	1650°F	— " —
			8#: 1125°F	1126°F	— " —
			1650°F	1650°F	— " —

ACCEPTED / REVIEWED / RELEASED  
 for and on behalf of: S. B. M. O. P. S. H. O. R. E.  
 Print Name: CHAMBERLAIN SAHA  
 Signature: [Signature]  
 Date: OCT 21 13  
 046  
**APPIUS VELOSI**  
 Velosi America LLC

If 'calibrated' column is blank. No adjustments were necessary

COMMENTS: STANDARD: PPS MINITEMP MODEL 1062, SER# B67568  
 QC INSPECTOR: [Signature] QC MANAGER: Ling Tang DATE: Aug 19, 2013

## CERTIFICATE OF CALIBRATION

REPORT NUMBER 13116913

This certificate attests that the equipment and/or standards used in the calibration are calibrated to recognized standards which are traceable to the International System of Units (SI) through the National Institute of Standards and Technology (NIST) or National Research Council of Canada (NRCC). The calibration was performed in accordance with the applicable portions of ISO/IEC 17025:2005, ISO 9001:2008, ANSI/NCSL Z540-1-1994 and technical requirements of the customer's order.

The instrument described below has been calibrated in our lab on date noted. Data not accredited will be identified by an asterisk (\*). Copyright of this Certificate is owned by the issuing laboratory and may not be reproduced other than in full.

Equipment	Mini-Temp Calibrator	Calibration Date	22-Apr-2013
Model	1062	Calibration Expiry Date	22-Apr-2014
Serial	B67568	Property of	Conrex Steel Limited
Accessories	None	Address	50 Taber Road
Asset	N/A		Revdale
Manufacturer	Transmatron		Ontario
Date Received	19-Apr-2013		M9W 3A9
Date of Last Calibration	12-Apr-2012	Procedure	CPR #0713
Condition When Received	Good	Method	Comparison
Humidity	42.5%		ISO/IEC 17025:2005 &
Temperature	22.8°C	Conformance Standards	ISO 9001:2008
Purchase Order	3027	Other Standards	N/A

### Calibration Standard(s) Used

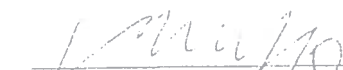
Asset Number	Traceability	Calibration Date	Calibration Expiry Date
AVO 381	ST3104386	23-Jun-2011	23-Jun-2014

The reported data is valid only at the time of the calibration and is related only to the instrument/equipment being calibrated.

The Calibration Expiry Date appearing on this Certificate of Calibration and the Calibration Label is determined by the client or by the appropriate ASTM Standard/Manufacturer and does not imply continued conformance to specifications.

The instrument/equipment was inspected, cleaned, and tested using manufacturer's specifications and procedures, client's procedures, or national/international standards and procedures.

Reported uncertainties are expressed as expanded uncertainty values at approximately the 95% confidence level assuming a normal distribution, with a coverage factor of k=2.

  
Francis Foo (Technician)

  
K. F. Lok (Authorized)



**RADIOGRAPH REVIEW FORM**

W.O. NO. 1176PQ  
SERIAL NO. 7468

- 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 08 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

## CHRIS VEENEMAN

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



	Natural Resources Canada	Ressources naturelles Canada			
	Qualifications CAN L05E 48 9732	6651			
Qualifications Qualifications					
Method Methode	Level Niveau	Sector Secteur	Cert. Date Date cert.	Date recent Date recent	Expires Expiration
MT	2	EMC	1997/05/08		2013/12/31
PT	2	EMC	1997/11/07		2013/12/31
RT	2	EMC	2000/01/06		2013/12/31
UT	2	EMC	2010/06/03		2013/12/31

# KV INSPECTION SERVICES LTD

Established 1980

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

## FRANK MARUNDE



Natural Resources  
Canada

Ressources naturelles  
Canada



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

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

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

Signature:



Natural Resources  
Canada

Ressources naturelles  
Canada

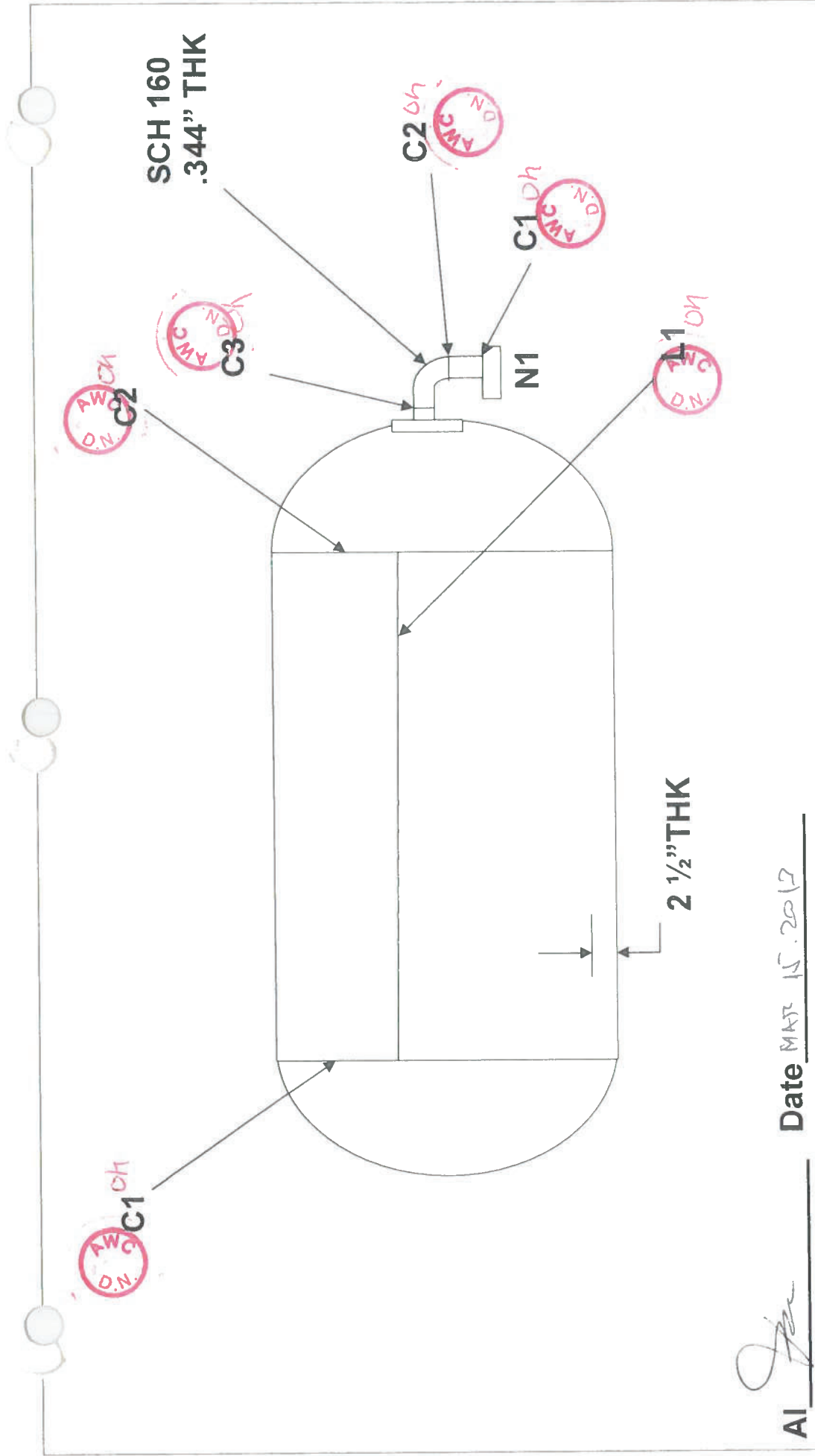
Registered to: Ceribhe.com CAN (ENB 48 931)

8885

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

Manager, Certifying Agency  
 Directeur Général, Organisme de Certification



SCH 160  
.344" THK

2 1/2" THK

AI *[Signature]* Date MAR 15, 2012

<p><b>ALL-WELD CO. LTD. - RT MAP</b></p> <p>CLIENT: ULTRAFAB</p> <p>WORK ORDER #: 1176PQ SN 7468</p> <p>JOB DESCRIPTION: 60" I.D. VERTICAL CONTACTOR</p> <p>DRAWING #: 1176-1</p> <p>PREPARED BY: D.NESCI</p> <p>DATE: FEB. 28/13</p>	<p><b>AFTER PWHT</b></p> <p>RT MAP - 1176PQ</p> <p>ASME SECTION VIII. DIV. 1</p> <p>100% (RT-1)</p> <p>MATERIAL SA-516 70N, SA-350 LF2, SA-333 6, SA-420 WPLG</p> <p>P.O. 13-0170-1176PQ</p>
---	--

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-WORDS	Date	OCT-5/13
Location	SCHMIDTBOUHLH	P. O. #	
Project	ULTRAFAB	Shop Order #	1176 PQ-7467
Procedure	KV 5 ROV 3	Worksheet #	
Technician	C. Veeneman	CGSB Reg #	6651
		ASNT/SNT-TC-1A Level	II

**Technical Data 60**

Material Type	Carbon	Alloys	Isotope	IR 192	Other	Physical/Focal Size	.199"
Base Material Thickness	2 1/2"		Exposure	Single Wall	Double Wall	Film per Cassette	1
Weld Thickness	"		View	Single Wall	Double Wall	PWHT	Yes No
Reinforcement	1/4"		Number of Exposures				7
Film Mfg.	KODAK		Minimum Source to Object Distance				30"
Film Type	MA		Maximum Distance from Source Side of Object to Film				2 3/4"

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
11	0-1								/	
	1-2								/	
	2-3								/	
	3-4								/	
	4-5								/	
	5-6								/	
	6-END								/	

~~Revenemat~~  
10/10/13  
for velocity

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

KV Inspection Technician

*[Signature]*

Date

OCT. 5/13

Customer Representative

Date

OCT 08 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. 5/13*  
 Location: *SCARBOROUGH* P. O. #  
 Project: *ULTRAFMS* Shop Order # *1176 PQ-7468*  
 Procedure: *KUG Rev 3* Worksheet #  
 Technician: *C. Veeneman* CGSB Reg # *6651* ASNT/SNT-TC-1A Level *II*

**Technical Data *Co60***

Material Type: Carbon Alloys Isotope: Other Physical/Focal Size: *.199*  
 Base Material Thickness: *2 1/2"* Exposure: Single Wall Double Wall Film per Cassette: *1*  
 Weld Thickness: *"* View: Single Wal Double Wall PWHT: Yes No  
 Reinforcement: *2 1/4"* Number of Exposures: *1*  
 Film Mfg.: *KODAK* Minimum Source to Object Distance: *PANORAMIC (5' I.D.)*  
 Film Type: *AA* Maximum Distance from Source Side of Object to Film: *23/4"*

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
<i>C1</i>	<i>0-1</i>								<input checked="" type="checkbox"/>	
	<i>1-2</i>								<input checked="" type="checkbox"/>	
	<i>2-3</i>								<input checked="" type="checkbox"/>	
	<i>3-4</i>								<input checked="" type="checkbox"/>	
	<i>4-5</i>								<input checked="" type="checkbox"/>	
	<i>5-6</i>					<input checked="" type="checkbox"/>			<input checked="" type="checkbox"/>	
	<i>6-7</i>								<input checked="" type="checkbox"/>	
	<i>7-8</i>								<input checked="" type="checkbox"/>	
	<i>8-9</i>								<input checked="" type="checkbox"/>	
	<i>9-10</i>								<input checked="" type="checkbox"/>	
	<i>10-11</i>								<input checked="" type="checkbox"/>	
	<i>11-12</i>								<input checked="" type="checkbox"/>	
	<i>12-13</i>								<input checked="" type="checkbox"/>	
	<i>13-14</i>								<input checked="" type="checkbox"/>	
	<i>14-0</i>								<input checked="" type="checkbox"/>	

*Revised*  
*AS 10/10/13*  
*for velocity*

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

KV Inspection Technician: *[Signature]* Date: *OCT 5/13*  
 Customer Representative: *[Signature]* Date: *OCT 08 2013*







**Inspection Services Ltd.**

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

# Radiographic Examination Report RT

## Specification - Acceptance Criteria

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

### General Data

Customer	ALL-WORLD	Date	OCT-5/13
Location	SCARBOROUGH	P. O. #	
Project	ULTRA-FMS	Shop Order #	1176 PQ-7468
Procedure	KV5 Rev 3	Worksheet #	
Technician	C. Veeneman	CGSB Reg #	6651
		ASNT/SNT-TC-1A Level	II

### Technical Data Co60

Material Type	Carbon	Alloys	Isotope	Other	Physical/Focal Size	.199	
Base Material Thickness	2 1/2"		Exposure	Single Wall	Double Wall	Film per Cassette	1
Weld Thickness	"		View	Single Wall	Double Wall	PWHT	Yes No
Reinforcement	2 1/4"		Number of Exposures				1
Film Mfg.	KODAK		Minimum Source to Object Distance				PANORAMIC (5' I.D.)
Film Type	AA		Maximum Distance from Source Side of Object to Film				2 3/4"

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
C-2	0-1								-	
	1-2								-	
	2-3								-	
	3-4								-	
	4-5								-	
	5-6								-	
	6-7								-	
	7-8								-	
	8-9								-	
	9-10								-	
	10-11								-	
	11-12								-	
	12-13								-	
	13-14								-	
	14-0								-	

*Reviewed  
10/10/13  
for welds*

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

KV Inspection Technician		Date	OCT-5/13
Customer Representative		Date	OCT 08 2013

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

# Radiographic Examination Report RT

## Specification - Acceptance Criteria

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

### General Data

Customer	ALL-WORD	Date	OCT. 5/13
Location	SCAR BONDWICH	P. O. #	
Project	ULTRA-FAB	Shop Order #	1176 PQ-7468
Procedure	Rv 6 Rv 2	Worksheet #	
Technician	C. Veeneeman	CGSB Reg #	6651
		ASNT/SNT-TC-1A Level	II

### Technical Data

Material Type	Carbon	Alloys	Isotope	IR 192	Other	Physical/Focal Size	.13"
Base Material Thickness	.344		Exposure	Single Wall	Double Wall	Film per Cassette	1
Weld Thickness	"		View	Single Wall	Double Wall	PWHT	Yes No
Reinforcement	2 1/8"		Number of Exposures				3 per
Film Mfg.	KODAK		Minimum Source to Object Distance				18"
Film Type	AA		Maximum Distance from Source Side of Object to Film				2"

UNIT No.	SIZE/LOC	SLAG	L.O.P.	L.O.F.	CRACK	POROSITY	U.C.	OTHERS	ACC	REJ
N1-C1	A								/	
	B								/	
	C								/	
N1-C2	A								/	
	B								/	
	C								/	
N1-C3	A								/	
	B								/	
	C								/	

*Reviewed*  
*10/10/13*  
*for 6651*

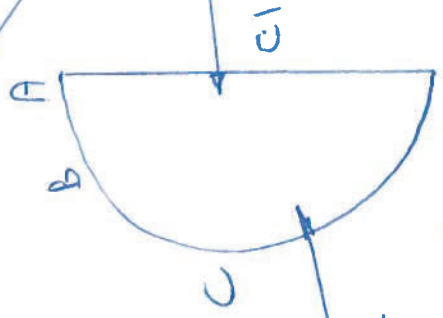
**CHRIS VEENEMAN**  
CGSB LEVEL II, REG.# 6651  
MT/PT/RT/UT  
SNT-TC-1A LEVEL II  
MT/PT/RT/UT

KV Inspection Technician		Date	OCT-5/13
Customer Representative		Date	OCT 0 8 2013

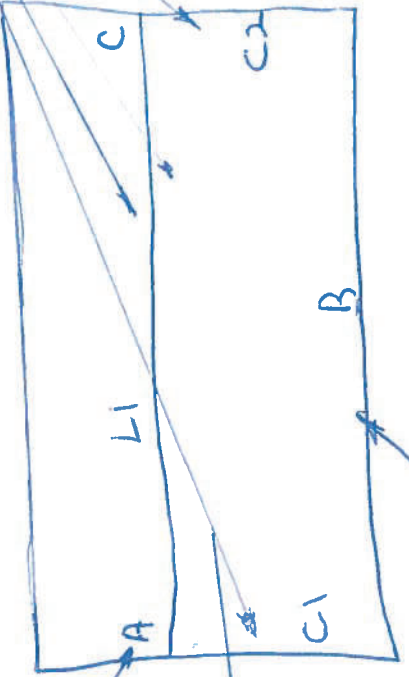


Thk Readings + 3 spots (A,B,C)

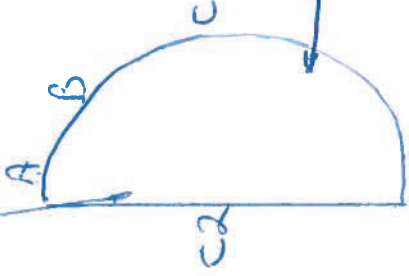
Scan for laminations  
3" to Seams Typ  
L1, C1, C2



Thk C1 (A,B,C)



HT #  
358699



Thk C2 (A,B,C)

ALL-WELD CO. LTD. -

CLIENT: Yitrafab

WORK ORDER #: 1176 PQ SNT468

JOB DESCRIPTION:

DRAWING #:

PREPARED BY: D.NESCI

DATE: FEB 27 2013

UT MAP - THK/Seams

ASME SECTION VIII. DIV. 1

Material SA516 Gr 70

P.O. 13-0154-1176PQ

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	1176 PQ Serial # 7468	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	Carbon 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 checked="" type="radio"/> YES <input type="radio"/> NO	Sensitivity (PRL)	50 dB
Heat Treatment		Surface Conditions	

### Transducers/Calibration Blocks

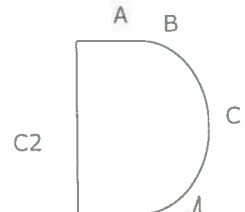
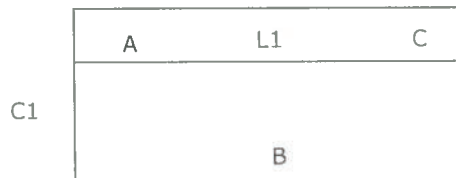
Diameter	Size	Beam Angle	Frequency	Manufacturer	Blocks
<input type="radio"/> 1/4"	<input type="radio"/> 5/8" x 5/8"	<input type="radio"/> 45°	<input type="radio"/> 1.00 MHz	<input type="radio"/> Techsonic	<input type="radio"/> IIW A2
<input type="radio"/> 3/8"	<input type="radio"/> 1/2" x 1"	<input type="radio"/> 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	2.559	2.636	2.663
B	2.549	2.535	2.549
C	2.538	2.499	2.491

All Dimensions are in inches



FEB 28 2013

Review  
 R/M  
 2/26/13  


### Scanning

Test Area	Disposition	From	Length	Depth	Amplitude

### Evaluation - Acceptance

<input 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.

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	1176 PQ Serial # 7468	Project			
Component		P.O. #	Worksheet #:	36451	
Drawing		Rev.	Technician	Frank Marunde	SNT-TC-1A Level III
NDT Specification	ASME SA 578	Appendix	NDT Procedure	KV-UT# 1 R.02	

### Technical Data - Ultrasonic Examination (UT)

Material Type	Carbon Steel	Technique	<input checked="" type="radio"/> Pulse Echo-Contact <input type="radio"/> Immersion <input type="radio"/> Dual		
Material Thickness	2 1/2"	Instrument Brand	<input checked="" type="radio"/> Olympus Epoch 1000i	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	Temperature	
Heat Treated	<input checked="" type="radio"/> YES <input type="radio"/> NO	Sensitivity (PRL)	56 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 checked="" 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 type="radio"/> 70°	<input type="radio"/> 5.00 MHz	<input type="radio"/> Krautkramer	<input checked="" 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 type="radio"/> ASME

### Scope of Testing

Lamination scan 3" both sides of joints C1, C2 & L1



FEB 27 2013

*Reviewed*  
*On*  
April 5, 2013

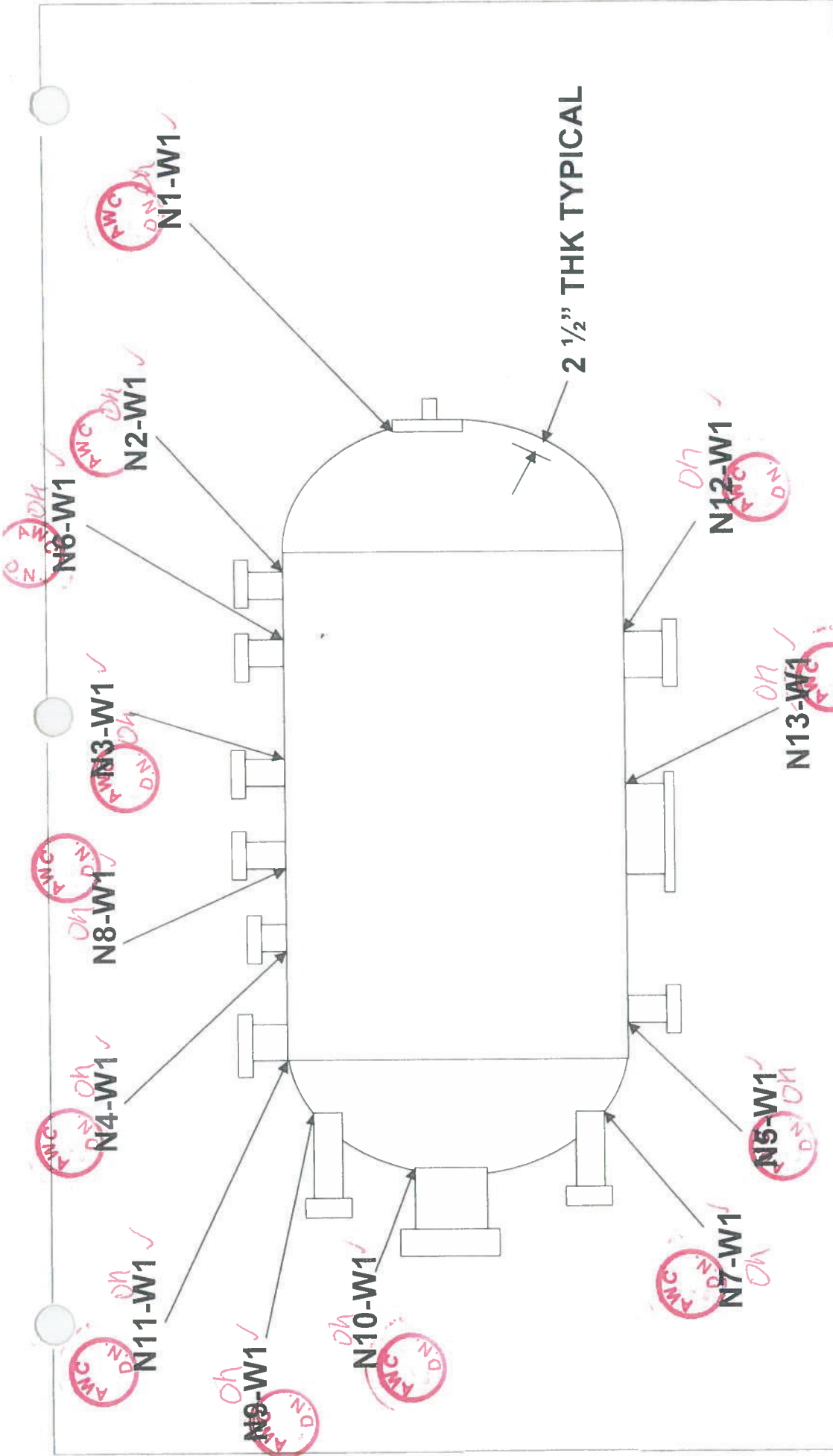


### Scanning

Test Area	Disposition	From	Length	Depth	Amplitude

### Evaluation - Acceptance

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



**AFTER PWHT**

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

UT MAP - 1176PQ

CLIENT: ULTRAFAB

ASME SECTION VIII. DIV. 1

WORK ORDER #: 1176PQ SN 7468  
 JOB DESCRIPTION: 60" I.D. VERTICAL CONTACTOR

MATERIAL SA-516 70N, SA-350 LF2, SA-333 6, SA-420 WPLG

DRAWING #: 1176-1

PREPARED BY: D.NESCI

DATE: March 4, 2013

P.O. 13-0224



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	October 4, 2013
Shop Order	1176PQ S/N7468	Project	
Component		P.O. #	Worksheet #: 37757
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	Carbon Steel	Technique	<input checked="" type="radio"/> Pulse Echo-Contact <input type="radio"/> Immersion <input type="radio"/> Dual
Material Thickness	2 1/2"	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	2 1/2"	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/ 54 dB /63dB
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"/> Normal	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/> ASME

### Scope of Testing

Examination of Category 'D' attachment welds after P.W.H.T.  
N1-W1, N2-W1, N3-W1, N4-W1, N5-W1, N6-W1, N7-W1, N8-W1,  
N9-W1, N10-W1, N11-W1, N12-W1, N13-W1

046

ACCEPTED/REVIEWED/RELEASED

for and on behalf of: SBM OPP STORE

Print Name: LIAMBERT SAHA

Signature: [Signature]

Date: Oct 23/13

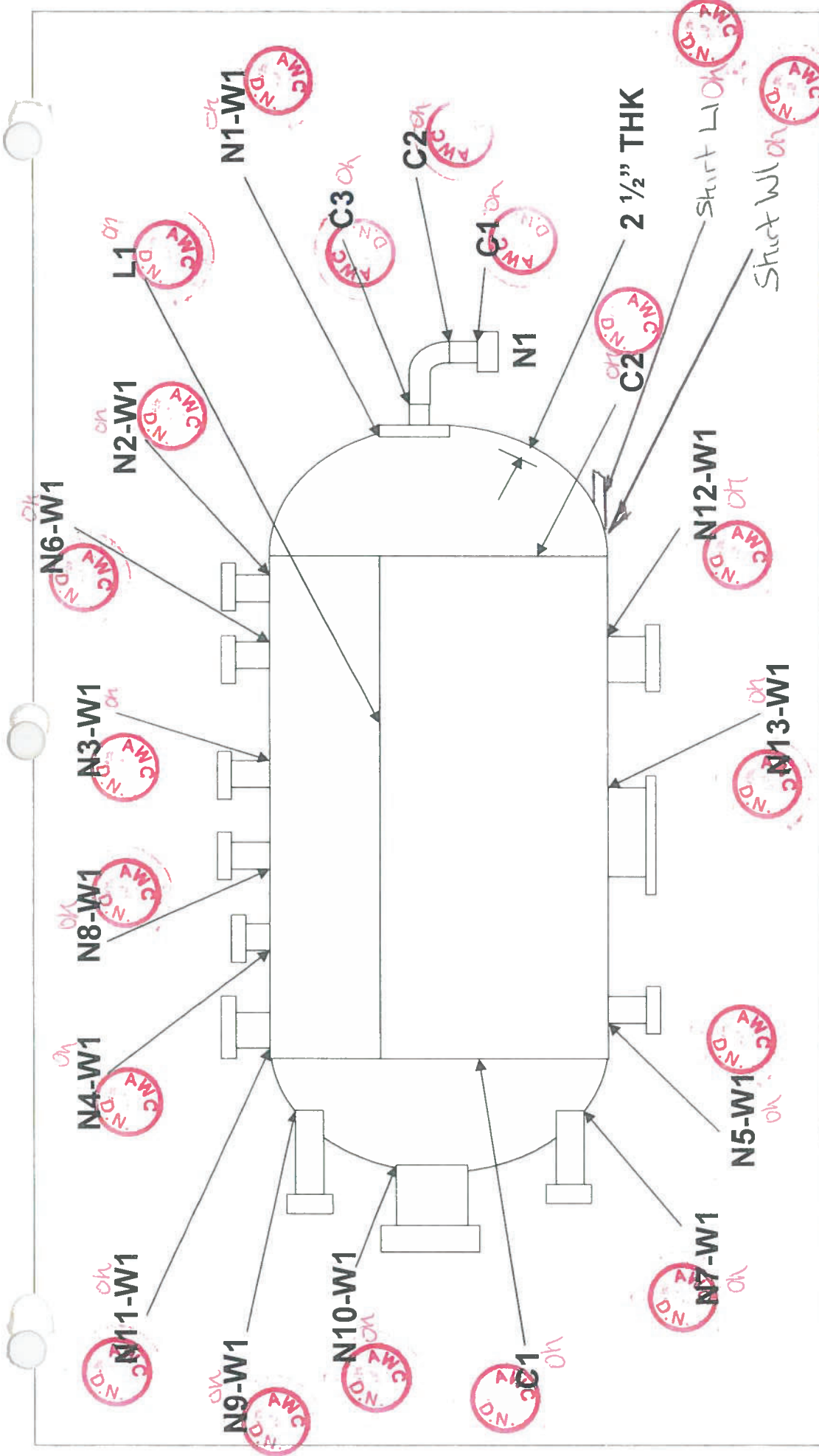
Applus<sup>®</sup>  
VELOSI  
Velosi America LLC

### Scanning

Test Area	Disposition	From	Length	Depth	Amplitude

### Evaluation - Acceptance

<input checked="" type="radio"/> Accepted	KV Inspection Services - Technician	<u>[Signature]</u>	Date	October 4, 2013
<input type="radio"/> Rejected	CGSB No. 48.9712-2000 Reg. No.	8885	Place	Scarborough, ON

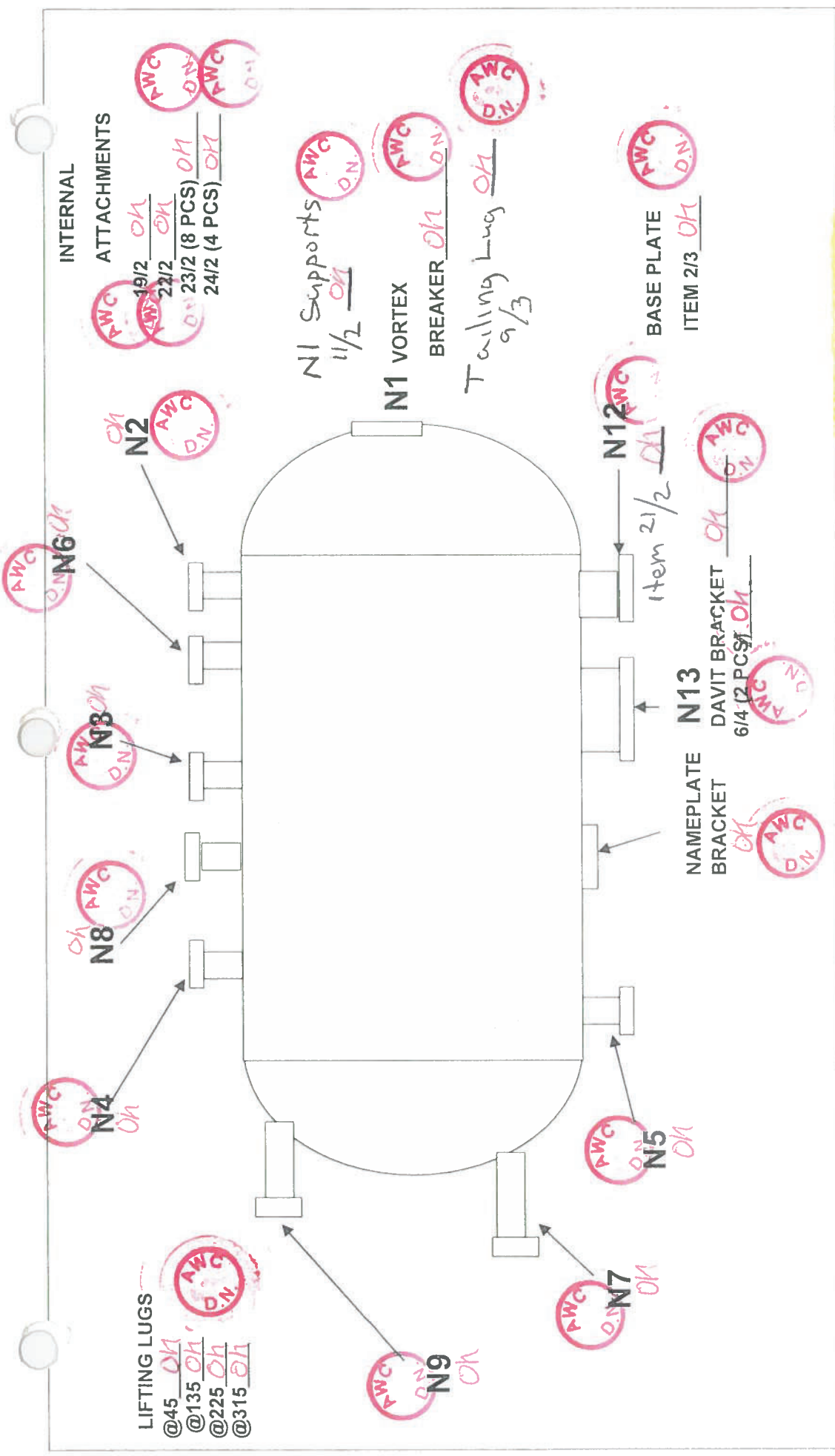


**AFTER PWHT**  
**MAG PARTICLE MAP - 1176PQ**  
**INSIDE / OUTSIDE WHERE APPLICABLE**  
**ASME SECTION VIII. DIV. 1**

MATERIAL SA-516 70N, SA-350 LF2, SA-333 6, SA-420 WPLG  
 P.O. 13-0198

**ALL-WELD CO. LTD. - MAG PARTICLE MAP**

CLIENT: ULTRAFAB  
 WORK ORDER #: 1176PQ SN 7468  
 JOB DESCRIPTION: 60" I.D. VERTICAL CONTACTOR  
 DRAWING #: 1176-1  
 PREPARED BY: D.NESCI  
 DATE: March 4, 2013



**INTERNAL ATTACHMENTS**

19/2 OK  
 23/2 OK  
 23/2 (8 PCS) OK  
 24/2 (4 PCS) OK

**INTERNAL ATTACHMENTS**

N1 Supports OK  
 1 1/2 OK

**N1 VORTEX BREAKER** OK

Tailing Lug OK  
 9/3

**BASE PLATE**  
 ITEM 2/3 OK

**N12**  
 DAVIT BRACKET OK  
 6/4 (2 PCS) OK

**N13**  
 NAMEPLATE BRACKET OK  
 6/4 (2 PCS) OK

**N11**  
 BASE PLATE OK  
 ITEM 2/3 OK

**MT SUPPORTS / ATTACHMENTS MAP - 1176PQ**  
**INSIDE / OUTSIDE WHERE APPLICABLE**  
**ASME SECTION VIII, DIV. 1**

**AFTER PWHT**

**ALL-WELDED CO. LTD.**  
**MT SUPPORTS / ATTACHMENTS MAP**

CLIENT: ULTRAFAB  
 WORK ORDER #: 1176PQ SN 7468  
 JOB DESCRIPTION: 60" I.D. VERTICAL CONTACTOR  
 DRAWING #: 1176-1  
 PREPARED BY: D.NESCI  
 DATE: March 4, 2013

MATERIAL SA-516 70N  
 P.O. 13-0198

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

## Magnetic Particle Inspection Report MT

### Specification - Acceptance Criteria

As per ASME Sec. VIII, Appx. 6, Div. 1

### General Data

Customer	All-Weld Company	Date	October 3, 2013
Location	Scarborough, Ontario	P. O. #	
Project		Shop Order #	1176 PQ S/N 7468
Procedure	KV #3 Rev. 02	Worksheet #	37756
Technician	Frank Marunde	CGSB Reg #	8885 ASNT/SNT-TC-1A Level II

### Technical Data - Magnetic Particle (MT)

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

<input checked="" type="radio"/> Dry <input type="radio"/> Wet <input type="radio"/> Wet Fluorescent
--

### Test Equipment

Indicators	<input checked="" type="radio"/> 825 R - Red <input type="radio"/> 3A - Black <input type="radio"/> 66 - Yellow <input type="radio"/> 803/1- Black Ink <input type="radio"/> Magnaglow 20B Fluorescent <input type="radio"/> 8800A Fluorescent
Background	<input checked="" type="radio"/> 8901W Contrast Aid <input type="radio"/> None
Equipment	<input checked="" type="radio"/> AC Yoke <input type="radio"/> Calibrated Blacklight <input type="radio"/> Other
Method	<input checked="" type="radio"/> Continuous <input type="radio"/> Residual
Light Meter	Type EA31 Serial # 07076803 Intensity 1400 Lx

Lighting Equipment Description: Flashlight

### Inspection

Description: After PWHT

Item #	Description of Weld/Test Area	Technique	Defect Location	Interpretation
1)	Nozzle attachment welds N1-W1, N2-W1, N3-W1, N4-W1, N5-W1, N6-W1, N7-W1, N8-W1, N9-W1, N10-W1, N11-W1, N12-W1, N13-W1 (internal and external)	L & T		Acceptable to specifications
2)	Circ Seams C1 & C2 and Long seam L1 (internal and external)	L & T		Acceptable to specifications

✓

ACCEPTED/REVIEWED/RELEASED 046  
 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 3, 2013
Customer Representative		Date	OCT 07 2013



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

## Magnetic Particle Inspection Report MT

### Specification - Acceptance Criteria

As per ASME Sec. VIII, Appx. 6, Div. 1

### General Data

Customer	All-Weld Company	Date	October 3, 2013		
Location	Scarborough, Ontario	P. O. #			
Project		Shop Order #	1176 PQ S/N 7468		
Procedure	KV #3 Rev. 02	Worksheet #	37756		
Technician	Frank Marunde	CGSB Reg #	8885	ASNT/SNT-TC-1A Level	II

### Technical Data - Magnetic Particle (MT)

Material Type     Carbon Steel     Other    Material Thickness

### Test Method

Dry     Wet     Wet Fluorescent

### Test Equipment

Indicators	<input checked="" type="radio"/> 825 R - Red	<input type="radio"/> 66 - Yellow	<input type="radio"/> Magnaglow 20B Fluorescent
	<input type="radio"/> 3A - Black	<input type="radio"/> 803/1- Black Ink	<input type="radio"/> 8800A Fluorescent
Background Equipment	<input checked="" type="radio"/> 8901W Contrast Aid	<input type="radio"/> None	
Method	<input checked="" type="radio"/> AC Yoke	<input type="radio"/> Calibrated Blacklight	<input type="radio"/> Other
	<input checked="" type="radio"/> Continuous	<input type="radio"/> Residual	
Light Meter	Type EA31	Serial # 07076803	Intensity 1400 Lx

Lighting Equipment Description: Flashlight

### Inspection

Description: After PWHT

Item #	Description of Weld/Test Area	Technique	Defect Location	Interpretation
1)	Skirt - W1 and Skirt - L1 (interior and exterior)	L & T		Acceptable to specifications
2)	Lifting lug attachment welds (x4) Tailing lug (x1)	L & T		Acceptable to specifications
3)	Name plate bracket & Davit bracket welds	L & T		Acceptable to specifications

046

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SOM ORP SHORE  
Print Name: GANESH SAHA  
Signature: [Signature]  
Date: 04 23/13  
**Applus®**  
**VELOSI**  
Velosi America LLC

KV Inspection Technician

*[Signature]*

Date

October 3, 2013

Customer Representative

Date

# KV Inspection Services Ltd.

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

## Magnetic Particle Inspection Report MT

### Specification - Acceptance Criteria

As per ASME Sec. VIII, Appx. 6, Div. 1

### General Data

Customer	All-Weld Company	Date	October 3, 2013
Location	Scarborough, Ontario	P. O. #	
Project		Shop Order #	1176 PQ S/N 7468
Procedure	KV #3 Rev. 02	Worksheet #	37756
Technician	Frank Marunde	CGSB Reg #	8885 ASNT/SNT-TC-1A Level II

### Technical Data - Magnetic Particle (MT)

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

- Dry
  Wet
  Wet Fluorescent

### Test Equipment

Indicators	<input checked="" type="radio"/> 825 R - Red <input type="radio"/> 3A - Black	<input type="radio"/> 66 - Yellow <input type="radio"/> 803/1- Black Ink	<input type="radio"/> Magnaglow 20B Fluorescent <input type="radio"/> 8800A Fluorescent
Background Equipment	<input checked="" type="radio"/> 8901W Contrast Aid <input type="radio"/> AC Yoke	<input type="radio"/> None <input type="radio"/> Calibrated Blacklight	<input type="radio"/> Other
Method	<input checked="" type="radio"/> Continuous	<input type="radio"/> Residual	
Light Meter	Type EA31	Serial # 07076803	Intensity 1400 Lx

Lighting Equipment Description: Flashlight

### Inspection

Description: After PWHT

Item #	Description of Weld/Test Area	Technique	Defect Location	Interpretation
1)	Nozzle support welds N1, N2, N3, N4, N5, N6, N7, N8, N9	L & T		Acceptable to specifications
2)	Item 6/4 (x2)	L & T		Acceptable to specifications
3)	N1-C1, N1-C2, N1-C3	L & T		Acceptable to specifications

046

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

*[Signature]*

Date

October 3, 2013

Customer Representative



Date

OCT 07 2013

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

## Magnetic Particle Inspection Report MT

### Specification - Acceptance Criteria

As per ASME Sec. VIII, Appx. 6, Div. 1

### General Data

Customer	All-Weld Company	Date	October 3, 2013
Location	Scarborough, Ontario	P. O. #	
Project		Shop Order #	1176 PQ S/N 7468
Procedure	KV #3 Rev. 02	Worksheet #	37756
Technician	Frank Marunde	CGSB Reg #	8885 ASNT/SNT-TC-1A Level II

### Technical Data - Magnetic Particle (MT)

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

### Test Method

<input checked="" type="radio"/> Dry <input type="radio"/> Wet <input type="radio"/> Wet Fluorescent
--

### Test Equipment

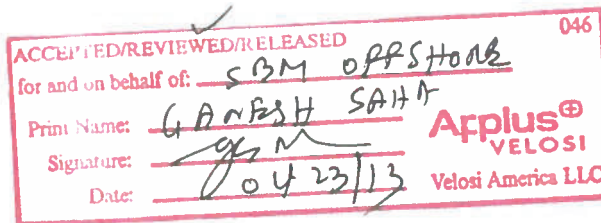
Indicators	<input checked="" type="radio"/> 825 R - Red <input type="radio"/> 3A - Black	<input type="radio"/> 66 - Yellow <input type="radio"/> 803/1- Black Ink	<input type="radio"/> Magnaglow 20B Fluorescent <input type="radio"/> 8800A Fluorescent
Background Equipment	<input checked="" type="radio"/> 8901W Contrast Aid <input checked="" type="radio"/> AC Yoke	<input type="radio"/> None <input type="radio"/> Calibrated Blacklight	<input type="radio"/> Other
Method	<input checked="" type="radio"/> Continuous	<input type="radio"/> Residual	
Light Meter	Type EA31	Serial # 07076803	Intensity 1400 Lx

Lighting Equipment Description: Flashlight

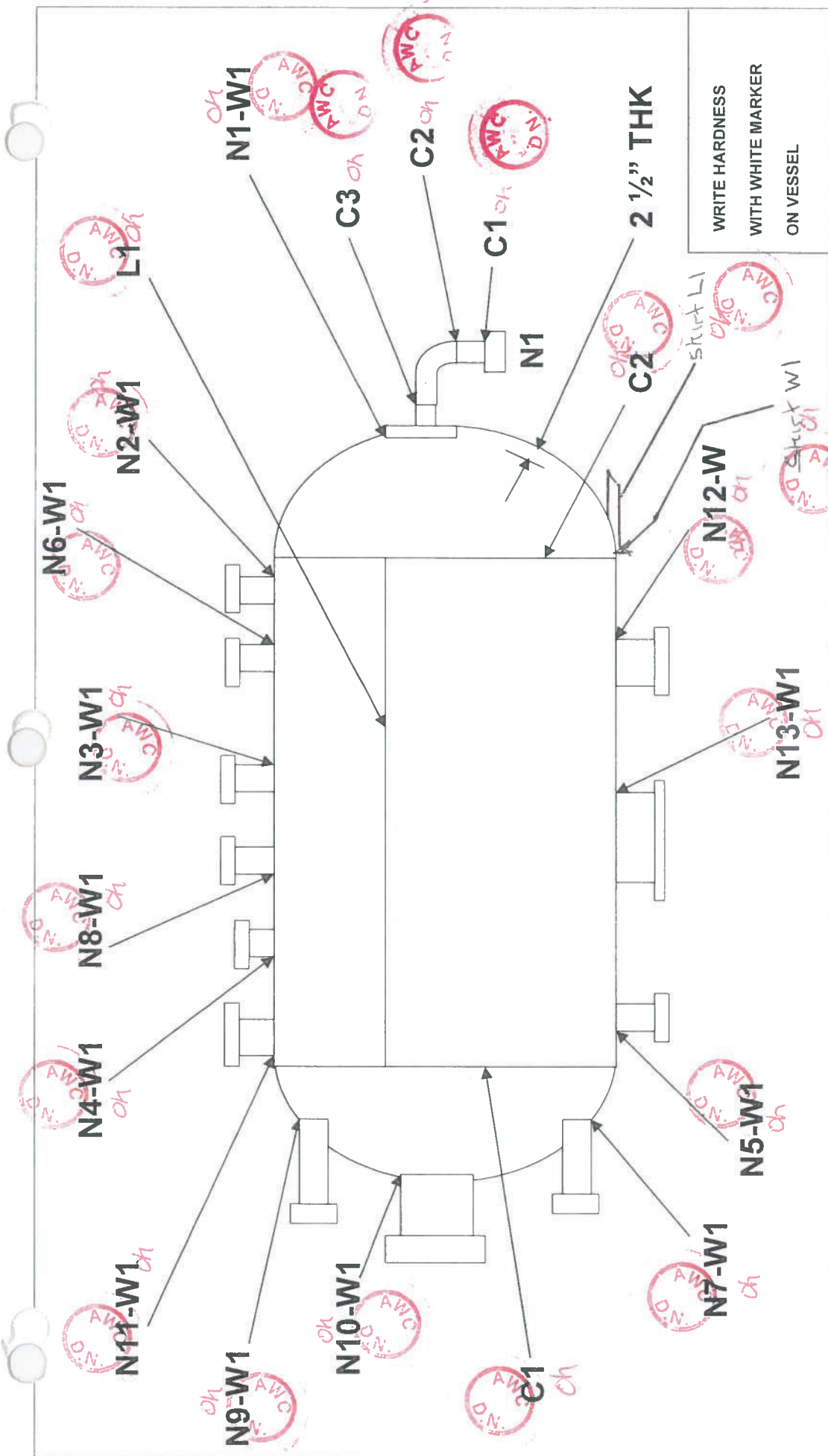
### Inspection

Description: After PWHT

Item #	Description of Weld/Test Area	Technique	Defect Location	Interpretation
1)	Vortex Breaker Attachment weld	L & T		Acceptable to specifications
2)	Item 21/2 - N12 Weld	L & T		Acceptable to specifications
3)	Item 2/3 - Skirt weld	L & T		Acceptable to specifications
4)	Internal attachment welds Item 19/2, 22/2, 23/2 (x8), 24/2 (x4)	L & T		Acceptable to specifications



KV Inspection Technician		Date	October 3, 2013
Customer Representative		Date	OCT 07 2013



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

CLIENT: ULTRAFAB  
 WORK ORDER #: 1176PQ SN 7468  
 JOB DESCRIPTION: 60" I.D. VERTICAL CONTACTOR  
 DRAWING #: 1176-1  
 PREPARED BY: D.NESCI  
 DATE: March 4, 2013

**AFTER PWHT**

HT MAP - 1176PQ  
 OUTSIDE

ASME SECTION VIII, DIV. 1  
 MATERIAL SA-516 70N, SA-350 LF2, SA-333 6, SA-420 WPLG  
 1 SET OF READINGS PER WELD  
 (BM, HAZ, W, HAZ, BM) 248 HV10 MAX  
 P.O. 13-0229



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

## Hardness Testing Report HT

### Specification – Acceptance Criteria

General Data			
Customer	All-Weld Company	Date	October 2, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1176 PQ S/N 7468
Procedure	KV HT# 35 Rev.00	Worksheet #	37734
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

### Technical Data – Hardness Testing (HT)

Material	Carbon Steel		
Test Method & Equipment			
Technique	<input checked="" type="radio"/> Impact Load – Digital Readout	<input type="radio"/> Impact Load – Ocular Viewing	
Equipment	<input checked="" type="radio"/> Equotip D Impact Device		
Readings Taken	<input type="radio"/> Average of 5 readings	<input checked="" type="radio"/> Average of 3 readings	<input type="radio"/> Other
Scale	<input type="radio"/> Brinell Hardness	<input checked="" type="radio"/> HV	Unit Setting: <span style="border: 1px solid black; padding: 2px;"> </span>

### Inspection

Description: After PWHT

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7468	N9-W1	139	137	140	137	114
	N10-W1	128	148	191	151	155
	N11-W1	146	154	191	161	134
	N12-W1	136	145	173	148	128
	N13-W1	158	142	146	119	134
	L1	147	140	191	138	157
	C1	120	105	175	148	132
	C2	149	131	190	130	114
	Skirt - W1	142	111	168	168	158
	Skirt - L1	136	151	133	155	120

046  
 ACCREDITED/REVIEWED/RELEASED  
 for and on behalf of: SBM OFFSHORE  
 Print Name: GAURESH SAHA  
 Signature: *[Signature]*  
 Date: 06/23/13  
**Applus®**  
**VELOSI**  
 Velosi America LLC

KV Inspection Technician	<i>[Signature]</i> 	120	October 2, 2013
Customer Representative		Date	OCT 07 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 2, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1176 PQ S/N 7468
Procedure	KV HT# 35 Rev.00	Worksheet #	37734
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

### Technical Data - Hardness Testing (HT)

Material Carbon Steel

### Test Method & Equipment

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

### Inspection

Description: After PWHT

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Set # 7468	N1-C1	138	138	217	135	145
	N1-C2	167	185	191	168	163
	N1-C3	137	152	212	137	150
	N1-W1	152	191	175	139	145
	N2-W1	148	183	197	149	140
	N3-W1	158	164	156	152	133
	N4-W1	147	136	126	126	128
	N5-W1	152	190	159	167	161
	N6-W1	140	154	160	132	147
	N7-W1	133	184	150	136	114
	N8-W1	167	160	129	138	128

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: S&M OFF SHORE  
 Print Name: Ganesh H SAHA  
 Signature: [Signature]  
 Date: 10/4/2013  
**Applus®**  
**VELOSI**  
 Velosi America LLC

KV Inspection Technician

120

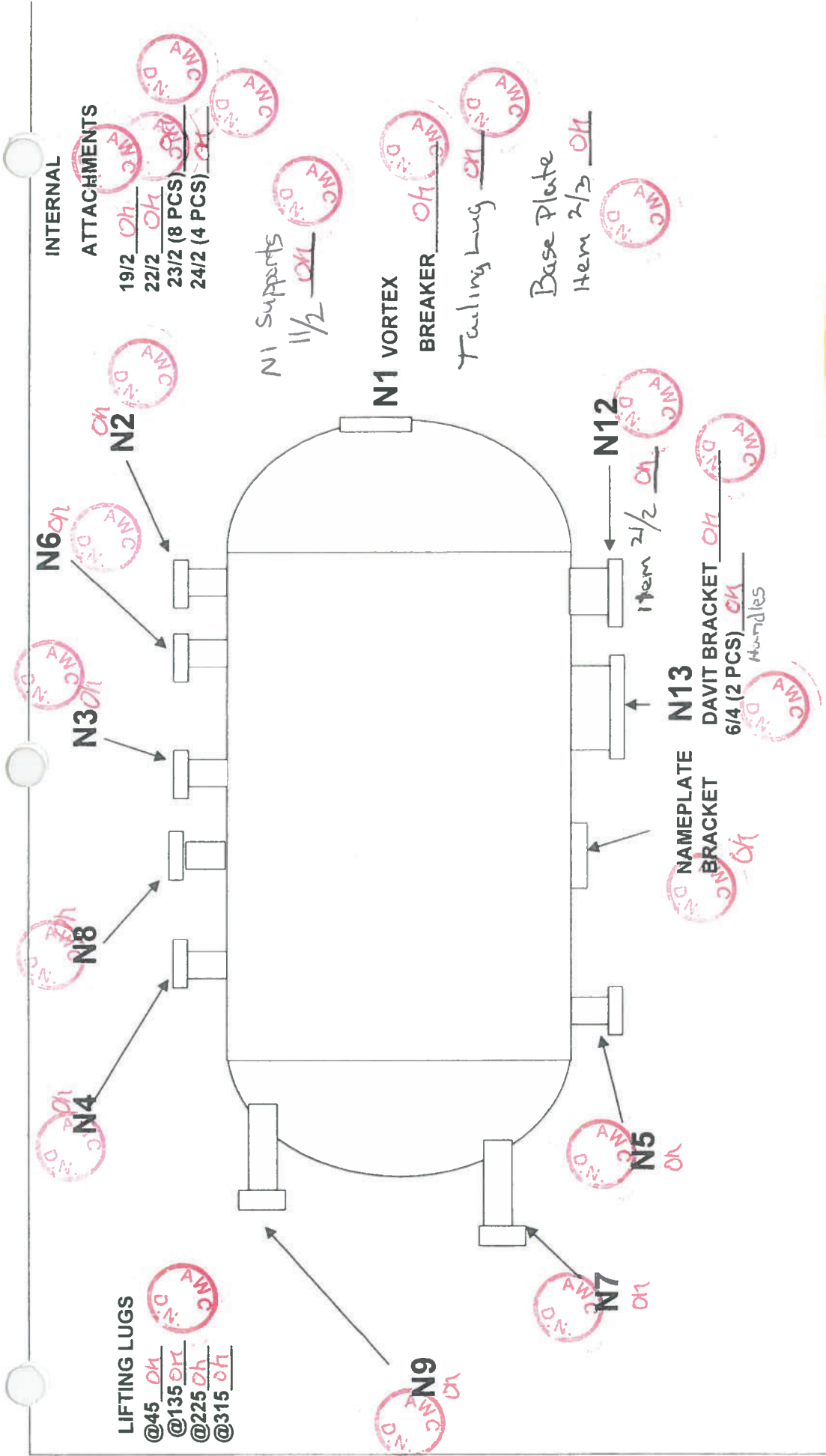
October 2, 2013

Customer Representative

Date

OCT 07 2013





**INTERNAL ATTACHMENTS**

- 19/2 OK
- 22/2 OK
- 23/2 (8 PCS) OK
- 24/2 (4 PCS) OK

N1 Supports  
1 1/2 OK

N1 VORTEX  
BREAKER OK

Tailing Lug OK

Base Plate  
Hem 2/3 OK

N13 NAMEPLATE  
BRACKET OK  
6/4 (2 PCS) OK  
Handles

N12 Item 2 1/2 OK

**INTERNAL ATTACHMENTS**

N6 OK

N2 OK

N3 OK

N8 OK

N4 OK

N5 OK

N7 OK

N9 OK

N10 OK

N11 OK

**ALL-WELD CO. LTD.**

**HT SUPPORTS / ATTACHMENTS MAP**

CLIENT: ULTRAFAB

WORK ORDER #: 1176PQ SN 7468

JOB DESCRIPTION: 60" I.D. VERTICAL CONTACTOR

DRAWING #: 1176-1

PREPARED BY: D.NESCI

DATE: March 4, 2013

**AFTER PWHT**

**HT SUPPORTS/ ATTACHMENTS MAP - 1176PQ**

**INSIDE / OUTSIDE WHERE APPLICABLE**

**ASME SECTION VIII. DIV. 1**

MATERIAL SA-516 70N

P.O. 13-0198

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

## Hardness Testing Report HT

### Specification – Acceptance Criteria

#### General Data

Customer	All-Weld Company	Date	October 2, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1176 PQ S/N 7468
Procedure	KV HT# 35 Rev.00	Worksheet #	37734
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

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

Material Carbon Steel

#### Test Method & Equipment

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

#### Inspection

Description: After PWHT Ser# 7468

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
N1	Support Weld # 1	119	125	160	136	125
	Support Weld # 2	165	170	159	131	139
	Support Weld # 3	117	114	173	140	128
	Support Weld # 4	163	149	167	134	140
N2	Support Weld # 1	150	156	197	129	114
	Support Weld # 2	157	154	197	121	127
	Support Weld # 3	151	160	191	119	119
	Support Weld # 4	143	153	207	123	121

046  
 ACCEPTED FOR RELEASE  
 for and on behalf of: SAM OF S HARB  
 Print Name: GARY BETH  
 Signature: [Signature]  
 Date: Oct 22, 13  
**Applus®**  
**VELOSI**  
 Velosi America LLC

KV Inspection Technician

120

October 2, 2013

Customer Representative

Date

OCT 07 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 2, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1176 PQ S/N 7468
Procedure	KV HT# 35 Rev.00	Worksheet #	37734
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

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

Material	Carbon Steel
----------	--------------

#### Test Method & Equipment

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

#### Inspection

Description: After PWHT Ser# 7468

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

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
N3	Support Weld # 1	166	135	181	127	137
	Support Weld # 2	141	134	171	150	142
	Support Weld # 3	147	142	172	144	138
	Support Weld # 4	157	166	181	153	173
	Support Weld # 1	155	139	167	140	133
	Support Weld # 2	143	141	164	167	150
	Support Weld # 3	162	144	159	131	136
	Support Weld # 4	146	148	174	156	161

KV Inspection Technician

*[Signature]*  


120

October 2, 2013

Customer Representative

Date

OCT 07 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 2, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1176 PQ S/N 7468
Procedure	KV HT# 35 Rev.00	Worksheet #	37734
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

### Technical Data – Hardness Testing (HT)

Material Carbon Steel

### Test Method & Equipment

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

### Inspection

Description: After PWHT Ser# 7468

046  
 ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: S. J. D. OFFSHORE  
G. MARUNDE  
 Print Name: G. MARUNDE  
 Signature: [Signature]  
 Date: 04/23/13  
**Applus®**  
**VELOSI**  
 Velosi America LLC

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
N5	Support Weld # 1	151	164	185	138	126
	Support Weld # 2	147	156	174	135	140
	Support Weld # 3	129	147	184	143	137
	Support Weld # 4	145	140	190	129	141
N6	Support Weld # 1	128	156	181	142	130
	Support Weld # 2	140	162	179	139	135
	Support Weld # 3	132	153	185	140	160
	Support Weld # 4	129	147	167	136	141

KV Inspection Technician

*[Signature]*

120

October 2, 2013

Customer Representative



Date

OCT 07 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 2, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1176 PQ S/N 7468
Procedure	KV HT# 35 Rev.00	Worksheet #	37734
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

### Technical Data - Hardness Testing (HT)

Material Carbon Steel

### Test Method & Equipment

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

### Inspection

Description: After PWHT Ser# 7468

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
N7	Support Weld # 1	120	121	168	114	111
	Support Weld # 2	119	128	181	126	126
	Support Weld # 3	121	131	163	149	164
	Support Weld # 4	131	133	163	170	132
	Support Weld # 1	118	130	170	127	121
	Support Weld # 2	130	145	185	130	131
	Support Weld # 3	129	143	174	150	140
	Support Weld # 4	133	137	183	141	139

046  
 ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SGM OFFSHORE  
G. AMEJIA SARA  
 Print Name: SGM  
 Signature: [Signature]  
 Date: 10/4/2013  
**Applus**  
**VELOSI**  
 Velosi America LLC

KV Inspection Technician

*[Signature]*

120

October 2, 2013

Customer Representative



Date

OCT 07 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 2, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1176 PQ S/N 7468
Procedure	KV HT# 35 Rev.00	Worksheet #	37734
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

### Technical Data – Hardness Testing (HT)

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

### Inspection

Description: After PWHT Ser# 7468

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
N9	Support Weld # 1	128	164	204	129	141
	Support Weld # 2	146	137	201	164	121
	Support Weld # 3	137	147	170	100	109
	Support Weld # 4	121	173	194	142	145
	Lifting Lugs @ 45°	119	121	119	146	157
	Lifting Lugs @ 135°	134	135	126	137	129
	Lifting Lugs @ 225°	131	137	169	118	130
	Lifting Lugs @ 315°	120	138	166	150	151

046  
ACCEPTED FOR VIEWING/RELEASED  
for and on behalf of: SBM OFFSHORE  
Print Name: CARMELO SAMA  
Signature: [Signature]  
Date: 10/02/13  
**Applus®**  
**VELOSI**  
Velosi America LLC

KV Inspection Technician		120	October 2, 2013
Customer Representative		Date	OCT 07 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 2, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1176 PQ S/N 7468
Procedure	KV HT# 35 Rev.00	Worksheet #	37734
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

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

Material	Carbon Steel
----------	--------------

#### Test Method & Equipment

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

046  
 ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBN OFFSHORE  
 Print Name: GRANVILLE SANJA  
 Signature: [Signature]  
 Date: 2013/10/13  
**Applus®**  
**VELOS**  
 Velos America LLC

#### Inspection

Description: After PWHT Ser# 7468

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Item 6/4	Weld #1	150	140	140	121	119
	Weld #2	148	137	137	119	124
	Weld #3	129	160	147	127	130
	Weld #4	133	173	150	133	117
Item 24/2	Weld #1	159	160	128	147	144
	Weld #2	140	140	150	130	131
	Weld #3	148	158	167	132	166
	Weld #4	147	156	166	139	141

KV Inspection Technician		120	October 2, 2013
Customer Representative		Date	OCT 07 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 2, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1176 PQ S/N 7468
Procedure	KV HT# 35 Rev.00	Worksheet #	37734
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

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

Material Carbon Steel

#### Test Method & Equipment

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

006  
 ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBM OFF-SHORE  
 Print Name: GONESH SANA  
 Signature: [Signature]  
 Date: 10/23/13  
**Applus**  
**VELOSI**  
 Velosi America LLC

#### Inspection

Description: After PWHT

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Ser# 7468	Nameplate bracket	139	169	197	--	146
	Davit bracket	150	175	137	143	114
	Tailing lug	129	120	133	150	121
	Vortex breaker	116	190	185	163	135
	Item 19/2	133	136	132	163	132
	Item 19/2	128	132	141	170	150
	Item 22/2	131	166	145	196	180
	Item 2/3	140	171	173	144	130
	Item 21/2	118	122	149	N/A	144

KV Inspection Technician

*[Signature]*

120

October 2, 2013

Customer Representative



Date

OCT 07 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 2, 2013
Location	Scarborough, ON	P. O. #	
Project		Shop Order #	1176 PQ S/N 7468
Procedure	KV HT# 35 Rev.00	Worksheet #	37734
Technician	Frank Marunde	HT Certified	<input checked="" type="checkbox"/> CGSB Reg # 8885

Technical Data – Hardness Testing (HT)	
Material	Carbon Steel

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

046  
 ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: **SAM OFFSHORE**  
 Print Name: **GABRIEL SAHIA**  
 Signature: *[Signature]*  
 Date: **2013-10-02**  
**Applus®**  
**VELOSI**  
 Veloci America LLC

### Inspection

Description: After PWHT Ser# 7468

Item #	Description of Test Area	Parent Material	HAZ	Weld	HAZ	Parent Material
Item 23/2	Weld #1	153	159	138	155	147
	Weld #2	133	143	149	136	143
	Weld #3	134	169	180	134	149
	Weld #4	128	148	140	138	155
	Weld #5	138	140	153	174	160
	Weld #6	135	147	179	191	164
	Weld #7	160	153	152	174	156
	Weld #8	144	150	163	181	167

KV Inspection Technician	<i>[Signature]</i>	120	October 2, 2013
Customer Representative		Date	OCT 07 2013



# Welding Procedure Specification (WPS)

STAINLESS TO  
CARBON STEEL

**Customer  
Work Order #**

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

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

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

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

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

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

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

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

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

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

<b>12</b>	<b>Electrical Characteristics and Technique (QW-409)-(QW-410)</b>
-----------	---

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

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

<b>(14)</b>	Company Representative Signature <u></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

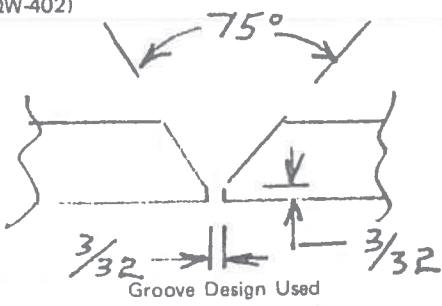
PROCEDURE QUALIFICATION RECORD

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

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)**

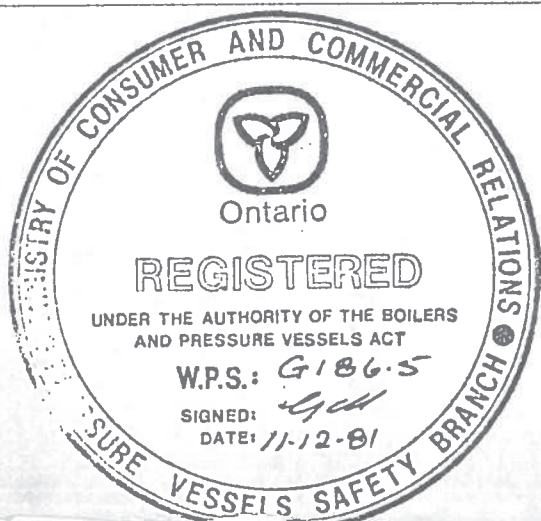
SPECIMEN NO.	NOTCH LOCATION	NOTCH TYPE	TEST TEMP.	IMPACT VALUES	LATERAL EXP.		DROPWEIGHT	
					% SHEAR	MILS	BREAK	NO BREAK

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/



# Welding Procedure Specification (WPS)

CARBON STEEL

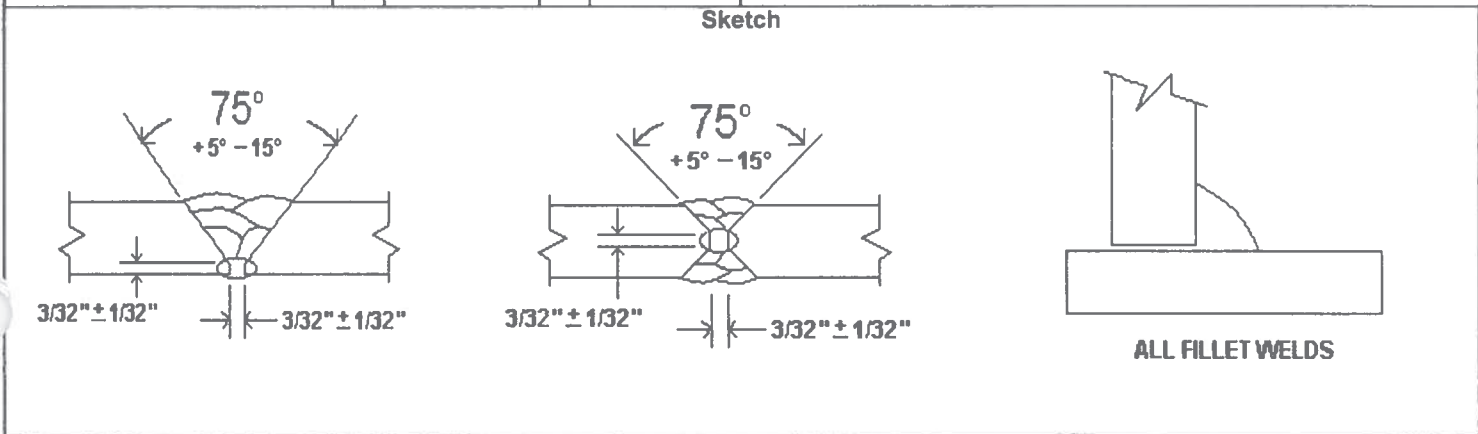
**Customer Work Order #**

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

<b>2</b>	<b>Provincial Registration</b>	WP T4660.5
<b>3</b>	<b>Procedure Identification</b>	
WPS NO.	29-2	Revision No. 0
Code Section	IX	Date 15 APRIL, 13
PQR No.	29X	

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

<b>5</b>	<b>Joints (QW-402)</b>			
Design	SINGLE , DOUBLE V GROOVE & FILLETS		Backing Material	WITH OR WITHOUT WELD METAL
Backing	Yes	<b>X</b>	No	<b>X</b>
	Other BACKING FOR SINGLE OR DOUBLE V GROOVE			



<b>6</b>	<b>Base Metals (QW-403)</b>	P. No. 1	Gr. No. 1	to P. No. 1	Gr. No. 2
or Specifications type and grade		SA-333-GR 6 to SA-36, 53-B, 105, 106-B, 234 WPB, 350-LF2 & 516-GR70			
or Chemical Analysis and Mech. Prop.		NONE			
Thickness Range Qualified	Total 1) 0.300" TO 0.600" FOR IMPACTS 2) 0.062" TO 0.600" NON IMPACT				
Other	1) NO SINGLE PASS TO BE GREATER THAN 1/2"				

<b>7</b>	<b>Filler Metals (QW-404)</b>											
1. AWS No.	ER70S-2	PRODUCT FORM - SOLID	SFA	5.18	F-No	6	A-No.	1	Dia.	1/16"		
2. AWS No.	ER70S-2		SFA	5.18	F-No	6	A-No.	1	Dia.	1/8"		
3. AWS No.			SFA		F-No		A-No.		Dia.			
Flux Tradename	NONE			Electrode Flux Classification						NONE		
Consumable Insert	NONE			Other							MAX. DEPOSITED METAL 0.600" THICK	

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

<b>9</b>	<b>Postweld Heat Treatment (QW-407)</b>
Temperature Range	1175 F + or - 25 F
Time Range	6.25 HR'S MAX
Other	NONE



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

11	<b>Gas (QW-408)</b>
Shielding Gas Composition	ARGON 99.9%
Gas Flow Rate	8-12 CFH
Backing Gas Composition	ARGON 99.9%
Trailing Shield Gas Composition	3-5 CFH
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	ER70S-2	1/8"	DC	SP	110-130	16-20	3 TO 6
FILL	GTAW	ER70S-2	1/8"	DC	SP	110-130	16-22	3 TO 6
<b>Heat Input ( Per QW-409.1 ) = 57,200 j / in</b>								

Tungsten Electrode Size and Type	2% THORIATED 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	3/8" TO 5/8"	
Oscillation	NONE	Width NONE Frequency NONE
Contact Tube to Work Distance	1/2" TO 1"	
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	

13	<b>Supplementary Comments</b>
1) CHARPY V NOTCH IMPACT TESTED TO - 50 F      2) MACROETCH EVALUATION TEST	
3) VICKERS HARDNESS TRANSFER TEST UNDER 248 HV10	

14 Company Representative Signature Robert C. Bentley Date 15 APRIL, 13  
 Robert C. Bentley C.E.T.

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



14 Tensile Tests				Reference:		
Specimen	Dimensions in Inches		Area in Inches <sup>2</sup>	Ultimate Total Load in Foot Pounds	Ultimate Unit Stress in PSI	Character and Location of Failure
	Width	Thickness				
T1	0.504"	0.287"	0.145"	9,598	66,500	All coupons failed a ductile manner the base metal
T2	0.504"	0.299"	0.151"	9,550	63,500	

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	HAZ SA-333-GR6	V NOTCH	-50 F	133 ft-lbf	100	76		
2	HAZ SA-333-GR6	V NOTCH	-50 F	168 ft-lbf	100	74		
3	HAZ SA-333-GR6	V NOTCH	-50 F	171 ft-lbf	100	78		
1	WELD	V NOTCH	-50 F	129 ft-lbf	100	79		
2	WELD	V NOTCH	-50 F	163 ft-lbf	100	84		
3	WELD	V NOTCH	-50 F	164 ft-lbf	100	86		
1	HAZ SA-350-LF2	V NOTCH	-50 F	155 ft-lbf	100	81		
2	HAZ SA-350-LF2	V NOTCH	-50 F	152 ft-lbf	100	74		
3	HAZ SA-350-LF2	V NOTCH	-50 F	97 ft-lbf	100	90		

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 - Results				Heat Input ( Per QW-409.1 ) = 57,200 J			

18 Other Tests		Reference:	
1) MACROETCH EXAMINATION PER LAB REPORT 638502-13. ( Report A )		W.P.S.: WP-T4660.5	
2) NACE MR0175/ISO 15156-2:2009/CIR..2011(E) VICKERS HARDNESS PER LAB REPORT 638502-13 ( Report B )		Date: April 23, 2013	

19 Welder's Name	Hafeez Mirza	Stamp No.	53
Tests conducted by	CAMBRIDGE MATERIAL TESTING LTD.	Laboratory Test No.	638497-2013, 638502-13 (Report A) 638500-2013, 638501-2013, 638502-13 (Report B)

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

20 Company Representative's Signature	<i>Robert Bentley</i>	Date	15 April, 2013
		Filler metal product from Solid WPS # 29-2	
		ROBERT C. BENTLEY, C.E.T.	

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

# Welding Procedure Specification (WPS)

Carbon Steel

**Customer :**  
**Work Order #**

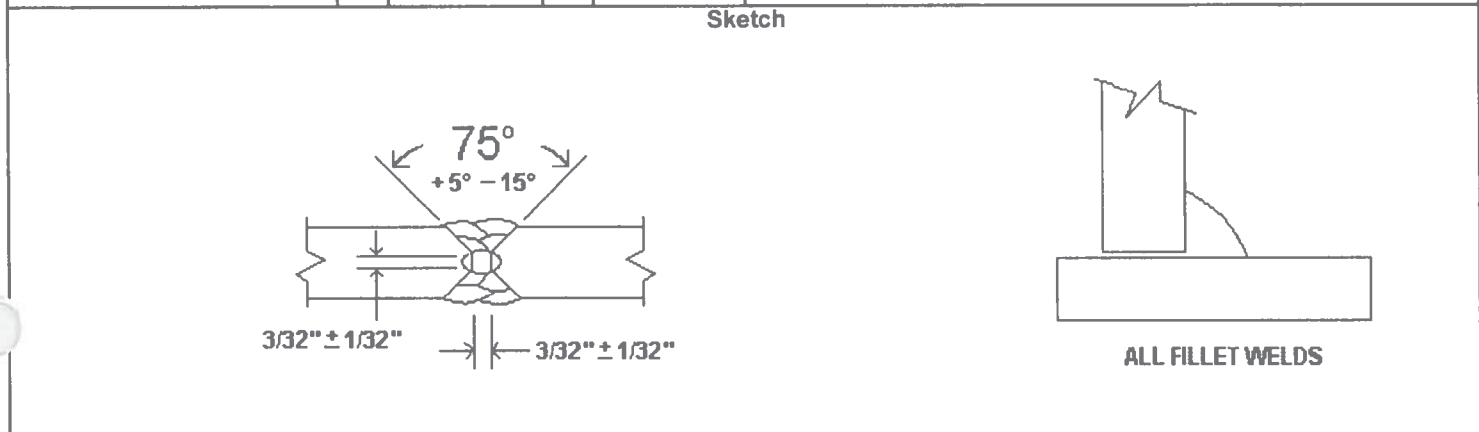
<b>1</b>	<b>Company</b>
Name/ ALL-WELD COMPANY LIMITED	
Address / 49 PASSMORE AVE. , 14 PASSMORE AVE. PLANT 1 PLANT 2	
SCARBOROUGH, ONTARIO	
Postal Code ( PLANT 1 ) M1V-4T1	Postal Code ( PLANT 2 ) M1V-2R6

<b>2</b>	<b>Provincial Registration</b>	WP <b>T4653.5</b>
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<b>3</b>	<b>Procedure Identification</b>	
WPS NO.	52-2	Revision No. <span style="float: right;">0</span>
Code Section	IX	Date <span style="float: right;">08 APRIL, 13</span>
PQR No.	52X	

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

<b>5</b>	<b>Joints (QW-402)</b>	
Design	<b>DOUBLE V GROOVE</b>	Backing Material <span style="float: right;">WELD METAL</span>
Backing	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	Other <span style="float: right;">NONE</span>



<b>6</b>	<b>Base Metals (QW-403)</b>	P. No. <u>1</u> Gr. No. <u>2</u> to P. No. <u>1</u> Gr. No. <u>2</u>
or Specifications type and grade SA - 516 - GR 70 N to SA - 516 - GR 70 N & SA - 350 - LF2		
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"		

<b>7</b>	<b>Filler Metals (QW-404)</b>	
1. AWS No. E7018-1H4		SFA 5.1 F-No 4 A-No. 1 Dia. 1/8 "
2. AWS No. E7018-1H4		SFA 5.1 F-No 4 A-No. 1 Dia. 3/16"
3. AWS No.		SFA F-No A-No. Dia.
Flux Tradename	NONE	Electrode Flux Classification <span style="float: right;">NONE</span>
Consumable Insert	NONE	Other <span style="float: right;">MAX DEPOSITED METAL 8 "</span>

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

<b>10</b>	<b>Postweld Heat Treatment (QW-407)</b>
Temperature Range	1175 + 25 ° / - 0 ° F
Time Range	FOR IMPACT TEST 6 1/2 HRS AND PER CODE FOR NON IMPACT
Other	

9	<b>Preheat (QW-406)</b>	
Preheat Temperature	Min.	IMPACT TEST 200° F / NON 100° F
Interpass Temperature	Max.	350° F
Preheat Maintenance		IMPACT TEST 200° F / NON 100° 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	<b>Electrical Characteristics and Technique (QW-409)-(QW-410)</b>							
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Weld Layer(s)	Process	Filler Metal		Current				Travel Speed Range
		Classification	Diameter	Type	Polarity	Amp. Range	Volt Range	
ROOT	SMAW	E7018-1H4	1/8 "	DC	RP	100 - 150	21 - 25	5 - 10 IPM
FILL	SMAW	E7018-1H4	3/16 "	DC	RP	200 - 275	21 - 25	5 - 10 IPM
<b>Max Heat Input ( Per QW-409.1 ) = 79,200 j / in</b>								

Tungsten Electrode Size and Type	NONE							
Mode of Metal Transfer for GMAW	NONE							
String or Weave Bead	STRING							
Method of Back Gouging	GRINDING OR ARC AIR GOUGING AND GRINDING							
Initial and Interpass Cleaning (Brushing, Grinding, etc.)	WIRE BRUSH OR GRINDING							
Orifice or Gas Cup Size	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	NONE							

13	<b>Supplementary Comments</b>							
NONE								

14	Company Representative Signature		Date	08 APRIL, 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.





Specimen	Dimensions in Inches		Area in Inches <sup>2</sup>	Ultimate Total Load in Foot Pounds	Ultimate Unit Stress in PSI	Character and Location of Failure
	Width	Thickness				
T2A	0.750"	1.114"	0.836"	60,281	72,000	All coupons failed in ductile manner in weld metal
T2B	0.752"	1.220"	0.917"	64,554	70,500	
T5A	0.750"	1.185"	0.889"	63,442	71,500	
T5B	0.751"	1.150"	0.864"	62,000	72,000	

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	186 ft-lbf	80	81		
2	Weld ( 1/16" below )	V NOTCH	-50 F	125 ft-lbf	60	80		
3	Weld ( 1/16" below )	V NOTCH	-50 F	19 ft-lbf	20	10		
1	HAZ	V NOTCH	-50 F	152 ft-lbf	80	81		
2	HAZ	V NOTCH	-50 F	111 ft-lbf	60	74		
3	HAZ	V NOTCH	-50 F	107 ft-lbf	60	67		
1	Weld ( 1/4t opposite )	V NOTCH	-50 F	83 ft-lbf	30	59		
2	Weld ( 1/4t opposite )	V NOTCH	-50 F	28 ft-lbf	20	14		
3	Weld ( 1/4t opposite )	V NOTCH	-50 F	136 ft-lbf	60	79		

17 Fillet Weld Test				Reference: Heat Input ( Per QW-409.1 ) = 79,200 j / in			
Result - Satisfactory	Yes <input type="checkbox"/>	No <input type="checkbox"/>	Penetration Into Parent Metal	Yes <input type="checkbox"/>	No <input type="checkbox"/>		

Macro - Results

18 Other Tests

1) MACROETCH EXAMINATION PER LAB REPORT 637267-13 ( Report A )

2) NACE MR0175/ISO 15156-2:2009/CIR..2011{E} VICKERS HARDNESS PER LAB REPORT 637267-13 ( Report B )

19 Welder's Name Steve Liew Stamp No. 90

637260-13, 637264-2013, 637265-2013, 637266-2013, 637267-13 (Report A)

Tests conducted by CAMBRIDGE MATERIAL TESTING LTD. Laboratory Test No. 637267-13 (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 Robert C. Bentley Date 8 April, 2013

ROBERT C. BENTLEY, C.E.T.

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

**Technical Standards and Safety Authority**

**Boilers and Pressure Vessels Safety Program**

**REGISTERED**

W.P.S.: WP-T4653-F

Signed: SL

Date: APR 19, 2013

PQR: 52-X

WPS: 52-2

# Welding Procedure Specification (WPS)

CARBON STEEL

**Customer Work Order #**

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

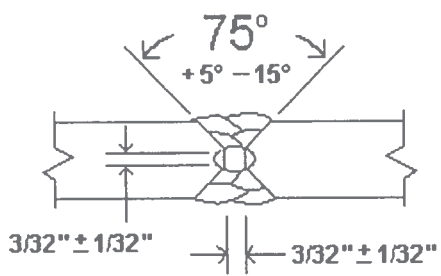
<b>2</b>	<b>Provincial Registration</b>	WP P659.5
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<b>3</b>	<b>Procedure Identification</b>	
WPS NO.	SAW-3-2	Revision No. 6
Code Section	IX	Date 27 March, 13
PQR No.	SAW-3	

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

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

Sketch



FLAT POSITION FILLET WELDS

<b>6</b>	<b>Base Metals (QW-403)</b>	P. No. 1 Gr. No. 2 to P. No. 1 Gr. No. 2
or Specifications type and grade		SA-516-GR 70 to SA-516-GR 70
or Chemical Analysis and Mech. Prop.		NONE
Thickness Range Qualified		Total 1) 5/8 " TO 8 " for Impact use 2) Non Impact use 3/16" to 8"
Other		1) NO SINGLE PASS TO BE GREATER THAN 1/2"

<b>7</b>	<b>Filler Metals (QW-404)</b>	
1. AWS No	EH11K	SFA 5.17 F-No 6 A-No. 1 Dia. 0.15625
2. AWS No.	EH11K	SFA 5.17 F-No 6 A-No. 1 Dia. 0.125
3. AWS No.		SFA F-No A-No. Dia.
Flux Tradename	LINCONWELD 880M	Electrode Flux Classification F7P6-EH11K-HB
Consumable Insert	NONE	Other MAX DEPOSITED METAL 8 "

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

<b>10</b>	<b>Postweld Heat Treatment (QW-407)</b>
Temperature Range	1150 F - 0 +25 F
Time Range : for Impact use 2 1/2 Hours Maximum Time Limit	
Time Range : per ASME	

<b>9 Preheat (QW-406)</b>		
Preheat Temperature	Min.	200° F
Interpass Temperature	Max.	300° F
Preheat Maintenance & Tacking		200° 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	SAW	EH11K	0.1562	DC	RP	745-750	30-32	18 IPM
FILL	SAW	EH11K	0.1562	DC	RP	745-750	34-35	18 IPM
			or					
ROOT	SAW	EH11K	0.125"	DC	RP	450 - 550	33 - 35	20 - 25
FILL	SAW	EH11K	0.125"	DC	RP	450 - 550	33 - 35	20 - 25
<b>Heat Input ( Per QW-409.1 ) = 87,500 j / in Maximum</b>								

Tungsten Electrode Size and Type	NONE							
Mode of Metal Transfer for GMAW	NONE							
String or Weave Bead	STRING							
Method of Back Gouging	GRINDING OR ARC AIR GOUGING AND GRINDING							
Initial and Interpass Cleaning (Brushing, Grinding, etc.)	WIRE BRUSH OR GRINDING							
Orifice or Gas Cup Size	3/4"							
Oscillation	NONE	Width	NONE	Frequency	NONE			
Contact Tube to Work Distance	1"							
Multiple or Single Pass (per side)	MULTIPLE							
Multiple or Single Electrode	SINGLE							
Electrode Wire feed speed range	60 IPM							
Other	Preheat Requirements for welding and tacking : See Section # 9							

**13 Supplementary Comments**

- 1 ) NACE MR0175/ISO 15156-2:2009/CIR.1:2011 Per Laboratory No. 636744-13
- 2 ) Macroetch to ASTM E3-11 Per Laboratory No. 634810-13

**14** Company Representative Signature Robert C. Bentley Date 27 March, 13  
 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.

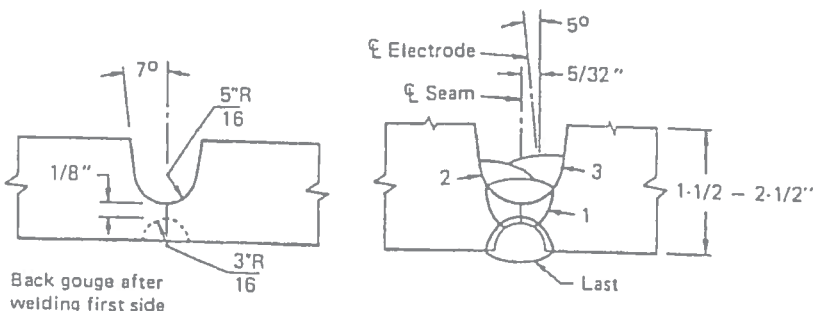
**QW-483 SUGGESTED FORMAT FOR PROCEDURE QUALIFICATION RECORD (PQR)**

(See QW-201.2, Section IX, ASME Boiler and Pressure Vessel Code)

Record Actual Conditions Used to Weld Test Coupon.

Company Name ALL-WELD CO. LTD., 49 PASSMORE AVE., SCARBOROUGH, ONTARIO, M1V 4T1  
 Procedure Qualification Record No. SAW-3 Date OCT. 10, 1991  
 WPS No. SAW-3-1  
 Welding Process(es) SAW  
 Types (Manual, Automatic, Semi-Auto.) AUTOMATIC

**JOINTS (QW-402)**



Groove Design of Test Coupon

(For combination qualifications, the deposited weld metal thickness shall be recorded for each filler metal or process used.)

**BASE METALS (QW-403)**  
 Material Spec. SA516-70  
 Type or Grade \_\_\_\_\_  
 P-No. 1 to P-No. 1  
 Thickness of Test Coupon 2"  
 Diameter of Test Coupon PLATE  
 Other NONE

**POSTWELD HEAT TREATMENT (QW-407)**  
 Temperature 1100°F  
 Time 2 HOURS  
 Other \_\_\_\_\_

	Percent Composition		
	Gases	(Mixture)	Flow Rate
Shielding	<u>NONE</u>	_____	_____
Trailing	<u>NONE</u>	_____	_____
Backing	<u>NONE</u>	_____	_____

**FILLER METALS (QW-404)**

SFA Specification	<u>5.17</u>
AWS Classification	<u>F7P6-EH11K</u>
Filler Metal F-No.	<u>6</u>
Weld Metal Analysis A-No.	<u>1</u>
Size of Filler Metal	<u>5/32</u>
Other	<u>FLUX LINCOLN 880M</u>
Deposited Weld Metal	_____

**ELECTRICAL CHARACTERISTICS (QW-409)**  
 Current DC  
 Polarity POSITIVE (REVERSE)  
 Amps. 745-750 Volts 30-34  
 Tungsten Electrode Size \_\_\_\_\_  
 Other NONE

**POSITION (QW-405)**  
 Position of Groove FLAT  
 Weld Progression (Uphill, Downhill) \_\_\_\_\_  
 Other \_\_\_\_\_

**TECHNIQUE (QW-410)**  
 Travel Speed 18' P.M.  
 String or Weave Bead STRING  
 Oscillation NONE  
 Multipass or Single Pass (per side) MULTI-PASS  
 Single or Multiple Electrodes SINGLE  
 Other NONE

**PREHEAT (QW-406)**  
 Preheat Temp. 200°F  
 Interpass Temp. 300°F  
 Other MAINT: 200°F



Tensile Test (QW-150)

Specimen No.	Width	Thickness	Area	Ultimate Total Load lb	Ultimate Unit Stress psi	Type of Failure & Location
T2A	.932	.758	.708	54,500	77,195	DUCTILE IN BASE
T2B	.904	.752	.608	52,600	77,352	" "
T5A	.873	.755	.659	50,500	76,631	" "
T5B	.916	.739	.677	53,000	78,286	" "

Guided-Bend Tests (QW-160)

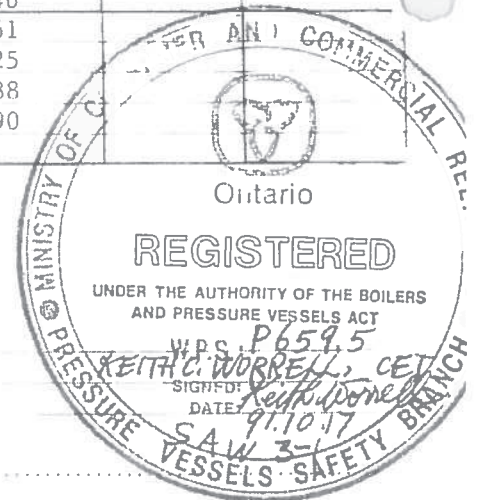
Type and Figure No.	Result
SIDE BEND 3/8" X 2" X 11	BEND AROUND
" " " "	1 1/2" D. PIN
" " " "	180°
" " " "	NO CRACKS OR OPEN DEFECTS GREATER THAN 1/8"

Toughness Tests (QW-170)

Specimen No.	Notch Location	Notch Type	Test Temp.	Impact Values	Lateral Exp.		Drop Weight	
					% Shear	Mils	Break	No Break
1	WELD 1/16	CHARPY	-50°F	51.6	10	46		
2	WELD 1/16	CHARPY	-50°F	62.3	10	59		
3	WELD 1/16	CHARPY	-50°F	85.6	20	71		
1	WELD MIDW	CHARPY	-50°F	45.7	10	34		
2	WELD MIDW	CHARPY	-50°F	60.5	10	46		
3	WELD MIDW	CHARPY	-50°F	79.7	20	61		
1	HAZ.	CHARPY	-50°F	60.5	40	25		
2	HAZ.	CHARPY	-50°F	140.1	90	88		
3	HAZ.	CHARPY	-50°F	143.1	90	90		

Other Tests

Type of Test NONE  
 Deposit Analysis NONE  
 Other NONE



Welder's Name ROBERT DIAS Clock No. 541 Stamp No. 8  
 Tests conducted by: CAMBRIDGE TESTING SERVICES LIMITED Laboratory Test No. 67507-91

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.

Manufacturer ALL-WELD CO. LTD.

Date Oct 15/91 By [Signature] QC MANAGER

(Detail of record of tests are illustrative only and may be modified to conform to the type and number of tests required by the Code.)

[Signature]  
 AUTHORIZED INSPECTOR

Oct. 15<sup>TH</sup> 1991

DATE

WPS 2-1  
W-0-1173 PQ

PO# 13-0765

5

# HOBART BROTHERS

McKay

## CERTIFICATE OF ANALYSIS

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

### ACTUAL CHEMICAL ANALYSIS (%)

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

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

Measured FN : 9  
 Delong FN : 13  
 Schaeffler : 9

### TYPICAL MECHANICAL PROPERTIES

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

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

Authorized Signature :

Brian Simpson, Q.A. Technician

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



**HOBART BROTHERS**

McKay

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

**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 ✓ AWS A5.4, ASME SFA 5.4 ✓	STOCK NUMBER: HEAT NO: CLASS:	S483944-033 744973 ✓ E309/309L-16 ✓

**ACTUAL CHEMICAL ANALYSIS (%)**

C	0.032 ✓
Mn	1.066 ✓
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  
 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").



WPS 29-2  
W.O.W' 1176 PQ

STOCK CODE	DIAMETER	HEAT / LOT #	SPECIFICATION	TYPE
S2116	1.6mm $\sqrt{1/16}$ "	SF22334	AWS A5.18 / ASME SFA 5.18	ER70S-2
				KOREA

**CHEMICAL COMPOSITION OF THE WELDING WIRE**

ELEMENT	SPECIFICATIONS	HEAT ANALYSIS (%)
Al	0.050 - 0.150	0.079
C	<0.070	0.040
Cr	<0.150	0.020
Cu	<0.500	0.150
Mn	0.900 - 1.400	1.120
Mo	<0.150	<0.010
Nb	-	<0.005
Ni	<0.150	<0.010
P	<0.025	0.010
S	<0.035	0.005
Si	0.400 - 0.700	0.530
Ti	0.050 - 0.150	0.066
V	<0.030	<0.005
Zr	0.020 - 0.120	0.050

YIELD POINT N/mm <sup>2</sup>	TENSILE STRENGTH N/mm <sup>2</sup>	ELONGATION% L <sub>0</sub> = 50mm	IMPACT STRENGTH ISO-V
586.1	643.7	26.2	185.1

THIS TEST REPORT REPRESENTS THE ACTUAL ATTRIBUTES OF THE MATERIAL FURNISHED AND THE TEST RESULTS ARE IN FULL COMPLIANCE WITH ALL APPLICABLE SPECIFICATIONS AND ORDER REQUIREMENTS.

TECHNIWELD CORPORATION 2309 WINSTON PARK DRIVE OAKVILLE, ONT. L6H 7J7	TECHNIWELD CORPORATION 9637A 45TH AVENUE EDMONTON, ALB. T6E 5Z8	POWERWELD INC. 2501 BEECH STREET VALPARAISO, IN. 46383	POWERWELD INC. 602 AVENUE K GRAND PRAIRIE, TX. 75050
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An employee owned company serving the welding industry worldwide.



# CERTIFICATE OF CHEMICAL ANALYSIS AND TESTING



**Air Liquide Canada Inc.**  
 1250 René-Lévesque Blvd West, Suite 1700  
 Montreal, Quebec H3B 5E5

WPS 29-2  
 W.O. 1176PQ

**Product:** *Blueshield ER70S-2*  
**Item #:** BLU-46307208 (3.2mm - 1/8")  
**Lot #:** SF26197

**Standard/Classification:** AWS/ASME A5.18-2006 / ER70S-2

**Test Date:** 03-May-2013

This is to certify that the specified lot of the above product has been tested in accordance with the requirements of specific classification of the applicable standard(s) or tested in compliance of customer specific requirements

<u>CHEMICAL ANALYSIS (%)</u>		Aluminum	Carbon	Chromium	Copper	Manganese	Nickel	Phosphor	Silicon	Sulphur	Titanium	Vanadium	Zirconium	Ni + Cr + Mo + V
Wire		0.077	0.04	0.02	0.1	1.11	0.01	0.012	0.53	0.005	0.067	<0.005	0.048	0.045
AWS ER70S-2		0.05 - 0.15	<0.07	NR	<0.5	0.9 - 1.4	NR	<0.025	0.4 - 0.7	<0.035	0.05 - 0.15	NR	0.02 - 0.12	<0.5

**Radiographic Test**  
 Met requirements

**MECHANICAL PROPERTIES**

WELDING PARAMETERS

Diameter used for testing mm (in): 3.2 (1/8)

TEST RESULTS

Tensile Strength MPa (ksi): 480 (69.6)  
 Yield Strength MPa (ksi): 400 (58.0)  
 Elongation (%): 22.0  
 Charpy V-notch Impact Energy J (ft-lb): -  
 Charpy Temperature °C (°F): -30.0 (-22.0)

Lot-tested Results

480 (69.6)  
 400 (58.0)  
 22.0  
 -  
 -

AWS ER70S-2 Requirements

>480 (69.6)  
 >400 (58.0)  
 >22.0  
 >27.0 (19.9)  
 -30.0 (-22.0)

The undersigned certifies that the product supplied meets the specified requirements

*Signature*

Signed by: **Jim Murphy, Specialist, Product Management**

Product Version: 3.0a.06

(2)  
+  
(4)

*SMAW*  
*5-2-2*

**BLUESHIELD™**  
Covered electrodes  
Électrodes enrobées

LA 7018

**BLU-32971708**  
LOT #: 007929K2

3.2mm X 350mm 20 kg (4X 5.0 kg)  
1/8" X 14" 44 lb (4X 11 lb)

AWS A5.1/ASME SFA 5.1 E7018-1-H4  
(gr. F No. 4, an. A No. 1)

Made in / Fabriqué au Canada

CWB to CSA W48 E4918-1-H4  
Lloyd's 3YHS/ABS 3YHS/DNV 3YHS



**AIR LIQUIDE**

0138

**Air Liquide Canada Inc.**

1250 René-Lévesque Blvd West, Suite 1700  
Montreal, Quebec H3B 5E5

Lot Number :007929K2

**Product: Blueshield LA 7018**

**Item #: BLU-32971708 (3.2mm - 1/8")**

**Standard/Classification: CSA W48-06 / E4918-1-H4**

**AWS 5.1-2004/ASME SFA A5.1 / E7018-1-H4**

**Test Date: 01-Nov-2010**

The above named product is of the same classification as the filler metal used for testing. The typical chemical analysis and mechanical properties were as follows:

<u>CHEMICAL ANALYSIS (%)</u>		Carbon	Chromium	Manganese	Molybdenum	Nickel	Phosphorus	Silicon	Sulphur	Vanadium	Mn + Ni + Cr + Mo + V
<b>Deposit</b>		0.04	0.04	1.11	<0.01	0.01	0.01	0.52	0.01	<0.01	1.16
CSA E4918-1-H4		<0.15	<0.2	<1.6	<0.3	<0.3	<0.035	<0.75	<0.035	<0.08	<1.75
AWS E7018-1-H4		<0.15	<0.2	<1.6	<0.3	<0.3	<0.035	<0.75	<0.035	<0.08	<1.75

**Radiographic Test**

Met requirements

**Fillet Weld Test**

Met requirements

**Diffusible Hydrogen Test (as per AWS A4.3)**

RH (%): 21.0 AbsH g/kg (gr/lb): 14.6 (102.2) Temp °C (°F): 20.0  
(68.0) Average (ml/100g): 3.0

**MECHANICAL PROPERTIES**

AS WELDED

WELDING PARAMETERS

Prepared according to : AWS CSA

Diameter used for testing mm (in): 4.0 (5/32)

Amperage (A): 180

Arc Voltage (V): 23.0

Current Polarity : AC

Weld Travel Speed cm/min (ipm): 12.8 (5.0)

No. of passes/layers : 13/6

Preheat Temp. °C (°F): 105 (221)

Interpass Temp. °C (°F): 170 (338)

Base Material : A516 Gr. 70

Welding Position : Flat

TEST RESULTS

Typical Results

Tensile Strength MPa (ksi): 540 (78.4)

Yield Strength MPa (ksi): 450 (65.3)

Elongation (%): 32.0

Charpy V-notch Impact Energy J (ft-lb): 127.0 (93.7)

Charpy Temperature °C (°F): -45.0 (-49.0)

Charpy Lateral Expansion mm (in): 1.5 (0.0604)

Charpy Shear Fracture (%): 36.7

CSA E4918-1-H4 Requirements

490-650 (70.0-94.0)

>400 (58.0)

>22.0

>27.0 (20.0)

-45.0 (-50.0)

AWS E7018-1-H4 Requirements

>490 (70.0)

>400 (58.0)

>22.0

>27.0 (20.0)

-45.0 (-50.0)

The undersigned certifies that the product supplied will meet the requirements of the applicable filler metal standard when tested in accordance with that standard's classification, and that no significant change has been made in the formulation and manufacturing procedures described in the qualification approval.

Signed by:



**Jim Murphy, Specialist, Product Management**

Note: The information shown in the section "Mechanical Properties - Welding Parameters" is the latest test performed to certify this product. Therefore, the diameter chosen for this test is representative and valid for all the other diameters of the product mentioned above. This certificate complies to the requirements of EN10204 Type 2.2

**BLUESHIELD™**  
Covered electrodes  
Électrodes enrobées

LA 7018

**BLU-32971710**  
LOT #: 038025A3

4.0mm X 350mm 20 kg (4X 5.0kg)  
5/32" X 14" 44 lb (4X 11 lb)

AWS A5.1/ASME SEAS 1 E7018-1-H1  
(gr. F No. 4, an. A No. 1)

Made in / Fabriqué au Canada

Conforms to CSA W48 E4918-1-H1  
Conforme à SYHS/ABS 3YHS/ DNV 3YHS



**Air Liquide Canada Inc.**

1250 René-Lévesque Blvd West, Suite: 1700  
Montreal, Quebec H3B 5E5

Lot Number :038025A3

**Product: Blueshield LA 7018**  
**Item #: BLU-32971710 (4.0mm - 5/32")**

**Standard/Classification: CSA W48-06 / E4918-1-H4**  
**AWS 5.1-2004/ASME SFA A5.1 / E7018-1-H4**

**Test Date: 01-Nov-2010**

The above named product is of the same classification as the filler metal used for testing. The typical chemical analysis and mechanical properties were as follows:

<u>CHEMICAL ANALYSIS (%)</u>		Carbon	Chromium	Manganese	Molybdenum	Nickel	Phosphorus	Silicon	Sulphur	Vanadium	Mn + Ni + Cr + Mo + V
Deposit		0.04	0.04	1.11	<0.01	0.01	0.01	0.52	0.01	<0.01	1.16
CSA E4918-1-H4		<0.15	<0.2	<1.6	<0.3	<0.3	<0.035	<0.75	<0.035	<0.08	<1.75
AWS E7018-1-H4		<0.15	<0.2	<1.6	<0.3	<0.3	<0.035	<0.75	<0.035	<0.08	<1.75

Radiographic Test  
Met requirements

Fillet Weld Test  
Met requirements

Diffusible Hydrogen Test (as per AWS A4.3)

RH (%): 21.0 AbsH g/kg (gr/lb): 14.6 (102.2) Temp °C (°F): 20.0  
(68.0) Average (ml/100g): 3.0

MECHANICAL PROPERTIES

AS WELDED

WELDING PARAMETERS

Prepared according to : AWS CSA

Diameter used for testing mm (in): 4.0 (5/32)

Amperage (A): 180

Arc Voltage (V): 23.0

Current Polarity : AC

Weld Travel Speed cm/min (ipm): 12.8 (5.0)

No. of passes/layers : 13/6

Preheat Temp. °C (°F): 105 (221)

Interpass Temp. °C (°F): 170 (338)

Base Material : A516 Gr. 70

Welding Position : Flat

TEST RESULTS

Typical Results

Tensile Strength MPa (ksi):

540 (78.4)

Yield Strength MPa (ksi):

450 (65.3)

Elongation (%):

32.0

Charpy V-notch Impact Energy J (ft-lb):

127.0 (93.7)

Charpy Temperature °C (°F):

-45.0 (-49.0)

Charpy Lateral Expansion mm (in):

1.5 (0.0604)

Charpy Shear Fracture (%):

36.7

CSA E4918-1-H4 Requirements

490-650 (70.0-94.0)

>400 (58.0)

>22.0

>27.0 (20.0)

-45.0 (-50.0)

AWS E7018-1-H4 Requirements

>490 (70.0)

>400 (58.0)

>22.0

>27.0 (20.0)

-45.0 (-50.0)

The undersigned certifies that the product supplied will meet the requirements of the applicable filler metal standard when tested in accordance with that standard's classification, and that no significant change has been made in the formulation and manufacturing procedures described in the qualification approval.

Signed by:



**Jim Murphy, Specialist, Product Management**

Note: The information shown in the section "Mechanical Properties - Welding Parameters" is the latest test performed to certify this product. Therefore, the diameter chosen for this test gave mechanical and chemical test results which are representative and valid for all the other diameters of the product mentioned above. This certificate complies to the requirements of EN10204 Type 2.2



**BLUESHIELD™**

Covered electrodes

Électrodes enrobées

**BLU-32971712**

LOT# : 030515A3

Made in / Fabriqué au Canada



LA 7018

5.0mm X 450mm 20 kg (4X 5.0 kg)

3/16" X 18" 44 lb (4X 11 lb)

AWS A5.1 DASHIE SP A5.1 E7018-1-1H ←

(gr. F No. 4 an. A No. 1)

CWB to CSA W.8 E7018-1-1H4

Lloyd's 3YHS/ ABS 3YHS/ DNV 3YHS

022



AIR LIQUIDE

**Air Liquide Canada Inc.**

1250 René-Lévesque Blvd West, Suite 1700  
Montreal, Quebec H3B 5E5

Lot Number :030515A3

**Product: Blueshield LA 7018**

**Item #: BLU-32971712 (5.0mm - 3/16")**

**Standard/Classification: CSA W48-06 / E4918-1-H4**

**AWS 5.1-2004/ASME SFA A5.1 / E7018-1-H4**

**Test Date: 01-Nov-2010**

The above named product is of the same classification as the filler metal used for testing. The typical chemical analysis and mechanical properties were as follows:

<u>CHEMICAL ANALYSIS (%)</u>		Carbon	Chromium	Manganese	Molybdenum	Nickel	Phosphorus	Silicon	Sulphur	Vanadium	Mn + Ni + Cr + Mo + V
Deposit		0.04	0.04	1.11	<0.01	0.01	0.01	0.52	0.01	<0.01	1.16
CSA E4918-1-H4		<0.15	<0.2	<1.6	<0.3	<0.3	<0.035	<0.75	<0.035	<0.08	<1.75
AWS E7018-1-H4		<0.15	<0.2	<1.6	<0.3	<0.3	<0.035	<0.75	<0.035	<0.08	<1.75

**Radiographic Test**

Met requirements

**Fillet Weld Test**

Met requirements

**Diffusible Hydrogen Test (as per AWS A4.3)**

RH (%): 21.0 AbsH g/kg (gr/lb): 14.6 (102.2) Temp °C (°F): 20.0  
(68.0) Average (ml/100g): 3.0

**MECHANICAL PROPERTIES**

AS WELDED

WELDING PARAMETERS

Prepared according to : AWS CSA

Diameter used for testing mm (in): 4.0 (5/32)

Amperage (A): 180

Arc Voltage (V): 23.0

Current Polarity : AC

Weld Travel Speed cm/min (ipm): 12.8 (5.0)

No. of passes/layers : 13/6

Preheat Temp. °C (°F): 105 (221)

Interpass Temp. °C (°F): 170 (338)

Base Material : A516 Gr. 70

Welding Position : Flat

TEST RESULTS

Typical Results

Tensile Strength MPa (ksi): 540 (78.4)

Yield Strength MPa (ksi): 450 (65.3)

Elongation (%): 32.0

Charpy V-notch Impact Energy J (ft-lb): 127.0 (93.7)

Charpy Temperature °C (°F): -45.0 (-49.0)

Charpy Lateral Expansion mm (in): 1.5 (0.0604)

Charpy Shear Fracture (%): 36.7

CSA E4918-1-H4 Requirements

490-650 (70.0-94.0)

>400 (58.0)

>22.0

>27.0 (20.0)

-45.0 (-50.0)

AWS E7018-1-H4 Requirements

>490 (70.0)

>400 (58.0)

>22.0

>27.0 (20.0)

-45.0 (-50.0)

The undersigned certifies that the product supplied will meet the requirements of the applicable filler metal standard when tested in accordance with that standard's classification, and that no significant change has been made in the formulation and manufacturing procedures described in the qualification approval.

Signed by:



**Jim Murphy, Specialist, Product Management**

Note: The information shown in the section "Mechanical Properties - Welding Parameters" is the latest test performed to certify this product. Therefore, the diameter chosen for this test gave mechanical and chemical test results which are representative and valid for all the other diameters of the product mentioned above. This certificate complies to the requirements of EN10204 Type 2.2

3

SAW-3-2

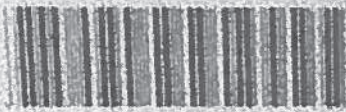
# 1/8 LINCOLNWELD L-56

60 lb NET COIL

COILED WIRE ELECTRODE  
FIL-ELECTRODE ENROULE

3.2 mm 27.22 kg APPROX. EQUIV.

CONF. AWS A5.18  
ASME SFA 5.18 ER70S-B  
AWS A5.17 ASMESFA-5.17 EH11K  
CERT.-C.W.B.  
CSA W48 EH11K (E-G 48 A 2 C G5)  
EN 7549Z 890M EN756S42.5 FB 8Z  
0035-CPD-C401 EN 13478 42 180.02



STOCK NO.

**ED500410**

Q1 LOT 13208499

**01C02AR**



MANUFACTURED UNDER A WORLDWIDE QUALITY SYSTEM CERTIFIED TO ISO 9001  
FABRIQUE SELON UN SYSTEME DE QUALITE CERTIFIE A ISO 9001  
MADE IN CANADA / FABRIQUE AU CANADA TORONTO ON M4G 2H9  
13000-3

LINCOLN ELECTRIC COMPANY OF CANADA LP

SAW-3-2

WPS 3-2  
W-0.211769

Lincoln Electric Company of Canada LP  
178 Wicksteed Ave  
Toronto ON M4G 2B9

**Certificate of Conformance to Requirements  
For Welding Electrode  
(Applies to Canadian Manufactured Product)**




TYPICAL VALUES ONLY

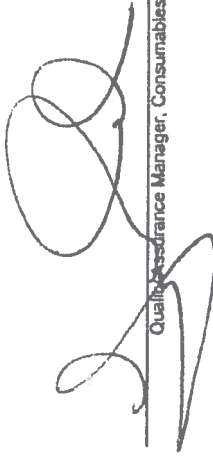
Product: Lincolnweld® L-56  
Classification: EH11K  
Specification: CSA W48.06, AWS A5.17-97, A5.23:2007, ASME SFA-5.17, SFA-5.23  
Test Completed: May 11, 2011

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 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 Lincoln Electric Company of Canada LP, Toronto, Ontario, which meets the requirements of ISO 9001:2008 and other specifications as applicable. The Quality System Program has been approved by ABS Quality Evaluations.

Chemical Composition of the electrode (weight %)		
%	CSA / AWS / ASME Requirements	Results
C	0.06 - 0.15	0.09
Mn	1.40 - 1.85	1.59
Si	0.80 - 1.15	0.84
S	0.030 max.	0.01
P	0.030 max.	0.006
Cu (total)	0.35 max.	0.14

Results below the detection limits of the instrument or lower than the precision required by specification are reported as zero.  
This certificate complies to the requirements of EN 10204, Type 2.2.  
The electrode diameter required to be tested for this classification is 5/32". The other sizes will also meet these requirements.

  
Technologist - Production Testing and Certification  
Date: JUNE 24 2011

  
Quality Assurance Manager, Consumables Division  
Date: JUNE - 24th 2011







W.O. N° 1176PQ

W.P.S 3AW-3-2



## THE LINCOLN ELECTRIC COMPANY

### PRODUCT CERTIFICATE LINCOLNWELD 880M 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.\* = 3.3

\*Calculated using Boniszewski formula shown below

$$B.I. = \frac{0.5 (\text{FeO} + \text{MnO}) + \text{CaO} + \text{MgO} + \text{Na}_2\text{O} + \text{K}_2\text{O} + \text{CaF}_2}{\text{SiO}_2 + 0.5 (\text{TiO}_2 + \text{ZrO}_2 + \text{Al}_2\text{O}_3)}$$

- Flux Sizing Distribution\*

+20 MESH	54%	Maximum
-20 +60 MESH	35%	Minimum
-60 MESH	11%	Maximum

\*U.S. sieve number per ASTM E11-04

- Flux Composition (Based on Elemental Values Determined by X-Ray Fluorescence)

Na <sub>2</sub> O	1%	SiO <sub>2</sub>	12%	MnO	1%
MgO	29%	CaO	8%	K <sub>2</sub> O	1%
Al <sub>2</sub> O <sub>3</sub>	18%	CaF <sub>2</sub>	29%		

- Density (g/cm<sup>3</sup>): 1.2

- Flux Classification: EN 760 – S A FB 1

 February 19, 2008  
Phillip J. Woodring, Certification Supervisor, Date



Technical Standards and Safety Authority

1100 Bloor Street West  
Toronto, Ontario M8X 2K4  
Web site: www.tssa.org

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

No. 257503

Welder's Last Name

GREER

Welder's First Name

ROBIN

Welder's Postal Code

K9J8K2

Stamp No.

9

Res. Address

335 MOUNTAIN ASH RD., PETERBOROUGH, ONT.,

ALL-WELD COMPANY LIMITED

49 PASSMORE AVE.,

SCARBOROUGH, ONTARIO

Welding Process(es) Used

G.TAW

Base Material(s) SA 106-B/SA 106-B

Provincial Code

M.I.V.4T.1

Type(s)

X manual

Provincial Registration No.

J745.5

Company PQR No.

20

Company WPS No. used

20-1

Thickness(es)

0.218"

Variables for All Processes

Actual Values

Range Qualified

Backing material (metal, weld metal, welded from both sides, flux, etc.)

ASME P or S No. to ASME P or S No.

( ) Plate ( X ) Pipe (enter diameter if pipe)

Filler Metal Specification (SFA) Class (QW-404) (Informational Only)

Consumable Insert for GTAW or PAW (QW-404)

Welding Position (1G, 5G, etc.) (QW-405)

Manual or Semi-automatic Variables (QW-350)

Filler Metal F No. (QW-404)

Filler Metal Product Form for GTAW, PAW (QW-404)

Weld deposit thickness for each welding process (QW-404)

Process 1 3 layers minimum X Yes No

Process 2 3 layers minimum Yes No

Progression (uphill/downhill) (QW-405)

GTAW, PAW or GMAW backing gas; or DFW fuel gas (QW-408)

GMAW transfer mode (spray/globular or pulse to short circuit) (QW-409)

GTAW welding current type & polarity (AC, DCEP, DCEN) (QW-409)

Machine Welding Variables (QW-361-2)

Direct or remote visual control

Automatic arc voltage control (GTAW)

Automatic joint tracking

Multiple or single pass per side

Automatic Welding Variables (QW-361-1)

Filler metal (EBW or LBW)

Laser type for LBW (CO<sub>2</sub> to YAG etc.)

Continuous drive or inertia welding (FW)

Vacuum or out of vacuum (EBW)

WITHOUT  
P1 to P1  
2 3/8" O.D.  
(5.18) ER-70S-3

WITH OR WITHOUT  
PL THRU P1SP P342 P4X PL. 2  
PIPE 1" O.D. 2 UP

6G

6G

F6

F6

0.218"

1/16" to 0.436" MAX.

3

UPHILL

UPHILL

ARGON 99.9%

ARGON 99.9%

DC/SP

DC/SP

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

X Bend test: X 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

Test requested by (Print name) ROBERT C. BENTLEY Tested at (Print address) 49 PASSMORE AVE., SCARB., ON

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

Organization ALL-WELD COMPANY LIMITED Signature R. Bentley Date July 12, 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 (X) applicable box below:

X To weld for the Employer named above only.

For seeking employment only.

This Certificate expires: PCE ASME IX

Inspector Name and Number (Print) MOHIB SOMI-ONT01932

Inspector Signature



Technical Standards and Safety Authority

14th Floor - Centre Tower  
3900 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. 257506

Welder's Last Name: VALENCIA Initial: CESAR First Name: CESAR Signature: *Cesar Valencia* Stamp No. 44

Res. Address: 25 RUBEN STREET WHITBY, ONTARIO Postal Code: L1R0A7 Provincial Registration No. QW2142.5R & R2100.5 Company PQR No. 3 & 3A Company WPS No. used 3-1

Employer Name: ALL - WELD COMPANY LIMITED Street Address: 48 PASSMORE AVE SCARBOROUGH, ONT Postal Code: M1V4T1

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

Base Material(s): SA-240-304 TO SA-340-304 Thickness(es): 3/8"  Test Coupon  Production Weld

Variables for All Processes	Actual Values	Range Qualified
Backing material (with/without)	WITHOUT	WITH OR WITHOUT
Base Metal P-Number to F-Number	8 to 8	P1 THRU P15F, P34 & P4X PLATE AND PIPE 2 7/8" OD AND UP
(X) Plate ( ) Pipe (enter diameter if pipe)	0.375"	
Filler Metal Specification (SFA) Class (QW-404) (informational Only)	54 E308-18	
Consumable insert for GTAW or PAW (QW-404)	NONE	
Welding Position (1G, 5G, etc.) (QW-405)	2G	2G

Manual or Semi-automatic Variables (QW-300)	Actual Values	Range Qualified
Filler Metal F-No. (QW-404)	F8	F8
Filler Metal Product Form for GTAW, PAW (QW-404)	NONE	
Weld deposit thickness for each welding process (QW-404)	3/8"	3/4" MAX PLATE GROOVE + PIPE 2 7/8" OD + UP
Process 1: _____ 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	4	+ 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-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-301.2)	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-301.1)	Actual Values	Range Qualified
Filler Metal (EBW or LBW)	NONE	
Laser type for LBW (CO <sub>2</sub> to YAG etc.)	NONE	
Continuous drive or inert gas 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(d)];  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 (b)	ACCEPTED				
(Face)		(ROOT)					

Alternative radiographic examination results (QW-191) NONE

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

Film or specimens evaluated by NONE Company NONE

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

Welding supervised by (Print name) ANDREW LEWIS

Test requested by (Print name) ROBERT BENTLEY Tested at (Print address) 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 *Robert Bentley* Date 01-09-2012  
(mm-dd-yyyy)

### FOR TSSA INSPECTOR USE ONLY

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

Check (✓) applicable box below:

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

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

COSTICA ROSU 019315  
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. 262456

Welder's Last Name: VALENCIA Initial: CESAR First Name: CESAR Signature: *Valencia* Stamp No: 44  
 Res Address: 25 RUBEN STREET, WHITBY, ONTARIO Postal Code: L1R0A7  
 Employer Name: ALL - WELD COMPANY LIMITED Street Address: 49 PASSMORE AVE  
 SCARBOROUGH, ONT Postal Code: M1V4T1  
 Provincial Registration No.: WP-R7543 Company PQR No.: 52-2A Company WPS No used: 52-2

Welding Process(es) Used: SMAW Type(s):  manual  machine  semi-automatic  automatic  
 Base Material(s): SA-516-GR70N TO SA-516-GR70N Thickness(es) 1"  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	P1 to P1	P1 THRU P15F, P34 & P4X PLATE AND PIPE 2 7/8" OD AND UP
( X ) Plate ( ) Pipe (enter diameter if pipe)	1"	
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)	(5.1) E7018-1H4	
Consumable Insert for GTAW or PAW (QW-404)	NONE	
Welding Position (1G, 5G, etc.) (QW-406)	2G	1G & 2G

Manual or Semi-automatic Variables (QW-300)	Actual Values	Range Qualified
Filler Metal F- No. (QW-404)	F4	F4
Filler Metal Product Form for GTAW, PAW (QW-404)	NONE	NONE
Weld deposit thickness for each welding process (QW-404)	1"	MAX TO BE WELDED (PLATE GROOVE + PIPE 2 7/8" OD + UP + ALL FILLETS)
Process 1: SMAW 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No		
Process 2: 3 layers minimum <input type="checkbox"/> Yes <input type="checkbox"/> No	NONE	NONE
Vertical progression (uphill/downhill) (QW-406)	NONE	NONE
GTAW, PAW or GMAW backing gas; or OPW test gas (QW-406)	NONE	NONE
GMAW transfer mode (spray/globular or pulse to short circuit) (QW-406)	NONE	NONE
GTAW welding current type & polarity (AC, DCEP, DCEN)(QW-406)	NONE	NONE

Machine Welding Variables (QW-301.2)	Actual Values	Range Qualified
Direct or remote visual control	NONE	NONE
Automatic arc voltage control (GTAW)	NONE	NONE
Automatic joint tracking	NONE	NONE
Multiple or single pass per side	NONE	NONE

Automatic Welding Variables (QW-301.1)	Actual Values	Range Qualified
Filler Metal (EBW or LBW)	NONE	NONE
Laser type for LBW (CO <sub>2</sub> to YAG etc.)	NONE	NONE
Continuous drive or inertia welding (FW)	NONE	NONE
Vacuum or out of vacuum (EBW)	NONE	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 N/A  
 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 *R Bentley* 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)  
 Inspector Name and Number (Print) COSTICA ROSU ON7915 Inspector Signature and Date *KR228.13*





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. 262931

Welder's Last Name: MIRZA Initial: HAFEEZ First Name: HAFEEZ Signature: [Signature] Stamp No: 53  
 Res Address: 2050 BRIDLETON CIRCLE # 607, ONTARIO Postal Code: M1W 2V5 Provincial Registration No.: WP-74660.J  
 Employer Name: ALL - WELD COMPANY LIMITED Company POR No.: 29X  
 Street Address: 49 PASSMORE AVE Company WPS No used: 29-2  
 SCARBOROUGH, ONT Postal Code: M1V 4T1  
 Welding Process(es) Used: GTAW Type(s):  manual  machine  semi-automatic  automatic  
 Base Material(s): SA-333-GR6 TO A-350-LF2 Thickness(es): 0.300"  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 1 GR 1 to 1 GR2 P1 THRU P15F, P34, & P4X PLATE AND PIPE 1/2" OD AND UP  
 ( ) Plate ( X ) Pipe (enter diameter if pipe) 3" 0.300"  
 Filler Metal Specification (SFA) Class (QW-404) (Informational Only) 5.18 ER70S-2  
 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) 0.300" 0.600" MAX PLATE GROOVE + PIPE 2 7/8" OD + UP  
 Process 1: GTAW 3 layers minimum  Yes  No 3 + ALL FILLETS  
 Process 2 3 layers minimum  Yes  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 (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 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 CAMBRIDGE MATERIAL TESTING Laboratory test no. 638497

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 15-04-2013 (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)

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. 262457

Welder's Last Name: MIRZA Initial: HAFEEZ(ABDUL) First Name: HAFEEZ(ABDUL) Signature: [Signature] Stamp No: 53  
 Res. Address: 1050 BRIDLE TOWNE CIRCLE, #607, SCARBOROUGH, ONTARIO Postal Code: M1W 2V5  
 Employer Name: ALL - WELD COMPANY LIMITED Company PQR No: WP-R7542.9  
 Street Address: 19 PASSMORE AVE Company WPS No. used: 52-2A  
 SCARBOROUGH, ONT Postal Code: M1V 4T1 Company WPS No. used: 52-2  
 Welding Process(es) Used: SMAW Type(s):  manual  machine  semi-automatic  automatic  
 Base Material(s): SA-516-GR70M TO SA-516-GR70M Thickness(es): 1"  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	P1 to P1	P1 THRU P15F, P34 & P4X PLATE AND PIPE 2 7/8" OD AND UP
( X ) Plate ( ) Pipe (enter diameter if pipe)	1"	
Filler Metal Specification (BFA) Class (QW-404) (Informational Only)	(5.1) E7018-1H4	
Consumable Insert for GTAW or PAW (QW-404)	NONE	
Welding Position (1G, 5G, etc.) (QW-405)	2G	1G & 2G
Manual or Semi-automatic Variables (QW-388)	Actual Values	Range Qualified
Filler Metal F-No. (QW-404)	F4	F4
Filler Metal Product Form for GTAW, PAW (QW-404)	NONE	NONE
Weld deposit thickness for each welding process (QW-404)	1"	MAX TO BE WELDED (PLATE GROOVE + PIPE 2 1/8" OD + UP + ALL FILLETS)
Process 1: SMAW 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No		
Process 2: 3 layers minimum <input type="checkbox"/> Yes <input type="checkbox"/> No	NONE	NONE
Vertical progression (uphill/downhill) (QW-405)	NONE	NONE
GTAW, PAW or GMAW backing gas; or CFW fuel gas (QW-406)	NONE	NONE
GMAW transfer mode (spray/globular or pulse to short circuit) (QW-406)	NONE	NONE
GTAW welding current type & polarity (AC, DCEP, DCEN)(QW-406)	NONE	NONE
Machine Welding Variables (QW-381.2)	Actual Values	Range Qualified
Direct or remote visual control	NONE	NONE
Automatic arc voltage control (GTAW)	NONE	NONE
Automatic joint tracking	NONE	NONE
Multiple or single pass per side	NONE	NONE
Automatic Welding Variables (QW-381.1)	Actual Values	Range Qualified
Filler Metal (EBW or LBW)	NONE	NONE
Laser type for LBW (CO <sub>2</sub> to YAG etc.)	NONE	NONE
Continuous drive or inertia welding (FW)	NONE	NONE
Vacuum or out of vacuum (EBW)	NONE	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-482.3(a)];  Longitudinal root and face [QW-482.3(b)];  Side (QW-482.2);  
 Pipe bend specimen, corrosion-resistant overlay [QW-482.5(c)];  Plate bend specimen, corrosion-resistant overlay [QW-482.5(d)];  
 Pipe specimen, macro test for fusion [QW-482.5(b)];  Plate specimen, macro test for fusion [QW-482.5(e)]

Type	Result	Type	Result	Type	Result	Type	Result
QW-482.2 (SIDE)	ACCEPTED	QW-482.2 (SIDE)	ACCEPTED				

Alternative radiographic examination results (QW-191) NONE  
 Fillet weld -- fracture test (QW-181.2) NONE Length and percent of defects N/A  
 Fillet welds in plate [QW-482.4(b)]  Fillet welds in pipe [QW-482.4(c)]  
 Macro examination (QW-184) NONE Fillet size (in.) NONE x NONE Concavity/convexity (in.) NONE  
 Other tests NONE  
 Film or specimens evaluated by NONE Company NONE  
 Mechanical tests conducted by ALL - WELD COMPANY LIMITED Laboratory test no. NONE  
 Welding supervised by (Print name) ANDREW LEWIS  
 Test requested by (Print name) ROBERT BENTLEY Tested at (Print address) 49 PASSMORE AVE, SCARBOROUGH, ONT

We certify that the statements in this record are correct and that the test coupons were prepared, welded, and tested in accordance with the requirements of Section IX of the ASME Boiler and Pressure Vessel Code.  
 Organization ALL - WELD COMPANY LIMITED Signature [Signature] Date 03-28-2013 (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)  
 [Signature] MAR 28, 2013  
 Inspector Name and Number (Print) COSTICA ROSU CNF915 Inspector Signature and Date

Welder's Last Name: **MIRZA** Initial: **HAFEEZ** First Name: **(ABDUL)** Signature: *[Signature]* Stamp No: **53**  
 Res Address: **2050 BRIDLETOWN CIRCLE, # 607, SCARB.** Postal Code: **M1W 2V5** Provincial Registration No.: **P 162.5**  
 Employer Name: **ALL-WELD COMPANY LIMITED** Company PQR No.: **SAW-1**  
 Street Address: **49 PASSMORE AVENUE** Postal Code: **M1V 4T1** Company WPS No used: **SAW-W-1**  
 Welding Process(es) Used: **SAW** Type(s):  manual  machine  semi-automatic  automatic  
 Base Material(s): **SA 516-GR. 70 / SA 516-GR. 70** Thickness(es): **1"**

Variables for All Processes	Actual Values	Range Qualified
Backing material (metal, weld metal, welded from both sides, flux, etc.)	<b>BASE &amp; WELD METAL</b>	<b>BASE &amp; WELD METAL</b>
ASME P or S No. to ASME P or S No.	<b>P1 to P1</b>	<b>P1 THROUGH P11 &amp; P4X PLATE &amp; PIPE</b>
( <input checked="" type="checkbox"/> ) Plate ( ) Pipe (enter diameter if pipe)	<b>1"</b>	<b>2 7/8" O.D. &amp; UP MAX. TO BE WELDED</b>
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)	<b>5.17 EM12K</b>	
Consumable insert for GTAW or PAW (QW-404)		
Welding Position (1G, 5G, etc.) (QW-406)	<b>1G</b>	<b>ALL FILLETS (FLAT ONLY)</b>
Manual or Semi-automatic Variables (QW-380)	Actual Values	Range Qualified
Filler Metal F- No. (QW-404)	<b>F6</b>	<b>F6</b>
Filler Metal Product Form for GTAW, PAW (QW-404)		
Weld deposit thickness for each welding process (QW-404)	<b>1"</b>	<b>MAX. TO BE WELDED</b>
Process 1: _____ 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<b>12</b>	
Process 2: _____ 3 layers minimum <input type="checkbox"/> Yes <input type="checkbox"/> No		
Progression (uphill/downhill) (QW-405)		
GTAW, PAW or GMAW backing gas; or OFW fuel gas (QW-406)		
GMAW transfer mode (spray/globular or pulse to short circuit) (QW-406)		
GTAW welding current type & polarity (AC, DCEP, DCEN)(QW-406)		
Machine Welding Variables (QW-361-2)	Actual Values	Range Qualified
Direct or remote visual control		
Automatic arc voltage control (GTAW)		
Automatic joint tracking		
Multiple or single pass per side		
Automatic Welding Variables (QW-361-1)	Actual Values	Range Qualified
Filler metal (EBW or LBW)		
Laser type for LBW (CO <sub>2</sub> to YAG etc.)		
Continuous drive or inertia welding (FW)		
Vacuum or out of vacuum (EBW)		

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

**RESULTS**

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

Type	Result	Type	Result	Type	Result

Alternative radiographic examination results (QW-191) **ACCEPTED**  
 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 **SCOTT PETERS** Company **KV INSPECTION SERV**  
 Mechanical tests conducted by \_\_\_\_\_ Laboratory test no. \_\_\_\_\_  
 Welding supervised by **ANDREW LEWIS**

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

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 **JUNE 24, 200**  
(mm-dd-yyyy)

**FOR TSSA INSPECTOR USE ONLY**

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

Check (✓) applicable box below:  
 To weld for the Employer named above only.  
 For seeking employment only.

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

**MOHIR SONI ONT00952**  
 Inspector Name and Number (Print)

*[Signature]*  
 Inspector (Print)



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

Res Address **76 LUCIENT STREET, MARKHAM, ONTARIO** Postal Code **L3R 5E1** Provincial Registration No. **J745.5 & R7545.5**

Company Name **ALL-WELD COMPANY LIMITED** Company PQR No. **20 & 20-2A**

Street Address **49 PASSMORE AVENUE** Company WPS No used **20-1**

Postal Code **M1V 4T1**

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.)	<b>WITHOUT</b>	<b>WITH OR WITHOUT</b>
ASME P or S No. to ASME P or S No.	<b>P1</b> to <b>P1</b>	<b>P1 THRU P11 &amp; P4X PLATE &amp; PIPE</b>
( ) Plate ( X ) Pipe (enter diameter if pipe)	<b>2 3/8" OD</b>	<b>1" OD &amp; UP</b>
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)	<b>(5.18) ER 70S-3</b>	
Consumable Insert for GTAW or PAW (QW-404)	<b>NONE</b>	
Welding Position (1G, 5G, etc.) (QW-405)	<b>6G</b>	<b>6G</b>
Manual or Semi-automatic Variables (QW-350)	Actual Values	Range Qualified
Filler Metal F- No. (QW-404)	<b>F6</b>	<b>F6</b>
Filler Metal Product Form for GTAW, PAW (QW-404)	<b>SOLID</b>	<b>SOLID</b>
Weld deposit thickness for each welding process (QW-404)	<b>0.218"</b>	<b>1/16" TO 0.436" MAX.</b>
Progression (uphill/downhill) (QW-405)	<b>UPHILL</b>	<b>---</b>
GTAW, PAW or GMAW backing gas, or OFW fuel gas (QW-408)	<b>ARGON 99.9%</b>	<b>ARGON 99.9%</b>
GMAW transfer mode (QW-409)	<b>NONE</b>	<b>---</b>
GTAW welding current type & polarity (QW-409)	<b>DC/SP</b>	<b>DC/SP</b>
Machine Welding Variables (QW-361-2)	Actual Values	Range Qualified
Direct or remote visual control	<b>---</b>	<b>---</b>
Automatic voltage control (GTAW)	<b>---</b>	<b>---</b>
Automatic joint tracking	<b>---</b>	<b>---</b>
Multiple or single pass per side	<b>---</b>	<b>---</b>
Automatic Welding Variables (QW-361-1)	Actual Values	Range Qualified
Filler metal (EBW or LBW)	<b>---</b>	<b>---</b>
Laser type for LBW (CO <sub>2</sub> to YAG etc.)	<b>---</b>	<b>---</b>
Continuous drive or inertia welding (FW)	<b>---</b>	<b>---</b>
Vacuum or out of vacuum (EBW)	<b>---</b>	<b>---</b>

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

RESULTS

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

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

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

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

Type	Result	Type	Result	Type	Result
(FACE)	ACCEPTED	(ROOT)	ACCEPTED		
(FACE)	ACCEPTED	(ROOT)	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 *Robert Bentley* Date **JUNE 27, 2007**



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

PER ASME  
SECT. IX  
Expiry Date: **83**

**FAN YANG**  
Welder

Symbol

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

**ALL-WELD COMPANY LIMITED**  
Subject to the limitations of this certificate

*[Signature]*  
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 # **---** Inspector # **852** Fee **105.**



Welder's Last Name <b>YANG</b>	Initial <b>FAN</b>	First Name <b>FAN</b>	Signature <i>Jun yang</i>	Stamp No. <b>83</b>
Res. Address <b>39 - 1050 BRISTOL ROAD W. MISSISSAUGA, ONT.</b>		Postal Code	Provincial Registration No <b>D700.5 &amp; R2363.5</b>	
Company Name <b>ALL-WELD COMPANY LIMITED</b>		Company PQR No. <b>1</b>		Company WPS No used <b>1-1</b>
Street Address <b>49 PASSMORE AVENUE</b>		Postal Code		
<b>SCARBOROUGH, ONTARIO</b>		<b>M1V 4T1</b>		
Welding Process(es) Used <b>SMAW</b>		Type(s)	<input checked="" type="checkbox"/> manual <input type="checkbox"/> machine <input type="checkbox"/> semi-automatic <input type="checkbox"/> automatic	
Base Material(s) <b>SA 516-GR 70 / SA 516-GR 70</b>		Thickness(es)	<b>5/16"</b>	
Variables for All Processes		Actual Values	Range Qualified	
Backing material (metal, weld metal, welded from both sides, flux, etc.)		<b>WITHOUT</b>	<b>WITH OR WITHOUT</b>	
ASME P or S No. to ASME P or S No.		<b>P1</b> to <b>P1</b>	<b>P1 THRU P11 &amp; P4X PLATE &amp; ALL</b>	
( <input checked="" type="checkbox"/> ) Plate ( ) Pipe (enter diameter if pipe)		<b>5/16"</b>	<b>PIPE 2 7/8" O.D. &amp; UP</b>	
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)		<b>(5.1) E7018</b>		
Consumable Insert for GTAW or PAW (QW-404)		<b>---</b>		
Welding Position (1G, 5G, etc.) (QW-405)		<b>2 G</b>	<b>2 G</b>	
Manual or Semi-automatic Variables (QW-350)		Actual Values	Range Qualified	
Filler Metal F-No. (QW-404)		<b>F4</b>	<b>F4</b>	
Filler Metal Product Form for GTAW, PAW (QW-404)		<b>---</b>	<b>---</b>	
Weld deposit thickness for each welding process (QW-404)		<b>5/16"</b>	<b>5/8" MAX</b>	
Progression (uphill/downhill) (QW-405)		<b>---</b>	<b>PLATE GROOVE &amp; PIPE 2 7/8" O.D.</b>	
GTAW, PAW or GMAW backing gas; or OFW fuel gas (QW-408)		<b>---</b>	<b>&amp; UP &amp; ALL FILLETS</b>	
GMAW transfer mode (QW-409)		<b>---</b>	<b>---</b>	
GTAW welding current type & polarity (QW-409)		<b>---</b>	<b>---</b>	
Machine Welding Variables (QW-361-2)		Actual Values	Range Qualified	
Direct or remote visual control		<b>---</b>	<b>---</b>	
Automatic voltage control (GTAW)		<b>---</b>	<b>---</b>	
Automatic joint tracking		<b>---</b>	<b>---</b>	
Multiple or single pass per side		<b>---</b>	<b>---</b>	
Automatic Welding Variables (QW-361-1)		Actual Values	Range Qualified	
Filler metal (EBW or LBW)		<b>---</b>	<b>---</b>	
Laser type for LBW (CO <sub>2</sub> to YAG etc.)		<b>---</b>	<b>---</b>	
Continuous drive or inertia welding (FW)		<b>---</b>	<b>---</b>	
Vacuum or out of vacuum (EBW)		<b>---</b>	<b>---</b>	

Manufacturer's Copy

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

**RESULTS**

Visual Examination of Completed Weld (QW-302.4) ACCEPTED

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

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

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

Type	Result	Type	Result	Type	Result
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

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

Organization ALL-WELD COMPANY LIMITED Signature *R Bentley* Date FEB. 15, 2006



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

**FAN YANG** **83**  
Welder Symbol

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

**ALL-WELD COMPANY LIMITED**  
Subject to the limitations of this certificate

Authorized Examiner *[Signature]* Director

Office Use Only	
Test Requested By	<b>ROBERT BENTLEY</b> (Print Person's Name)
	<b>49 PASSMORE AVE., SCARBOROUGH, ONT.</b>
Tested At	<b>ALL-WELD COMPANY LIMITED</b> (Print Address)
District #	<b>13</b>
Inspector #	<b>001-037</b>
Fee	<b>105,-</b>





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. 262889

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. WP-R7542.5	
Employer Name ALL - WELD COMPANY LIMITED		Company PQR No. 52-2A		
Street Address .49 PASSMORE AVE		Postal Code M 1 V 4 T 1	Company WPS No. used 52-2	
SCARBOROUGH, ONT		Type(s) <input checked="" type="checkbox"/> manual <input type="checkbox"/> machine <input type="checkbox"/> semi-automatic <input type="checkbox"/> automatic		
Welding Process(es) Used SMAW		Thickness(es) 1" <input checked="" type="checkbox"/> Test Coupon <input type="checkbox"/> Production Weld		
Base Material(s) SA-516-GR70N TO SA-516-GR70N				

Variables for All Processes	Actual Values	Range Qualified
Backing material (with/without)	WITH	WITH
Base Metal P-Number to P-Number	P1 to P1	P1 THRU P15F, P34 & P4X PLATE AND PIPE 2 7/8" OD AND UP
( <input checked="" type="checkbox"/> ) Plate ( ) Pipe (enter diameter if pipe)	1"	
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)	(5.1) E7018-1H4	
Consumable Insert for GTAW or PAW (QW-404)	NONE	
Welding Position (1G, 5G, etc.) (QW-405)	2G	1G & 2G
Manual or Semi-automatic Variables (QW-350)	Actual Values	Range Qualified
Filler Metal F- No. (QW-404)	F4	F1, F2, F3 & F4
Filler Metal Product Form for GTAW, PAW (QW-404)	NONE	NONE
Weld deposit thickness for each welding process (QW-404)	1"	MAX TO BE WELDED (PLATE GROOVE + PIPE 2 7/8" OD + UP + ALL FILLETS)
Process 1: SMAW 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	.	
Process 2: 3 layers minimum <input type="checkbox"/> Yes <input type="checkbox"/> No	NONE	NONE
Vertical progression (uphill/downhill) (QW-405)	NONE	NONE
GTAW, PAW or GMAW backing gas; or OFW fuel gas (QW-408)	NONE	NONE
GMAW transfer mode (spray/globular or pulse to short circuit) (QW-409)	NONE	NONE
GTAW welding current type & polarity (AC, DCEP, DCEN) (QW-409)	NONE	NONE
Machine Welding Variables (QW-361.2)	Actual Values	Range Qualified
Direct or remote visual control	NONE	NONE
Automatic arc voltage control (GTAW)	NONE	NONE
Automatic joint tracking	NONE	NONE
Multiple or single pass per side	NONE	NONE
Automatic Welding Variables (QW-361.1)	Actual Values	Range Qualified
Filler Metal (EBW or LBW)	NONE	NONE
Laser type for LBW (CO <sub>2</sub> to YAG etc.)	NONE	NONE
Continuous drive or inertia welding (FW)	NONE	NONE
Vacuum or out of vacuum (EBW)	NONE	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 N/A

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)

ROBERT ROBU ONT 915  
Inspector Name and Number (Print)

APR 08. 2013  
Inspector Signature and Date





Technical Standards and Safety Authority

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

# Welder/Welding Operator Certificate

Technical Standards and Safety Act  
Boilers and Pressure Vessels Regulation

No. 258827

Welder's Last Name <b>ALROUBAYI</b>		Initial <b>A</b>	First Name <b>RAZZAK</b>	Signature 	Stamp No. <b>109</b>
Res. Address <b>140 QUANTRELL TRIAL SCARBOROUGH, ONT</b>		Postal Code <b>M 1 B 1 L B</b>		Provincial Registration No. <b>P 162.5</b>	
Employer Name <b>ALL - WELD COMPANY LIMITED</b>		Street Address <b>49 PASSMORE AVE</b>		Company POR No. <b>SAW - 1</b>	
SCARBOROUGH, ONT		Postal Code <b>M 1 V 4 T 1</b>		Company WPS No used <b>SAW - W - 1</b>	
Welding Process(es) Used <b>SAW</b>		Type(s) <input type="checkbox"/> manual <input type="checkbox"/> machine <input type="checkbox"/> semi-automatic <input checked="" type="checkbox"/> automatic			
Base Material(s) <b>SA - 516 - GR 70</b>		Thickness(es) <b>1"</b>		<input checked="" type="checkbox"/> Test Coupon <input type="checkbox"/> Production Weld	
Variables for All Processes		Actual Values		Range Qualified	
Backing material (with/without)		BASE & WELD METAL		BASE & WELD METAL	
Base Metal P-Number to P-Number		P1 to P1		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"			
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)		5.17 EM12K			
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 <sub>2</sub> to YAG etc.)		NONE			
Continuous drive or inertia welding (FW)		NONE			
Vacuum or out of vacuum (EBW)		NONE			

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

Visual Examination of Completed Weld (QW-302.4) ACCEPTED

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

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

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

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

Alternative radiographic examination results (QW-191) NONE

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

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

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

Other tests NONE

Film or specimens evaluated by NONE Company NONE

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

Welding supervised by (Print name) ANDREW LEWIS

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

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

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

**FOR TSSA INSPECTOR USE ONLY**

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

Check  applicable box below:

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

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

COSTICA ROSU ONT915  
Inspector Name and Number (Print)

MAR. 09, 2012  
Inspector Signature and Date



Technical Standards and Safety Authority

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

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

No. 262458

Welder's Last Name: INNIS Initial: A First Name: ANDREW Signature: [Signature] Stamp No.: 110  
 Res. Address: 21 BORNHOLM DRIVE TORONTO, ONTARIO Postal Code: M1B1L8 Provincial Registration No.: WP-R7542.5  
 Employer Name: ALL - WELD COMPANY LIMITED Company PQR No.: 52-2A  
 Street Address: 19 PASSMORE AVE Company WPS No. used: 52-2  
 SCARBOROUGH, ONT Postal Code: M1V4T1  
 Welding Process(es) Used: SMAW Type(s):  manual  machine  semi-automatic  automatic

Base Material(s): SA-516-GR70N TO SA-516-GR70N Thickness(es): 1"  Test Coupon  Production Weld  
 Variables for All Processes: Actual Values Range Qualified

Variables for All Processes	Actual Values	Range Qualified
Backing material (with/without)	WITH	WITH
Base Metal P-Number to P-Number	P1 to P1	P1 THRU P15F, P24 & P4X PLATE AND PIPE 2 7/8" OD AND UP
(X) Plate ( ) Pipe (enter diameter if pipe)	1"	
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)	(5.1) E7018-1H4	
Consumable insert for GTAW or PAW (QW-404)	NONE	
Welding Position (1G, 5G, etc.) (QW-405)	2G	1G & 2G
Manual or Semi-automatic Variables (QW-350)	Actual Values	Range Qualified
Filler Metal F- No. (QW-404)	F4	F4
Filler Metal Product Form for GTAW, PAW (QW-404)	NONE	NONE
Weld deposit thickness for each welding process (QW-404)	1"	MAX TO BE WELDED (PLATE GROOVE + PIPE 2 7/8" OD + UP + ALL FILLETS)
Process 1: SMAW 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	-	
Process 2: 3 layers minimum <input type="checkbox"/> Yes <input type="checkbox"/> No	NONE	NONE
Vertical progression (uphill/downhill) (QW-405)	NONE	NONE
GTAW, PAW or GMAW backing gas; or OFW fuel gas (QW-406)	NONE	NONE
GMAW transfer mode (spray/globular or pulse to short circuit) (QW-406)	NONE	NONE
GTAW welding current type & polarity (AC, DCEP, DCEN) (QW-406)	NONE	NONE
Machine Welding Variables (QW-361.2)	Actual Values	Range Qualified
Direct or remote visual control	NONE	NONE
Automatic arc voltage control (GTAW)	NONE	NONE
Automatic joint tracking	NONE	NONE
Multiple or single pass per side	NONE	NONE
Automatic Welding Variables (QW-361.1)	Actual Values	Range Qualified
Filler Metal (EBW or LSB)	NONE	NONE
Laser type for LBW (CO2 to YAG etc.)	NONE	NONE
Continuous drive or Inertia welding (FW)	NONE	NONE
Vacuum or out of vacuum (EBW)	NONE	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 N/A

Fillet welds in plate (QW-482.4(b))  Fillet welds in pipe (QW-482.4(c))  
 Macro examination (QW-184) NONE Fillet size (in.) NONE x NONE Concavity/convexity (in.) NONE

Other tests NONE

Film or specimens evaluated by NONE Company NONE

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

Welding supervised by (Print name) ANDREW LEWIS

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

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

Organization ALL - WELD COMPANY LIMITED Signature [Signature] Date 03-28-2013 (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)

COSTICK ROW ONT915  
 Inspector Name and Number (Print)

[Signature] MAR 28, 2013  
 Inspector Signature and Date



Technical Standards and Safety Authority

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

# Welder/Welding Operator Certificate

Technical Standards and Safety Act  
Boilers and Pressure Vessels Regulation

No. 262468

Welder's Last Name: STEWART Initial: STEPHEN First Name: STEPHEN Signature: [Signature] Stamp No.: 111

Res. Address: 49 MANDRAKE ROAD AJAX, ONT Postal Code: L1S5H1 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 Postal Code: M1V4T1 Company WPS No. used: 1-1

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

Base Material(s): SA-516-GR 70 TO SA-516-GR 70 Thickness(es): 3/8"  Test Coupon  Production Weld

Variables for All Processes	Actual Values	Range Qualified
Backing material (with/without)	WITHOUT	WITH OR WITHOUT
Base Metal P-Number to P-Number	P1 to P1	P1 THRU P1SF, 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)	5.1 E7018-1H4	
Consumable Insert for GTAW or PAW (QW-404)	NONE	
Welding Position (1G, 5G, etc.) (QW-405)	2G	1G & 2G

Manual or Semi-automatic Variables (QW-350)	Actual Values	Range Qualified
Filler Metal F-No. (QW-404)	F4	F4
Filler Metal Product Form for GTAW, PAW (QW-404)	NONE	
Weld deposit thickness for each welding process (QW-404)	3/8"	3/4" MAX PLATE GROOVE + PIPE 2 7/8" OD + UP
Process 1: _____ 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	4	+ ALL FILLETS
Process 2: _____ 3 layers minimum <input type="checkbox"/> Yes <input type="checkbox"/> No	NONE	
Vertical progression (uphill/downhill) (QW-405)	NONE	
GTAW, PAW or GMAW backing gas; or OFW fuel gas (QW-408)	NONE	
GMAW transfer mode (spray/globular or pulse to short circuit) (QW-409)	NONE	
GTAW welding current type & polarity (AC, DCEP, DCEN) (QW-409)	NONE	

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

Automatic Welding Variables (QW-361.1)	Actual Values	Range Qualified
Filler Metal (EBW or LBW)	NONE	
Laser type for LBW (CO <sub>2</sub> to YAG etc.)	NONE	
Continuous drive or inertia welding (FW)	NONE	
Vacuum or out of vacuum (EBW)	NONE	

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

Visual Examination of Completed Weld (QW-302.4) ACCEPTED

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

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

Alternative radiographic examination results (QW-191) NONE

Fillet weld - fracture test (QW-181.2) NONE Length and percent of defects \_\_\_\_\_  
 Fillet welds in plate [QW-462.4(b)]  Fillet welds in pipe [QW-462.4(c)]

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

Other tests NONE

Film or specimens evaluated by NONE Company NONE

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

Welding supervised by (Print name) ANDREW LEWIS

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

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

Organization ALL - WELD COMPANY LIMITED Signature [Signature] Date 09-12-2012  
(mm-dd-yyyy)

### FOR TSSA INSPECTOR USE ONLY

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

Check (✓) applicable box below:

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

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

LOGSTON ROSU ONT915  
Inspector Name and Number (Print)

[Signature] SEP 12, 2012  
Inspector Signature and Date



Technical Standards and Safety Authority

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

Technical Standards and Safety Act  
Boilers and Pressure Vessels Regulation

No. 262446

Welder's Last Name: **WRIGHT** Initial: **JOHN** First Name: **JOHN** Signature: *[Signature]* Stamp No: **118**

Res. Address: **230 BOYERS SIDE ROAD KESWICK, ONTARIO** Postal Code: **L 3 C 8** Provincial Registration No. **D700.5, R2363.5 & R2060.5**

Employer Name: **ALL - WELD COMPANY LIMITED** Company PQR No. **78, 1 & 1-A**

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

Postal Code: **M 1 V 4 T 1**

SCARBOROUGH, ONT

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

Base Material(s): **SA-516-GR 70 TO SA-516-GR 70** Thickness(es): **3/8"**  Test Coupon  Production Weld

Variables for All Processes	Actual Values	Range Qualified
Backing material (with/without)	<b>WITHOUT</b>	<b>WITH OR WITHOUT</b>
Base Metal P-Number to P-Number	<b>P1 to P1</b>	<b>P1 THRU P1SF, P34 &amp; P4X PLATE AND PIPE 2 7/8" OD AND UP</b>
( <input checked="" type="checkbox"/> ) Plate ( ) Pipe (enter diameter if pipe)	<b>8.375"</b>	
Filler Metal Specification (SFA) Class (QW-404) (informational Only)	<b>E7018-1H4</b>	
Consumable insert for GTAW or PAW (QW-404)	<b>NONE</b>	
Welding Position (1G, 5G, etc.) (QW-405)	<b>2G</b>	<b>1G &amp; 2G</b>
Manual or Semi-automatic Variables (QW-350)	Actual Values	Range Qualified
Filler Metal F-No. (QW-404)	<b>F4</b>	<b>F4</b>
Filler Metal Product Form for GTAW, PAW (QW-404)	<b>NONE</b>	
Weld deposit thickness for each welding process (QW-404)	<b>3/8"</b>	<b>3/4" MAX PLATE GROOVE + PIPE 2 7/8" OD + UP</b>
Process 1: _____ 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	<b>4</b>	<b>+ ALL FILLETS</b>
Process 2: _____ 3 layers minimum <input type="checkbox"/> Yes <input type="checkbox"/> No	<b>NONE</b>	
Vertical progression (uphill/downhill) (QW-405)	<b>NONE</b>	
GTAW, PAW or GMAW backing gas; or OFW fuel gas (QW-408)	<b>NONE</b>	
GMAW transfer mode (spray/globular or pulse to short circuit) (QW-409)	<b>NONE</b>	
GTAW welding current type & polarity (AC, DCEP, DCEN) (QW-409)	<b>NONE</b>	
Machine Welding Variables (QW-361.2)	Actual Values	Range Qualified
Direct or remote visual control	<b>NONE</b>	
Automatic arc voltage control (GTAW)	<b>NONE</b>	
Automatic joint tracking	<b>NONE</b>	
Multiple or single pass per side	<b>NONE</b>	
Automatic Welding Variables (QW-361.1)	Actual Values	Range Qualified
Filler Metal (EBW or LBW)	<b>NONE</b>	
Laser type for LBW (CO <sub>2</sub> to YAG etc.)	<b>NONE</b>	
Continuous drive or inertia welding (FW)	<b>NONE</b>	
Vacuum or out of vacuum (EBW)	<b>NONE</b>	

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

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

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

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

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

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

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

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

Other tests **NONE**

Film or specimens evaluated by **NONE** Company **NONE**

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

Welding supervised by (Print name) **ANDREW LEWIS**

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

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

Organization **ALL - WELD COMPANY LIMITED** Signature *[Signature]* **06-12-2012**  
(mm-dd-yyyy)

**FOR TSSA INSPECTOR USE ONLY**

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

Check (✓) applicable box below:

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

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

**COSTICA ROW** **017 915**  
Inspector Name and Number (Print)

*[Signature]* **JUNE 14, 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. 262449

Welder's Last Name <b>YUMUL</b>	Initial <b>MANOLITO</b>	First Name <b>MANOLITO</b>	Signature 	Stamp No. <b>120</b>
Res. Address <b>831 KENNEDY ROAD, ONTARIO</b>		Postal Code <b>M 1 K 2 E S</b>	Provincial Registration No. <b>D700.5, R2363.5 &amp; R2060.5</b>	
Employer Name <b>ALL - WELD COMPANY LIMITED</b>			Company PQR No. <b>78, 1 &amp; 1-A</b>	
Street Address <b>49 PASSMORE AVE</b>			Company WPS No. used	
SCARBOROUGH, ONT			Postal Code <b>M 1 V 4 T 1</b>	<b>1-1</b>
Welding Process(es) Used <b>SMAW</b>			Type(s) <input checked="" type="checkbox"/> manual <input type="checkbox"/> machine <input type="checkbox"/> semi-automatic <input type="checkbox"/> automatic	
Base Material(s) <b>SA-516-GR 70 TO SA-516-GR 70</b>			Thickness(es) <b>3/8"</b>	<input checked="" type="checkbox"/> Test Coupon <input type="checkbox"/> Production Weld
Variables for All Processes		Actual Values		Range Qualified
Backing material (with/without)		WITHOUT		WITH OR WITHOUT
Base Metal P-Number to P-Number ( <input checked="" type="checkbox"/> ) Plate ( ) Pipe (enter diameter if pipe)		P1 to P1		P1 THRU P15F, P34 & P4X PLATE AND PIPE 2 7/8" OD AND UP
Filler Metal Specification (SFA) Class (QW-404) (Informational Only)		5.1 E7018-1H4		
Consumable insert for GTAW or PAW (QW-404)		NONE		
Welding Position (1G, 5G, etc.) (QW-405)		2G		1G & 2G
Manual or Semi-automatic Variables (QW-350)		Actual Values		Range Qualified
Filler Metal F- No. (QW-404)		F4		F4
Filler Metal Product Form for GTAW, PAW (QW-404)		NONE		
Weld deposit thickness for each welding process (QW-404)		3/8"		3/4" MAX PLATE GROOVE + PIPE 2 7/8" OD + UP
Process 1: _____ 3 layers minimum <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No		4		+ ALL FILLETS
Process 2: _____ 3 layers minimum <input type="checkbox"/> Yes <input type="checkbox"/> No		NONE		
Vertical progression (uphill/downhill) (QW-405)		NONE		
GTAW, PAW or GMAW backing gas; or OFW fuel gas (QW-408)		NONE		
GMAW transfer mode (spray/globular or pulse to short circuit) (QW-409)		NONE		
GTAW welding current type & polarity (AC, DCEP, DCEN) (QW-409)		NONE		
Machine Welding Variables (QW-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 <sub>2</sub> to YAG etc.)		NONE		
Continuous drive or Inertia welding (FW)		NONE		
Vacuum or out of vacuum (EBW)		NONE		

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

Visual Examination of Completed Weld (QW-302.4) ACCEPTED

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

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

Alternative radiographic examination results (QW-191) NONE

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

Fillet welds in plate (QW-462.4(b))  Fillet welds in pipe (QW-462.4(c))  
 Macro examination (QW-184) NONE Fillet size (in.) NONE x NONE Concavity/convexity (in.) NONE

Other tests NONE

Film or specimens evaluated by NONE Company NONE

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

Welding supervised by (Print name) ANDREW LEWIS

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

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

Organization ALL - WELD COMPANY LIMITED Signature Robert Bentley Date 10 - 11 - 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)

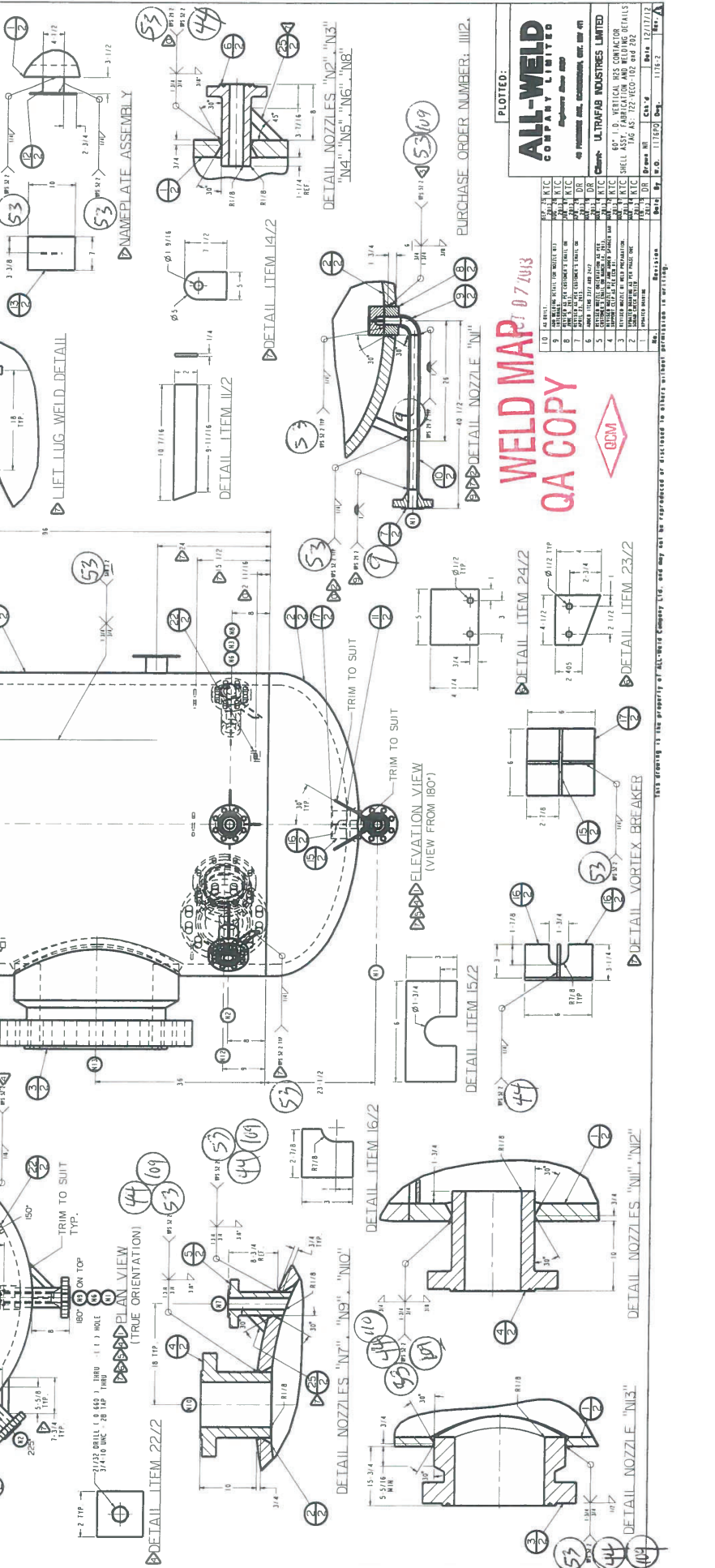
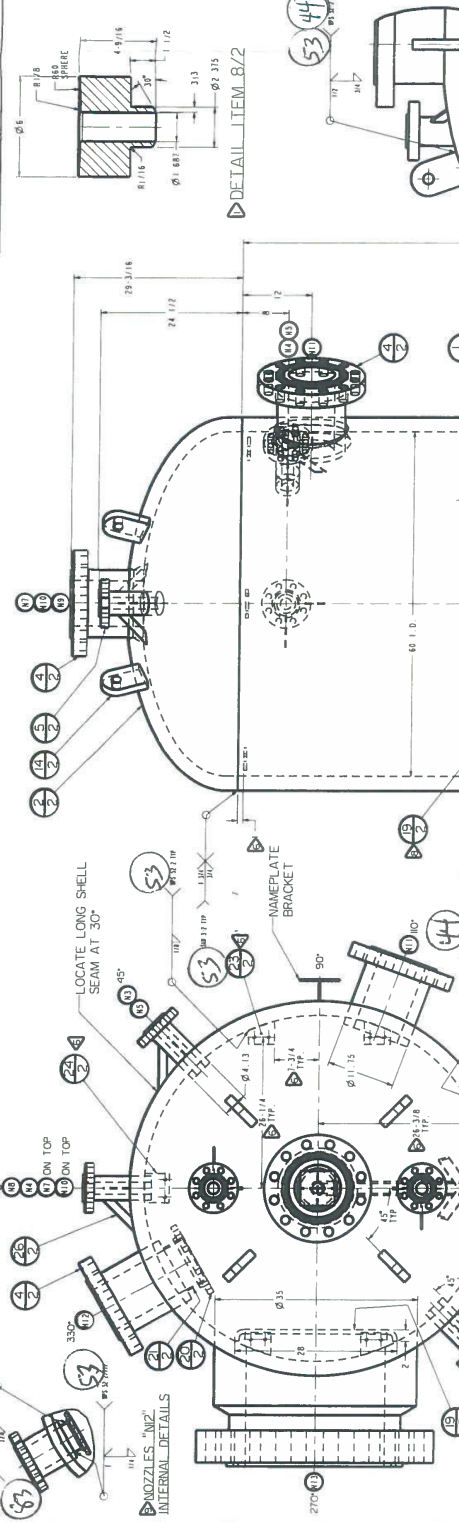
LOSTICA ROSU ONT915  
Inspector Name and Number (Print)

Robert Bentley Oct 16, 2012  
Inspector Signature and Date





ITEM	QTY.	DESCRIPTION	SPEC.
1	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
2	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
3	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
4	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
5	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
6	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
7	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
8	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
9	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
10	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
11	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
12	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
13	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
14	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
15	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
16	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
17	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
18	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
19	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
20	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
21	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
22	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
23	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
24	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
25	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
26	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
27	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
28	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
29	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
30	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
31	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
32	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
33	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
34	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
35	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
36	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
37	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
38	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
39	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
40	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
41	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
42	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
43	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
44	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
45	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
46	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
47	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
48	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
49	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
50	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
51	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
52	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
53	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
54	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
55	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
56	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
57	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
58	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
59	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
60	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
61	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
62	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
63	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
64	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
65	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
66	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
67	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
68	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
69	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
70	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
71	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
72	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
73	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
74	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
75	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
76	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
77	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
78	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
79	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
80	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
81	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
82	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
83	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
84	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
85	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
86	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
87	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
88	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
89	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
90	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
91	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
92	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
93	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
94	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
95	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
96	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
97	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
98	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
99	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100
100	1	2 1/2" PIP 60° CONE (WELD TO 18" 1.1)	SA-318 100



**WELD MAR 07 2013**  
**QA COPY**

**ALL-WELD COMPANY LIMITED**  
 45 PINE AVE. CAMDEN, ONT. M9H 4R1  
 Canada  
 UL TRAFAL INDUSTRIES LIMITED  
 655  
 455  
 SHELL TAG 45-122-REC-102 and 292 SHALL  
 BE USED FOR ALL FABRICATIONS.  
 ALL WELDING SHALL BE PERFORMED IN  
 ACCORDANCE WITH THE  
 WELDING PROCEDURE SPECIFICATION  
 (WPS) FOR THE PROJECT.

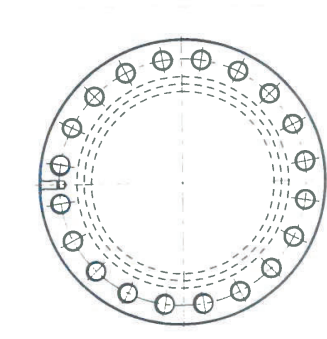
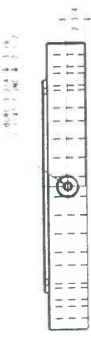
Revised: 11/18/12  
 Drawn: 11/18/12  
 Checked: 11/18/12  
 Date: 12/11/12

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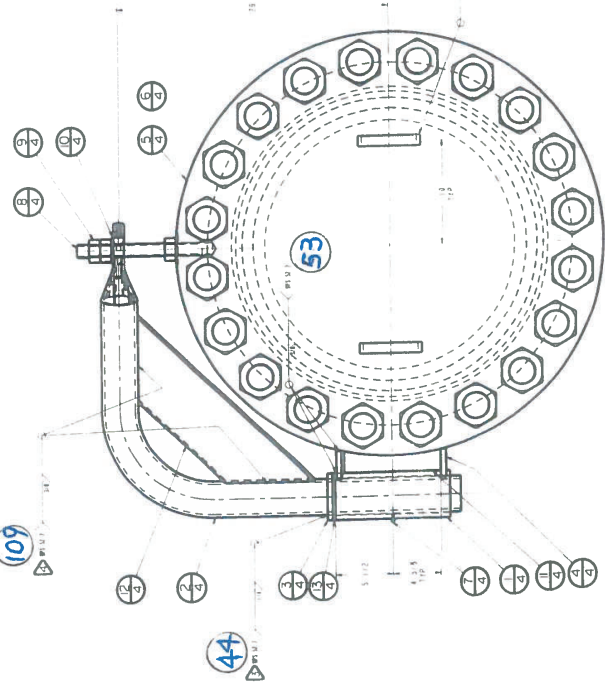
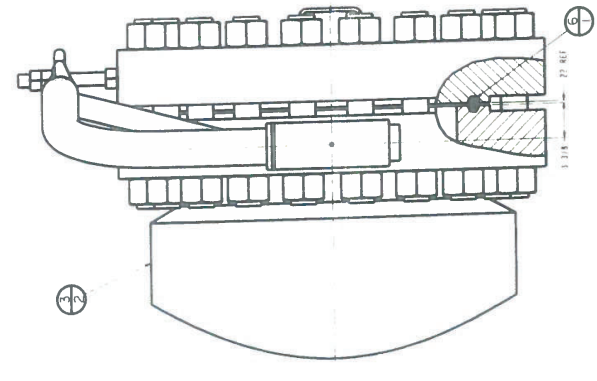
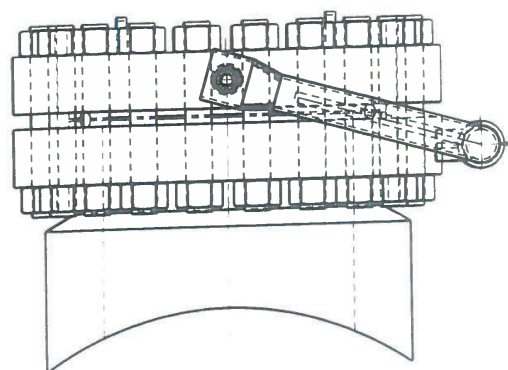


ITEM NO.	DESCRIPTION	QTY	UNIT	REMARKS
24	27/4	1	PC	20 1/8"
25	3/4	1	PC	20 1/8"
26	4/4	2	PC	20 1/8"
27	5/4	1	PC	20 1/8"
28	6/4	2	PC	20 1/8"
29	7/4	1	PC	20 1/8"
30	8/4	1	PC	20 1/8"
31	9/4	3	PC	20 1/8"
32	10/4	2	PC	20 1/8"
33	11/4	1	PC	20 1/8"
34	12/4	1	PC	20 1/8"
35	13/4	1	PC	20 1/8"

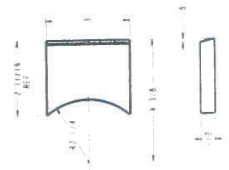


DETAIL ITEM 11/4

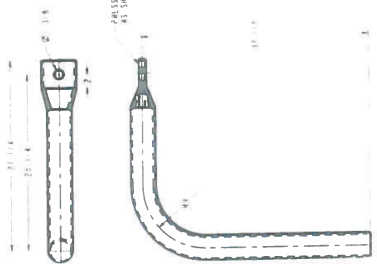
DETAIL ITEM 5/4



NOZZLE 11/3



DETAIL ITEM 3/4



DETAIL ITEM 1/4

NOTE:  
 THIS ASSEMBLY IS DESIGNED  
 TO SUPPORT THREE (3) BOND FLANGE WEIGHT.  
 PURCHASE ORDER NUMBER: 1112.

# WELD MAP

ITEM NO.	DESCRIPTION	QTY	UNIT	REMARKS
1	WELD MAP	1	PC	
2	WELD MAP	1	PC	
3	WELD MAP	1	PC	
4	WELD MAP	1	PC	

NOV 13 2013

121 REQUIRED

PLOTTED:

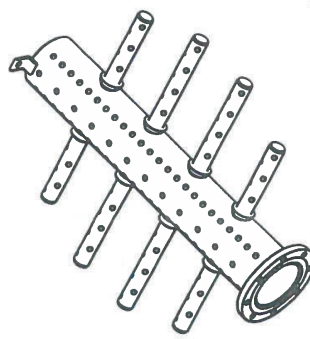
**ALL-WELD COMPANY LIMITED**  
 10000 100th Ave. S.E.  
 Kent, WA 98032  
 Phone: (206) 851-1111  
 Fax: (206) 851-1112  
 Email: sales@all-weld.com

Check: ULTRAFAB INDUSTRIES LIMITED  
 10000 100th Ave. S.E.  
 Kent, WA 98032  
 Phone: (206) 851-1111  
 Fax: (206) 851-1112  
 Email: sales@ultrafab.com

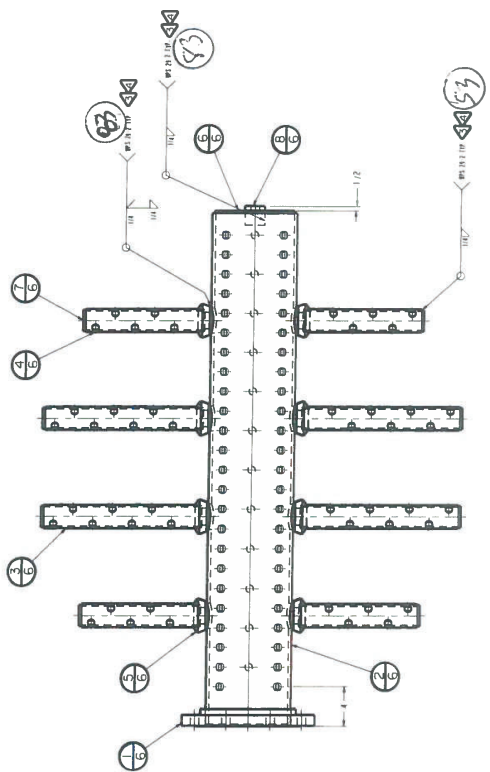
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**BILL OF MATERIAL**

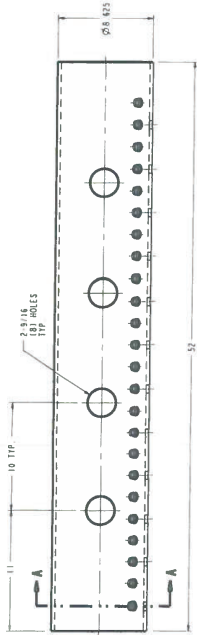
ITEM QTY.	DESCRIPTION	SPEC.
391	1" DIA. 10' LONG	SA-307B
40	1" DIA. 10' LONG	SA-307B
21/6	1" DIA. 10' LONG	SA-307B
31/6	1" DIA. 10' LONG	SA-307B
41/6	1" DIA. 10' LONG	SA-307B
51/6	1" DIA. 10' LONG	SA-307B
61/6	1" DIA. 10' LONG	SA-307B
71/6	1" DIA. 10' LONG	SA-307B
81/6	1" DIA. 10' LONG	SA-307B
91/6	1" DIA. 10' LONG	SA-307B
101/6	1" DIA. 10' LONG	SA-307B
111/6	1" DIA. 10' LONG	SA-307B
121/6	1" DIA. 10' LONG	SA-307B
131/6	1" DIA. 10' LONG	SA-307B
141/6	1" DIA. 10' LONG	SA-307B
C.1		



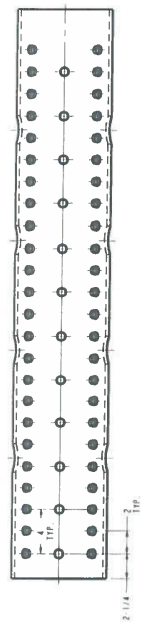
ISO VIEW



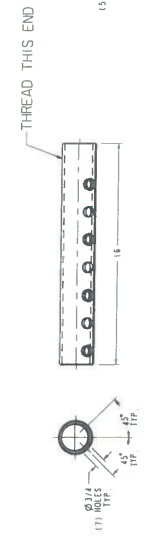
PLAN VIEW  
(TRUE ORIENTATION)



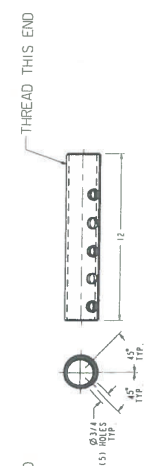
DETAIL ITEM 2/6



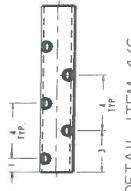
DETAIL ITEM 3/6



DETAIL ITEM 4/6



DETAIL ITEM 5/6



DETAIL ITEM 6/6

(2) REQUIRED  
NO PAWIT REQUIRED  
PURCHASE ORDER NUMBER:  
1112.

**QA COPY**  
OCT 07 2013  
**WELD MAP**  
QCM

PLOTTED:

**ALL-WELD COMPANY LIMITED**  
Engineering and Fabrication  
1175-5

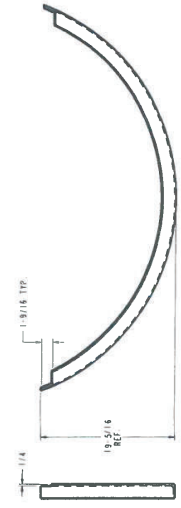
Rev.	Description	Date	By	Appr.
1	ISSUE FOR FABRICATION	03/14/13		
2	REVISION TO NOZZLE W/2			
3	REVISION TO NOZZLE W/2			
4	REVISION TO NOZZLE W/2			

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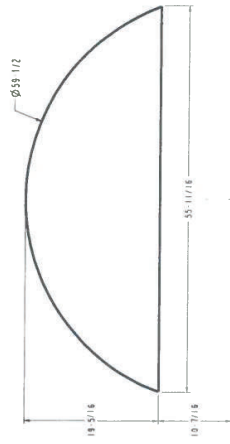


ITEM QTY.	DESCRIPTION	SPEC.
1/7 1	1/4" X 1/8" X 30" TYP. TUBING	C.1.
2/7 2	1/4" X 1/8" X 30" TYP. TUBING	C.1.
3/7 4	2" X 1/4" ANGLE	SA-36
4/7 2	2" X 1/4" ANGLE	SA-36
5/7 12	3/8" X 1/4" ANGLE	SA-36
6/7 6	3/8" X 1/4" ANGLE	SA-36
7/7 18	3/8" X 1/4" ANGLE	SA-36
8/7 36	3/8" X 1/4" ANGLE	SA-36
9/7 2	1/4" X 1/8" X 30" TYP. TUBING	SA-36
10/7 2	1/4" X 1/8" X 30" TYP. TUBING	SA-36

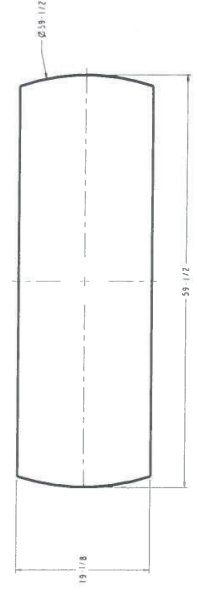
ITEM QTY.	DESCRIPTION	SPEC.
1/7 1	1/4" X 1/8" X 30" TYP. TUBING	C.1.
2/7 2	1/4" X 1/8" X 30" TYP. TUBING	C.1.
3/7 4	2" X 1/4" ANGLE	SA-36
4/7 2	2" X 1/4" ANGLE	SA-36
5/7 12	3/8" X 1/4" ANGLE	SA-36
6/7 6	3/8" X 1/4" ANGLE	SA-36
7/7 18	3/8" X 1/4" ANGLE	SA-36
8/7 36	3/8" X 1/4" ANGLE	SA-36
9/7 2	1/4" X 1/8" X 30" TYP. TUBING	SA-36
10/7 2	1/4" X 1/8" X 30" TYP. TUBING	SA-36



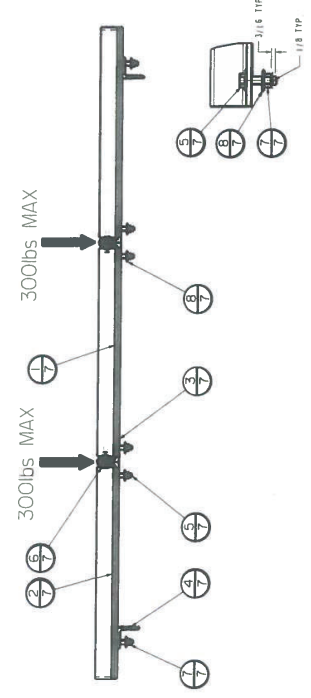
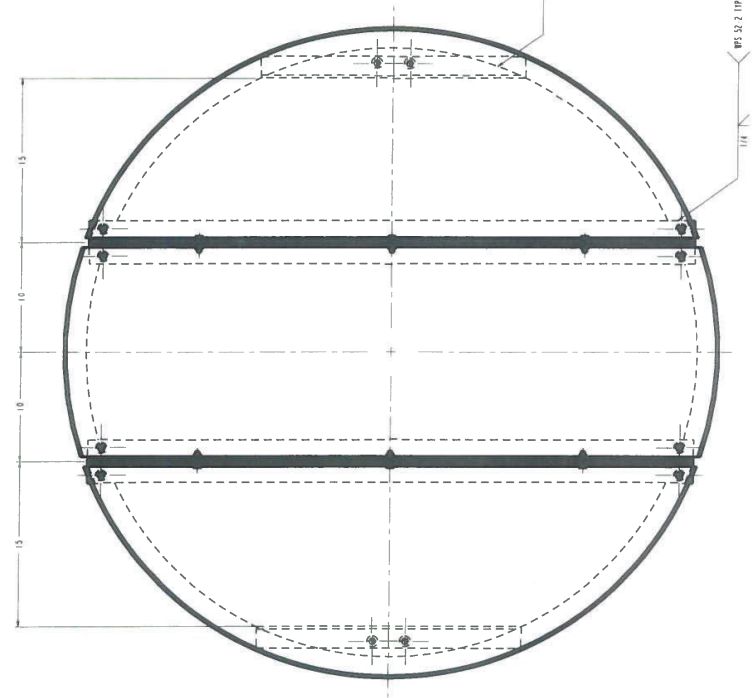
DETAIL ITEM 9/Z



DETAIL ITEM 2/Z



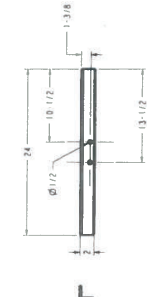
DETAIL ITEM 1/Z



BOILING DETAIL



DETAIL ITEM 10/Z



DETAIL ITEM 4/Z

PURCHASE ORDER NUMBER: 1112.

21 REQUIRED

PLOTTED:

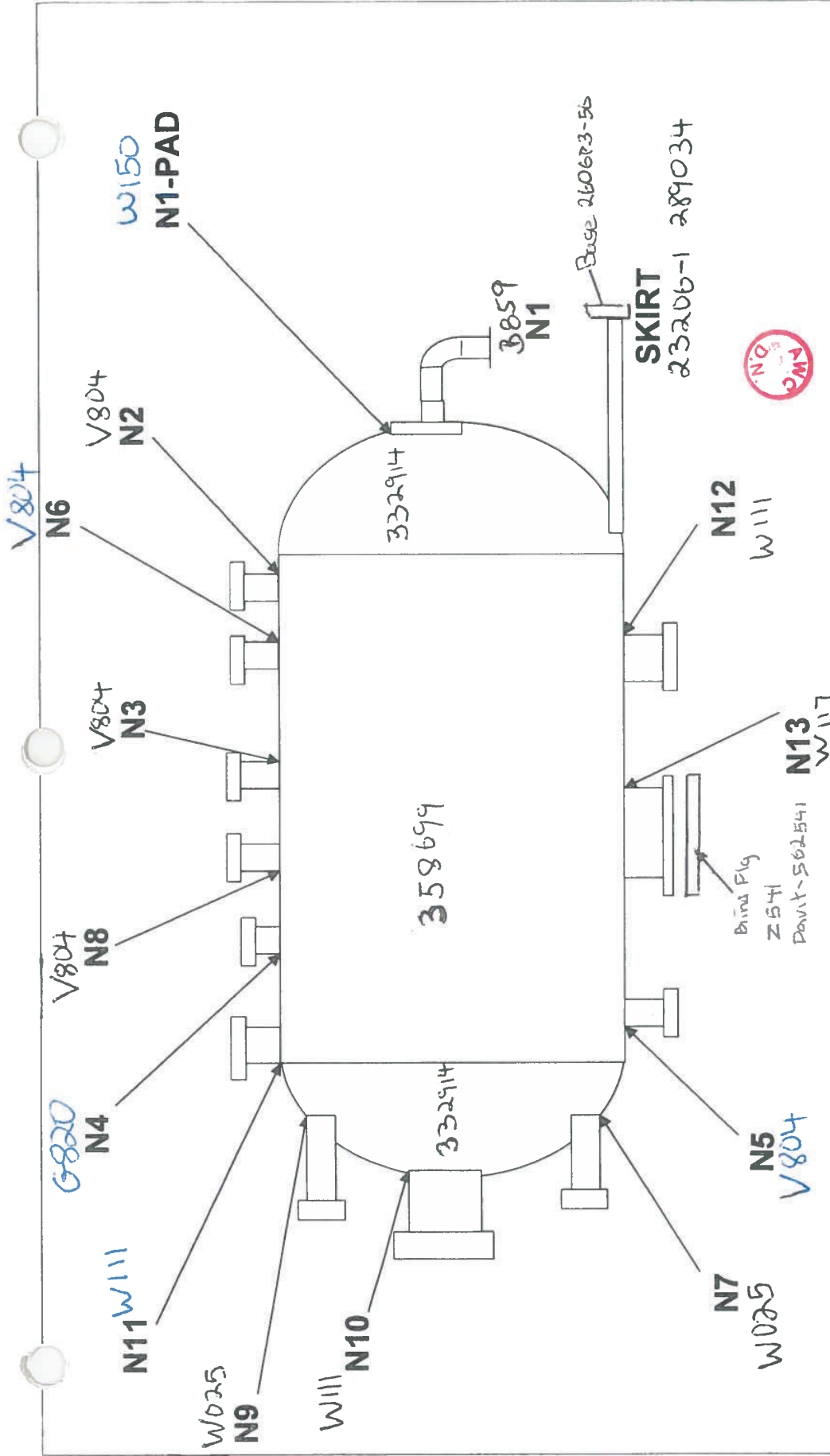
**ALL-WELD COMPANY LIMITED**  
 Equipment Sales and  
 Fabrication and Construction Co. Inc.  
 Client: ULTRAFAB INDUSTRIES LIMITED

**QA COPY**  
**WELD MAP**

3	WORK A.L. WORKING AND WITH OTHER WORK	DATE
2	WORK DONE BY THE FIRM	DATE
1	WORK DONE BY THE CONTRACTOR	DATE

Revision: \_\_\_\_\_  
 Date: 03/19/13  
 Scale: 1:10  
 Sheet No. 1112.1

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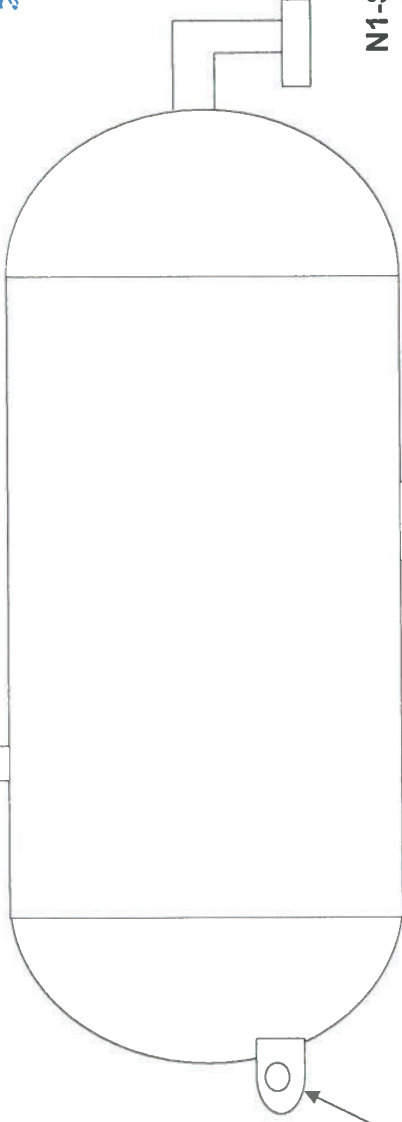


<b>ALL-WELD CO. LTD. - HEAT NUMBER MAP</b>	
CLIENT: ULTRAFAB	HEAT NUMBER MAP - 1176PQ
WORK ORDER #: 1176PQ SN 7468	ASME SECTION VIII. DIV. 1
JOB DESCRIPTION: 60" I.D. VERTICAL CONTACTOR	MATERIAL SA-516 70N, SA-350 LF2, SA-333 6, SA-420 WPLG
DRAWING #: 1176-1	
PREPARED BY: D.NESCI	
DATE: March 4, 2013	

N2, N3, N4, N5,  
N6, N7, N8, N9- SUPPORTS

HT # 4019P3-52

19/2- HT # 2797P3-05  
22/2- HT # 2797P3-05  
23-2- HT # 6396P3-01  
24/2- HT # 6396P3-01  
VORTEX BREAKER-8888L-3862  
20/2- A39V3  
2 1/2- J2L9676



N1-SUPPORTS

HT # 8888L-38624

NAMEPLATE  
BRACKET

HT #  
8888L-38624

DAVIT BRACKET- HT # 8952M356  
6/4- HT # 5416M-75082



14/2

HT # 2138P3-54

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

HEAT NUMBER MAP- PARTS - 1176PQ

CLIENT: ULTRAFAB

WORK ORDER #: 1176PQ SN 7468

JOB DESCRIPTION: 60" I.D. VERTICAL CONTACTOR

DRAWING #: 1176-1

PREPARED BY: D.NESCI

DATE: AUGUST 26, 2013

ASME SECTION VIII. DIV. 1

MATERIAL SA-516 70N



DILLINGER HÜTTE

Erläuterungen siehe Rückseite/Explications voir au verso/See reverse for explanations (www.dillinger.de/certificate)

A02 INSPECTION CERTIFICATE 3.1 AS PER EN 10204:2004  
INSPECTION CERTIFICATE 3.1.B AS PER EN 10204:1991+A1:1995 + AS PER ISO 10474:1991

MATERIAL TEST REPORT (MTR)  
A06 Established inspecting body A06 Purchaser EDMONTON STEEL, EDMON A071 No. ED10523-J11010-LG  
DH Final receiver EDMONTON STEEL, EDMON A072 No. SA20-S5

B02 Steel design. SA516-70

B03 Any suppl. requirements ASME-2A:07+A08  
DIL-HUE-16:R16-2007-1.1-20

A08/ Manufacturer's order/ A03 Certificate No. 345549-002  
B01 Product HOT ROLLED PLATES

A10 Advice of dispatch No./ Date of dispatch 330806-24.02.09

Sheet 1/...

A09 Purchaser article number

B14 Item No.	B08 Number of pieces	B09 Thickness	B10 Width	B11 Length	B12 Theoretical mass	B04 Product delivery condition	B07.2 Heat No.	B07.1 Rolled plate Test No.	A09 Purchaser article number
01	1	2,5000 x	121,00000 x	480,00000 x	18678 N	N	332914	19027-01	
01	1	2,5000 x	121,00000 x	480,00000 x	18678 N	N	332914	19031-01	
01	1	2,5000 x	121,00000 x	480,00000 x	18678 N	N	332914	19034-01	
01	1	2,5000 x	121,00000 x	480,00000 x	18678 N	N	332914	19130-01	
01	1	2,5000 x	121,00000 x	480,00000 x	18678 N	N	332915	18894-01	
**	5				93390				
***	5				93390				

B04 Product delivery condition

ITEM NO.: 01  
N: HT: 1670 GR.F +36 -27 GR.F  
SOAKING TIME TO ATTAIN THE TARGET TEMPERATURE OVER THE WHOLE SECTION: 1-1,75 MIN/MM (25-45 MIN/INCH)  
COOLING IN STILL AIR

B06 Marking of the product

ITEM NO.: 01  
STEEL DESIGNATION SA516 70 MTLTV SA516 60 MTLTV  
HEAT NO. / TRADEMARK / ROLLED PLATE NO.-TEST NO. / INSPECTOR'S STAMP

A04 Z01Z02Z03 We hereby certify, that the above mentioned materials have been delivered in accordance with the terms of order.  
QM-System: Certification as per ISO 9001

A01 AG der Dillinger Hüttenwerke  
Postfach 1580, D-66748 Dillingen/Saar  
Inspection department

Inspector's stamp Date 24.02.09 PP 1

DR. CH. DILG Test House Manager  
AG der Dillinger Hüttenwerke Postfach 1580, D-66748 Dillingen/Saar Inspection department

ACCEPTED/REVIEWED/RELEASED for and on behalf of: *Sally Velosi America*  
Print Name: *C.F. Velosi SAHA*  
Signature: *[Signature]*  
Date: *March 14/13*  
046  
Applus®  
VELOSI  
Velosi America LLC

Q.C.I. E.Y.

Q.C.I. N.D.







DILLINGER HÜTTE

Erläuterungen siehe Rückseite/Explications voir au verso/Suppreverse for explanations (www.dillinger.de/certificate)

A02 INSPECTION CERTIFICATE 3.1 AS PER EN 10204:2004

INSPECTION CERTIFICATE 3.1.B AS PER EN 10204:1991+A1:1995 + AS PER ISO 10474:1991

MATERIAL TEST REPORT (MTR)

A05 Established inspecting body A06 Purchaser EDMONTON STEEL, EDMON A07.1 No. ED10523-J1010-LG

DH Final receiver EDMONTON STEEL, EDMON A07.2 No. SA20-S5

B02 Steel design. SA516-70

B03 Any suppl. ASME-2A: 07+A08

requirements DIL-HUE-16:R16-2007-11-20

A10 Advice of dispatch No./ Date of dispatch

330806-24.02.09

A08/ Manufacturer's order/ A03 Certificate No.

345549-002

B01 Product

HOT ROLLED PLATES

Sheet

2/...

C10-C29 Tensile test

B14 Item No.	B07.2 Heat No.	B07.1 Rol./plate/ Test No.	B05 Reference (heat) treatment	C01	C02/ C03 C01	C03 Temp. GR.F	C10 C11 KSI RP02	C12 RM	C13	A % L0=2IN	C14-C15
01	332914	19027	K1 QV	RT	47,9	76,1	36,6				
01	332914	19031	K1 QV	RT	47,1	75,8	35,8				
01	332914	19034	K1 QV	RT	48,6	75,3	38,2				
01	332914	19130	K1 QV	RT	49,0	75,3	36,0				
01	332915	18894	K1 QV	RT	48,4	76,3	37,0				

046

ACCEPTED FOR REVIEW AND RELEASED for and on behalf of

APPLUS® VELOSI

Print Name: GAMESA SAH

Signature: [Signature]

Date: March 14/13

Velosi America LLC

C30-C39 Hardness test

B14 Item No.	B07.2 Heat No.	B07.1 Rol./plate/ Test No.	B05 Reference (heat) treatment	C01	C02/C01	C03 Temp. GR.F	C33 Testing method	C35 C31 Individual values	C32 Mean value
01	332914	19027	K1	O	RT HBW 10/3000	HB 148	150	151	150
01	332914	19031	K1	O	RT HBW 10/3000	HB 150	151	150	150
01	332914	19034	K1	O	RT HBW 10/3000	HB 146	149	147	147
01	332914	19130	K1	O	RT HBW 10/3000	HB 148	148	145	147
01	332915	18894	K1	O	RT HBW 10/3000	HB 147	153	145	148

C40-C49 Impact test

B14 Item No.	B07.2 Heat No.	B07.1 Rol./plate/ Test No.	B05 Reference (heat) treatment	C01	C02/ C01	C03 Temp. GR.F	C41 Width of test piece	C40 Type of test piece	C44 Testing method	C46 Energy	C45 C42 Individual values AV/FT.LBF	C43 Mean value
01	332914	19027	K1	LV	-51	CHP-V	AV 74	85	105	88		
01	332914	19031	K1	LV	-51	CHP-V	AV 95	110	114	106		
01	332914	19034	K1	LV	-51	CHP-V	AV 100	86	100	95		
01	332914	19130	K1	LV	-51	CHP-V	AV 106	87	100	98		
01	332915	18894	K1	LV	-51	CHP-V	AV 105	80	108	98		

A04 Z01/Z02/Z03 We hereby certify, that the above mentioned materials have been delivered in accordance with the terms of order.



QM-System: Certification as per ISO 9001



AG der Dillinger Hüttenwerke Postfach 1580, D-66748 Dillingen/Saar Inspection department

Inspector's stamp Date 24.02.09

DR. CH. DILG Test House Manager

Signature



DILLINGER HÜTTE

Erläuterungen siehe Rückseite/Explications voir au verso/Sae reverse for explanations (www.dillinger.de/certificate)

A02 INSPECTION CERTIFICATE 3.1 AS PER EN 10204:2004  
 INSPECTION CERTIFICATE 3.1-B AS PER EN 10204:1991+A1:1995 + AS PER ISO 10474:1991

MATERIAL TEST REPORT (MTR)

A05 Established inspecting body A06 Purchaser EDMONTON STEEL, EDMONT A07.1 No. ED10523-J1010-IG  
 DH Final receiver EDMONTON STEEL, EDMONT A07.2 No. SA20-S5

B02/ Steel design. SA516-70  
 B03 Any suppl. ASME-2A: 07+A08  
 requirements DIL-HUE-16:R16-2007-11-20

A10 Advice of dispatch No./ Date of dispatch 330806-24.02.09

A08/ Manufacturer's order/ A03 Certificate No. 345549-002

Sheet 3/...

ACCEPTED/REVERTEDE/RELEASED  
 for and on behalf of: *Applus+ VELOSI*  
 Print Name: *APRILIA SAI*  
 Signature: *[Signature]*  
 Date: *12/14/13*  
 046  
 HOT ROLLED PLATES  
 Applus+ VELOSI  
 Velosi America LLC

**C70-C99 Chemical composition % - Heat analysis**

Heat	C70	C	SI	MN	P	S	N	CU	MO	NI	CR	V	NB	SN	TI
332914	Y	0,182	0,377	1,17	0,009	0,0006	0,0061	0,033	0,028	0,076	0,212	0,001	0,000	0,000	0,002
332915	Y	0,175	0,375	1,18	0,007	0,0007	0,0058	0,044	0,034	0,078	0,222	0,000	0,000	0,000	0,003

**C70**

Heat	B	CA	AL-T
332914	Y	0,0002	0,0017
332915	Y	0,0002	0,0017

**C94 Heat analysis Carbon equivalent / Alloying restrictions**

**C95 Ladle treatment**

ITEM NO.: 01  
 HEAT OF THE INDICATED ITEM: VACUUM DEGASSED / SULPHIDE SHAPE CONTROL

W.O.# 1176Q  
 M.L.# 1  
 TRK.#  
 P.O.# 12-1619-1178Q

Certification of Material - Per ASME  
 HT# 332914  
 Qualifies to all requirements of  
 SA516-GR70 per  
 Sect. II 10 Edition II Addenda

LIMITS OF UNSPECIFIED ELEMENTS PER ASME  
 SECTION II (SA-20)  
 CU + Ni + CR + MO = 0.34  
 CR+MO = 0.24

**C70-C99 Chemical composition % - Product analysis**

Heat	C01	C	SI	MN	P	S	N	CU	MO	NI	CR	V	NB	SN	TI
332914	K1	0,181	0,373	1,17	0,009	0,0009	0,0059	0,031	0,027	0,073	0,206	0,001	0,000	0,000	0,003
332915	K1	0,178	0,372	1,16	0,008	0,0010	0,0057	0,031	0,027	0,072	0,205	0,001	0,000	0,000	0,002

**B07.2**

Heat	B	CA	AL-T
332914	K1	0,0000	0,0016
332915	K1	0,0000	0,0016

Q.C.I. E.Y.  
 Q.C.I. N.D.  
 FFR 0 2010

A04 201/202/203 We hereby certify, that the above mentioned materials have been delivered in accordance with the terms of order.  
 QM-System: Certification as per ISO 9001

AG der Dillinger Hüttenwerke  
 Postfach 1580, D-66748 Dillingen/Saar  
 Inspection department

A01

DR. CH. DILLG Test House Manager  
 Inspector's stamp: ADB  
 Date: 24.02.09

Manufacturer's mark



DILLINGER HÜTTE

Erläuterungen siehe Rückseite/Explications voir au verso/See reverse for explanations (www.dillinger.de/certificate)

A02 INSPECTION CERTIFICATE 3.1 AS PER EN 10204:2004	A10 Advice of dispatch No./ Date of dispatch	A08/ Manufacturer's order/ A03 Certificate No.	Sheet
INSPECTION CERTIFICATE 3.1.B AS PER EN 10204:1991+A1:1995 + AS PER ISO 10474:1991	330806-24.02.09	345549-002	4
MATERIAL TEST REPORT (MTR)		B01 Product	
A05 Established inspecting body	EDMONTON STEEL, EDMON	HOT ROLLED PLATES	
DH	Final receiver		
	EDMONTON STEEL, EDMON		
B02/ Steel design.	SA516-70		
B03 Any suppl. requirements	ASME-2A:07+A08 DIL-HUE-16:R16-2007-11-20		
	A07.1 No. ED10523-J1010-LG		
	A07.2 No. SA20-S5		

C94 Product analysis Carbon equivalent / Alloying restrictions

B07.2 Heat	B07.1 Test No.	C01
332914	18962	K1 FO-02= 0,43 FO-55= 0,34
332915	18894	K1 FO-02= 0,42 FO-55= 0,34

C94 Carbon equivalent formula / Alloying restrictions

FO-02 = C + (MN/6) + (CR+MO+V) / 5 + (NI+CU) / 15  
 FO-55 = CU+MO+NI+CR  
 FO-78 = CR+MO  
 FO-91 = MN/C

D01 Marking and identification, surface appearance, shape and dimensional properties

ITEM NO.: 01  
 RESULT OF MARKING, SURFACE, SHAPE AND DIMENSIONS: NO REMARKS  
 SURFACE AS PER ASME-SA20  
 THICKNESS AS PER ASME-SA20  
 LENGTH AND WIDTH AS PER ASME-SA20  
 FLATNESS AS PER 1/2-ASME-SA20

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: *Velosi America LLC*  
 Print Name: *YFRANESH S PANA*  
 Signature: *[Signature]*  
 Date: *11/13/2013*

Q.C.I. E.V.  
 Q.C.I. N.D.  
 FEB 0 1 2013



A04	201202203 We hereby certify, that the above mentioned materials have been delivered in accordance with the terms of order.	AG der Dillinger Hüttenwerke Postfach 1580, D-66748 Dillingen/Saar Inspection department	A01
	QM-System: Certification as per ISO 9001	AHB	PP 1
Manufacturer's mark	DR. CH. DILG Test House Manager	Inspector's stamp	Date 24.02.09



edmonton exchanger  
& manufacturing ltd.

# CERTIFICATE OF COMPLIANCE

MTR L's

59 Street Edmonton, Alberta Canada T6E 5W9 www.edmontonexchanger.com tel 780.468.6722 • QC fax 780.466.4668 • sales fax 780.466.5155

Customer ALL-WELD COMPANY LIMITED Po 12-1619-1178Q Work Order C96984 Date 2013/01/21 CofC# 38471 Page 1 of

MTR ID	Pages	Heat#	Thickness	Material Grades
15031	4	332914-19027	2.5"	SA 516-70 N
		332914-19130	2.5"	SA 516-70 N
15033	3	332914-18895	2.5"	SA 516-70 N
15749	4	350397-57045	2.5"	SA 516-70 N

Heat#	Material Grades	MTR ID
332914-18895	SA 516-70 N	15033
332914-19027	SA 516-70 N	15031
332914-19130	SA 516-70 N	15031
350397-57045	SA 516-70 N	15749

TOP  
BTM

ACCEPTED/REVIEWED FOR RELEASE ✓  
for and on behalf of: Velosi America  
Print Name: APRIL SAHIT  
Signature: [Signature] **Applus<sup>®</sup>**  
Date: March 14/13 **VELOSI**  
**Velosi America LLC**

Q.C.I.  
E.Y.

Q.C.I.  
N.D.

FEB 04 2013





**edmonton exchanger**  
& manufacturing ltd.

**CERTIFICATE OF COMPLIANCE**

5545-89 Street Edmonton, Alberta Canada T6E 5W9    www.edmontonexchanger.com    tel 780.468.6722 • QC fax 780.466.4668 • sales fax 780.466.5155

Customer ALL-WELD COMPANY LIMITED    PO 12-1619-1178Q    Work Order C96984    Date 2013/01/21    CofCs 38471    Page 1 of 1

Item#	Description	Qty	Heat#	Required Min Thk	Recorded Min Thk	Form. Proc.
H96984-1	HEAD(S) - Semi-Elliptical 2:1 - 2.5000" NOM (2.2820" MIN) X 60" ID (Material Spec: SA 516-70 Normalized) <b>Conforms to NACE MR0175 / ISO 15156-2 2009 Annex A</b>	1	350397-57045	2.2820"	2.4630"	1
		1	332914-18895	2.2820"	2.4590"	1
		1	332914-19027	2.2820"	2.4590"	1
		1	332914-19130	2.2820"	2.4350"	1

**Forming Procedure:**  
1. Hot Formed @ 1650F/899C and Air Cooled

**Brinell Equipment:** Newage Calibrated Pin  
Brinell Hardness Tester

**Supplementary Requirements**

Item H96984-1-3, H96984-1-4 had cosmetic surface repairs done in accordance with ASME Sec.VIII, Div.1 and ASME Sec.IX. Repairs were done per approved Weld Procedure WP-2 (as welded) or WP-63 (PWHT). All repaired areas were MT examined.

**Normalized Material Identification Marking:**  
 'MT' indicates normalized by the mill per ASME Code Section II, Part A, SA 20, Paragraph 13.1.1.  
 'GMT' indicates normalized by Edmonton Exchanger per ASME Code Section II, Part A, SA 20, Paragraph 13.1.2.  
 'GT' indicates normalized by Edmonton Exchanger per ASME Code Section VIII Division 1, UG-85 or ASME Code Section I, PG-77.4.

The Item(s) listed above comply with the requirements of ASME Code Section I, PG-29, PG-81 and ASME Code Section VIII, Division 1, UCS-79(d), UCS-79 & UG-81. All welders and procedures are qualified to ASME Code Section IX. Material being supplied conforms to the latest ASME Code Section II, Part A, 2010 Edition, Addenda July 1, 2011.

**Supplementary Examination - Items**

**Edmonton Exchanger**  
**MPI - Dry MPI**  
(for -1-3, -1-4)  
Acceptable to ASME Code

X SEC. VIII, DIV.1	SEC. IV
_ SEC. VIII, DIV.2	B31.1
_ SEC. I	B31.3
_ Bevelled Edge	Backgouge
_ Completed Welds	
X Surface Repair Area	

EE Procedure: MPI-001 REV.13  
 Material: SA 516-70 N  
 Thickness: 2.5"  
 Parker B300 Yoke  
 Magnaflux 8A-Red (Dry)  
 AC Continuous  
 Light: Natural  
 Tech: Roy Brown (#16669)  
 CGSB / SNT: Level II  
 Date: 2013/01/18  
 Time: Day Shift



FEB 04 2013

ACCEPTED/REVIEWED/RELEASED 046

for and on behalf of: SBM

Print Name: G.A. NESH SAHA

Signature: [Signature]

Date: Feb 26/13

**Applus®**  
VELOSI  
Velosi America LLC

CONREX STEEL LIMITED  
 50 TABER ROAD  
 REXDALE, ONTARIO M9W 3A9  
 HEAT TRACING RECORD

CSL WO#	QTY	DESCRIPTION	CUSTOMER	CUST PO#
73681	4	SE heads 60" ID x 2 1/2" thick	Allweld Company	13-0095

ACCEPTED/REVIEWED/RELEASED  
 for and to behalf of: SMM OFFSHORE  
 Print Name: GABRIEL SATH  
 Signature: [Signature]  
 Date: JUN 14 13

**Applu**  
**VEL**  
 Veloci Amer

HEAT TREATMENT SPECIFICATION: CSL-MR-001  
 HEAT AT 400 F PER HOUR FROM 600 F  
 HOLD min 68 MINUTES AT 1670 F +/- 25 F  
 COOL AT in air PER HOUR TO —

DCM  
 FEB 07 2013

THERMOCOUPLES: # 1, 2, 3, 4

NOTES: \_\_\_\_\_

All temperatures in degrees Fahrenheit unless noted

SIGNED FOR CSL [Signature] DATE Feb 6/13

TIME	STEP	SETPT	CHART TEMPERATURES					
			TC#1	TC#2	TC#3	TC#4	TC#5	TC#6
14:50	1	133	124	106	130	141	0	0
15:00	1	211	221	179	201	235	0	0
15:10	1	288	308	246	271	321	0	0
15:20	1	366	391	300	352	412	0	0
15:30	1	443	469	378	416	482	0	0
15:40	1	521	544	453	487	555	0	0
15:50	1	598	624	528	569	639	0	0
16:00	1	676	699	607	646	711	0	0
16:10	1	753	771	679	725	789	0	0
16:20	2	817	840	764	792	852	0	0
16:30	2	858	873	808	833	881	0	0
16:40	2	900	910	857	874	919	0	0

CHART TEMPERATURES								
TIME	STEP	SETPT	TC#1	TC#2	TC#3	TC#4	TC#5	TC#6
16:50	2	942	949	895	920	962	0	0
17:00	2	983	989	948	958	994	0	0
17:10	2	1025	1028	977	1008	1039	0	0
17:20	2	1067	1067	1024	1049	1079	0	0
17:30	2	1108	1111	1068	1091	1118	0	0
17:40	2	1150	1152	1117	1132	1158	0	0
17:50	2	1192	1194	1160	1178	1203	0	0
18:00	2	1233	1232	1203	1215	1235	0	0
18:10	2	1275	1273	1242	1262	1281	0	0
18:20	3	1310	1311	1285	1296	1316	0	0
18:30	3	1335	1335	1313	1323	1337	0	0
18:40	3	1359	1358	1339	1348	1362	0	0
18:50	3	1384	1379	1364	1375	1386	0	0
19:00	3	1409	1403	1386	1397	1406	0	0
19:10	3	1433	1433	1408	1422	1438	0	0
19:20	3	1458	1455	1435	1449	1463	0	0
19:30	3	1483	1478	1463	1473	1487	0	0
19:40	3	1507	1501	1486	1497	1508	0	0
19:50	3	1532	1531	1512	1526	1538	0	0
20:00	3	1557	1554	1537	1551	1564	0	0
20:10	3	1581	1578	1564	1574	1584	0	0
20:20	3	1606	1606	1590	1603	1610	0	0
20:30	3	1631	1630	1617	1627	1633	0	0
20:40	3	1655	1655	1641	1650	1657	0	0
20:50	4	1670	1675	1661	1669	1674	0	0
21:00	4	1670	1674	1664	1667	1672	0	0
21:10	4	1670	1674	1664	1670	1673	0	0
21:20	4	1670	1672	1665	1670	1673	0	0
21:30	4	1670	1672	1664	1665	1669	0	0
21:40	4	1670	1672	1665	1670	1672	0	0
21:50	4	1670	1675	1667	1672	1674	0	0
22:00	4	1670	1674	1668	1671	1671	0	0
22:10	4	1370	1480	1454	1402	1409	0	0
22:20	4	1158	1216	1243	1170	1181	0	0
22:30	4	921	955	1023	977	948	0	0
22:40	4	761	807	880	809	775	0	0

REF#2617

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBM OFF SHORE  
 Print Name: GANESH S P H  
 Signature: [Signature]  
 Date: July 10/13

**Applus**  
 VELO  
 Velosi America

# CONREX STEEL

A CONREX COMPANY

03/09/90  
Rev. 0

## PROCEDURE FOR NORMALIZING CSL-NR-001

The following is a standard procedure for normalizing followed unless otherwise specified by the customer.

1. The component shall be heated uniformly to a temperature range of 1600 to 1700 degrees Fahrenheit. The exact temperature depends on the material specification.
2. The temperature of the furnace shall not exceed 800 degrees F at the time the component is placed in it.
3. Above 800 degrees F, the maximum heating rate shall be 400 degrees F/hour. During the heating period, variation in temperature throughout the portion of the component being heated shall not be greater than 250 degrees F within any 15 feet interval of length.
4. The component shall be held within the specified temperature limit for a minimum of time specified in the following table, based on the component thickness, to ensure homogenization :

### Minimum Holding Time

Up to 2 inches

Over 2 inches

---

1/2 hour/inch, 30 minutes  
minimum

1/2 hour per inch up to  
2 inches, 15 minutes per  
inch thereafter

5. The component shall be cooled in still air.



# CONREX STEEL LTD.

50 Taber Road. Rexdale. Ontario, M9W 3A9 Phone (416)-747-4665 Fax (416)-747-4667

## CALIBRATION CERTIFICATE

INSTRUMENT: Stress Relief Furnace #1  
 MANUFACTURER: Allen Bradley (SLC 503)  
 SERIAL NUMBER: Conrex #1

Standard	As Found	Calibrated	Standard	As Found	Calibrated
LOAD#1			ADDITIONAL TEMPERATURE CONTROLS		
1125°F	1128°F	8/17/2012	1#: 1125°F	1127°F	8/17/2012
1650°F	1652°F	8/17/2012	1650°F	1652°F	8/17/2012
			2#: 1125°F	1126°F	8/17/2012
LOAD#2			1650°F	1652°F	8/17/2012
1125°F	1126°F	8/17/2012	3#: 1125°F	1126°F	8/17/2012
1650°F	1652°F	8/17/2012	1650°F	1651°F	8/17/2012
			4#: 1125°F	1126°F	8/17/2012
LOAD#3			1650°F	1651°F	8/17/2012
1125°F	1126°F	8/17/2012	5#: 1125°F	1126°F	8/17/2012
1650°F	1652°F	8/17/2012	1650°F	1651°F	8/17/2012
			6#: 1125°F	1126°F	8/17/2012
			1650°F	1651°F	8/17/2012
			7#: 1125°F		
			1650°F		
			8#: 1125°F		
			1650°F		

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SAM OFFSHORE  
 Print Name: GABRIEL SAHIA  
 Signature: [Signature]  
 Date: July 14/12  
 046  
**Applus®**  
**VELOSI**  
 Velosi America LLC

If 'calibrated' column is blank. No adjustments were necessary

COMMENTS: STANDARD: PPS MINITEMP MODEL 1062, SER# B67568

QC INSPECTOR: [Signature] QC MANAGER: Ling Tong DATE: Aug 17, 2012

**CERTIFICATE OF CALIBRATION****Customer:** CONREX STEEL  
50 TABER ROAD  
REXDALE, ON M9W 3A9 .**Customer Nbr:** 9-283590-000  
**PO Nbr:** 2292  
**Date Received:** March 29, 2012**Cert/SO Nbr:** 33-8X7EE-1-1  
**Manufacturer:** Transmatom  
**Model Nbr:** 1062**Date Completed:** April 12, 2012  
**Due Date:** April 12, 2013**Description:** Thermocouple Calibrator  
**Serial Nbr:** B67568  
**ID Nbr:** NONE  
**Unit Barcode:** 900A3296141**Calibrated To:** Manufacturer Specification  
**Calibration Proc:** 1-AC17451-1  
**Item Received:** In Tolerance  
**Item Returned:** In Tolerance

For calibration data, see Supplemental Report for SO Nbr 33-8X7EE-1-1

Transcat Calibration Laboratories have been audited and found in compliance with ISO/IEC 17025:2005. Accredited calibrations performed within the Lab's Scope of Accreditation are indicated by the presence of the Accrediting Body's Logo and Certificate Number on this Certificate of Calibration. Any measurements on an accredited calibration not covered by that Lab's Scope are listed in the notes section of the certificate. This report must not be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the Federal Government.

Transcat calibrations, as applicable, are performed in compliance with the requirements of ISO 9001:2008, ISO TS16949, ANSI/NCSL Z540-1994, and ISO 10012:1992. When specified contractually the requirements of 10CFR21, 10CFR50 App. B and NQA-1 are also covered.

Traceability includes no less than an unbroken chain of comparison realization of SI units, measurement uncertainty, documentation, competence, periodic recalibration and measurement assurance. Transcat documents the traceability of measurements to the SI units through the National Institute of Standards and Technology (NIST) or the National Research Council of Canada (NRC), or other recognized national measurement institutes (NMI's) or international standard bodies, or to measurable conditions created in our laboratory, or accepted fundamental and/or natural physical constants, ratio type of calibration, or by comparison to consensus standards. The specific path of traceability for the reported measurement results is maintained at the Transcat facility and is available there for review.

Complete records of work performed are maintained by Transcat and are available for inspection. Laboratory standards used in the performance of this calibration are shown on the Supplemental Report.

The results in this report relate only to the item calibrated or tested and the determination of in or out of tolerance is specific to the model/serial no. referenced above based on the tolerances shown on the supplemental report, these tolerances are either the original equipment manufacturer's (OEM's) warranted specifications or the client's requested specifications.

The applied uncertainty is the uncertainty of the calibration process. The Test Uncertainty Ratio (TUR) is calculated as per NCSL International RP9, section 8.2. All calibrations have been performed using processes having a TUR of 4:1 or better, unless otherwise noted on the Supplemental Report. Uncertainties have been estimated at a 95 percent confidence level ( $k=2$ ). Calibration at a 4:1 TUR (or greater) provides reasonable confidence that the instrument is within the stated tolerances. For measuring instruments in order to consider the contribution to the uncertainty from reproducibility of the unit under test (UUT), add 0.6 of the UUT's least significant digit to the reported uncertainty. For mass calibrations, conventional mass referenced to 0 g/cm<sup>3</sup>.

A number of factors can cause a unit to drift out of tolerance at any time following its calibration. Limitations on the uses of this instrument are detailed in the OEM's operating instructions.

**Notes:****Calibrated At:**4043 Carling Avenue  
Ottawa, ON K2K 2A4  
By: Keith Manson**Facility Responsible:**4043 Carling Avenue  
Ottawa, ON K2K 2A4  
613-591-8140 Digitally Signed By Keith Powell

Date: April 13, 2012

Keith Powell  
Lab Manager Digitally Signed On April 12, 2012**Revision 0**

This certificate may not be reproduced except in full without the written approval of Transcat. Additional information if applicable may be included on separate reports.

FORM 12 8/12/2011

Certificate - Page 1 of 1

QM-System: Certification as per ISO 9001



Erläuterungen siehe Rückseite/Explications voir au verso/See reverse for explanations (www.dillinger.de/certificate)

A02 INSPECTION CERTIFICATE 3.1 AS PER EN 10204:2004  
 INSPECTION CERTIFICATE 3.1.B AS PER EN 10204:1991+A1:1995 + AS PER ISO 10474:1991  
 MATERIAL TEST REPORT (MTR)

A03 Manufacturer's order/  
 Certificate No. 364846-001

A10 Advice of dispatch No./  
 Date of dispatch 388605-15.05.11

A06 Purchaser EDMONTON STEEL, EDMON A07.1 No. ED10566-J1010-ER  
 Final receiver EDMONTON STEEL, EDMON A07.2 No. SA20-S5

A05 Established inspecting body DH  
 B02 Steel design. SA516-70  
 B03 Any suppl. ASME-II-A:10 requirements DIL-HUE-16:R19-2010-11-22

B01 Product  
 HOT ROLLED PLATES

Sheet 1/...



B01-B99 Description of the product

B14 Item No.	B08 Number of pieces	B09 Thickness	B10 Width	B11 Length	B12 Theoretical mass	B04 Product delivery condition	B07.2 Heat No.	B07.1 Rolled plate No./ Test No.	A09 Purchaser article number
INCH									
01	1	2,5000 X	97,00000 X	482,00000 X	15036 N	N	358699	92215-01	ITEM 03
01	1	2,5000 X	97,00000 X	482,00000 X	15036 N	N	358699	92219-01	ITEM 03
01	1	2,5000 X	97,00000 X	482,00000 X	15036 N	N	358699	92223-01	ITEM 03
01	1	2,5000 X	97,00000 X	482,00000 X	15036 N	N	358699	92224-01	ITEM 03
01	1	2,5000 X	97,00000 X	482,00000 X	15036 N	N	358699	92233-01	ITEM 03
01	1	2,5000 X	97,00000 X	482,00000 X	15036 N	N	358701	90320-01	ITEM 03
01	1	2,5000 X	97,00000 X	482,00000 X	15036 N	N	358701	92027-01	ITEM 03
**	7				105252				
***	7				105252				

B04 Product delivery condition

ITEM NO.: 01  
 N: HT: 1670 GR.F +36 -27 GR.F  
 SOAKING TIME TO ATTAIN THE TARGET TEMPERATURE OVER THE WHOLE SECTION: 1-1,75 MIN/MM (25-45 MIN/INCH)  
 COOLING IN STILL AIR

B06 Marking of the product

ITEM NO.: 01  
 STEEL DESIGNATION SA516 70 MTLTV SA516 60 MTLTV  
 HEAT NO. / TRADEMARK / ROLLED PLATE NO.-TEST NO. / INSPECTOR'S STAMP

B07-B99 Further information about the product

ITEM NO.: 01  
 THICKNESS REDUCTION RATIO >= 3,0 IS FULFILLED (CF. A/SA20 PAR. 5.3)

A04



Manufacturer's mark

Z01/Z02/Z03 We hereby certify, that the above mentioned materials have been delivered in accordance with the terms of order.

AG der Dillinger Hüttenwerke  
 Postfach 1580, D-66748 Dillingen/Saar  
 Inspection department



B. BALDAUF  
 Test House Manager

Inspector's stamp

Date 16.05.11

PP 1



ACCEPTED FOR DELIVERY ON BEHALF OF: SA 20 MTLTV SA 516  
 for and on behalf of: SA 20 MTLTV SA 516  
 Signature: [Signature]  
 Date: 04.2013  
 Applus VELOSI  
 Velosi America LLC



DILLINGER HÜTTE

QM-System: Certification as per ISO 9001

Erklärungen, siehe Rückseite/Explications voir au verso/See reverse for explanations (www.dillinger.de/certificate)

A02 INSPECTION CERTIFICATE 3.1 AS PER EN 10204:2004  
 INSPECTION CERTIFICATE 3.1.B AS PER EN 10204:1991+A1:1995 + AS PER ISO 10474:1991

A10 Advice of dispatch No./ Date of dispatch  
 388605-15.05.11

A087 Manufacturer's order/ A03 Certificate No.  
 364846-001

B01 Product  
 HOT ROLLED PLATES

A05 Established inspecting body  
 DH

A06 Purchaser  
 EDMONTON STEEL, EDMON

A07.1 No. ED105666-J1010-ER

Final receiver  
 EDMONTON STEEL, EDMON

A07.2 No. SA20-S5

B02/ Steel design. SA516-70

B03 Any suppl. ASME-II-A:10 requirements DIL-HUE-16:R19-2010-11-22

**C10-C29 Tensile test**

B14 Item No.	B07.2 Heat No.	B07.1 Rol./plate/ Test No.	B05 Reference (heat) treatment	C01 C01	C02/ C01	C03 Temp. GR.F	C10 C10	C11 KSI RP02	C12 RM	C13	A % LO=2IN
01	358699	92215		K1 QV	RT	RT		47,9	75,1		36
01	358699	92219		K1 QV	RT	RT		48,6	74,5		37
01	358699	92223		K1 QV	RT	RT		48,0	75,0		37
01	358699	92224		K1 QV	RT	RT		48,7	74,5		36
01	358699	92233		F1 QV	RT	RT		47,6	75,0		35
01	358701	90320		K1 QV	RT	RT		48,0	75,5		35
01	358701	92027		K1 QV	RT	RT		48,1	75,5		35

C14-C15

ACCEPTED/REMOVED/RELEASED  
 for and on behalf of: *Appius America LLC*  
 Print Name: *G. P. B. SAH*  
 Signature: *[Signature]*  
 Date: *[Date]*

**C30-C39 Hardness test**

B14 Item No.	B07.2 Heat No.	B07.1 Rol./plate/ Test No.	B05 Reference (heat) treatment	C01 C01	C02/ C01	C03 Temp. GR.F	C30 Method of test	C35 C31 Individual values	C32 Mean value
01	358699	92215		K1	O	RT	HBW 10/3000	HB 147	147
01	358699	92219		K1	O	RT	HBW 10/3000	HB 147	147
01	358699	92223		K1	O	RT	HBW 10/3000	HB 148	148
01	358699	92224		K1	O	RT	HBW 10/3000	HB 146	147
01	358699	92233		F1	O	RT	HBW 10/3000	HB 147	147
01	358701	90320		K1	O	RT	HBW 10/3000	HB 144	144
01	358701	92027		K1	O	RT	HBW 10/3000	HB 143	144

Q.C.I. N.D.

Q.C.I. E.V.

FEB 04 2013



**QM-System: Certification as per ISO 9001**

Erläuterungen siehe Rückseite/Explications voir au verso/See reverse for explanations (www.dillinger.de/certificate)

A02 INSPECTION CERTIFICATE 3.1 / AS PER EN 10204:2004

A02 INSPECTION CERTIFICATE 3.1.B AS PER EN 10204:1991+A1:1995 + AS PER ISO 10474:1991

A10 Advice of dispatch No./ Date of dispatch: 388605-15.05.11

A01 Manufacturer's order/ Certificate No.: 364846-001

Sheet: 3/...

B01 Product: HOT ROLLED PLATES

MATERIAL TEST REPORT (MTR)

A06 Purchaser: EDMONTON STEEL, EDMON

A07.1 No.: ED10566-J1010-ER

A07.2 No.: SA20-S5

A05 Established inspecting body: DIL-HUE-16:R1.9-2010-1.1-22

Final receiver: EDMONTON STEEL, EDMON

B02/ Steel design: SA516-70

B03 Any suppl. requirements: ASME-II-A:10

**C40-C49 Impact test**

B14 Item No.	B07.2 Heat No.	B05 Reference (heat) treatment	C01	C02/ C01	C03 Temp. GR.F	C41 Width of test piece	C40 Type of test piece	C44 Testing method	C46 Energy	C45 Individual values AV=FT.LBF	C43 Mean value
01	358699	92215	K1	LV	-51	CHP-V	CHP-V	AV 86	108	103	99
01	358699	92219	K1	LV	-51	CHP-V	CHP-V	AV 98	134	114	115
01	358699	92223	K1	LV	-51	CHP-V	CHP-V	AV 105	94	67	89
01	358699	92224	K1	LV	-51	CHP-V	CHP-V	AV 89	82	91	87
01	358699	92233	F1	LV	-51	CHP-V	CHP-V	AV 119	137	123	126
01	358701	90320	K1	LV	-51	CHP-V	CHP-V	AV 97	111	39	82
01	358701	92027	K1	LV	-51	CHP-V	CHP-V	AV 80	106	77	88

**C70-C99 Chemical composition % - Heat analysis**

B07.2 Heat	C70	C	Si	Mn	P	S	N	CU	MO	NI	CR	V	NB	SN	TI
358699	Y	0,173	0,372	1,18	0,008	0,0007	0,0081	0,028	0,009	0,065	0,231	0,001	0,000	0,001	0,002
358701	Y	0,179	0,377	1,19	0,008	0,0008	0,0068	0,025	0,009	0,039	0,226	0,001	0,000	0,001	0,002

**C94 Heat analysis Carbon equivalent / Alloying restrictions**

B07.2 Heat	FO-02=	FO-51=	FO-55=	FO-78=	FO-91=
358699	0,42	0,43	0,001	0,24	6,8
358701	0,43	0,43	0,001	0,24	6,6

Q.C.I. N.D.

Q.C.I. E.Y.

FEB 04 2013

Certification of Material - Per ASME  
 HT# 358699  
 Qualifies to all requirements of  
 SA516-GR70 per  
 Sect. II, Edition II, Appendix

**LIMITS OF UNSPECIFIED ELEMENTS PER ASME SECTION II (SA-20)**  
 CU + NI + CR + MO = .331  
 CR + MO = .24

A04 Z01/Z02/Z03 We hereby certify that the above mentioned materials have been delivered in accordance with the terms of order

APPLUS® VELOSI

Signature: *[Signature]* Date: *[Date]*

Inspector's stamp: B. BALDAUF

Inspector's name: B. BALDAUF

Inspector's stamp: AHB

AG der Dillinger Hüttenwerke  
 Postfach 1580, D-66748 Dillingen/Saar  
 Inspection department

Date: 16.05.11

PP

**QM-System: Certification as per ISO 9001**

Erläuterungen siehe Rückseite/Explications voir au verso/See reverse for explanations (www.dillinger.de/certificate)

<b>A02</b>	INSPECTION CERTIFICATE 3.1 AS PER EN 10204:2004	A10 Advice of dispatch No./ Date of dispatch	388605-15.05.11	A08/ Manufacturer's order/ A03 Certificate No.	364846-001	Sheet	4/...
<b>A03</b>	INSPECTION CERTIFICATE 3.1.B AS PER EN 10204:1991+A1:1995 + AS PER ISO 10474:1991						
<b>MATERIAL TEST REPORT (MTR)</b>							
<b>A05</b>	Established inspecting body	A06 Purchaser	EDMONTON STEEL, EDMON	A07.1 No.	ED10566-J1010-ER	B01 Product	
<b>DH</b>		Final receiver	EDMONTON STEEL, EDMON	A07.2 No.		HOT ROLLED PLATES	
<b>B02/</b>	Steel design.	SA20-S5					
<b>B03</b>	Any suppl. requirements	DIL-HUE-16:R19-2010-11-22					

**C95 Ladle treatment**

**ITEM NO.: 01**  
HEAT OF THE INDICATED ITEM: VACUUM DEGASSED / SULPHIDE SHAPE CONTROL

**C95 Further information about ladle treatment**

**ITEM NO.: 01**  
CALCIUM TREATED

**C70-C99 Chemical composition % - Product analysis**

Heat	C01	C	SI	MN	P	S	N	CU	MO	NI	CR	V	NB	SN	TI
B07.1	K1	0,175	0,367	1,17	0,008	0,0008	0,0068	0,027	0,010	0,065	0,226	0,001	0,001	0,001	0,002
358699	K1	0,180	0,369	1,17	0,008	0,0006	0,0064	0,024	0,009	0,043	0,221	0,000	0,000	0,000	0,002
358701	K1														

**C94 Product analysis Carbon equivalent / Alloying restrictions**

Heat	C01	CA	AL-T
B07.1	K1	0,0001	0,0025
358699	K1	0,0001	0,0017
358701	K1		

**C94 Carbon equivalent formula / Alloying restrictions**

FO-02 = C + (MN/6) + (CR+MO+V) / 5 + (NI+CU) / 15

FO-51 = V + NB

FO-55 = CU+MO+NI+CR

FO-78 = CR+MO

FO-91 = MN/C

**ACCEPTED/REVIEWED/RELEASED**

for and on behalf of: SBM OFF SHORE 046

Print Name: Y F N B S I T A

Signature: [Signature]

Date: 16.05.11

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

**Z01/Z02/Z03** We hereby certify, that the above mentioned materials have been delivered in accordance with the terms of order.

**B. BALDAUF**  
Test House Manager

**AHB**

Inspector's stamp Date 16.05.11 PP 1

**AG der Dillinger Hüttenwerke**  
Postfach 1580, D-66748 Dillingen/Saar  
Inspection department



**QM-System: Certification as per ISO 9001**



**DILLINGER HÜTTE**

Erläuterungen, siehe Rückseite/Explications voir au verso/See reverse for explanations (www.dillinger.de/certificate)

A02	INSPECTION CERTIFICATE 3.1	AS PER EN 10204:2004	A10	Advice of dispatch No./ Date of dispatch	388605-15.05.11	A08/ Manufacturer's order/ A03 Certificate No.	364846-001	Sheet	5
	INSPECTION CERTIFICATE 3.1.B	AS PER EN 10204:1991+A1:1995 + AS PER ISO 10474:1991							
	MATERIAL TEST REPORT (MTR)								
A05	Established inspecting body	A06 Purchaser	EDMONTON STEEL, EDMON	A07.1 No.	ED10566-J1010-ER				
	DH	Final receiver	EDMONTON STEEL, EDMON	A07.2 No.					
B02/	Steel design.	SA516-70							
B03	Any suppl. requirements	ASME-II-A:1.0 DIL-HUE-16:R19-2010-11-22							

**D01 Marking and identification, surface appearance, shape and dimensional properties**

ITEM NO.: 01  
 RESULT OF MARKING, SURFACE, SHAPE AND DIMENSIONS: NO REMARKS  
 SURFACE AS PER ASME-SA20  
 THICKNESS AS PER ASME-SA20  
 LENGTH AND WIDTH AS PER ASME-SA20  
 FLATNESS AS PER 1/2-ASME-SA20



ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: S. B. off shore  
 Print Name: SHANESHI SAHA  
 Signature: [Signature]  
 Date: March 14/13  
**Applus**  
**VELOSI**  
 Velosi America LLC



A04 201202Z03 We hereby certify, that the above mentioned materials have been delivered in accordance with the terms of order.  
 AG der Dillinger Hüttenwerke  
 Postfach 1580, D-66748 Dillingen/Saar  
 inspection department  
 B. Baldauf  
 Test House Manager  
 Inspector's stamp  
 Date 16.05.11  
 PP 1



edmonton exchanger  
& manufacturing ltd.

# CERTIFICATE OF COMPLIANCE

MTR Lis

59 Street Edmonton, Alberta Canada T6E 5W9 www.edmontonexchanger.com tel 780.468.6722 • QC fax 780.466.4668 • sales fax 780.466.5155

Customer ALL-WELD COMPANY LIMITED po 12-1619-1178Q Work Order C96984 Date 2013/01/10 CofC# 38253 Page 1 of

MTR ID	Pages	Heat#	Thickness	Material Grades
16196	5	358699-92224	2.5"	SA 516-70 N

Heat#	Material Grades	MTR ID
358699-92224	SA 516-70 N	16196

ACCEPTED/REVIEWED/RELEASED 046  
 for and on behalf of: SBM OFFSHORE  
 Print Name: K. A. ANESH SAHA  
 Signature: [Signature]  
 Date: March 14/13

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



FEB 04 2013





edmonton exchanger  
& manufacturing ltd.

# CERTIFICATE OF COMPLIANCE

5545-89 Street Edmonton, Alberta Canada T6E 5W9 www.edmontonexchanger.com tel 780.468.6722 • QC fax 780.466.4668 • sales fax 780.466.5155

Customer ALL-WELD COMPANY LIMITED PO 12-1619-1178Q Work Order C96984 Date 2013/01/10 CorC# 38253 Page 1 of 1

Item#	Description	Qty	Heat#	Weld Proc.	Form. Proc.
S96984-2-1	SHELL(S) - 2.5000" NOM X 60" ID X 96" (Material Spec: SA 516-70 Normalized) Conforms to NACE MR0175 / ISO 15156-2 2009 Annex A	1	358699-92224	WP600	4
S96984-2-2	SHELL(S) - 2.5000" NOM X 60" ID X 96" (Material Spec: SA 516-70 Normalized) Conforms to NACE MR0175 / ISO 15156-2 2009 Annex A	1	358699-92224	WP600	4

#### Forming Procedure:

#### 4. Cold Formed

Brinell Equipment: Newage Calibrated Pin  
Brinell Hardness Tester

#### Supplementary Requirements

Item S96984-2-2 had cosmetic surface repairs done in accordance with ASME Sec.VIII, Div.1 and ASME Sec.IX. Repairs were done per approved Weld Procedure WP-2 (as welded) or WP-63 (PWHT). All repaired areas were MT examined.

#### Normalized Material Identification Marking:

'MT' indicates normalized by the mill per ASME Code Section II, Part A, SA 20, Paragraph 13.1.1.

'GMT' indicates normalized by Edmonton Exchanger per ASME Code Section II, Part A, SA 20, Paragraph 13.1.2.

'GT' indicates normalized by Edmonton Exchanger per ASME Code Section VIII Division 1, UG-85 or ASME Code Section I, PG-77.4.

Item(s) listed above comply with the requirements of ASME Code Section I, PG-80 and ASME Code Section VIII, Division 1, UCS-79(d), UG-79 & UG-80. All welders and procedures are qualified to ASME Code Section IX. For tacking carbon steel items, roundbar used is 1018 Cold Rolled. Material being supplied conforms to the latest ASME Code Section II, Part A, 2010 Edition, Addenda July 1, 2011.

#### Supplementary Examination - Items

#### Edmonton Exchanger

#### MPI - Dry MPI

(for -2-2)

Acceptable to ASME Code

X SEC. VIII, DIV.1	_ SEC. IV
_ SEC. VIII, DIV.2	_ B31.1
_ SEC. I	_ B31.3
_ Bevelled Edge	_ Backgouge
_ Completed Welds	
X Surface Repair Area	

EE Procedure: MPI-001 REV.13  
Material: SA 516-70 N  
Thickness: 2.5"  
Parker B300 Yoke  
Magnaflux 8A-Red (Dry)  
AC Continuous  
Light: Natural  
Tech: Tracy Enman (#11226)  
CGSB / SNT: Level II  
Date: 2013/01/09  
Time: Day Shift



FEB 04 2013

ACCEPTED/REVIEWED/RELEASED 046

for and on behalf of: SBM

Print Name: GANESH SAHA

Signature: [Signature]

Date: March 24 13

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



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

REPORT NUMBER 71990

DATE 2/21/2013

FCI ORDER NUMBER 59174

Processed LAW, EM0204 3/11  
LAW NAES MR01/21

CUSTOMER ORDER NUMBER 13 0073  
SOLD/SHIPPED TO ALL WELD COMPANY LTD.  
49 Passmore Ave.

Scarborough ON M1V 4T1 Canada

Item Quantity Description

1 2 24 X 90 X 34 25 LB QTY 14 WITH 35" OD, REINFORCEMENT ITEM 1176 3

HEAT NUMBER: W117

MATERIAL TYPE: SA350LF3CL1

Manufactured in USA

LAW ASMT 2012/11/08

CHEMICAL ANALYSIS

PHYSICAL PROPERTIES

	PRODUCT	
C	185	180 ✓
Mn	100	108 ✓
P	0100	004 ✓
S	0130	000 ✓
Si	190	160 ✓
Cr	100	130 ✓
Mo	140	130 ✓
V	220	0 ✓
Cu	100	0 ✓
Ni	040	0.1 ✓
Cl	0.1	0.2 ✓
As	100	0 ✓
Sb	101	0 ✓
Ti	0020	0.05 ✓
Al	2.5	0.1 ✓
B	0.00	0 ✓
C.E.	0 ✓	0.1 ✓

Yield PSI	57200 ✓
Tensile PSI	65800 ✓
Elongation	29 ✓
Reduction of Area	50
Hardness	115-137 ✓
CVN @ -51 °F FT LBS	20-27 ✓
% Shear	210 ✓
MLE	

LIMITS OF UNSPECIFIED ELEMENTS PER ASME SECTION II (SA-20)  
CU + Ni + CR + MO = 3.87  
CR+MO = 1.75

W.O. # 11760  
M.L. # 3 (3/2)  
THK. #  
P.O. # 13-0073

Q.C.I. E.Y.

Certification of Material - Per ASME  
HT# W117  
Qualifies to all requirements of SA350-LF3-CL1 per Sect. II 10 Edition 11 Addenda

MAR 18 2013

Q.C.I. N.D.

Heat Treatment NORMALIZED ✓  
Temperature 1650 °F  
Time at Temperature 15 HRS  
Cooling Media AIR

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

Prepared by [Signature]

Name: [Blank] Title: QA Representative ✓

ACCEPTED/REVIEWED/RELEASED 046  
for and on behalf of: SBM  
Print Name: GANESH SAHAI  
Signature: [Signature] near 2/21/13  
Applus VELOSI  
Velosi America LLC



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

Page 1 of 1  
REPORT NUMBER 71957

DATE 2/20/2013

FCI ORDER NUMBER 59174

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

CUSTOMER ORDER NUMBER 13 0073  
SOLD/SHIPPED TO ALL WELD COMPANY LTD  
49 Passmore Ave.

Scarborough ON M1V 4T1 Canada

Item Quantity Description

2 6 1.5" X 0.5" X 11.25" LG RNDWN ITEM 11764

HEAT NUMBER:  
W111

MATERIAL TYPE:  
SA350LF2CL1

Material Origin: USA  
Manufactured in USA

I.A.W. ASME B11.1 TO 11.0

CHEMICAL ANALYSIS

PHYSICAL PROPERTIES

	PRODUCT	
C	160	190 ✓
Mn	100	1095 ✓
P	0.008	0.008 ✓
S	0.005	0.005 ✓
Si	0.20	0.20 ✓
Cr	1.0	1.0 ✓
Mo	0.05	0.05 ✓
V	0.01	0.01 ✓
Cu	1.0	0.5 ✓
Ni	1.0	1.0 ✓
Cb	0.01	0.01 ✓
As	0.02	0.02 ✓
Sb	0.01	0.01 ✓
Ti	0.01	0.01 ✓
Al	0.01	0.01 ✓
B	0.001	0.001 ✓

Yield PSI	48,500 ✓
Tensile PSI	78,000 ✓
Elongation	25 ✓
Reduction of Area	45 ✓
Hardness	140-150 ✓
CVN @ -51 °F FT LBS	80-100 ✓
% Shear	40-45 ✓
MLE	0.54-0.51 ✓

Certification of Material - Per ASME  
HT# W111  
Qualifies to all requirements of  
SA350LF2CL1 per  
Sect. II 10 Edition II Addenda

LIMITS OF UNSPECIFIED  
ELEMENTS PER ASME  
SECTION II (SA-20)  
CU + Ni + CR + MO = 0.34  
CR + MO = 0.70

CE 0.42 ✓

Heat Treatment NORMALIZED ✓  
Temperature 1600 F  
Time at Temperature 10 - 20 IN PER MIN  
Cooling Media AIR

W.O. # 11764  
M.L. # 4(7/2)  
THK. # 1.967  
P.O. # 13-0073

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

Prepared by [Signature]

Name Rene O. Perez Title QA Representative ✓

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SBM  
Print Name: GAMESH SAHA  
Signature: [Signature]  
Date: 2/20/13  
Applus VELOSI  
Applus America LLC

Q.C.I.  
E.Y.

Q.018  
N.D.

2013



14527 Smith Rd.  
Humble, Texas 77396  
TEL: (281) 441-4088  
FAX: (281) 441-8999

REPORT NUMBER 72411

DATE 3/5/2013

FCI ORDER NUMBER 59174

Process: 601A W, EN10204 3.1  
1A W - NACE MR0175

CUSTOMER ORDER NUMBER 13-0073  
SOLD/SHIPPED TO ALL-WELD CO., LTD.  
49 PASSMORE AVE.

SCARBOROUGH ONT MIV 4T1 CANADA

Item Quantity Description

3 2 2" X 000 X 13" LG. FIT U/LWN ITEM 1176 5

HEAT NUMBER: W025

MATERIAL TYPE: SA350 LF2CL1

Material Origin: USA  
Manufactured in USA

1A W ASME B16.34

CHEMICAL ANALYSIS

PHYSICAL PROPERTIES

	PRODUCT	
C	180	180
Mn	1.020	0.90
P	0.055	0.070
S	0.011	0.035
Si	210	190
Cr	150	120
Mo	0.30	0.20
V	0.15	0.14
Cu	240	220
Ni	0.70	0.60
Cb	0.01	0.15
	0.015	
	0.12	
As	0.04	
Sb	0.02	
Ti	0.015	
Al	0.01	
B	0.002	
CE	0.001	0.001

Yield PSI	85,000
Tensile PSI	74,000
Elongation	25
Reduction of Area	72
Hardness	137-143 HBW
CVN @ 51 °F FT LBS	47-49 ft
% Shear	20-24
MLE	285-335 ft

LIMITS OF UNSPECIFIED ELEMENTS PER ASME SECTION II (SA-20)  
CU + Ni + CR + MO = .42  
CR + MO = .14

N7, N9  
Certification of Material - Per ASME  
HT# W025  
Qualifies to all requirements of  
SA350 LF2CL1 per  
Sect. II 10 Edition 11 Addenda

W.O. # 11760  
M.L. # 5 (5/2)  
THK. # 1.107  
P.O. # 13-0073

Q.C.I. N.D.  
Q.C.I. E.Y.  
MAR 18 2013

Heat Treatment NORMALIZED  
Temperature 1650 °F  
Time at Temperature 02 HR IN THK. MAT  
Cooling Media AIR

We hereby certify that all test results and process information contained herein are correct and are being reported to the records of the company.

Prepared by [Signature]

Name Title Organization QA Representative

ACCEPTED/REVISUED/RELEASED  
for and on behalf of: SBM  
Print Name: GAMBESH SAHA  
Signature: [Signature]  
Date: March 26/13  
Applus VELOSI  
Velosi America LLC  
046





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

REPORT NUMBER 71956

DATE 2/19/2013

FCI ORDER NUMBER 59174

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

CUSTOMER ORDER NUMBER 13-0073  
SOLD/SHIPPED TO ALL-WELD CO., LTD.  
49 PASSMORE AVE.

SCARBOROUGH ONT MIV 4T1 CANADA

Item Quantity Description

4 13 2" X 900 X 11.75" LG RTJ LWN ITEM 1176-6

HEAT NUMBER: V804

MATERIAL TYPE: SA350LF2CL1

Manufactured in USA

I.A.W. ASME 2010 ED 11AD

CHEMICAL ANALYSIS

PHYSICAL PROPERTIES

	PRODUCT	
C	180	199
Mn	1.040	1.057
P	0060	0090
S	0000	0060
Si	230	230
Cr	140	137
Mo	030	025
V	014	012
Cu	190	179
Ni	070	064
Cb	000	001
	0055	
	013	
As	003	
Sb	001	
Ti	0010	
Al	026	
B	0000	
C E	41	430

Yield PSI 48,150  
 Tensile PSI 78,043  
 Elongation 35  
 Reduction of Area 70  
 Hardness 156 HBW  
 CVN @ -58 °F FT LBS 25 27 28  
 % Shear  
 MLE

**N2, 3, 5, 6, 8**  
 Certification of Material - Per ASME  
 HT# **V804**  
 Qualifies to all requirements of  
**SA350-LF2CL1** per  
 Sect. II **10** Edition **11** Addenda

W.O. # **1176-6**  
 M.L. # **6(6/2)**  
 THK. #  
 P.O. # **13-0073**

**LIMITS OF UNSPECIFIED ELEMENTS PER ASME SECTION II (SA-20)**  
 CU + Ni + CR + MO = **.406**  
 CR + MO = **.163**

MAR 18 2013

Heat Treatment NORMALIZED  
 Temperature 1670 °F  
 Time at Temperature  
 Cooling Media AIR

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

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: *Helen Fielder*

Name Helen Fielder Title QA Representative

ACCEPTED/REVIEWED/RELEASED 046  
 for and on behalf of: **SAM**  
 Print Name: **GANESH SAHA**  
 Signature: *[Signature]*  
 Date: **March 21, 2013**  
 Applus VELOSI  
 Velosi America LLC



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

REPORT NUMBER 72048

DATE 2/21/2013

FCI ORDER NUMBER 59174

Processed by: L.A.W. EN10204 R  
L.A.W. FACE MED175

CUSTOMER ORDER NUMBER 13-0073  
SOLD/SHIPPED TO ALL WELD COMPANY LTD  
49 Passmore Ave

Scarborough ON M1V 4T1 Canada

Item Quantity Description

6 2 24" X 900 FITJ BLIND

ITEM 1176-B

HEAT NUMBER:  
2541

MATERIAL TYPE:  
SA350LF2CL1

Material Origin: USA  
Manufactured in USA  
LAW ASM# 20012110

CHEMICAL ANALYSIS

PHYSICAL PROPERTIES

	PRODUCT	
C	.61	.75 ✓
Mn	1.190	1.130 ✓
P	.0050	.0076 ✓
S	.0047	.0031 ✓
Si	.270	.200 ✓
Cr	.070	.73 ✓
Mo	.010	.005 ✓
V	.042	.14 ✓
Cu	.00	.04 ✓
Ni	.20	.60 ✓
Cb	.001	.002 ✓
	.015	
	.007	
As	.000	
Sb	.000	
Ti	.0034	
Al	.021	
B	.0012	
CE	.58 ✓	.71 ✓

Yield PSI	89,600 ✓
Tensile PSI	78,400 ✓
Elongation	37.5 ✓
Reduction of Area	68.5 ✓
Hardness	143 (49 HRC) ✓
CVN @ 51 F FT LBS	130 (44 J) ✓
% Shear	76.96 ✓
MLE	295 (195 J) ✓

Certification of Material - Per ASME  
HT# 2541  
Qualifies to all requirements of  
SA350-LF2-CL1 per  
Sect. II 10 Edition II Addenda

W.O. # 11760  
M.L. # 8(514)  
THK. # -  
P.O. # 13-0073

Q.C.I.  
E.Y.

Q.C.I.  
N.D.

Heat Treatment NORMALIZED ✓  
Temperature 1850 F  
Time at Temperature 1 1/2 HR IN TANK MIN  
Cooling Media AIR

LIMITS OF UNSPECIFIED  
ELEMENTS PER ASME  
SECTION II (SA-20)  
CU + Ni + CR + MO = .189  
CR+MO = .079

MAR 18 2013

We hereby certify that all test results and process information contained herein are correct and true to the best of our knowledge and records of the company.

Prepared by *[Signature]*

Name Rene Ordonez Title QA Representative

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



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

REPORT NUMBER 72154

DATE 2/25/2013

FCI ORDER NUMBER 59174

Processed IAW EN10004-1  
IAW NACE MR0175

CUSTOMER ORDER NUMBER 13-0073  
SOLD/SHIPPED TO ALL WELD COMPANY LTD.  
49 Passmore Ave

Scarborough ON M1V 4J1 CANADA

Item Quantity Description

7 2 5 X 900 FILL BLIND

ITEM 11769

HEAT NUMBER: W112

MATERIAL TYPE: SA350LF2CL1

Material Origin: USA  
Manufactured in USA

IAW ASME SECTION II

CHEMICAL ANALYSIS

PHYSICAL PROPERTIES

	PRODUCT	
C	130	131 ✓
Mn	1180	1130 ✓
P	0.080	0.006 ✓
S	0.020	0.005 ✓
Si	250	227 ✓
Cr	0.95	0.94 ✓
Mo	0.10	0.09 ✓
V	0.11	0.05 ✓
Cu	0.50	0.05 ✓
Ni	0.20	0.14 ✓
Cb	0.01	0.01 ✓
As	0.13	0.01 ✓
Sb	0.05	0.01 ✓
Ti	0.030	0.01 ✓
Al	0.05	0.01 ✓
B	0.004	0.001 ✓
CE	0.1	0.01 ✓

Yield PSI	41-43 ✓
Tensile PSI	41-43 ✓
Elongation	34 ✓
Reduction of Area	35 ✓
Hardness	120-125 ✓
CVN @ 51 FT LBS	50-60 ✓
% Shear	20-25 ✓
MLE	100-105 ✓

Certification of Material - Per ASME  
HT# W112  
Qualifies to all requirements of  
SA350 LF2CL1 per  
Sect. II 10 Edition II Addenda

W.O. # 11769  
M.L. # 9(41)  
THK. # -  
P.O. # 13-0073

Heat Treatment NORMALIZED ✓  
Temperature 1650 °F  
Time at Temperature 12 HR/IN THK MIN  
Cooling Media AIR

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



MAR 18 2013

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

Prepared by [Signature]

Name Rene D. Jones Title QA Representative

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SBM  
Print Name: GANESH SAHA  
Signature: [Signature]  
Date: March 26/13  
Applus VELOSI  
Velos America LLC



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

REPORT NUMBER 72565

DATE 3/8/2013

FCI ORDER NUMBER 59720

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

CUSTOMER ORDER NUMBER 13-0206  
SOLD/SHIPPED TO ALL-WELD CO., LTD.  
49 PASSMORE AVE.

SCARBOROUGH ONT MIV 4T1 CANADA

Item	Quantity	Description
1	2	FORGINGS SUFFICIENT TO FINISH TO 6" OD X 5" LG

HEAT NUMBER:  
W150

MATERIAL TYPE:  
SA350LF2CL1

Material Origin: USA  
Manufactured in USA

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

CHEMICAL ANALYSIS

PHYSICAL PROPERTIES

C	.190
Mn	1.130
P	.0110
S	.0030
Si	.180
Cr	.090
Mo	.020
V	.005
Cu	.220
Ni	.070
Cb	.001
N	.0050
Sn	.008
As	.005
Sb	.000
Ti	.0010
Al	.024
B	#Type1
CE	.42

Yield PSI	47,800
Tensile PSI	72,900
Elongation	38.9
Reduction of Area	68.2
Hardness	137/137 HBW
CVN @ -51 °F FT LBS	73/78/70
% Shear	40/40/40
MLE	.064/.066/.061

PART HARDNESS (HBW): 143/143

LIMITS OF UNSPECIFIED ELEMENTS PER ASME SECTION II (SA-20)  
CU + Ni + CR + MO = .4  
CR + MO = .11

Q.C.I. N.D.

MAR 13 2013

Certification of Material - Per ASME  
IIT# W150  
Qualifies to all requirements of  
SA350-LF2CL1 per  
Sect. II 10 Edition 11 Addenda

Q.C.I. E.Y.

MAR 13 2013

Heat Treatment NORMALIZED  
Temperature 1650 °F  
Time at Temperature 1/2 HR/IN THK MIN  
Cooling Media AIR

W.O. # 11760  
M.L. # 13(8/2)  
THK. # 6.0  
P.O. # 13-0206

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: SAM off shore  
Print Name: U A NISH SAHA  
Signature: [Signature]  
Date: March 14/13  
Applus® VELOSI  
Velosi America LLC





# QUALITY PLATES & PROFILES LIMITED

20 Nicholas Ave Road, R.R.#3 (Aberfoyle), Guelph, ON N1H 6H9  
 ALL-WELD COMPANY LIMITED  
 PO/Rel: 13-0220  
 PLATE CPL 516N 1-1/2" x DWG# 1176-2-14 TAG 1176-16

**Certificate of Mill Test Results**  
 Inv: 1055184 Date: 03/19/2013  
 Contact: HELENE/BRIAN  
 Heat: 2138P3



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

0006053

SO No, Item & Date:	406001 000100 2012/12/13	Shipment No. & Date:	1000027/69 2012/12/31
Sold to Customer Name and Address:	CANADIAN PLATE AND PROFILES IN KAMATO ROAD 920 MISSISSAUGA, Ontario, Canada L4W 2T6	Ship to Customer Name and Address:	CANADIAN PLATE AND PROFILES IN KAMATO ROAD 920 MISSISSAUGA, Ontario, Canada L4W 2T6
TC No., Date & Time:	FSA-38154 2013/01/03 - 11:42:10	Customer PO No./Item:	19025-STK / 10
		BOL NO.:	1000022769
		Carrier:	INTERNATIONAL FREIGHT SYSTEMS

Customer Specification: HR STEEL PLATE Carbon Multi Cert ASME SA516 GR 70 (10) ASME SA516 GR 70 (11A) Minus HAZ CRACKING, NACE MR 0175 latest Ed., NACE MR 0175 latest Ed., BHN < 200, Calcium Treated for Sulphide Stress Cracking Resistance, Temp 1670 °F 30 min per inch CVNL Req 157 12 FT-LBP at 0-50 0 F-Sld Thickness Tol PVQ Top and Bottom Standard Surface Flatness 1/2 ASD Fine Grain Ind. Vol. 10, 160 Repair

Supplementary instructions: Test Cert 1 drafting@canadianplate.com Test Cert 2: 905-206-1370

Insp T/R: Test Report As Per Spec

Curt Use: PVC

ESSAR STEEL ALGOMA INC. HEREBY CERTIFIES THAT THE MATERIAL HEREIN DESCRIBED WAS MADE AND TESTED IN ACCORDANCE WITH THE RULES OF THE SPECIFICATION(S) SHOWN. ALL RESULTS ARE RETAINED IN ACCORDANCE WITH THE COMPANY'S STANDARD RECORD KEEPING PRACTICES. THIS MILL TEST REPORT MAY NOT BE REPRODUCED EXCEPT BY FULL WRITTEN APPROVAL OF ESSAR STEEL ALGOMA INC. IF YOU RECEIVE THIS DOCUMENT AND ARE NOT THE INTENDED RECEIVER, PLEASE CALL 705-945-4005 FOR INSTRUCTIONS ON METHOD OF DISPOSAL OF DOCUMENT.

FOR THE MOST UP TO DATE ENVIRONMENTAL CERTIFICATES, VISIT US AT WWW.ESSARSTEELALGOMA.COM

ALL HEATS FULLY DELIVERED  
 HEATS INDICATED WITH \* FULL GRAIN OR  
 HEATS INDICATED WITH # FULL GRAIN STEEL

Dimensions (L x W x L)	Batch No.	Heat No.-AS	Quantity	Pcs
2138P3	2138P3	2138P3	24,000 (1)	1

Heat No. (wt%)	C	Mn	P	S	Si	Cr	Ni	Cu	Mo	Al	Rb	V	Ti	DO
2138P3	0.02	0.004	0.012	0.004	0.320	0.02	0.15	0.03	0.00	0.026	0.000	0.014	0.0003	0.0002

Hardness Tests	Heat No.	Batch No.	SRCE	LAB	GAUGE	COND	LOC	MTHD	HARDNESS
	2138P3	AR6713	166	ALG	15000	NORM B	HBW	151	

Impact Tests	Heat No.	Batch No.	SRCE	LAB	GAUGE	COND	METH	DIR	LOC	SIZE	TEMP(F)	ENERGY (ft-lb)	AVG(ft-lb)
	2138P3	AB6713	166	ALG	15000	NORM CVT	L	R	FULL	50	41	64	62

MECHANICAL PROPERTIES

**LIMITS OF UNSPECIFIED ELEMENTS PER ASME SECTION II (SA-20) CU + Ni + CR + MO = .02**

**Q.C. N.D.**

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

**APR 03 2013**

**2138P3-54**

**SA 516 GR 70**

**per Addendum 11**

**Section II**

**ASME**

**Qualifies to all requirements of**

**per**

**279**

**Velocity America**

**Don Lund**

**APR 11 2013**

**MANAGER METALLURGICAL SERVICES**

**K. UGHADPAGA**

**MILL TEST REPORTS APPROVED BY Q.C. P.O.**

**MAR 27 2013**

**DATE: 2013/01/03 Time: 11:42:10 Page No: 1 of 2**



# QUALITY PLATES & PROFILES LIMITED

20 Nicholas Eber Road, R.R.#3 (Aberfoyle), Guelph, ON N1H 6H9  
 ALL-WELD COMPANY LIMITED PO/Rel: 13-0220  
 PLATE CPL 516N 1-1/2" x DWG# 1176-2-14 TAG 1176-16

# Certificate of Mill Test Results

Contact: HELENE/BRIAN  
 Inv: I055184 Date: 03/19/2013  
 Heat: 2138P3

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



SO No. Item & Date: 8006691 000100 2012/12/12	Shipment No. & Date: 1000022769 2012/12/31	TC No., Date & Time: FSA-38154 2013/01/03 - 11:42:10
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: 19025-STK 710 BOL. NO.: 1000022769 Cust. Part No: INTERNATIONAL FREIGHT SYSTEMS -
Customer Specification: HR STEEL PLATE Carbon Multi Cert ASTM A516 GR 70 (110) / ASME SA516 GR 70 (11A) Wheels NACE MR 0175 latest Ed., Blk < 200, Calcium Treated for Sulphide Stress Cracking Control Normalized Temp 1670 °F, 30 min per inch CVNL Req 15.7 12 FT-LBF at 0.50 0" Sid Thickness Tol PVC Top and Bottom Standard Surface Finish 1/2 A20 Fine Grain Fully Killed No Weld Repair		
Supplementary Instructions: Test Cert 1:dratring@canadianplate.com Test Cert 2:505-206-1370		
Insp T/R: Test Report As Per Spec		Cust Use: PVO
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 TRAINED IN ACCORDANCE WITH THE COMPANY'S STANDARD RECORD KEEPING PRACTICES. THIS MILL TEST REPORT MAY NOT BE REPRODUCED WITHOUT THE WRITTEN APPROVAL OF ESSAR STEEL ALGOMA INC. IF YOU RECEIVE THIS DOCUMENT AND ARE NOT THE INTENDED RECEIVER PLEASE CALL (705) 944-4995 FOR INSTRUCTIONS ON METHOD OF DISPOSAL OF DOCUMENT.		
MATERIAL INFORMATION TYPE 31 EQUALITY AND ENVIRONMENTAL CERTIFICATES AVAILABLE AT WWW.ESSARSTEELALGOMA.COM . . . . . MECHANICAL PROPERTIES . . . . .		
Tensile Tests		
Heat No	SRCE LAB GAUGE COND METH DIR LOC YIELD(KSI) TENSILE(KSI) EL SCALE	ELONG(%)
2138P3	100' AIG 1500U NDHM 2 T H 49.9 76.0 2'	30

Q.C.I.  
E.Y.

APR 03 2013

Q.C.I.  
N.D.

Velosi America

MAR 27 2013

279  
March 1, 2013

K. UGHADPAGA  
 MANAGER METALLURGICAL SERVICES

# QUALITY PLATES & PROFILES LIMITED

20 Nicholas Eber Road, R.R.#3 (Aberfoyle), Guelph, ON N1H 6H9  
 ALL-WELD COMPANY LIMITED  
 PO/Rel: 13-0220  
 TAG 1176-17

# Certificate of Mill Test Results

Contact: HELENE/BRIAN  
 Inv: 1055184  
 Date: 03/19/2013  
 Heat: 8888L

## ESSAR Steel Algoma Inc.

105 West St., Sault Ste. Marie, Ontario, Canada, P6A 7B4  
 0005097  
 CUSTOMER PURCHASE ORDER NUMBER: P005643  
 ENTRY DATE: 2011/08/29  
 CREATE DATE: 2011/10/17  
 TALLY NUMBER: 246425  
 SHIPPERS NUMBER: -  
 CARRIER: W.J. DEANS TRANSPORTATION -2221 A/B  
 MILL ORDER: 10816

CHARGE TO CUSTOMER NAME & ADDRESS: QUALITY PLATES & PROFILES LTD  
 20 NICHOLAS BEAVER ROAD RR#3  
 ABERFOYLE, ON N1H 6H9

SHIP TO CUSTOMER NAME & ADDRESS: QUALITY PLATES & PROFILES LTD  
 20 NICHOLAS BEAVER ROAD  
 RR#3  
 ABERFOYLE, ON

CUSTOMER SPECIFICATION: HR PLATE - CARBON - ASME SA516 GR 70 (10) - CVNL 15/12 FT LBS AT -50 F - C.23  
 MAX, DO CE 0.43 MAX, V 0.02% MAX, NB 0.02% MAX, V+NB 0.03% MAX - FINE GRAIN  
 - MEETS ASME SECTION II LATEST ADDENDA - PVQ - NORMALIZED - FLATNESS 1/2 A-20

### SUPPLEMENTARY INSTRUCTIONS

TEST CERT 1: MICHELLE CRAVEIRO 519-837-2227 TEST CERT 2: PLAT  
 E TEST COUPON:  
 K. UGHADPAGA  
 MANAGER METALLURGICAL SERVICES  
 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)945-2424 COLLECT FOR INSTRUCTIONS ON METHOD OF DISPOSAL OF DOCUMENT.

INSN/T/R TEST REPORTS REQUIRED  
 CUST USE RESALE  
 2000200546 PF  
 2011/10/17 18:27

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

CUSTOMER ITEM 00001 OUR ITEM 002 DIMENSIONS .250 X 96 X 288"  
 S H I P P E D  
 Vessel America  
 279  
 Q.C.I. N.D.  
 Q.C.I. E.Y.  
 APPROVED BY Q.C.  
 P.O. \_\_\_\_\_  
 APR 13 2013

PLATE NUMBER	HEAT-MS	PIECES	NO. WEIGHT
8888L-04	8888L-04	3	5880
38621	8888L-04	3	5880
38623	8888L-04	3	5880
38625	8888L-04	3	5880

PLATE NUMBER	YIELD KSI	TENSILE KSI	% ELONG
8888L	54.0	74.0	26 (8")
38621	51.0	74.0	24 (8")
38623	53.2	74.4	26 (8")
38625	54.2	74.4	25 (8")
8888L	54.0	74.4	27 (8")
38627	54.4	75.0	25 (8")

### \*\*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 CHEMICAL 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.



# Certificate of Mill Test Results

# QUALITY PLATES & PROFILES LIMITED

20 Nicholas Laver Road, R.R.#3 (Aberfoyle), Guelph, ON N1H 6H9  
 ALL-WELD COMPANY LIMITED  
 PO/Rel: 13-0220  
 TAG-1176-17

Contact: HELENE/BRIAN  
 Inv: 1055184 Date: 03/19/2013  
 Heat: 8888L

**ESSAR Steel Algoma Inc.** 105 West St., Sault Ste. Marie, Ontario, Canada, P6A 7B4

CUSTOMER PURCHASE ORDER NUMBER <b>P005643</b>	ENTRY DATE 2011/08/29	CREATE DATE 2011/10/17	TALLY NUMBER 246425	SHIPPERS NUMBER -	CARRIER W.J. DEANS	TRANSPORTATION -2221	A/B A/B	MILL ORDER 10816
--	--------------------------	---------------------------	------------------------	----------------------	-----------------------	-------------------------	------------	---------------------

SHIP TO CUSTOMER NAME & ADDRESS  
 QUALITY PLATES & PROFILES LTD  
 20 NICHOLAS BEAVER ROAD RR#3  
 ABERFOYLE, ON N1H 6H9

SHIP TO CUSTOMER NAME & ADDRESS  
 QUALITY PLATES & PROFILES LTD  
 20 NICHOLAS BEAVER ROAD RR#3  
 ABERFOYLE, ON

CUSTOMER SPECIFICATION  
 HR PLATE - ASME SA516 GR 70 (10) - CVNL 15/12 FT LBS AT - 50 F - C .23  
 MAX, DO CE 0.43 MAX, V 0.02% MAX, NB 0.02% MAX, V+NB 0.03% MAX - FINE GRAIN  
 - MEETS ASME SECTION II LASTEST ADDENDA - PVQ - NORMALIZED - FLATNESS 1/2 A-20

SUPPLEMENTARY INSTRUCTIONS  
 TEST CERT 1: MICHELLE CRAVEIRO 519-837-2227 TEST CERT 2: PLAT  
 E TEST COUPON:  
 2000200546 PF  
 2011/10/17 18:27

TEST REPORTS REQUIRED  
 RESALE

HEAT	PLATE NUMBER	SRCE	GAUGE IN	COND	METH	TEST DIR	SIZE	TEMP	FULLSIZE	ENERGY	AVG
8888L	38621	166"	2500	N	CVN	L	1/2	-50F	104	112	110
8888L	38622	166"	2500	N	CVN	L	1/2	-50F	73	68	90
8888L	38623	166"	2500	N	CVN	L	1/2	-50F	100	76	87
8888L	38624	166"	2500	N	CVN	L	1/2	-50F	76	68	109
8888L	38625	166"	2500	N	CVN	L	1/2	-50F	66	63	70
8888L	38627	166"	2500	N	CVN	L	1/2	-50F	66	63	70

IMPACT TESTS:  
 HEAT (WT %)  
 8888L\*+ C 1.19 1.08 .011 .007 .31 .02 .02 .03 .01 .044 .000 .001 .0002 .38

W.O. # 1176  
 M.L. # 17 (11219151713)  
 THK. # 6 264  
 P.O. # 13-0220

Q.C.I. E.Y.  
 Q.C.I. N.D.  
 APR 3 2013

Valspar America  
 279  
 2013

LIMITS OF UNSPECIFIED ELEMENTS PER ASME SECTION II (SA-20)  
 CR + Ni + CR + MO = 0.08  
 CR + MO = 0.03

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 CHEMICAL 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.

\*\*WARNING\*\*

PAGE 2 OF 2



# Cambridge materials testing limited

1177 Franklin Boulevard,  
Cambridge, Ontario N1R 7W4  
Tel: (519) 621-6600 Fax: (519) 621-6082  
www.cambridgematerials.com

ISO17025 Accredited

Report for: Quality Plates & Profiles Ltd.  
20 Nicholas Beaver Road  
R. R. # 3  
ABERFOYLE, Ontario  
N1H 6H9  
Phone: 1-800-268-2853  
Fax: 1-519-837-2224

Laboratory No. 598087-2012

Report Date: January 24, 2012  
Received Date: January 19, 2012

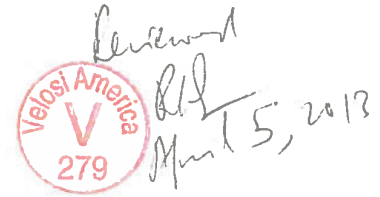
Customer P.O.#: P006311

Attention: Dave Braga

Specimen: Material: ASME SA516 - 70 Normalized ✓  
.25" Thick x 3" x 3", Algoma Heat # 8888L-38625

## ROCKWELL HARDNESS TEST REPORT

80,79,79 HRBW



NACE MR0175/ISO 15156-2 (A.2.1.2) Rockwell Hardness Requirement:  
22 HRC maximum

Conclusion: Pass

Testing performed according to  
NACE MR0175/ISO 15156-2:2009/Cir.1:2011(E), ISO 6508-1:1999(E),  
ASME Boiler and Pressure Vessel Code Section II, Part A, SA-370  
(2010 Edition, 2011 Addenda) and ASTM E18-08b.



APR 03 2013

Page 1 of 1

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

Per R. D. Ball  
Quality Assurance

Per Matthew Links  
Technician

# **CANPRESS METAL FABRICATORS INC.**

1610 Feldspar Court, Pickering, Ontario, L1W 3R7, CANADA

tel. (905) 831-2882 fax (905) 831-2880

<http://www.canpressmetalfab.com>

e-mail: [info@canpressmetalfab.com](mailto:info@canpressmetalfab.com)

## Certificate Of Compliance

Customer: All-Weld

Date: March 12/13

Attn: Quality Control

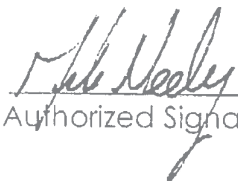
Purchase Order: 13-0209

Work Order #9913

Material SA 516-70N Impact Tested -20 degree min.

Item #1176-19 Qty 2 3/4" x 61 3/4" ID x 25" Long

We hereby certify that these shells conform to the above description and that they were cold formed to A.S.M.E. Code section VIII division 1 latest edition and latest addenda including UG 79 and were not post formed heat treated.

  
Authorized Signature

Inspection certificate 3.1 / DIN EN 10204 (A02)		No. (A03) 761758
		Page 2/11
		Date 10.07.2012
No (A07) 9381	20.04.2012	No (A07)
Purchaser (A06) Olbert Metal Sales Limited MISSISSAUGA, ONT. L5T 2J8 KANADA	Customer (A06) Olbert Metal Sales Limited MISSISSAUGA, ONT. L5T 2J8 KANADA	
Product (B01) Heavy plate	Works order No. (A08) 0000059029	
Steel grade and terms of delivery (B02-B03) SA 516 Gr. 70 MTLTV ASME sect. II part A ed. 2010, add. 2011 ASME SA 20, SA 516 ASTM A 20 -10, A 516 -10 PO 9381	Inspection (A05) WS	

**Material data (B01-B99)**

Item	Quantity (B08)	Product No (B07)	Heat No (B07)	Cond. of delivery (B04)	Thickness x Width x Length (B09-B11)	in x in x in
05	1	283937	1	22644	N	0,562 x 120,000 x 480,000
06	1	283932	1	74313	N	0,625 x 120,000 x 480,000
06	1	283933	1	74313	N	0,625 x 120,000 x 480,000
06	1	283934	1	74313	N	0,625 x 120,000 x 480,000
06	1	283935	1	74313	N	0,625 x 120,000 x 480,000
07	1	289030	1	23206	N	0,750 x 120,000 x 480,000
07	1	289031	1	23206	N	0,750 x 120,000 x 480,000
07	1	289032	1	23206	N	0,750 x 120,000 x 480,000
07	1	289033	1	23206	N	0,750 x 120,000 x 480,000
07	1	289034	1	23206	N	0,750 x 120,000 x 480,000
07	1	289035	1	23206	N	0,750 x 120,000 x 480,000
08	1	288317	1	22059	N	1,000 x 120,000 x 480,000
08	1	288318	1	22058	N	1,000 x 120,000 x 480,000
08	1	289041	1	23206	N	1,000 x 120,000 x 480,000
08	1	289042	1	23206	N	1,000 x 120,000 x 480,000
08	1	289043	1	23206	N	1,000 x 120,000 x 480,000
08	1	289649	1	23206	N	1,000 x 120,000 x 480,000
09	1	284096	1	22058	N	1,250 x 120,000 x 480,000
09	1	286958	1	21795	N	1,250 x 120,000 x 480,000
10	1	284095	1	22058	N	1,500 x 120,000 x 480,000
10	1	286956	1	21795	N	1,500 x 120,000 x 480,000
12	1	282733	1	22059	N	2,250 x 120,000 x 288,000
12	1	282734	1	22059	N	2,250 x 120,000 x 288,000
14	1	286430	1	44491	N	2,750 x 120,000 x 288,000
14	1	286959	1	21795	N	2,750 x 120,000 x 288,000
15	1	282730	1	22059	N	3,000 x 120,000 x 242,000
15	1	282731	1	22059	N	3,000 x 120,000 x 242,000
16	1	286587	1	22910	N	3,250 x 102,000 x 242,000
17	1	286589	1	22910	N	3,500 x 102,000 x 242,000
17	1	286590	1	22910	N	3,500 x 102,000 x 242,000
18	1	286559	1	22577	N	3,750 x 102,000 x 182,000
18	1	286560	1	16412	N	3,750 x 102,000 x 182,000
19	1	286577	1	22910	N	4,000 x 102,000 x 178,071
19	1	286578	1	22910	N	4,000 x 102,000 x 169,291
20	1	286576	1	22910	N	4,250 x 102,000 x 182,000
21	1	286573	1	22910	N	4,500 x 102,000 x 182,000
21	1	286574	1	22910	N	4,500 x 102,000 x 182,000

ACCU-1 (REVIEWED/RELEASED)  
 for and on behalf of: *S.P.M. off shore*  
 Print Name: *Yves Sale*  
 Signature: *[Signature]*  
 Date: *March 14/13*  
**APPLUS**  
**VELOSI**  
 Velosi America LLC

Q.C.I.  
N.D.

Q.C.I.  
E.Y.

N normalized

MAR 13 2013

 We hereby certify that the delivered material complies with the terms of the order  
 (Z01)

QM-System Certification as per ISO 9001 since 28 February 1990


 Trademark  
 (A04)

 Ilsenburger Grobblech GmbH  
 Veckenstedter Weg 10  
 D-38871 Ilsenburg  
 (A01)


 Inspection Stamp  
 (Z03)

 Inspection Representative  
 (Z02)

Cyron



**Inspection certificate 3.1**  
DIN EN 10204 (A02)

No. (A03) 761758  
Page 4/11  
Date 10.07.2012

No (A07) 9381 20.04.2012 No (A07)  
Purchaser Olbert Metal Sales Limited Customer Olbert Metal Sales Limited  
(A06) MISSISSAUGA, ONT. L5T 2J8 (A06) MISSISSAUGA, ONT. L5T 2J8  
KANADA KANADA

Product Heavy plate  
(B01)

Works order No 0000059029  
(A08)

Steel grade and terms of delivery SA 516 Gr. 70 MTLIV  
(B02-B03) ASME sect. II part A ed. 2010, add. 2011  
ASME SA 20, SA 516  
ASTM A 20 -10, A 516 -10  
PO 9381

Inspection WS  
(A05)

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SBM offshore 046

Print Name: GAORISH SANA  
Signature: [Signature]  
Date: March 11/13

**Ladle analysis (C70-C99)**  
Manufacturer standard

Heat No (B07)	C %	Si % 0,15 - 0,40	Mn % 0,85 - 1,50	P % ≤ 0,015	S % ≤ 0,005	N %	Al % ≥ 0,020	Cu % ≤ 0,40	Cr % ≤ 0,30	Ni % ≤ 0,40
22058	0,20	0,25	1,15	0,013	0,002	0,003	0,047	0,03	0,04	0,04
22059	0,21	0,25	1,18	0,010	0,002	0,003	0,043	0,02	0,03	0,04
22577	0,17	0,20	1,43	0,011	0,001	0,004	0,033	0,03	0,04	0,03
22644	0,17	0,36	1,14	0,014	0,001	0,004	0,053	0,03	0,03	0,17
22910	0,17	0,21	1,48	0,012	0,001	0,003	0,032	0,02	0,03	0,03
23206	0,19	0,24	1,14	0,015	0,001	0,004	0,049	0,03	0,04	0,04
44491	0,19	0,25	1,14	0,007	0,002	0,005	0,036	0,01	0,02	0,03
74313	0,15	0,33	1,16	0,013	0,001	0,005	0,046	0,01	0,03	0,17

Heat No (B07)	Mo % ≤ 0,12	V % ≤ 0,03	Ti % ≤ 0,03	Nb % ≤ 0,02	B % ≤ 0,001	Ca %	EV1 1) % ≤ 0,45	Nb+V % ≤ 0,33	EV2 2) %
22058	0,01	0,003	0,003	0,02	0,0002	0,001	0,41	0,02	0,03
22059	0,003	0,003	0,003	0,02	0,0002	0,001	0,42	0,02	0,03
22577	0,004	0,01	0,002	0,02	0,000	0,001	0,42	0,03	0,03
22644	0,004	0,004	0,004	0,02	0,000	0,002	0,38	0,02	0,03
22910	0,003	0,003	0,002	0,02	0,0001	0,001	0,43	0,02	0,03
23206	0,003	0,003	0,01	0,02	0,0001	0,001	0,39	0,02	0,03
44491	0,002	0,003	0,003	0,02	0,0002	0,001	0,39	0,02	0,03
74313	0,003	0,004	0,004	0,02	0,0004	0,001	0,36	0,02	0,03

1) EV1 CEV=C+Mn/6+Mo/5+Ni/15+Cr/5+V/5+Cu/15  
2) EV2 V+Nb+Ti

Steel making: Basic oxygen process (C70)

Material is vacuum degassed

Fully killed and fine grained steel produced with shape control

Ca- treated

**LIMITS OF UNSPECIFIED ELEMENTS PER ASME SECTION II (SA-20)**  
CU + Ni + CR + MO = 0,13  
CR+MO = 0,043

Q.C.I.  
N.D.

W.O. # 11760  
M.L. # 18 (13)  
THK. # 760  
P.O. # 13-0207

Q.C.I.  
E.Y.

Certification of Material - Per ASM  
HT# 23206-1-28903  
Qualifies to all requirements of  
SASIE-CARTON p  
Sect. II 10 Edition 11 Adden

MAR 13 2013

We hereby certify that the delivered material complies with the terms of the order (Z01)  
QM-System: Certification as per ISO 9001 since 28 February 1990

Trademark (A04)

Isenburger Grobblech GmbH  
Veckenstedter Weg 10  
D-38871 Isenburg  
(A01)

Inspection Stamp (Z03)

[Signature]

Inspection Representative (Z02)

Cyron

**Inspection certificate 3.1**  
DIN EN 10204

No. (A07) 9381      20.04.2012      No (A07)      761758  
 Purchase: Olbert Metal Sales Limited      Customer: Olbert Metal Sales Limited      Page: 6/11  
 (A06) MISSISSAUGA, ONT. L5T 2J8      (A06) MISSISSAUGA, ONT. L5T 2J8      Date: 10.07.2012  
 KANADA      KANADA

Product: Heavy plate      Works order No: 0000059029  
 (B01)

Steel grade and terms of delivery: SA 516 Gr. 70 MTH.V  
 (B02-B03) ASME sect. II part A ed.2010, add.2011  
 ASME SA 20, SA 516  
 ASTM A 20 -10, A 516 -10  
 PO 9381      Inspection: WS  
 (A05)

**Tensile test (C10-C29)**

Specimen No (C00)	Heat No (B37)	Location (C01)		Direct (C02)	Cond (B05)	Type (C10)	Yield strength (C11) Rp0,2 N/mm2 ≥ 260	Tensile strength (C12) Rm N/mm2 485 - 620	Elongation (C13) 8 in %	Elongation (C13) 2 in %
		1) 2) 3)	4)							
286577	22910	K6V	Q	Q	N	C	313	514		
286578	22910	K6V	Q	Q	N	C	321	509		39
286587	22910	K6V	Q	Q	N	C	339	515		36
286589	22910	K6V	Q	Q	N	C	327	513		39
286590	22910	K6V	Q	Q	N	C	319	513		41
286889	74313	K6G	Q	Q	N	P	390	518	23	37
286956	21795	K6G	Q	Q	N	P	352	523	28	
286958	21795	K6G	Q	Q	N	P	354	527	27	
286959	21795	K6V	Q	Q	N	C	340	514		
287048	20870	K6G	Q	Q	N	P	416	535	24	39
288317	22059	K6G	Q	Q	N	P	350	528	24	
288318	22058	K6G	Q	Q	N	P	340	527	26	
289030	23206	K6G	Q	Q	N	P	360	522	29	
289031	23206	K6G	Q	Q	N	P	360	522	28	
289032	23206	K6G	Q	Q	N	P	365	523	28	
289033	23206	K6G	Q	Q	N	P	363	525	29	
289034	23206	K6G	Q	Q	N	P	366	522	28	
289035	23206	K6G	Q	Q	N	P	371	528	27	
289041	23206	K6G	Q	Q	N	P	356	521	29	
289042	23206	K6G	Q	Q	N	P	351	520	27	
289043	23206	K6G	Q	Q	N	P	359	523	29	
289649	23206	K6G	Q	Q	N	P	357	523	24	

1) K Top  
 2) 6 1/6 Width  
 3) G Thickness of product  
 V 1/4 Thickness

4) Q transversal  
 5) N normalized  
 6) C cylndric  
 P: or smatic

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: S.B.H. Off Shore  
 Print Name: G. A. WESLI SAHA  
 Signature: [Signature]  
 Date: MARCH 14/13  
 046  
**Applus® VELOSI**  
 Velosi America LLC

Q.C.I.  
N.D.

Q.C.I.  
E.Y.

MAR 13 2013

We hereby certify that the delivered material complies with the terms of the order.  
 (Z01)  
 QM-System Certification as per ISO 9001 since 28 February 1990



Ilseburger Grobblech GmbH  
 Veckenstedter Weg 10  
 D-38871 Ilseburg  
 (A01)

Inspection Stamp (Z03)  
 [Signature]

Inspection Representative (Z02)

Cyron

**Inspection certificate 3.1**  
DIN EN 10204 (A02)

No (A03) 761758  
Page 8/11  
Date 10.07.2012

No (A07) 9381 20.04.2012 No (A07)  
Purchaser Olbert Metal Sales Limited Customer Olbert Metal Sales Limited  
(A06) MISSISSAUGA, ONT. L5T 2J8 (A06) MISSISSAUGA, ONT. L5T 2J8  
KANADA KANADA

Product Heavy plate Works order No: 0000059029  
(B01) (A08)

Steel grade and terms of delivery SA 516 Gr. 70 MTLTV Inspection: WS  
(B02-B03) ASME sect. II part A ed.2010, add.2011 (A05)  
ASME SA 20, SA 516  
ASTM A 20 -10, A 516 -10  
PO 9381

**Impact test (C40-C49)**

Specimen No (C00)	Heat No (B07)	Location (C01)	Direct (C02)		Cond (B05)	Type of specimen (C40-C41)	Temperature (C03) °F	Impact energy (C42-C43)			
			1) 2) 3)	4)				5)	1 ftlbf	2	3
286578	22910	K6V	L	N	N	Charpy V-notch	-051	65	131	144	114
286587	22910	K6V	L	N	N	Charpy V-notch	-051	127	41	119	96
286589	22910	K6V	L	N	N	Charpy V-notch	-051	125	122	116	121
286590	22910	K6V	L	N	N	Charpy V-notch	-051	45	124	119	96
286889	74313	K60	L	N	N	Charpy V-notch	-051	75	75	44	65
286956	21795	K6V	L	N	N	Charpy V-notch	-051	50	78	61	63
286958	21795	K6V	L	N	N	Charpy V-notch	-051	107	87	72	89
286959	21795	K6V	L	N	N	Charpy V-notch	-051	56	71	34	54
287048	20870	K60	L	N	N	Charpy V-notch	-051	76	83	50	69
288317	22059	K6V	L	N	N	Charpy V-notch	-051	78	49	95	74
288318	22058	K6V	L	N	N	Charpy V-notch	-051	27	83	47	52
289030	23206	K6V	L	N	N	Charpy V-notch	-051	100	63	106	89
289031	23206	K6V	L	N	N	Charpy V-notch	-051	92	74	46	71
289032	23206	K6V	L	N	N	Charpy V-notch	-051	66	77	66	70
289033	23206	K6V	L	N	N	Charpy V-notch	-051	72	58	30	53
289034	23206	K6V	L	N	N	Charpy V-notch	-051	82	97	91	90
289035	23206	K6V	L	N	N	Charpy V-notch	-051	67	34	86	63
289041	23206	K6V	L	N	N	Charpy V-notch	-051	106	91	70	89
289042	23206	K6V	L	N	N	Charpy V-notch	-051	74	118	74	89
289043	23206	K6V	L	N	N	Charpy V-notch	-051	79	20	86	62
289649	23206	K6V	L	N	N	Charpy V-notch	-051	72	80	67	73

1) K Top  
2) 5 1/6 Width  
3) 0 near surface  
V 1/4 Thickness

4) L longitudinal  
5) N normalized  
6) MW Average

Specimen size:  
5,0 x 10 x 55 mm (from 5,00 mm up to 8,99 mm plate thickness)  
7,5 x 10 x 55 mm (from 9,00 mm to 11,99 mm plate thickness)  
10 x 10 x 55 mm (from 12,00 mm plate thickness)

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: S.B.M. off-shore  
Print Name: LIAMONSHI SAHA  
Signature: [Signature]  
Date: March 14/13

046  
Q.C.I.  
E.Y.  
Applus  
VELOSI  
Velosi America LLC  
MAR 13 2013  
Q.C.I.  
N.D.

We hereby certify that the delivered material complies with the terms of the order.  
(Z01)

QM-System, Certification as per ISO 9001 since 28 February 1990

Trademark  
(A04)

Ilsenburger Grobblech GmbH  
Vackenstedter Weg 10  
D-38871 Ilsenburg  
(A01)

Inspection Stamp  
(Z03)

Inspection Representative  
(Z02)

Cyron

<b>Inspection certificate 3.1</b>		No. (A03)	761758
<b>DIN EN 10204</b>		Page	10/11
(A02)		Date	10.07.2012
No. (A07)	9381	20.04.2012	No. (A07)
Purchaser (A06)	Olbert Metal Sales Limited MISSISSAUGA, ONT. L5T 2J8 KANADA	Customer (A06)	Olbert Metal Sales Limited MISSISSAUGA, ONT. L5T 2J8 KANADA
Product (B01)	Heavy plate	Works order No. (A03)	0000059029
Steel grade and terms of delivery (B02-B03)	SA 516 Gr. 70 MTLTV ASME sect. II part A ed.2010, add.2011 ASME SA 20, SA 516 ASTM A 20 -10, A 516 -10 PO 9381	Inspection (A05)	WS

**Other tests (C50-C69)**

Specimen No (C00)	Heat No (B07)	Location (C01)	Direct. (C02)	Cond (B05)	Hardness test (C30-C39)			
		1) 2) 3)	4)	5)	HB30 ≤ 199			
286589	22910	K6		N	152			
286590	22910	K6		N	153			
286889	74313	K6		N	156			
286956	21795	K6		N	156			
286958	21795	K6		N	157			
286959	21795	K6		N	152			
287048	20870	K6		N	158			
288317	22059	K6		N	155			
288318	22058	K6		N	155			
289030	23206	K6		N	155			
289031	23206	K6		N	154			
289032	23206	K6		N	156			
289033	23206	K6		N	156			
289034	23206	K6		N	155			
289035	23206	K6		N	158			
289041	23206	K6		N	155			
289042	23206	K6		N	153			
289043	23206	K6		N	155			
289649	23206	K6		N	156			

1) K Top  
2) 6 1/8 Width  
5) N: normalized

Our products are free of radioactive substances and do not exceed the clearing limit value of 100 Bq/kg, which guarantees the compliance with limit values given in the Radiation Protection Ordinance (StrlSchV) for the unrestricted clearance of solid material (StrlSchV Annex III, Section 5) for ferrous nuclides.

Heat treatment: Temperature : 910 +/-10°C  
Soaking time: 30 min/inch  
Cooling in still air

NACE MR-0103 (2.1.1-2.1.4) - 2010  
NACE MP-0175 2003

no weld repair

Melted and manufactured in Germany

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

**MAR 13 2013**

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: *SBM OFFICE*

Print Name: *C. A. VELSI SILVA*


Signature: *[Signature]*

Date: *March 13*

**App**  
**Velosi A**

We hereby certify that the delivered material complies with the terms of the order (Z01)

DM - System Certification as per ISO 9001 since 28 February 1990

 Trademark (A04)

Ilseburger Grobblech GmbH  
Vackenstedter Weg 10  
D-38871 Ilseburg  
(A01)

**Aj** Inspection Stamp (Z03)

Inspection Representative (Z02)  
*[Signature]*  
Cyron





**Inspection certificate 3.1**  
**DIN EN 10204**  
 (A02)

No. (A03) 761758  
 Page 1/11  
 Date 10.07.2012

No (A07) 9381 20.04.2012 No (A07)  
 Purchaser Olbert Metal Sales Limited Customer Olbert Metal Sales Limited  
 (A06) MISSISSAUGA, ONT. L5T 2J8 (A06) MISSISSAUGA, ONT. L5T 2J8  
 KANADA KANADA

Product Heavy plate Works order No 0000059029  
 (B01) (A08)

Steel grade and terms of delivery SA 516 Gr. 70 MTLTV Inspection WS  
 (B02-B03) ASME sect. II part A ed.2010, add.2011 (A05)  
 ASME SA 20, SA 516  
 ASTM A 20 -10, A 516 -10  
 PO 9381

Marking of the product (B06)  
 Trademark/Steelgrade/Heat-No/Product-No/  
 inspector's stamp

**Material data (B01-B99)**

Item	Quantity (B08)	Product No (B07)	Heat No (B07)	Cond of delivery (B04)	Thickness x Width x Length (B09-B11)	in x in x in
01	1	282780 1	22644	N	0,250 x 120,000 x 480,000	
01	1	282783 1	22644	N	0,250 x 120,000 x 480,000	
01	1	282783 2	22644	N	0,250 x 120,000 x 480,000	
01	1	283904 1	22644	N	0,250 x 120,000 x 480,000	
01	1	283904 2	22644	N	0,250 x 120,000 x 480,000	
01	1	286889 1	74313	N	0,250 x 120,000 x 480,000	
01	1	286889 2	74313	N	0,250 x 120,000 x 480,000	
01	1	287048 1	20870	N	0,250 x 120,000 x 480,000	
02	1	283899 1	22644	N	0,312 x 120,000 x 480,000	
02	1	283899 2	22644	N	0,312 x 120,000 x 480,000	
02	1	283900 1	22644	N	0,312 x 120,000 x 480,000	
02	1	283900 2	22644	N	0,312 x 120,000 x 480,000	
02	1	283901 1	22644	N	0,312 x 120,000 x 480,000	
02	1	283901 2	22644	N	0,312 x 120,000 x 480,000	
02	1	283902 1	22644	N	0,312 x 120,000 x 480,000	
02	1	283902 2	22644	N	0,312 x 120,000 x 480,000	
02	1	283903 1	22644	N	0,312 x 120,000 x 480,000	
02	1	283903 2	22644	N	0,312 x 120,000 x 480,000	
03	1	283905 1	22644	N	0,375 x 120,000 x 480,000	
03	1	283905 2	22644	N	0,375 x 120,000 x 480,000	
03	1	283906 1	22644	N	0,375 x 120,000 x 480,000	
03	1	283906 2	22644	N	0,375 x 120,000 x 480,000	
03	1	283907 1	22644	N	0,375 x 120,000 x 480,000	
03	1	283907 2	22644	N	0,375 x 120,000 x 480,000	
03	1	283908 1	22644	N	0,375 x 120,000 x 480,000	
03	1	283908 2	22644	N	0,375 x 120,000 x 480,000	
03	1	283909 1	22644	N	0,375 x 120,000 x 480,000	
03	1	283909 2	22644	N	0,375 x 120,000 x 480,000	
04	1	283939 1	22644	N	0,500 x 120,000 x 480,000	
04	1	283939 2	22644	N	0,500 x 120,000 x 480,000	
04	1	283940 1	22644	N	0,500 x 120,000 x 480,000	
04	1	283940 2	22644	N	0,500 x 120,000 x 480,000	
04	1	283941 1	22644	N	0,500 x 120,000 x 480,000	
04	1	283941 2	22644	N	0,500 x 120,000 x 480,000	
04	1	286153 1	74313	N	0,500 x 120,000 x 480,000	
04	1	286153 2	74313	N	0,500 x 120,000 x 480,000	
05	1	283936 1	22644	N	0,562 x 120,000 x 480,000	

N normalized

We hereby certify that the delivered material complies with the terms of the order.  
 (Z01)  
 QM-System Certification as per ISO 9001 since 28 February 1990



Ilsenburger Grobblech GmbH  
 Veckenstedter Weg 10  
 D-38871 Ilsenburg  
 (A01)

Inspection Stamp (Z03)

Inspection Representative (Z02)

Cyron

<b>Inspection certificate 3.1</b>		No. (A03)	761758
<b>DIN EN 10204</b>		Page	3/11
(A02)		Date	10.07.2012
No (A07)	9381	20.04.2012	No. (A07)
Purchaser (A06)	Olbert Metal Sales Limited MISSISSAUGA, ONT. L5T 2J8 KANADA	Customer (A06)	Olbert Metal Sales Limited MISSISSAUGA, ONT. L5T 2J8 KANADA
Product (B01)	Heavy plate	Works order No (A08)	0000059029
Steel grade and terms of delivery (B02-B03)	SA 516 Gr. 70 MTLTV ASME sect. II part A ed.2010, add.2011 ASME SA 20, SA 516 ASTM A 20 -10, A 516 -10 PO 9381	Inspection (A05)	WS

Material data (B01-B99)			
01	8	Weight	14.816 kgs
02	10	(B12)	23.100
03	10		27.800
04	8		29.640
05	2		8.326
06	4		18.528
07	6		33.342
08	6		44.460
09	2		18.524
10	2		22.228
12	2		20.006
14	2		24.450
15	2		22.414
16	1		10.320
17	2		22.228
18	2		17.912
19	2		18.231
20	1		10.150
21	2		21.494
Σ	74		407.969

Dimensional check and visual examination of the surface condition:  
without objection

Ladle analysis (C70-C99)										
Manufacturer standard										
Heat No (B07)	C %	Si % 0,15 - 0,40	Mn % 0,85 - 1,50	P % ≤ 0,015	S % ≤ 0,005	N %	Al % ≥ 0,020	Cu % ≤ 0,40	Cr % ≤ 0,30	Ni % ≤ 0,40
16412	0,18	0,19	1,46	0,014	0,004	0,004	0,042	0,06	0,03	0,06
20870	0,15	0,35	1,16	0,010	0,003	0,005	0,040	0,04	0,04	0,17
21795	0,20	0,24	1,16	0,006	0,002	0,007	0,042	0,03	0,02	0,04
Heat No (B07)	Mo % ≤ 0,12	V % ≤ 0,03	Ti % ≤ 0,03	Nb % ≤ 0,02	B % ≤ 0,001	Ca %	EV1 1) % ≤ 0,45	Nb+V % ≤ 0,03	EV2 2) %	
16412	0,004	0,01	0,003	0,02	0,0002	0,001	0,44	0,03	0,03	
20870	0,004	0,003	0,002	0,02	0,000	0,002	0,37	0,02	0,03	
21795	0,004	0,002	0,003	0,02	0,0001	0,001	0,40	0,02	0,03	

1) EV1 CEV=C+Mn/5+Mo/5+Nb/15+Cr/5+V/5+Cu/15  
2) EV2 V+Nb+Ti

We hereby certify that the delivered material complies with the terms of the order (Z01)

QM-System: Certification as per ISO 9001 since 28 February 1990

 Trademark (A04)
  Ilisenburger Grobblech GmbH  
 Veckenstedter Weg 10  
 D-38871 Ilisenburg  
 (A01)

 Inspection Stamp (Z03)
 
 Inspection Representative (Z02)  
 Cyron

<b>Inspection certificate 3.1</b>		No. (A03)	761758
<b>DIN EN 10204</b>		Page	5/11
(A02)		Date	10.07.2012
No. (A07)	9381	20.04.2012	No. (A07)
Purchaser (A06)	Olbert Metal Sales Limited MISSISSAUGA, ONT. L5T 2J8 KANADA	Customer (A06)	Olbert Metal Sales Limited MISSISSAUGA, ONT. L5T 2J8 KANADA
Product (B01)	Heavy plate	Works order No (A08)	0000059029
Steel grade and terms of delivery (B02-B03)	SA 516 Gr. 70 MTLTV ASME sect. II part A ed.2010, add.2011 ASME SA 20, SA 516 ASTM A 20 -10, A 516 -10 PO 9381	Inspection (A05)	WS

Tensile test (C10-C29)										
Specimen No (C30)	Heat No (B07)	Location (C01)	Direct (C02)	Cond. (B05)	Type (C10)	Yield strength (C11) Rp0,2 N/mm2 ≥ 250	Tensile strength (C12) Rm N/mm2 485 - 620	Elongation (C13) 8 in %	Elongation (C13) 2 in %	
282730	22059	K6V	Q	N	C	334	517			
282731	22059	K6V	Q	N	C	310	513			39
282733	22059	K6G	Q	N	P	320	508	32		36
282734	22059	K6G	Q	N	P	325	511	31		
282780	22644	K6G	Q	N	P	407	522	19		
282783	22644	K6G	Q	N	P	405	528	23		
283899	22644	K6G	Q	N	P	393	531	25		
283900	22644	K6G	Q	N	P	392	528	21		
283901	22644	K6G	Q	N	P	398	531	24		
283902	22644	K6G	Q	N	P	398	530	25		
283903	22644	K6G	Q	N	P	403	530	24		
283904	22644	K6G	Q	N	P	397	523	23		
283905	22644	K6G	Q	N	P	389	524	21		
283906	22644	K6G	Q	N	P	388	527	22		
283907	22644	K6G	Q	N	P	402	530	23		
283908	22644	K6G	Q	N	P	401	528	23		
283909	22644	K6G	Q	N	P	392	527	21		
283932	74313	K6G	Q	N	P	365	507	26		
283933	74313	K6G	Q	N	P	357	504	27		
283934	74313	K6G	Q	N	P	347	503	26		
283935	74313	K6G	Q	N	P	356	503	26		
283936	22644	K6G	Q	N	P	376	520	24		
283937	22644	K6G	Q	N	P	377	517	25		
283939	22644	K6G	Q	N	P	373	519	22		
283940	22644	K6G	Q	N	P	384	522	25		
283941	22644	K6G	Q	N	P	380	520	25		
284095	22058	K6G	Q	N	P	350	520	28		
284096	22058	K6G	Q	N	P	346	524	27		
286153	74313	K6G	Q	N	P	369	512	27		
286430	44491	K6V	Q	N	C	330	506			38
286559	22577	K6V	Q	N	C	333	503			40
286560	16412	K6V	Q	N	C	341	522			38
286573	22910	K6V	Q	N	C	329	507			41
286574	22910	K6V	Q	N	C	323	507			37
286576	22910	K6V	Q	N	C	314	511			39

1) K Top  
 2) 6 1/8 Width  
 3) G Thickness of product  
 V: 1/4 Thickness

4) Q transversal  
 5) N normalized  
 6) C: cylindrical  
 P: prismatic

We hereby certify that the delivered material complies with the terms of the order (Z01)

QM-System: Certification as per ISO 9001 since 28 February 1990

 Trademark (A04)

Ilseburger Grobblech GmbH  
Vackenstedter Weg 10  
D-38871 Ilseburg  
(A01)

 Inspection Representative (Z02)

Inspection Representative (Z02)

Cyron

Inspection certificate 3.1 DIN EN 10204 (A02)		No. (A03) Page Date	761758 7/11 10.07.2012
No. (A07) Purchaser (A06)	9381 Olbert Metal Sales Limited MISSISSAUGA, ONT. L5T 2J8 KANADA	20.04.2012 Customer (A06)	Olbert Metal Sales Limited MISSISSAUGA, ONT. L5T 2J8 KANADA
Product (B01)	Heavy plate	Works order No (A08)	0000059029
Steel grade and terms of delivery (B02-B03)	SA 516 Gr. 70 MTLTV ASME sect. II part A ed.2010, add.2011 ASME SA 20, SA 516 ASTM A 20 -10, A 516 -10 PO 9381	Inspection (A05)	WS

**Impact test (C40-C49)**

Specimen No (C00)	Heat No (B07)	Location (C01)	Direct (C02)	Cond (B05)	Type of specimen (C40-C41)	Temperature (C03) °F	Impact energy (C42-C43)			
							1 ftlbf	2	3	MW 6) ftlbf
282730	22059	K6V	L	N	Charpy V-notch	-051	41	18	32	30
282731	22059	K6V	L	N	Charpy V-notch	-051	20	55	45	40
282733	22059	K6V	L	N	Charpy V-notch	-051	44	40	59	48
282734	22059	K6V	L	N	Charpy V-notch	-051	53	45	46	48
282780	22644	K60	L	N	Charpy V-notch	-051	49	43	74	55
282783	22644	K60	L	N	Charpy V-notch	-051	41	69	43	51
283899	22644	K60	L	N	Charpy V-notch	-051	30	44	35	36
283900	22644	K60	L	N	Charpy V-notch	-051	36	23	41	33
283901	22644	K60	L	N	Charpy V-notch	-051	35	47	38	40
283902	22644	K60	L	N	Charpy V-notch	-051	42	38	58	46
283903	22644	K60	L	N	Charpy V-notch	-051	39	46	34	40
283904	22644	K60	L	N	Charpy V-notch	-051	28	44	44	38
283905	22644	K60	L	N	Charpy V-notch	-051	122	107	93	107
283906	22644	K60	L	N	Charpy V-notch	-051	148	135	140	141
283907	22644	K60	L	N	Charpy V-notch	-051	142	147	99	129
283908	22644	K60	L	N	Charpy V-notch	-051	136	139	132	136
283909	22644	K60	L	N	Charpy V-notch	-051	145	99	139	128
283932	74313	K6V	L	N	Charpy V-notch	-051	206	100	140	149
283933	74313	K6V	L	N	Charpy V-notch	-051	225	224	204	218
283934	74313	K6V	L	N	Charpy V-notch	-051	128	131	207	156
283935	74313	K6V	L	N	Charpy V-notch	-051	105	129	96	110
283936	22644	K6V	L	N	Charpy V-notch	-051	170	114	119	134
283937	22644	K6V	L	N	Charpy V-notch	-051	90	69	107	89
283939	22644	K6V	L	N	Charpy V-notch	-051	110	117	102	109
283940	22644	K6V	L	N	Charpy V-notch	-051	119	132	105	119
283941	22644	K6V	L	N	Charpy V-notch	-051	115	46	58	73
284095	22058	K6V	L	N	Charpy V-notch	-051	64	61	35	53
284096	22058	K6V	L	N	Charpy V-notch	-051	44	30	46	40
286153	74313	K6V	L	N	Charpy V-notch	-051	211	204	99	171
286430	44491	K6V	L	N	Charpy V-notch	-051	61	35	47	48
286559	22577	K6V	L	N	Charpy V-notch	-051	131	145	130	135
286560	16412	K6V	L	N	Charpy V-notch	-051	72	116	106	98
286573	22910	K6V	L	N	Charpy V-notch	-051	96	114	105	105
286574	22910	K6V	L	N	Charpy V-notch	-051	114	134	126	125
286576	22910	K6V	L	N	Charpy V-notch	-051	112	140	136	129
286577	22910	K6V	L	N	Charpy V-notch	-051	205	128	58	131

- 1) K Top  
2) 6 1/8 Width  
3) 0 near surface  
V 1/4 Thickness

- 4) L longitudinal  
5) N normalized  
6) MW Average

We hereby certify that the delivered material complies with the terms of the order  
(Z01)

QM-System: Certification as per ISO 9001 since 28 February 1990



Ilseburger Grobblech GmbH  
Veckenstedter Weg 10  
D-38871 Ilseburg  
(A01)

Inspection Stamp  
(Z03)

Inspection Representative  
(Z02)

Cyron



<b>Inspection certificate 3.1</b>		No. (A03)	761758
<b>DIN EN 10204</b>		Page	9/11
(A02)		Date	10.07.2012
No (A07)	9381	20.04.2012	No (A07)
Purchaser	Olbert Metal Sales Limited		Customer
(A06)	MISSISSAUGA, ONT. L5T 2J8		(A06)
	KANADA		Olbert Metal Sales Limited
			MISSISSAUGA, ONT. L5T 2J8
			KANADA
Product	Heavy plate	Works order No	0000059029
(B01)		(A08)	
Steel grade and terms of delivery	SA 516 Gr. 70 MTLTV	Inspection	WS
(B02-B03)	ASME sect. II part A ed.2010, add.2011	(A05)	
	ASME SA 20, SA 516		
	ASTM A 20 -10, A 516 -10		
	PO 9381		

**Other tests (C50-C69)**

Specimen No (C00)	Heat No (B07)	Location (C01)	Direct (C02)	Cond (B05)	Hardness test (C30-C39) HB30 ≤199
		1) 2) 3)	4)	5)	
282730	22059	K6		N	155
282731	22059	K6		N	153
282733	22059	K6		N	151
282734	22059	K6		N	150
282780	22644	K6		N	156
282783	22644	K6		N	155
283899	22644	K6		N	157
283900	22644	K6		N	157
283901	22644	K6		N	156
283902	22644	K6		N	157
283903	22644	K6		N	159
283904	22644	K6		N	156
283905	22644	K6		N	155
283906	22644	K6		N	158
283907	22644	K6		N	157
283908	22644	K6		N	158
283909	22644	K6		N	157
283932	74313	K6		N	151
283933	74313	K6		N	150
283934	74313	K6		N	149
283935	74313	K6		N	148
283936	22644	K6		N	156
283937	22644	K6		N	153
283939	22644	K6		N	155
283940	22644	K6		N	156
283941	22644	K6		N	154
284095	22058	K6		N	154
284096	22058	K6		N	155
286153	74313	K6		N	150
286430	44491	K6		N	151
286559	22577	K6		N	149
286560	16412	K6		N	154
286573	22910	K6		N	149
286574	22910	K6		N	152
286576	22910	K6		N	151
286577	22910	K6		N	152
286578	22910	K6		N	151
286587	22910	K6		N	153

1) K: Top  
2) 6: 1/8 Width  
5) N: normalized

We hereby certify that the delivered material complies with the terms of the order  
(Z01)

QM-System. Certification as per ISO 9001 since 28 February 1990



Ilsenburger Grobblech GmbH  
Veckenstedter Weg 10  
D-38871 Ilsenburg  
(A01)

Inspection Stamp  
(Z03)

Inspection Representative  
(Z02)

Cyron

<b>Inspection certificate 3.1</b> <b>DIN EN 10204</b> (A02)		No. (A03) 761758 Page 11/11 Date 10.07.2012
No. (A07) 9381 Purchaser (A06) Olbert Metal Sales Limited MISSISSAUGA, ONT. L5T 2J8 KANADA	20.04.2012 No. (A07) Customer (A06) Olbert Metal Sales Limited MISSISSAUGA, ONT. L5T 2J8 KANADA	
Product (B01) Heavy plate		Works order No (A08) 0000059029 Inspection (A05) WS
Steel grade and terms of delivery (B02-B03) SA 516 Gr. 70 MTLTV ASME sect. II part A ed.2010, add.2011 ASME SA 20, SA 516 ASTM A 20 -10, A 516 -10 PO 9381		
PED 97/23 EG		

We hereby certify that the delivered material complies with the terms of the order  
 (Z01)

QM-System: Certification as per ISO 9001 since 28 February 1990



Ilseburger Grobblech GmbH  
 Veckenstedter Weg 10  
 D-38871 Ilseburg  
 (A01)

Inspection Stamp  
 (Z03)

Inspection Representative  
 (Z02)

Cyron

**Certificate of Mill Test Results**

Inv: 1055184 Date: 03/19/2013  
Heat: 2606P3

Contact: HELENE/BRIAN

Quality Plates & Profiles Limited  
20 Nicholas Street, R.R.#3 (Aberfoyle), Guelph, ON N1H 6H9  
PO/Rel: 13-0220  
PLATE CPL 516N 1" x 73" OD X 58" ID TAG 1176-20



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:	100023647 2013/01/06	TC No., Date & Time	ESA-38932 2013/01/07 10:50:07
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	P06775572 100023647
Customer Specification:	HR STEEL PLATE Carbon Multi Cert ASTM A516 GR 70 (11A) Meets NACE MR 0175 latest Ed. BHN < 200, D OCEQ 43 max, Inclusion Shape Control Calcium Treated Normalized Temp 1670 ± F 34 min CVN. Req. 15/12 FT. LBF at 0.50 F Sid Thickness Tol PVQ Top and Bottom Standard Surface Flatness 1/2 A20 Latest Ed + Addenda of ASME Code section II part A applies Fine Grain Fully Killed No Weld Repair			Carrier	ROBINSON TRANSPORT LTD - 205(661)
Supplementary Instructions:	Test Cert 1:519-837-2227				
Insp TR:	Test Report As Per Spec				Cur 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 WITH OUR WRITTEN APPROVAL OF ESSAR STEEL ALGOMA INC. IF YOU RECEIVE THIS DOCUMENT AND ARE NOT THE INTENDED RECEIVER PLEASE CALL 1709 945-4229 FOR INSTRUCTIONS ON METHOD OF DISPOSAL OF DOCUMENT.

SO QUALITY AND ENVIRONMENTAL CERTIFICATE AVAILABLE AT WWW.ESSARSTEEL.COM/ALGOMA/2AM

ALL HEATS FULLY KILLED  
HEATS INDICATED WITH (+) FAC GRABND  
HEATS INDICATED WITH (-) MADE IN CANADA WITH DOMESTIC AND NORTH AMERICAN MATERIALS

Dimensions (T x W x L)	Heat No.-MS	Quantity	No. of PCS	Dimensions (T x W x L)	Batch No	Quantity	Heat No.-MS	Quantity	No. of PCS
1.0000" x 120.0000" x 384.00"	AB8769	13,068 LB	1	1.0000" x 120.0000" x 384.00"	AB8770	13,068 LB	2606P3-56	13,068 LB	1
1.0000" x 120.0000" x 384.00"	AB8771	13,068 LB	1						

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

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

**LIMITS OF UNSPECIFIED ELEMENTS PER ASME SECTION II (SA-20)**  
**CU + NI + CR + MO = CR+MO = 0.27%**

W.O. # 11766X  
M.I. # 200(243)  
TRK. # 1  
P.O. # 13-0220

Certification of Material - Per ASME  
HT# 2606P3-56  
SAS16&R70N  
per Addenda  
Sect. II 10 Edition 11

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

K. UCHADAPAGA  
MANAGER METALLURGICAL SERVICES

Q.C.I. N.D.

Q.C.I. E.Y.

APR 03 2013

\*\*WARNING\*\* THE TEST RESULTS AND VALUES REPORTED HEREIN INDICATE ONLY THAT THE PARTICULATE STEEL FOR WHICH THIS CERTIFICATE IS ISSUED MEETS THE MINIMUM SPECIFIED YIELD STRENGTH AND TENSILE STRENGTH REQUIREMENTS OF EACH STEEL TYPE IN COMPLIANCE WITH THE REQUIREMENTS OF THE SPECIFICATION INDICATED. THE RESULTS OR VALUES REPORTED HEREIN CAN NOT BE USED TO DETERMINE THE ACTUAL STRENGTH OF SUCH STEEL. THE USER SHOULD OBTAIN THE ACTUAL STRENGTH OF SUCH STEEL.

Date 2013/01/07 Time 12:25:32 Page no 1 of 2

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APR 11 2013

**Certificate of Mill Test Results**

**QUALITY PLATES & PROFILES LIMITED**

20 Nicholas Eber Road, R.R.#3 (Aberfoyle), Guelph, ON N1H 6H9  
 ALL-WELD COMPANY LIMITED  
 PO/Rel: 13-0220  
 PLATE CPL 516N 1" x 73" OD X 58" ID TAG 1176-20

Contact: HELENE/BRIAN

Inv: 1055184 Date: 03/19/2013  
 Heat: 2606P3



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

SO No./Item & Date:	9006515 000020 2013/01/05	Shipment No & Date:	100023647 2013/01/06	TC No., Date & Time	ESA-38832 2013/01/07 10:15:07							
Sold to Customer Name and Address:		Ship to Customer Name and Address:		Customer PO NO./Item	P007755 / 2							
QUALITY PLATES & PROFILES LTD NICHOLAS BEAVER ROAD RR#3 20 ABERFOYLE, Ontario Canada N1H 6H9		QUALITY PLATES & PROFILES LTD NICHOLAS BEAVER ROAD RR#3 20 ABERFOYLE, Ontario Canada N1H 6H9		BOL NO:	1000023647							
Customer Specification:		Customer Specification:		Cust. Part No:	ROBINSON TRANSPORT LTD - 205(661)							
HR STEEL PLATE Carbon Multi Cert ASTM A516 GR 70 (11A) Meets NACE MR 0175 latest Ed. BHN < 200. D O GEO. 4.3 max. Inclusion Shape Control Calcium Treated Normalized Temperature 1670 °F 34 min CVN. Reel 15' 12 FT-LBF at 0 - 50.0 F Std Thickness Tol PVQ Top and Bottom Standard Surface Finish 1/2 A20 Latest Ed + Addenda of ASME Code section II part A applies Fine Grain Fully Killed No Weld Repair		HR STEEL PLATE Carbon Multi Cert ASTM A516 GR 70 (11A) Meets NACE MR 0175 latest Ed. BHN < 200. D O GEO. 4.3 max. Inclusion Shape Control Calcium Treated Normalized Temperature 1670 °F 34 min CVN. Reel 15' 12 FT-LBF at 0 - 50.0 F Std Thickness Tol PVQ Top and Bottom Standard Surface Finish 1/2 A20 Latest Ed + Addenda of ASME Code section II part A applies Fine Grain Fully Killed No Weld Repair		Carrier:								
Supplementary Instructions: Test Cert 1.519-837-2227												
Imp: TIR: Test Report As Per Spec												
ESSAR STEEL ALGOMA INC. HEREBY CERTIFIES THAT THE MATERIAL 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 1(800)945-4025 FOR INSTRUCTIONS ON METHOD OF DISPOSAL OF DOCUMENT.												
MEETS EN 10204 2004 "MPC 3.1"												
ISO QUALITY AND ENVIRONMENTAL CERTIFICATES AVAILABLE AT WWW.ESSARSTEELALGOMA.COM												
. . . . . M E C H A N I C A L P R O P E R T I E S . . . . .												
Impact Tests	Batch No.	SRCE	LAB	GAUGE	COND	METH	DIR	LOC	SIZE	TEMP (°F)	ENERGY (ft-lbf)	ENERGY AVG (ft-lbf)
2606P3	AB8769	166"	ALG	1.0000	NORM	CVN	L	B	FULL	-50	71 69 77	72
2606P3	AB8770	166"	ALG	1.0000	NORM	CVN	L	B	FULL	-50	59 61 73	64
2797P3	AB8771	166"	ALG	1.0000	NORM	CVN	L	B	FULL	-50	84 86 65	79
Tensile Tests	Batch No.	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

MAR 27 2013

Q.C.I. N.D.

Q.C.I. E.Y.

APR 03 2013

K. UGHADPAGA  
MANAGER METALLURGICAL SERVICES

Velo America  
April 1, 2013 279

\*\*\*WARNING\*\*\* THE TEST RESULTS AND VALUES REPORTED HEREIN INDICATE ONLY THAT THE PARTICULAR STEEL FOR WHICH THIS CERTIFICATE IS ISSUED MEETS THE MINIMUM SPECIFIED YIELD STRENGTH AND THE ANALYSIS AND PHYSICAL PROPERTIES OF SUCH STEEL, ARE IN CONFORMANCE WITH THE REQUIREMENTS OF THE SPECIFICATION INDICATED. THE RESULTS ON 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) REPRESENTING THE ACTUAL STRENGTH OF SUCH STEEL.



# Certificate of Mill Test Results

# QUALITY PLATES & PROFILES LIMITED

20 Nicholas Eber Road, R.R.#3 (Aberfoyle), Guelph, ON N1H 6H9  
 ALL-WELD COMPANY LIMITED  
 PO/Rel: 13-0220  
 PLATE C/PL 516N 3/8" x 6" x 30-1/4" TAG 1176-21

Contact: HELENE/BRIAN

Inv: I055184 Date: 03/19/2013  
 Heat: 7905M



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

STEEL

SO No., Item & Date:	8003926 000010 2012/11/08	Shipment No. & Date:	1000014698 2012/11/08	TC No., Date & Time:	ESA-24903 2012/11/09 - 20:48:10
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:	P007192 / 1
BOL NO.:	1000014698	Cust. Part No.:		Carrier:	INTERNATIONAL FREIGHT SYSTEMS - OSH44

000584

Customer Specification: HR STEEL PLATE Carbon Multi Cert ASTM A516 GR 70 (10) / ASME SA516 GR 70 (11A) Meets NACE MR 0103 latest Ed. NACE MR 0175 latest Ed., BHN < 200, D.O.C.E.O. 43 max. Inclusion Shape Control Calcium Treated Normalized Temp 1670 F 12 min CVNL Req. 15/12 FT-LBF at -50.0 F. Std. Thickness for PVG Top and Bottom Standard Surface Flatness 1/2 A20 Niobium max 0.015 Sum-Nb+V max 0.030 Vanadium max 0.020 Latest Ed. Addenda of ASME Code section II part A applies Fine Grain Fully Killed No Weld Repair

Supplementary Instructions: Test Cert 1.519-837-2227

Insp Y/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.

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)	0.3750" x 120.000" x 384.00"	Batch No.	AA5430	Heat No.-MS	7905M-55	Quantity	9,802 LB	Pcs	2
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Heat No. (wt%)	CHEMICAL PROPERTIES										MECHANICAL PROPERTIES				
	C	Mn	P	S	Si	Cr	Ni	Cu	Mo	Al	Nb	V	B	TI	DO
7905M*	0.19	1.08	0.016	0.004	0.320	0.03	0.15	0.02	0.01	0.029	0.000	0.015	0.0002	0.003	0.3900

Hardness Testis	Batch No.	SRCE	LAB	GAUGE	COND	LOC	MTHD	HARDNESS	ENERGY AVG(ft-lbf)	TEMP(°F)	ENERGY(ft-lbf)	LIMITS OF UNSPECIFIED ELEMENTS PER ASME	
												SECTION II (SA-20)	CR+MO
7905M	AA5430	166"	ALG	0.3750	NORM	B	HBW	154	60	-50	54 71 54	CU + Ni + CR + MO = 24	CR+MO = 04

Q.C.I. E.V.

APR 03 2013

Q.C.I. N.D.

MAR 27 2013

W.O. # 11769  
 M.I. # 21(2/3)  
 TRAC # 581  
 P.O. # 13-0220



MILL TEST REPORTS APPROVED BY Q.C.

P.O.

K. UGHADPAGA  
 MANAGER METALLURGICAL SERVICES

Certification of Material - Per ASME  
 HT# 7905M-55  
 Qualifies to all requirements of SA516-GR70 per Sect. II Edition 11 Addenda

\*\*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.

**QUALITY PLATES & PROFILES LIMITED**  
 20 Nicholas (er Road, R.R.#3 (Aberfoyle), Guelph, ON N1H 6H9  
 ALL-WELD COMPANY LIMITED  
 PO/Rel: 13-0220  
 PLATE CPL 516N 3/8" x 6" x 30-1/4" TAG 1176-21

**Certificate of Mill Test Results**  
 Inv: I055184 Date: 03/19/2013  
 Contact: HELENE/BRIAN Heat: 7905M



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

SO No., Item & Date:	8003926 000010 2012/11/08	Shipment No. & Date:	1000014698 2012/11/08	TC No., Date & Time:	ESA-24903 2012/11/09 - 20:48:10								
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:	P007192 / 1								
Customer Specification:	HR STEEL PLATE Carbon Multi Cert ASTM A516 GR 70 (10) / ASME SA516 GR 70 (11A) Meets NACE MR 0175 latest Ed. BHN < 200. D O CEQ .43 max. Inclusion Shape Control Calcium Treated Normalized Temp 1670 °F 12 min CVNL Req. 15/12 FT-LBE at -50.0°F Std Thickness Tol PVC Top and Bottom Standard Surface Flatness 1/2 A20 Niobium max 0.015 Sum-Nb+V max 0.030 Vanadium max 0.020 Latest Ed. +Addenda of ASME Code section II part A applies Fine Grain Fully Killed No Weld Repair			BOL NO.:	10000014698								
Supplementary Instructions:	Test Cert 1:519-837-2227			Cust. Part No.:	INTERNATIONAL FREIGHT SYSTEMS - OSH44								
Insp T/R:	Test Report As Per Spec			Carrier:									
ESSAR STEEL ALGOMA INC. HEREBY CERTIFIES THAT THE MATERIAL HEREIN DESCRIBED WAS MADE AND TESTED IN ACCORDANCE WITH THE RULES OF THE SPECIFICATION SHOWN. ALL RESULTS ARE RETAINED IN ACCORDANCE WITH THE COMPANY'S STANDARD RECORD KEEPING PRACTICES. THIS MILL TEST REPORT MAY NOT BE REPRODUCED EXCEPT IN FULL WITHOUT WRITTEN APPROVAL OF ESSAR STEEL ALGOMA INC. IF YOU RECEIVE THIS DOCUMENT AND ARE NOT THE INTENDED RECEIVER, PLEASE CALL (705)945-4095 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 *****													
Tensile Testis	SRCE	LAB	GAUGE	COND	METH	DIR	LOC	TENSILE(KSI)	EL SCALE	ELONG(%)			
Heat No.	7905M	Batch No.	AA5430	166"	ALG	0.3750	NORM	2	T	B	8"	76	24

**Q.C.I. E.Y.**  
 APR 3 2013

*Velocity America*  
 279  
 APR 1, 2013

**Q.C.I. N.D.**

MAR 27 2013

K. UGHADPAGA  
 MANAGER METALLURGICAL SERVICES

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# Certificate of Mill Test Results

## QUALITY PLATES & PROFILES LIMITED

20 Nicholas Lane, R.R.#3 (Aberfoyle), Guelph, ON N1H 6H9  
 ALL-WELD COMPANY LIMITED PO/Rel: 13-0220  
 PLATE CPL 516N 3/8" x 4" x 55-3/8" TAG 1176-21

Contact: HELENE/BRIAN

Inv: I055184 Date: 03/19/2013  
 Heat: 5416M

### ESSAR Steel Algoma Inc.

CUSTOMER PURCHASE ORDER NUMBER  
 P006596

ENTRY DATE  
 2012/03/29

105 West Street, Sault Ste. Marie, Ontario Canada P6A 7B4

TALLY NUMBER SHIPPER'S NO. CARRIER  
 278694 02-3498 NATIONAL TRANSPORTATION C

MILL ORDER  
 18996

CHARGE TO CUSTOMER NAME AND ADDRESS

QUALITY PLATES & PROFILES LTD.  
 20 NICHOLAS BEAVER ROAD RR#3  
 ABERFOYLE, ON N1H 6H9

SHIP TO CUSTOMER NAME AND ADDRESS

QUALITY PLATES & PROFILES LTD  
 20 NICHOLAS BEAVER ROAD  
 RR#3  
 ABERFOYLE, ON

### MILL TEST REPORTS

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.

K. UGHADPAGA  
 MANAGER METALLURGICAL SERVICES

### SUPPLEMENTARY INSTRUCTIONS

TEST CERT 1: MICHELLE CRAVEIRO 519-837-2227 TEST CERT 2: PLAT  
 E TEST COUPON:

### TEST REPORTS REQUIRED

2000226082 PF  
 2012/05/23 19:21

### INSP YR

2012/05/23 19:21

### CNST USE

RESALE

### IMPACT TESTS:

HEAT 5416M\*\*

SRCE 166"

GAUGE IN .3750

COND METH CVN N

TEST DIR SIZE L 3/4

TEMP \* -50F

FULLSIZE \* FTLB 57 79 83 73

ENERGY \* AVG \* 73

PROPERTIES \* \* \* \* \*

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HEAT (WT %) C TI MN P N S AS ZR SI CR NI SB CU MO AL

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# Certificate of Mill Test Results

## QUALITY PLATES & PROFILES LIMITED

20 Nicholas L...er Road, R.R.#3 (Aberfoyle), Guelph, ON N1H 6H9  
 ALL-WELD COMPANY LIMITED  
 PO/Rel: 13-0220  
 TAG 1176-21

Contact: HELENE/BRIAN  
 Inv: I055184 Date: 03/19/2013  
 Heat: 5416M

### ESSAR Steel Algoma Inc.

105 West Street, Sault Ste. Marie, Ontario Canada P6A 7B4  
 0005491

Customer Purchase Order Number: P006596  
 Create Date: 2012/03/29  
 Entry Date: 2012/05/23

Tally Number: 278694  
 Shipper's No: 02-3498  
 Carrier: NATIONAL TRANSPORTATION C - 0695 (100)

Mill Order: 18996

#### MILL TEST REPORTS

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

K. UGHADPAGA  
 MANAGER METALLURGICAL SERVICES

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SHIP TO CUSTOMER NAME AND ADDRESS  
 QUALITY PLATES & PROFILES LTD  
 20 NICHOLAS BEAVER ROAD  
 RR#3  
 ABERFOYLE, ON

CUSTOMER SPECIFICATION  
 HR PLATE - CARBON - ASME SA516 GR 70 (11A) - CVNL 15/12 FT LBS AT -50 F - MEETS NACE FULLY KILLED - FINE GRAIN SULFIDE SHAPE CONTROL CALCIUM TREATED - EN 10204 3.1 MR 0103 LASTEST ED. - NACE MR 0175 LATEST ED. - BEN 200 MAX - PER EN 10204 3.1 - PVO - NORMALIZED - FLATNESS 1/2 A-20 - NORM 12 MIN MIN. @ 1670F-NO WELD REPAIRS - CE. 43 MAX-TO MEET ASME SEC II LAT ADD

SUPPLEMENTARY INSTRUCTIONS  
 TEST CERT 1: MICHELLE CRAVEIRO 519-837-2227 TEST CERT 2: PLAT  
 E TEST COUPON:  
 2000226082 PF  
 2012/05/23 19:21

INSPECTION TEST REPORTS REQUIRED  
 CUSTOMER RESALE  
 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  
 CUSTOMER ITEM 00001 OUR ITEM 003 DIMENSIONS .375 X 120 X 384 "

PLATE NUMBER 75082  
 HEAT-MS 5416M-52  
 NO. WEIGHT 2 9801  
 PLATE NUMBER 75082  
 HEAT-MS 5416M-52  
 NO. WEIGHT 2 9801

TENSILE TESTS:  
 PLATE NUMBER 75082  
 HEAT NUMBER 5416M  
 SAMPLE SRCE 166"  
 GAUGE .3750  
 COND METH N  
 TEST DIR T  
 YIELD TENSILE KSI 52.4  
 KSI 75.3  
 \* ELONG 26(8")

HARDNESS TESTS:  
 PLATE NUMBER 75082  
 HEAT NUMBER 5416M  
 SRCE 166"  
 GAUGE IN 3.750  
 TEST HBW  
 HARDNESS 152

MILL TEST REPORTS APPROVED BY Q.C.

P.O. APR 03 2013 LAB ALG



PAGE 1 OF 2

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 CHEMICAL 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 THAT THE PARTICULAR STEEL INDICATED CAN NOT BE RELIED UPON FOR ANY PURPOSE (INCLUDING DESIGN OR CALCULATIONS) AS REPRESENTING THE ACTUAL STRENGTH OF SUCH STEEL.



Tubos de Acero de Mexico S.A.  
 Central: Mexico Venezuela 066-3337-511  
 C. Pinar del Rio, Trinidad, Venezuela  
 C. Pinar del Rio, Venezuela  
 (52) 229 6671 1100 04  
 (52) 229 6651 1600 02

INSPECTION CERTIFICATE 3.1  
 CERTIFICADO DE INSPECCIÓN 3.1  
 EN 10204 3.1: 2004

Number / Número: 12074141  
 Date / Día: October 30, 2012

Page / Página: 1 / 7

Customer's Order Item / Orden Cliente - Item: G1-3611 ITEM 2  
 Customer's Reference / Ref. del Cliente: N/A  
 Manufacturer's Works Order N° / Confirmación de Venta: 18686102

Customer / Cliente: COMCO PIPE & SUPPLY  
 Manufacturing Process / Proceso de Manufactura: SEAMLESS HOT ROLLED  
 LAMINADO EN CALIENTE SIN COSTURA  
 Standard or Specification / Normas o Especificaciones: ASTM A106 11  
 Dimensions / Dimensiones: 4.12 X 0.237 INCH  
 114.3 X 6 MM  
 Schedule / Código: 040  
 Length / Longitud: 38.02 / 39.37 FT  
 11.59 / 12.00 MTS  
 Product Type / Tipo de Producto: LINE PIPE SEAMLESS  
 CONDUCCION SIN COSTURA  
 Surface / Superficie: VARNISHED  
 BARNIZADO  
 Ends / Extremos: NORMAL BEVEL  
 BISELADO NORMAL  
 Nominal Weight / Peso Nominal: 10.80 LB/FT  
 16.08 KG/M

**TENSILE TEST / ENSAYO DE TENSION**

Heat N° Cebada N°	Sample N° Muestra N°	Specimen condition Condición de la probeta	Specimen dimensions Dimensiones de la probeta	Test Temp Temp. ensayo	Y.S. Eul 0.50 %	U.T.S. Req. Min: 60 000 Max: 90 650	Elongation / Alargamiento	
							Req. Max.	Obt.
04385	67422	B AM Ss L	25.51 X 06.20	RT	50.437	80.787	0.70	23.7
04385	67423	B AM Ss L	25.53 X 06.04	RT	57.048	82.109	0.69	23.6
04389	67425	B AM Ss L	25.53 X 06.37	RT	54.915	79.260	0.70	23.8
04389	67426	B AM Ss L	25.76 X 08.15	RT	54.062	77.970	0.69	23.7

AM: As manufactured / Según proceso de fabricación  
 B: Body / Cuerpo  
 L: Longitudinal / Longitudinal  
 Lo: Initial length / Longitud inicial  
 LS: Location of sample / Ubicación de la muestra  
 Max: Maximum / Máximo  
 Min: Minimum / Mínimo  
 Obt: Obtained / Obtenido  
 Ori: Orientation / Orientación  
 Req. Max: Required maximum / Máximo requerido  
 Req. Required / Requerido  
 RT: Room temperature / Temperatura ambiente  
 Ss: Strip specimen / Muestra rectangular  
 U.T.S: Ultimate tensile strength / Resistencia  
 Y.S: Yield strength / Fluencia

Velosi America  
 279  
 APR 04 2013  
 G.C.I.  
 N.D.

This certificate is issued by a computerized system and it is valid with electronic signature. On the original certificate the trace mark given colored "Tenaris" is stamped. In case the owner of the original certificate would release a copy of it, he must attest its conformity to the original one taking upon himself the responsibility for any unlawful or not a lawful use. Any alteration and/or falsification will be subjected to the law.

FOR03171

Tubos de Acero de Mexico S.A.  
 Calle: Mexico Veracruz Rd 427 3N  
 Ciudad: Veracruz, Veracruz, Veracruz, Veracruz  
 C.P.: 239 649-1100 Tel:  
 (239) 239 649-1100 Fax

INSPECTION CERTIFICATE 3.1  
 CERTIFICADO DE INSPECCIÓN 3.1  
 EN 10204 3.1: 2004

Number / Número: 12074141  
 Page / Página: 2 / 7  
 Date / Día: October 30, 2012

Customer / Cliente: COMCO PIPE & SUPPLY  
 Manufacturer / Proceso de Manufactura: SEAMLESS HOT ROLLED  
 LAMINADO EN CALIENTE SIN COSTURA  
 Standard of Specification / Normas o Especificaciones: ASTM A 106.11

Customer's Order Item / Orden Cliente - Item: 161-3611 ITEM 2  
 Customer's Reference / Ref. del Cliente: N/A  
 Manufacturer's Work Order N° / Confirmación de Venta: 18886102  
 Surface / Superficie: VARNISHED  
 BARNIZADO  
 Ends / Extremos: NORMAL BEVEL  
 BISELADO NORMAL  
 Nominal Weight / Peso Nominal: 10.80 LB/FT  
 16.08 KG/M

Product Type / Tipo de Producto: LINE PIPE SEAMLESS  
 CONDUCCION SIN COSTURA  
 Steel Grade / Grado de acero: B  
 Quantity / Cantidad: 99 Pcs/Pz  
 3876.280 FT  
 1181.490 MTS  
 Length / Longitud: 38.02 / 39.37 FT  
 11.59 / 12.00 MTS  
 Schedule / Cédula: 040  
 Dimensions / Dimensiones: 4.1/2 X 0.237 INCH  
 114.3 X 6 MM

CHEMICAL COMPOSITION / COMPOSICION QUIMICA

Heat N° Colada N°	Sample N° Muestra N°	Composition % / Composición %																					
		x 100							x 1000							x 100							
C	Mn	Si	Cr	Mo	S	P	Ni	V	Cu	Al	Sn	As	Nb	Ti	Ca	B	N	Co. 1	Co. 2	Co. 1	Co. 2		
04385	00001	25	135	50	40	15	35	30	400	80	400	—	—	—	110	110	—	10	—	—	—	99.99	
04385	67422	25	135	50	40	15	35	30	400	80	400	—	—	—	110	110	—	10	—	—	—	300	
04385	67423	25	135	50	40	15	35	30	400	80	400	—	—	—	110	110	—	10	—	—	—	300	
04389	0000*	20	92	22	2	0.5	3	9	10	4	38	17	9	1	0	2	17	2	47	37	36	480	7.8
04385	67422	21	91	23	2	0.5	2.2	9	20	0	34	20	4	1	0	0	21	0	47	38	37	433.32	7.9
04385	67423	22	94	24	2	0.5	2.3	10	20	0	35	20	5	1	0	0	20	0	47	39	39	427.27	8
04389	0000*	20	91	22	2	0.5	1.8	8	20	2	48	21	8	0	1	13	1	58	37	38	455	9.5	
04385	67425	21	90	22	2	0.5	1.7	7	22	0	41	24	5	1	0	5	16	0	56	38	37	429.57	8.5
04389	67426	21	91	23	2	0.5	1.2	7	20	0	41	23	5	1	0	16	0	56	38	37	433.32	8.6	

Certification of Material - Per ASME  
 HT# 04389  
 Qualifies to all requirements of  
 SA106-GRB per  
 Sect. II 10 Edition II Addenda

Col. 1: REL Min/C  
 Col. 2: SUMA 100-Cr-Ni-Cu-V  
 H: Heat / Colada  
 Max: Maximum / Maximo  
 Min: Minimum / Minimo  
 P: Product / Producto

W.O. # 11768  
 M.I. # 22(5/13)  
 THK. # 237  
 P.O. # 13-0249

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

APR 04 2013

Velocity America 279

This certificate is issued by a computerized system and it is valid with electronic signature. On the original certificate the trace-back system should be stamped. In case the owner of the original certificate would release a copy of it, he must attest the conformity to the original one having upon himself the respective duty for any unlawful or not allowed use. Any alteration and/or falsification will be subjected to the law.

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APR 05 2013

Tubos de Acero de Mexico, S.A.  
 Carretera a Veracruz, Km 143.7 SN  
 Carretera Veracruz-Tajinera, Veracruz, Veracruz  
 C.P. 91697 / MEXICO  
 (52) 229 269 1100 Int.  
 (52) 229 899 1530 Int.

Number / Número: 12074141  
 Page / Página: 3 / 7  
 Date / Día: October 30, 2012  
 Customer's Reference / Ref. del Cliente: N/A

INSPECTION CERTIFICATE 3.1  
 CERTIFICADO DE INSPECCIÓN 3.1  
 EN 10204 3.1: 2004

Customer / Cliente: COMCO PIPE & SUPPLY  
 Customer's Order Item / Orden Cliente - Item: G1-3611 ITEM 2  
 Product Type / Tipo de Producto: LINE PIPE SEAMLESS  
 CONDUCCION SIN COSTURA

Manufacturer's Works Order N° / Confirmación de Venta: 186867/02	Surface / Superficie: VARNISHED BARNIZADO
Ends / Extremos: NORMAL BEVEL BISELADO NORMAL	Nominal Weight / Peso Nominal: 10.80 LB/FT 16.08 KG/M
Quantity / Cantidad: 99 Pcs/Pz 3876.280 FT 1181.490 MTS	Steel Grade / Grado de acero: B
Length / Longitud: 38.02 / 39.37 FT 11.59 / 12.00 MTS	Schedule / Código: 040
Dimensions / Dimensiones: 4.12 X 0.237 INCH 114.3 X 6 MM	

**THROUGH WALL HARDNESS / DUREZA EN EL ESPESOR**

Heat N° / Colada N°	Sample N° / Muestra N°	Average / Promedio			Harcness type HRC		
		Min. -	Max. -	Var. -	Tipo de dureza		
04385	67422	Quad			1 2 3		
		Sc			AVG.		
		AM			80.2	80.1	80.1
04385	67423	Quad			1 2 3		
		Sc			AVG.		
		AM			82.8	81.1	82.2
04389	67425	Quad			1 2 3		
		Sc			AVG.		
		AM			81.0	81.9	81.9
04389	67426	Quad			1 2 3		
		Sc			AVG.		
		AM			85.1	81.3	82.0

AM: As manufactured / Según proceso de fabricación  
 Avg: Average / Promedio  
 B: Body / Cuerpo  
 Ls: Location of sample / Ubicación de la muestra  
 Max: Maximum / Máximo  
 Min: Minimum / Mínimo  
 Mw: Middle wall / Centro  
 Quad: Quadrant / Cuadrante  
 Sc: Specimen condition / Condición de la probeta  
 Var: Variation / Variación

**FLATTENING TEST / ENSAYO DE APLASTAMIENTO**

Standard / Norma:	Heat N° / Colada N°	Sample N° / Muestra N°	Result / Resultado
ASME B31.3	04385	67422	Good / Bueno
ASME B31.3	04385	67423	Good / Bueno
ASME B31.3	04389	67425	Good / Bueno
ASME B31.3	04389	67426	Good / Bueno

046  
**ACCEPTED / REVIEWED / RELEASED**  
 for and on behalf of: SIM DFFSHORVE  
 Print Name: GABRIEL SAHIA  
 Signature: [Signature]  
 Date: [Date]  
 Applus® VELOSI  
 Velosi America LLC

APR 04 2013  
 O.C.I. N.D.

FOR03171

This certificate is valid only if accompanied by the original certificate of the manufacturer. In case the original certificate is not available, the purchaser must obtain a copy of it. The purchaser is responsible for the accuracy of the information provided. Any alteration or falsification will be subject to the law.



Tubos de Acero de Mexico S.A.  
 Central Mexico Siquiluz Rd 433 T 9V  
 Mexico D.F. 06700  
 C.P. 06687, MEXICO  
 (52) 55 980 1190 Ext.  
 (52) 55 980 1000 Ext.

INSPECTION CERTIFICATE 3.1  
 CERTIFICADO DE INSPECCION 3.1  
 EN 10204 3.1: 2004

Number / Número:  
 12074141

Date / Día: October 30, 2012

Customer's Reference / Ref. del Cliente:  
 N/A

Customer's Order Item / Orden Cliente - Item:  
 G1-3611 ITEM 2

Manufacturer's Works Order N° / Confirmación de Venta:  
 188861002

Surface / Superficie:  
 VARNISHED  
 BARNIZADO

Ends / Extremos:  
 NORMAL BEVEL  
 BISELADO NORMAL

Nominal Weight / Peso Nominal:  
 10.80 LB/FT  
 16.08 KG/M

Customer / Cliente: COMCO PIPE & SUPPLY	Product Type / Tipo de Producto: LINE PIPE SEAMLESS CONDUCCION SIN COSTURA	Steel Grade / Grado de acero: B
Manufacturing Process / Proceso de Manufactura: SEAMLESS HOT ROLLED LAMINADO EN CALIENTE SIN COSTURA	Quantity / Cantidad: 99 Pcs/Pz 3876.280 FT 1181.490 MTS	Standard or Specification / Normas o Especificaciones: ASTM A 106,11
Dimensions / Dimensiones: 4 1/2 X 0.237 INCH 114.3 X 6 MM	Length / Longitud: 38.02 / 39.37 FT 11.59 / 12.00 MTS	

**HYDROSTATIC TEST / PRUEBA HIDRAULICA**

Pressure / Presión	Time / Tiempo	Result / Resultado
psi	Seconds / Segundos	Satisfactory / Satisfactorio
2,650	5	

**HEAT TREATMENT / TRATAMIENTO TERMICO**

Heat treatment / Tratamiento térmico: Pipe / Tubo  
 Quench media of heat treatment process / Medio de enfriamiento del tratamiento térmico: N/A  
 Temperature Scale / Escala de Temperatura: N/A  
 Type / Tipo: As rolled

**SUPPLEMENTARY INFORMATION / INFORMACION SUPLEMENTARIA**

Supplementary information / Información Suplementaria  
 Manufactured by Tenaris Tamsa  
 Steel making process: Electric Arc Furnace-Ladle Furnace-Continuous Casting Machine.  
 Fully Killed Steel  
 Material free from Mercury contamination

This is a certified copy and it is valid only if it is accompanied by the original certificate. The original certificate is the only one that must be used for any unallowable or not allowed use. Any alteration and falsification will be subject to the law.  
 Este certificado es una copia certificada y es válida solo si se acompaña con el original. El original es el único que debe utilizarse para cualquier uso no autorizado o no permitido. Cualquier alteración o falsificación estará sujeta a la ley.

046  
 ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SABM D.F.S. Hoyle  
 Print Name: Guayres II SAIJA  
 Signature: [Signature]  
 Date: [Date]  
 APPLUS®  
 O.S.I.  
 Veritas Intertek LLC

FOR03171



Tubos de Acero de Mexico, S.A.  
 Calle de la Industria No. 1414 Col. I. E. P.  
 Cuajalajara, Veracruz, Veracruz  
 C.P. 91697, MEXICO  
 (52) 229 958 1100 (L)  
 (52) 229 958 1600 (E)

INSPECTION CERTIFICATE 3.1  
 CERTIFICADO DE INSPECCIÓN 3.1  
 EN 10204 3.1: 2004

Number / Número: 12074141  
 Page / Página: 5 / 7  
 Date / Día: October 30, 2012

Customer's Order Item / Orden Cliente - Item: GT-3611 ITEM 2  
 Customer's Reference / Ref. del Cliente: N/A  
 Manufacturer's Work Order N° / Confirmación de Venta: 18686102

Customer / Cliente: COMCO PIPE & SUPPLY	Product Type / Tipo de Producto: LINE PIPE SEAMLESS	Surface / Superficie: VARNISHED
Manufacturing Process / Proceso de Manufactura: SEAMLESS HOT ROLLED	CONDUCCION SIN COSTURA	BARNIZADO
Standard or Specification / Normas o Especificaciones: ASTM A106,11	Steel Grade / Grado de acero: B	Ends / Extremos: NORMAL BEVEL
Dimensions / Dimensiones: 4 1/2 X 0.237 INCH	Quantity / Cantidad: 99 Pcs/IPZ	BISELADO NORMAL
114.3 X 6 MM	Length / Longitud: 38.02 / 39.37 FT	Nominal Weight / Peso Nominal: 10.80 LB/FT
	11.59 / 12.00 MTS	16.08 KG/M
	Schedule / Cédula: 040	
	Weight / Peso: 1181.490 MTS	

**SUPPLEMENTARY INFORMATION / INFORMACION SUPLEMENTARIA**

Supplementary Information / Información Suplementaria

Not repaired by welding / No reparado por soldadura  
 Non destructive test. Satisfactory / Control no destructivo. Satisfactorio  
 Inspection method / Método de Inspección: - EM - FLV - MPI - VEM

MATERIAL ACCORDING TO ASTM A106 GR. B, 1 ASME SA106 GR. B, 20\*  
 CSA Z245.1 GR.280 CAT. SS, APRIL 2007  
 MATERIAL ACCORDING TO NACE MR0175-2003 & NACE MR0175-2003  
 REL MNC MIN 3  
 SURF. Mg-Cr-Ni-Cu-V MAX 0.9999  
 CERTIFICATE ACCORDING TO EN 10204 3.1: 2004

ACCEPTED / REVISADO / APROBADO  
 SDA O R I S I  
 G A D I S I L S P 11 P  
 Signature: [Handwritten Signature]

**MARKING / MARCACION**

Marking / Marcación

MASCARILLA DE TUBO ESTARCIDO:  
 #N\*\*\*\* TENARIS TM ASTM A106/ASME SA106 / CSA Z245.1 #FE1 114.3 6.00 16.08 SCH 040 GR B/280 CAT 1  
 SS S TEST PRESSURENDE #M\*\*\*\* MT #K\*\*\*\* KG HEAT #C\*\*\*\* O.P. 209426 / #N\*\*\*\* HABILITADA MADE IN MEXICO  
 DONDE:  
 Numero de calada #C\*\*\*\*  
 Fecha de Fabricación #FE1:

This certificate is issued by a computerized system and is valid with electronic signature. On the original certificate the red-mark green contour "Tenaris" is stamped. In case the owner of the original certificate would to make a copy of it, he must print its conformity to the original one taking upon himself the responsibility for any unlawful or not allowed use. Any alteration under signature will be also valid to the law.

Tubo de Acero de Mexico, S.A.  
 Calle de la Industria 3 SA  
 Ciudad Madero, T. Mex. Ynvest. Veracruz  
 C.P. 81687 MEXICO  
 521 223 924 1100 Int.  
 521 223 624 1600 Int.

INSPECTION CERTIFICATE 3.1  
 CERTIFICADO DE INSPECCIÓN 3.1  
 EN 10204 3.1: 2004

Number / Número: 12074141  
 Date / Día: October 30, 2012

Customer's Order Item / Orden Cliente - Item: G1-3611 ITEM 2  
 Customer's Reference / Ref. del Cliente: N/A

Manufacturer's Work Order / Confirmation de Venta: 186861/02

Customer / Cliente: COMCO PIPE & SUPPLY	Product Type / Tipo de Producto: LINE PIPE SEAMLESS CONDUCCION SIN COSTURA	Surficio / Superficie: VARNISHED BARNIZADO
Manufacturing Process / Proceso de Manufactura: SEAMLESS HOT ROLLED LAMINADO EN CALIENTE SIN COSTURA	Standard or Specification / Normas o Especificaciones: ASTM A106, 11	Ends / Extremos: NORMAL BEVEL BISELADO NORMAL
Dimensions / Dimensiones: 4 1/2 X 0.237 INCH 114.3 X 6 MM	Schedule / Cédula: 040	Nominal Weight / Peso Nominal: 10.80 LB/FT 16.08 KG/M
Length / Longitud: 38.02 / 39.37 FT 11.59 / 12.00 MTS	Quantity / Cantidad: 99 Pcs/PZ 3876.280 FT 1181.490 MTS	

**MARKING / MARCACION**

Marking / Marcación  
 Peso real del tubo en Kgs #K\*\*\*\*:  
 Longitud del tubo en Mts #M\*\*\*\*:  
 Número de secuencia #N\*\*\*\*:  
 HABILITADA G1-3611

**SUMMARY REPORT / REPORTE RESUMEN**

Heat # / Colada N°	Quantity / Cantidad	Length / Longitud	Weight / Peso
(ft)	(Pcs)	(m)	(Tons)
04385	96	17.62	0.588
Average length per pipe / Longitud promedio por tubo: 38.154 m			
Nominal weight per pipe / Peso nominal por tubo: 16.08 (lb/ft) 16.08 (kg/m)			

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: S M  
 Print Name: S M  
 Signature: [Signature]  
 Date: 10/30/12  
 046  
**Applus®**  
**VELOSI**  
 Velosi America LLC

This certificate is issued by a computerized system and it is void with electronic signature. On the original certificate the trademark group contains "Tenaris" is stamped. In case the owner of the original certificate would release a copy of it, he must attest its conformity to the original one taking upon himself the responsibility for any use, reprint or not allowed use. Any alteration and/or falsification will be subjected to the law.  
 Este certificado es emitido por un sistema computarizado y es válido con firma electrónica. El cert. con original posee impresa el logo "Tenaris" es estampado. En caso de que el poseedor del certificado entregue una copia, deberá garantizar la conformidad con el original haciéndose responsable por cualquier uso legal o no autorizado. Cualquier alteración, uso falsificación deberá sujeta a la ley.

Tubos de Acero de Mexico, S.A.  
 Carretera Mexico Veracruz Km 53.7 SN  
 Callejo Veracruz, Tlaxiaco, Veracruz, Veracruz  
 C.P. 81697 MEXICO  
 (52) 229 345 1100 ext  
 (52) 229 039 1600 fax


Page / Página: 7 / 7  
 Number / Número: 12074141  
 Date / Día: October 30, 2012


**INSPECTION CERTIFICATE 3.1**  
**CERTIFICADO DE INSPECCIÓN 3.1**  
**EN 10204 3.1: 2004**

Customer's Order Item / Orden Cliente - Item: G1-3611 ITEM 2  
 Customer's Reference / Ref. del Cliente: N/A  
 Manufacturer's Works Order N° / Confirmación de Venta: 18686102

Customer / Cliente: COMCO PIPE & SUPPLY	Surfaced / Superficie: VARNISHED
Manufacturing Process / Proceso de Manufactura: SEAMLESS HOT ROLLED	Ends / Extremos: BARNIZADO
LAMINADO EN CALIENTE SIN COSTURA	NORMAL BEVEL
Standard or Specification / Normas o Especificaciones: ASTM A106,11	BISELADO NORMAL
Dimensions / Dimensiones: 4-1/2 X 0.237 INCH	Nominal Weight / Peso Nominal: 10.80 LB/FT
114.3 X 6 MM	16.08 KG/M
Schedule / Cálculo: 040	Quantity / Cantidad: 99 Pes/Pz
Length / Longitud: 38.02 / 39.37 FT	42721.212 LB
11.59 / 12.00 MTS	19378.000 KG
Sheet Grade / Grado de acero: B	

Por el presente certificamos que el material aquí descrito ha sido fabricado, muestreado, ensayado e inspeccionado de acuerdo a los requisitos de su orden de compra. Este certificado no es, ni puede ser usado, como una declaración de origen.

<b>CUSTOMER - THIRD PARTY</b>	<b>TENARIS QUALITY DEPARTMENT SIGNATURE</b>
INSPECTION COMPANY COMPAÑIA DE INSPECCION	
NO APLICA Employee Name: N/A	CHIEF OF QUALITY CERTIFICATION DEPT. RESPONSABLE DEL DEPTO. DE CERTIFICACION DE CALIDAD Ricardo Lozano Arreola

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBM OFFSHORE  
 Print Name: GIA MRS H SAHA  
 Signature:   
 Date: Apr 18 15  
**Applus®**  
**VELOSI**  
 Velosi America LLC

This certificate is issued by a computerized system and it is void with electronic signature. On the original certificate the photo, name, green color code and Tenaris is stamped. In case the owner of the original certificate would release a copy of it, he must attest its conformity to the original one taking upon himself the responsibility for any unlawful or not a bonded use. Any alteration and/or falsification will be subjected to the law.

FOR03171





SIDERCA S.A.L.C.  
Dr Jorge A. Simini 250  
(02604474) Campana  
Buenos Aires, Argentina  
(54) 3489 433100 Int.  
(54) 3489 433405 fax

# INSPECTION CERTIFICATE

(BS EN 10204 3.1: 2004 - ISO 10474 3.1B: 1991)

Cliente / Customer <b>COMCO PIPE &amp; SUPPLY CO.</b>		Expedient Manufacturing Order <b>58143.02</b>		Fecha / Date <b>24/06/2005</b>		Pág./Page <b>1 / 5</b>	
Producto / Product <b>SMLS LINE PIPE</b>		Orden de Compra / Purchase Order <b>G1609215</b>		Referencia del Cliente / Customer Reference			
Norma / Standard <b>API 5L/ASTM A-106/ASME SA-106 + CSA/Z45.1-P4.17</b>		Grado / Grade <b>BX42+290SS</b>		Extremos / Ends <b>ASMEB16.28FZA(ANSB16.25)</b>			
Dimensiones / Dimensions <b>114.30 x 11.10 mm</b> <b>4 1/2 x 0.438 inches</b>		Peso Nominal / Nominal Weight <b>28.25 KG/MT</b> <b>19.02 LB/FT</b>		Superficie Externa / External Surface <b>VARNISHED</b>		Cantidades / Quantities <b>27 Pz</b> <b>27 Pcs</b>	
Longitud / Length <b>11,673,4 m</b>				328.02 m 1069.62 Ft		9169 Kg 20214 Lb	

## ENSAYOS DE TRACCION / TENSILE TEST

Código Ensayo	Nº de Ensayo	Condición de la probeta	Temp de Ensa	Dimensiones		Sección	Fluencia / Yield Strength				Rotura/U.T.S				Relación FIR	Alargamiento Elongation		Red. de area	Dureza / Hardness	Tipo / type: BHN
				Stco	inches		Offset Method	V. obt.	EUL Method	Req. Min	V. obt.	Req. Max	Y.S.U.T.S Ratio	Req. Min		V. obt.	Req. Max			
3830	407390	CB PRO	TART	0.984	0.435	0.433	0.5	42	44.9	70.9	60	60.5	28.4	42.0	14.3	200				
<p>Q.C.I. N.D. (Red diamond stamp)</p> <p>Q.C.I. E.Y. (Red diamond stamp)</p> <p>AUG 25 2006 (Stamp)</p> <p>DCN (Stamp)</p> <p>W.O. # 117608</p> <p>M.L. # 2301434</p> <p>THK. # 430</p> <p>P.O. # D567-73326</p> <p>certification of Material - Per ASME T# 29330</p> <p>qualifies to all requirements of SA-106-18</p> <p>sect. II IR Edición 19A Adenda</p>																				

### TEST TECHNOLOGICO / TECHNOLOGICAL TEST

Abastecido / Curved Flanging Test	Abastecido / Flaring Test	Flangeo Test	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Proceso / Process Normalizado / Normalized DIST = Dimensiones / Stress Relief Q.S.T = Templado y Revenido / Quenched & Tempered TART = Temp. Ambiente / Room Temperature	RE = Rectangular CI = Cilindrico / Cylindrical ST = Segmento Tubular / Tubular segment TU = Tubo / Tube	RB = Resaca / Body RU = Rosca / Thread P/A = Promedio / Average Min = Mínimo / minimum Max = Máximo / Maximum	CB = Cuerpo / Body P/A = Promedio / Average Min = Mínimo / minimum Max = Máximo / Maximum	L = Longitudinal T = Transversal PIT = Tubo / Pipe EXT = Extremo / End MI = Medio / Middle	V. Obt. = Valor Obtenido / Obtained value E = Comienzo de marcadura / Starting O = Extremo opuesto al E / Opposite extreme to E CH = Ensayo en Caliente / Hot Testing															

ACCEPTED BY: BWBRE/ELKSD  
 for and on behalf of: SPM OFFSHORE  
 Print Name: GANESH SAMI  
 Signature: [Signature]







# INSPECTION CERTIFICATE

(BS EN 10204 3.1: 2004 - ISO 10474 3.1B: 1991)

SIDERCA S.A.I.C.  
Dr Jorge A. Smith 250  
(B2800MHA) Campana  
Buenos Aires, Argentina  
(54) 3489 433100 tel.  
(54) 3489 433405 fax

<b>Cliente / Customer</b> COMCO PIPE & SUPPLY CO.		<b>Expediental Manufacturing Order</b> 56143.02		<b>Número / Number</b> 265419		<b>Fecha / Date</b> 24/09/2005		<b>Pág./Page</b> 3 / 5	
<b>Producto / Product</b> SMLS LINE PIPE		<b>Orden de Compra / Purchase Order</b> G1609215		<b>Item</b> 00008		<b>Referencia del Cliente / Customer Reference</b>			
<b>Norma / Standard</b> API 5L/ASTM A-106/ASME SA-106 + CSAZ45.1-P4.17		<b>Grado / Grade</b> BIX42-280SS		<b>Extremo / Ends</b> ASMEB16.25F2(ANSIB16.25)		<b>Cantidades / Quantities</b> 27 Pz 326.02 m 9169 Kg 27 Pcs 1069.62 Ft 20214 Lb			
<b>Dimensiones / Dimensions</b> 114.30 x 11.10 mm		<b>Peso Nominal / Nominal Weight</b> 28.25 KG/MT 19.02 LB/FT		<b>Superficie Externa / External Surface</b> VARNISHED					
<b>4 1/2 x 0.438 inches</b>		<b>Schedule</b> 120		<b>Longitud / Length</b> 11,613,4 m					
<b>Marcas / Marking</b> LLL = Longitud / length HXXXXXXXX = Coleada / Heat		<b>MNNNN = Número de tubo / Nbr of pipe</b> YIT = Año / Trimestre Year / Quarter		<b>PPP = Peso / Weight</b> <b>HHHHHHH = Coleada / Heat</b>		<b>@ = Monograma / Monogram API</b>			
<b>Prueba Hidráulica / Hydrostatic Test</b> Tiempo / Time Segundos / Seconds 5,00		<b>Resultado / Results</b> Satisfactorio / Satisfactory							
<b>Unidad / Unit</b> PSI		<b>Presión / Pressure</b> Vector / Value 3000,00							
<b>Estándar (Tubo) / Stencilling (Pipe)</b> NNNNN LLLL PPRPP TENARIS SD 5L0098 @ MM.YY ASTM/ASME A/SA106 API5L CSA Z245.1-ED 2002 BIX42PSL-1/280 C1 SS S 114.3 X 11.1 19,02 4 SCH 120 3000PSI PO G1609215 5/6143.02 MADE IN ARGENTINA HXXXXXXXX									
<b>Tarjeta / Card:</b> SIDERCA MADE IN ARGENTINA P.O.: G1609215 OF: 56143-02 PIECES: LENGTH: WEIGHT(KG): LIFT: SIZE: 114.30 X 11.10 GDO-BIX42-280SS SPEC: API-ASTM HEAT: CL-COMCO PIPE & SUPPLY COMPANY									
<b>*FABRICADO POR SIDERCA*</b> <b>*PROCESO DE ACERACIÓN*</b> FABRICACIÓN DE ACERO: FUNDICIÓN POR ARCO ELECTRICO Y COLADO CONTINUO - ACERO CALAMADO AL ALUMINIO. -LA PRÁCTICA DE AFINO EN EL HORNO - CLICHARA INCLUYE UNA INYECCIÓN FINAL DE UNA VARILLA DE SILICIO DE CALCIO PARA OBTENER UNA FORMA GLOBULAR DE EVENTUALES MICROINCLUSIONES. -MATERIAL LIBRE DE CONTAMINACIÓN DE MERCURIO. <b>*PROCESO DE LAMINACIÓN*</b> -FABRICACIÓN DE TUBO: LAMINADO EN CALIENTE Y SIN COSTURA.									
<b>*MANUFACTURED BY SIDERCA*</b> <b>*ACIERAGE PROCESS*</b> STEEL MAKING PROCESS: E.A.F.L.F. AND CONTINUOUS CASTING - FULL ALUMINIUM KILLED AND FINE GRAIN PRACTICE. -THE LF PRACTICE INCLUDES A FINAL INJECTION OF CALCIUM SILICIDE WIRE FOR MICROINCLUSION SHAPE CONTROL. -MATERIAL FREE FROM MERCURY CONTAMINATION. <b>*ROLLING PROCESS*</b> -MANUFACTURING PROCESS : SEAMLESS HOT ROLLED.									

046  
ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SAM OFFSHORE  
Print Name: GRANEST SAH  
Signature: [Signature]  
Date: July 15/13  
**Applus+**  
VELOSI  
Velosi America LLC



APR 17 2013







# INSPECTION CERTIFICATE

(BS EN 10204 3.1: 2004 - ISO 10474 3.1B: 1991)

SIDERCA S.A.I.C.  
 Dr Jorge A. Simini 250  
 (B2804VHA) Carrizosa  
 Buenos Aires, Argentina  
 (54) 3489 433100 tel.  
 (54) 3489 433405 fax

Cliente / Customer COMCO PIPE & SUPPLY CO.	Expediental / Manufacturing Order 50143.02	Número / Number 285419	Fecha / Date 24/06/2005	Pág./Page 5 / 5
Producto / Product SMILS LINE PIPE	Orden de Compra / Purchase Order G1800215	Item 00006	Referencia del Cliente / Customer Reference	
Norma / Standard API 5L/ASTM A-106/ASME SA-106 + CSAZ45.1-P4.17	Grado / Grade B0X42+230SS	Extremo / Ends ASMEB16.25F2A(ANSIB16.25)		
Dimensiones / Dimensions 114.30 x 11.10 mm 4 1/2 x 0.438 inches	Peso Nominal / Nominal Weight 20.25 KG/MT 19.02 LB/FT	Superficie Externa / External Surface VARNISHED	Cantidades / Quantities 27 Pz 27 Pcs	9169 Kg 20214 Lb
Longitud / Length 11,873,4 m				

END MARKING: ONE GREEN BAND.

Protectores / End Protectors:  
 NON LIFTABLE CLOSED PLASTIC PROTECTOR FOR FLAT / BEVELED PIPE. SUPPLIER METALCENTRO.

046

ACCEPTED/REVIEWED/RELEASED

for and on behalf of: SOM OFF SHORE

Print Name: G. MIZSI SAH

Signature: [Signature]

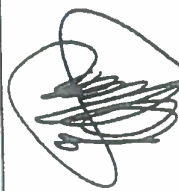
Date: July 10/03

**Applus**  
VELOSI

Velosi America LLC

Q.C.I.  
E.Y.

Q.C.I.  
N.D.

<p>Por la presente certificamos que el material aquí descrito ha sido fabricado de acuerdo con las normas y especificaciones solicitadas en vuestra orden y se adhieren los correspondientes requerimientos.</p> <p>Este certificado se emite mediante un sistema computarizado y es válido con firma electrónica. El certificado original presenta el logo Tenaris (verde claro), impreso en la parte inferior de la hoja. En caso que el poseedor del certificado entregue una copia del mismo, deberá garantizar la conformidad con el original, haciéndose responsable por cualquier uso ilegal o inusitado.</p> <p>Cualquier reclamación y/o falsificación estará sujeta a la ley.</p> <p>Si necesita asegurar la autenticidad de este certificado, contactarse con Siderca S.A.C., e-mail: <a href="mailto:eyes@siderca.com">eyes@siderca.com</a></p>	<p>We hereby certify that material herein described has been manufactured in accordance with the standards and specifications required in your order and satisfies the corresponding requirements.</p> <p>This certificate is issued by a computerized system and it is valid with electronic signature.</p> <p>On the original certificate the trade-mark Tenaris light-green coloured at the bottom of the page is stamped. In case the owner of the certificate would release a copy of it, he must attest its conformity to the original one taking upon himself the responsibility for any unlawful or not allowed use.</p> <p>Any objection and/or falsification will be subject to the law.</p> <p>If you need to ensure the authenticity of this certificate, please do not hesitate to contact Siderca S.A.C. through this e-address: <a href="mailto:eyes@siderca.com">eyes@siderca.com</a></p>
	
QUALITY CERTIFICATION DEPT. DTO CERTIFICACION DE CALIDAD <b>EDUARDO A. AYERBE</b>	

CAU 17504





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Benteler Steel/Tube GmbH  
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 33043 Paderborn  
 Deutschland  
 Tel.: +49.5254.81-0 Fax: +49.5254.13666

**ABNAHMEPRÜFZEUGNIS EN 10204-3.1**  
 INSPECTION CERTIFICATE EN 10204-3.1  
 CERTIFICAT DE RECEPTION EN 10204-3.1  
 EN 10204:2005-01

Benteler Steel/Tube GmbH - Postfach 1340 - 33043 Paderborn - Deutschland  
 COMCO PIPE & SUPPLY CO.  
 R.R. #3  
 GUELPH, ON N1H 6H9  
 KANADA

Dokument-Nr.: 65-615576/001/P

Inspection No.:  
 No. du certificat:

Kunden-Bestell-Nr.: BST 10-5222 / Comco G1-1346

Purchase Order No.:  
 No. de commande du client:

Benteler Auftrags-Nr.: 1555314

Benteler Order No.:  
 No. de commande Benteler:

Versandanzeigen-Nr.: 6595674

Dispatch Note No.:  
 No. d'avis d'expédition:

Produkt: NAHTLOSE STAHLROHRE  
 Product: SEAMLESS STEEL TUBES  
 Produit: TUBES D'ACIER SANS SOUDURE

Prof.-Nr.:  
 Inspection No.:  
 No. du certificat:

Hersteller:  
 Manufacturer:  
 Producteur:

Herstellerzeichen:  
 Manufacturer's brand:  
 Marque du producteur:

Stempel des Abnahmebeauftragten: WA  
 Stamp of the inspection representative:  
 Poignon du contrôleur:

Stahlerschmelzungsverfahren: ELEKTROSTAHL  
 Steelmaking process: ELECTRIC FURNACE  
 Procédé d'élaboration de l'acier: FOUR ELECTRIQUE

ASME SA-106, ASME Section II Part A Edition 2007 Addenda 2009b, S5, API Specification 5L  
 Forty-Fourth Edition, October 2007, ISO 3183:2007, PSL 1, incl. ADDENDUM 2, ASTM-A 106-2008, S6, CSA  
 Standard Z245.1-07 Category I, Sour Service, NACE MR0175/ISO 15156-1:2001, NACE MR0175/ISO  
 15156-2:2003

ASME B36.10M-2004, ASME SA-530, ASME Section II Part A Edition 2010, ASTM-A 530-2004a

GRADE 290, GRADE B, GRADE X 42

Hot rolled

see attachment product marking

Product marking:  
 Marquage du produit:



APR 05 2013

Pos.	Stück	Maße	Länge	Gewicht	Schmelzen-Nr.	Prüfdruck	Rohr-Nr.-Gruppe	Vielfachhängen
Item	Number	Dimensions	Length	Weight	Heat No.	Test pressure	Tube number group	Multiple lengths
Poste	Nombre	Dimensions	Longueur	Poids	No. de coulée	Pression d'épreuve	Série de no. des tubes	Longueurs multiples
			feet	lbs		PSI		
0009	19	2" NPS * Sched. 160 38 FT - 42 FT	755,09	5728	562541	3000	S	5



*Handwritten signature and date: April 5 2013*

APR 06 2013



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Dokument-Nr.: 65-615576/001/P  
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ABNAHMEPRÜFZEUGNIS EN 10204-3.1  
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Pos.	Stück Item	Maße Dimensions	Länge Length	Gewicht Weight	Schmelzen-Nr. Heat No.	Prüfdruck Test pressure	Rohr-Nr.-Gruppe Tube number group	Vielfachlänger Multiple lengths
Poste	Nombre	Dimensions	Longueur	Poids	No. de coulée	Pression d'épreuve	Série de no. des tubes	Longueurs multiples
			feet	lbs		PSI		
0012	168	2" NPS * Sched. 80 38 FT - 42 FT	6867,55	34736	562617	3000	5	
0017	30	3" NPS * Sched. 80 38 FT - 42 FT	1223,46	12699	562651	3000	5	
0019	22	3" NPS * XXS 38 FT - 42 FT	537,96	10042	562541	3000	5	
0020	18	3 1/2" NPS * Sched. 40 38 FT - 42 FT	732,61	6753	562651	2860	5	
0021	8	4" NPS * Sched. 160 38 FT - 42 FT	329,76	7507	561984	3000	5	



APR 05 2013

Schmelzenanalyse [%] / Heat analysis [%] / Analyse sur coulée [%]

Pos.	Schmelzen-Nr. Item	C	SI	MN	P	S	CR	MO	NI	CU	V	NB	TI	B
Poste	No. de coulée													
0009	562541	0,130	0,230	0,84	0,009	0,001	0,09	0,02	0,08	0,14	0,002	0,001	0,003	0,0001
0012	562617	0,140	0,180	0,80	0,015	0,001	0,16	0,03	0,09	0,15	0,002	0,010	0,001	0,0001
0017	562651	0,130	0,200	0,82	0,010	0,002	0,10	0,03	0,08	0,15	0,002	0,010	0,001	0,0001
0019	562541	0,130	0,230	0,84	0,009	0,001	0,09	0,02	0,08	0,14	0,002	0,001	0,003	0,0001
0020	562651	0,130	0,200	0,82	0,010	0,002	0,10	0,03	0,08	0,15	0,002	0,010	0,001	0,0001
0021	561984	0,130	0,220	0,83	0,007	0,004	0,09	0,03	0,08	0,15	0,002	0,001	0,001	0,0002

- Formel: CE IIW=C+(Mn/6)+((Cr+Mo+V)/5)+((Cu+Ni)/15)<=0,40 %
- Formel: CEV=C+F\*((Mn/6)+(Si/24)+(Cu/15)+(Ni/20)+((Cr+Mo+V+Ni)/5) + (5\*B)) <=0,40
- Formel: Mn/C>=3/1
- Formel: Cr+Cu+Mo+Ni+V<=1,00 %

W.O. # 11768  
 M.L. # 24 (24)  
 THK. # 624  
 P.O. # 13-0249



Certification of Material - Per ASME  
 HT# 562541  
 Qualifies to all requirements of  
 SA106-GRB per  
 Sect. II 10 Edition II Addenda

APR 04 2013

Rev. 1.5.2013



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 No. du certificat:

Dokument-Nr.: 65-615576/001/P  
 Document No.:  
 No. du document:  
 Biegeversuch: PASSED  
 Bending test:  
 Essai de cintrage:  
 POS. / Item / Poste: 0009, 0012  
 Maßkontrolle: PASSED  
 Dimensions examination:  
 Vérification des dimensions:

Augensichtkontrolle: PASSED  
 Visual inspection:  
 Examen visuel:  
 Ringfaltversuch: PASSED  
 Flattening test:  
 Essai d'aplatissement:  
 POS. / Item / Poste: 0017, 0019, 0020, 0021

Ergebnisse der mechanischen Prüfung / Results of mechanical testing / Résultats des essais mécaniques

Die Probenahme erfolgte an Vielfachlängen.  
 The sampling was carried out on multiple lengths.  
 L'echantillonnage était réalisé aux longueurs multiples.

Zugversuch Streifenprobe / Tensile test Strip test specimen / Essai de traction Bande decoupee sur tube

Pos. / Item / Poste	Proben-Nr. / Specimen No. / No. de l'éprouvette	Schmelzen-Nr. / Heat No. / No. de coulée	Probenabmessung / Specimen dimensions / Dimensions de l'éprouv.	Streckgrenze / Yield strength / Limite élastique	Zugfestigkeit / Tensile strength / Résistance à la traction	Dehnung / Elongation / Allongement	Einschnürung / Area reduction / Coefficient de striction	Re/Rm / Re/Rm / Re/Rm
			mm	MPa / MIN 290	MPa / 415-625	% / A2"		
0009	000001	562541	19,00 X 8,75	314	465	48		
0012	000001	562617	19,00 X 5,50	349	490	34		
0017	000001	562651	25,40 X 8,70	321	457	44		
0019	000001	562541	25,40 X 15,25	300	455	48		
0020	000001	562651	25,40 X 5,80	346	477	37		
0021	000001	561984	25,40 X 13,80	302	452	48		



APR 05 2013

*Revised*  
*APR 15, 2013*



APR 04 2013





Steel/Tube

Benteler Steel/Tube GmbH  
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Prüf-Nr.:  
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Formel-Nr.:  
 Formula No.:

Formel-Nr.:  
 Formula No.:

ABNAHMEPRÜFZEUGNIS EN 10204-3.1  
 INSPECTION CERTIFICATE EN 10204-3.1  
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Formelergbnisse / Formula results / Résultats des formules

Pos.	Schmelzen-Nr.	1. Formel	2. Formel	3. Formel	4. Formel
Item	Heat No.	1. Formula	2. Formula	3. Formula	4. Formula
Poste	No. de coulée	1. Formule	2. Formule	3. Formule	4. Formule
0009	562541	0,307	0,279	6,462	0,332
0012	562617	0,328	0,307	5,714	0,432
0017	562651	0,308	0,280	6,308	0,362
0019	562541	0,307	0,279	6,462	0,332
0020	562651	0,308	0,280	6,308	0,362
0021	561984	0,308	0,280	6,385	0,352

Produktanalyse [%] / Product analysis [%] / Analyse sur produit [%]

Pos.	Schmelzen-Nr.	C	SI	MN	P	S	CR	MO	NI	CU	V	NB	TI	B
Item	Heat No.													
Poste	No. de coulée													
0009	562541	0,130	0,200	0,82	0,006	0,005	0,09	0,05	0,07	0,15	0,002	0,001	0,001	0,0001
0009	562541	0,130	0,210	0,82	0,007	0,004	0,09	0,04	0,07	0,14	0,001	0,001	0,001	0,0001
0012	562617	0,130	0,190	0,81	0,010	0,004	0,13	0,03	0,09	0,11	0,002	0,010	0,002	0,0001
0012	562617	0,130	0,200	0,80	0,010	0,004	0,13	0,02	0,09	0,12	0,001	0,010	0,002	0,0001
0017	562651	0,130	0,190	0,82	0,011	0,002	0,10	0,02	0,08	0,15	0,001	0,010	0,001	0,0001
0017	562651	0,130	0,200	0,82	0,012	0,003	0,11	0,03	0,08	0,14	0,001	0,010	0,001	0,0001
0019	562541	0,130	0,230	0,85	0,008	0,002	0,09	0,02	0,08	0,14	0,002	0,001	0,003	0,0001
0019	562541	0,130	0,230	0,85	0,008	0,002	0,10	0,02	0,08	0,14	0,002	0,001	0,003	0,0001
0020	562651	0,130	0,180	0,82	0,012	0,004	0,13	0,03	0,10	0,15	0,001	0,010	0,001	0,0002
0020	562651	0,130	0,170	0,81	0,013	0,004	0,12	0,02	0,09	0,16	0,002	0,010	0,001	0,0002
0021	561984	0,130	0,210	0,82	0,006	0,004	0,10	0,03	0,08	0,14	0,002	0,002	0,001	0,0001
0021	561984	0,130	0,220	0,83	0,007	0,004	0,09	0,04	0,08	0,15	0,001	0,001	0,001	0,0001

APR 04 2013





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 No. du certificat:

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ABNAHMEPRÜFZEUGNIS EN 10204-3.1  
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 CERTIFICAT DE RECEPTION EN 10204-3.1

1. Formel:  $CE\ IIW=C+(Mn/6)+((Cr+Mo+V)/5)+((Cu+Ni)/15)\leq 0,40\ \%$
2. Formel:  $CEV=C+F*((Mn/6)+(Si/24)+(Cu/15)+(Ni/20)+((Cr+Mo+V+ Nb)/5) + (5*B))\leq 0,40$
3. Formel:  $Mn/C\geq 3/1$
4. Formel:  $Cr+Cu+Mo+Ni+V\leq 1,00\ \%$

Formelergebnisse / Formula results / Résultats des formules

Pos.	Schmelzen-Nr	1. Formel	2. Formel	3. Formel	4. Formel
Item	Heat No.	1. Formula	2. Formula	3. Formula	4. Formula
Poste	No. de coulée	1. Formule	2. Formule	3. Formule	4. Formule
0009	562541	0,309	0,280	6,307	0,362
0009	562541	0,306	0,278	6,307	0,341
0012	562617	0,310	0,282	6,230	0,362
0012	562617	0,307	0,279	6,153	0,361
0017	562651	0,306	0,278	6,307	0,351
0017	562651	0,309	0,281	6,307	0,361
0019	562541	0,308	0,280	6,538	0,332
0019	562541	0,310	0,282	6,538	0,342
0020	562651	0,315	0,285	6,307	0,411
0020	562651	0,310	0,281	6,230	0,392
0021	561984	0,307	0,279	6,307	0,352
0021	561984	0,309	0,281	6,384	0,361



APR 05 2013

Prüfergebnisse / Test results / Résultats des essais

Die Rohre sind auf Dichtheit geprüft durch:  
 The tubes have been submitted to a leak tightness test by:  
 Les tubes ont passé un contrôle d'étanchéité par:

Hydrostatic test: acc. to CSA Z245.1, holding time min 5 seconds, Test pressure/Time-record

PASSED

Die Rohre wurden zerstörungsfrei geprüft:  
 The tubes are non destructive tested:  
 Les tubes ont passé un essai non destructif:

ET-test: acc. to CSA Z245.1; for imperfections; drilled hole: 3,20 mm

PASSED



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ABNAHMEPRÜFZEUGNIS EN 10204-3.1  
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Härteprüfung / Hardness test / Essai de dureté

Dokument-Nr.: 65-615576/001/P  
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Pos. Proben-Nr. Schmelzen-Nr. Härte  
 Item Specimen No. Heat No. Hardness  
 Poste No. de l'éprouv. No. de coulée Dureté

			HRC	HB	HV	HRB	HBW
<b>Anforderungen</b>							
<b>Requirements</b>							
<b>Exigences</b>							
0009	000001	562541		MAX 200			
0009	000002	562541		136			
0009	000003	562541		136			
0012	000001	562617		135			
0012	000002	562617		135			
0012	000003	562617		135			
0012	000004	562617		134			
0017	000001	562651		135			
0017	000002	562651		136			
0017	000003	562651		135			
0019	000001	562541		132			
0019	000002	562541		131			
0019	000003	562541		132			
0020	000001	562651		135			
0020	000002	562651		134			
0020	000003	562651		134			
0021	000001	561984		131			
0021	000002	561984		135			
0021	000003	561984		133			



Restmagnetismus / Demagnetize / Démagnétiser  
 demagnetized tubes; 1 measurement per 4 hours on both tube ends Two readings 180° apart around the circumference. Average value  
 max 3.0 Millitesla (24 A/cm), individual value max 3.5 Millitesla (28 A/cm)



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 Inspection No.:  
 No. du certificat:

65-615576/001/P

Dokument-Nr.:  
 Document No.:  
 No. du document:

ABNAHMEPRÜFZEUGNIS EN 10204-3.1  
 INSPECTION CERTIFICATE EN 10204-3.1  
 CERTIFICAT DE RECEPTION EN 10204-3.1

Vermerk / Remark / Remarque

Pos. / Item / Poste: 0009, 0012, 0012, 0012, 0012  
 NACE Standard: Hardness acc. to NACE MR0175/ISO 15156: HRC max 22., The material meets the requirements of NACE MR0103;  
 Certificate remarks: The Material is Aluminium deoxidized and inclusion shape controlled with Calcium-Silicon treatment, This is  
 to confirm that the seamless linepipe supplied by Benteler and verified to CSA Standard Z245.1-07 meets the requirement for  
 micro hardness of max. 248 HV 500 gf., No weld repair has been carried out; Bend test: mandrel diameter 12D; Bending angle: 90 °

Pos. / Item / Poste: 0017, 0019, 0021, 0020, 0021, 0020, 0019, 0020, 0021, 0019  
 NACE Standard: Hardness acc. to NACE MR0175/ISO 15156: HRC max 22., The material meets the requirements of NACE MR0103;  
 Certificate remarks: The Material is Aluminium deoxidized and inclusion shape controlled with Calcium-Silicon treatment, This is  
 to confirm that the seamless linepipe supplied by Benteler and verified to CSA Standard Z245.1-07 meets the requirement for  
 micro hardness of max. 248 HV 500 gf., No weld repair has been carried out

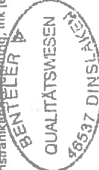
Beiblatt Produktkennzeichnung / Attachment product marking / Supplément marquage du produit

Pos. Produktkennzeichnung  
 Item Produktkennzeichnung  
 Poste Marquage du produit

- 0009, 0012, 0017, 0020  
 FS: BENTELER Z.245.1-07 - ISO 3183 - A 106-S6 - SA-106-S5 5L-0151 API SIGN 1110 PSL1 B/X42/290 SS HEAT-NO. TEST  
 PRESSURE NDE DIMENSIONS TUBES-LENGTH FEET WA GERMANY P.O. G1-1346
- 0019  
 FS: BENTELER Z.245.1-07 - ISO 3183 - A 106-S6 - SA-106-S5 5L-0151 API SIGN 1110 PSL1 B/X42/290 SS HEAT-NO. TEST  
 PRESSURE NDE WEIGHT CLASS TUBES-LENGTH FEET WA GERMANY P.O. G1-1346
- 0021  
 FS: BENTELER Z.245.1-07 - ISO 3183 - A 106-S6 - SA-106-S5 5L-0151 API SIGN 1010 PSL1 B/X42/290 SS HEAT-NO. TEST  
 PRESSURE NDE DIMENSIONS TUBES-LENGTH FEET WA GERMANY P.O. G1-1346

AEZ = Azübenbeschriftung, Eching ink marking, Gravure à l'encre | FK = Farbkennzeichnung, colour marking, marquage par couleur | FS = Farbschablonierung, paint stencilling, marquage par poinçonnage | FS = Tintenstrahlbeschriftung, ink jet spray marking, imprimante à jet d'encre  
 | LK = Laserkennzeichnung, Laser marking, Marquage laser | PKE = Etikettenkennzeichnung, tag marking, marquage sur étiquette | PS = Prägestempel, die stamp, marquage par poinçonnage | TS = Tintenstrahlbeschriftung, ink jet spray marking, imprimante à jet d'encre

Verkäufer(in) / Salesman/ woman in charge / Personne chargée : Mr Pottmeier, Tel.: 05254/81-4265, Fax: 4289



Dinslaken, 02.12.2010, TEL.: 02064.623-537 FAX: 02064.623-539

Abnahmebeauftragter  
 Inspection représentative  
 Contrôleur  
 DR. BASEL KENTA / Thei

Es wird bestätigt, daß die gelieferten Erzeugnisse den techn. Lieferbedingungen des Auftrages entsprechen. Dieses Dokument wurde mittels EDV erstellt und ist ohne Unterschrift gültig.  
 We certify that the supplied products comply with the order specification. This document was prepared by means of electronic data processing and is valid without signature.  
 Nous attestons que les produits livrés sont conformes aux stipulations de la commande. Ce document a été établi par traitement électronique de l'information et est valide sans signature.

# Certificate of Mill Test Results

# QUALITY PLATES & PROFILES LIMITED

20 Nicholas Lane Road, R.R.#3 (Aberfoyle), Guelph, ON N1H 6H9  
 ALI-VELD COMPANY LIMITED  
 PO/Rel: 13-0220  
 CONTACT: HELENE/BRIAN  
 Inv: 1055184 Date: 03/19/2013  
 Heat: 8952M3

PLATE CPL 516N 1/2" x DWG# 1176-4-4 TAG 1176-26



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

0005751

SO No., Item & Date:	8003926 00020 2012/10/18	Shipment No. & Date:	1000011159 2012/10/18	TC No., Date & Time:	ESA-19141 2012/10/19 - 07:59:10
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:	P007192 / 2
Customer Specification:	HR STEEL PLATE Carbon Multi Cert ASTM A516 GR 70 (10) / ASME SA516 GR 70 (11A) Meets NACE MR 0103 latest Ed., NACE MR 0175 latest Ed., BHN < 200, D.O.CEQ. 43 max, Inclusion Shape Control Calcium Treated Normalized Temp 1670 °F 17 min CVNL Req. 15/12 FT-LBF at -50.0 F Std Thickness Tol PVQ Top and Bottom Standard Surface No Weld Repair Flatness 1/2 A20 Latest Ed. + Addenda or ASME Niobium max 0.015 Sur-Nb+V max 0.030 Vanadium max 0.020			BOL NO.:	1000011159
Supplementary Instructions:	Test Cert 1:519-837-2227			Cust. Part No.:	
Insp T/R:	Test Report As Per Spec			Carrier:	NATIONAL TRANSPORTATION - 0685(1009) REV

Cust Use : PVQ

ESSAR STEEL ALGOMA INC. HEREBY CERTIFIES THAT THE MATERIAL HEREIN DESCRIBED WAS MADE AND TESTED IN ACCORDANCE WITH THE RULES OF THE SPECIFICATION SHOWN. ALL RESULTS ARE RETAINED IN ACCORDANCE WITH THE COMPANY'S STANDARD RECORD KEEPING PRACTICES. THIS MILL TEST REPORT MAY NOT BE REPRODUCED EXCEPT IN FULL WITHOUT WRITTEN APPROVAL OF ESSAR STEEL ALGOMA INC. IF YOU RECEIVE THIS DOCUMENT AND ARE NOT THE INTENDED RECEIVER, PLEASE CALL (705)945-4695 FOR INSTRUCTIONS ON METHOD OF DOCUMENT.

MEETS EN 10204-2004 TYPE 3.1  
 ISO QUALITY AND ENVIRONMENTAL CERTIFICATES AVAILABLE AT WWW.ESSARSTEELALGOMA.COM

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
0.5000" x 120.000" x 384.00"	AA5660	8952M3-05	6.534 LB	1	0.5000" x 120.000" x 384.00"	AA5421	8952M3-56	13.068 LB	2
0.5000" x 120.000" x 384.00"	AA5422	8952M3-56	13.068 LB	2	0.5000" x 120.000" x 384.00"	AA5423	9339M3-03	13.068 LB	2

Heat No. (wt%)	CHEMICAL PROPERTIES														
	C	Mn	P	S	Si	Cr	Ni	Cu	Mo	Al	Nb	V	B	Ti	DO
8952M3	0.20	1.18	0.013	0.003	0.340	0.03	0.15	0.03	0.00	0.029	0.000	0.015	0.0003	0.003	4.0400
9339M3	0.19	1.07	0.014	0.005	0.330	0.03	0.15	0.04	0.00	0.029	0.000	0.014	0.0002	0.003	0.3900
	0.19	1.12	0.016	0.005	0.350	0.02	0.15	0.04	0.00	0.027	0.000	0.015	0.0002	0.003	0.4000

Hardness Test	Batch No.	SRCE	LAB	GAUGE	COND	LOC	MTHD	HARDNESS	
								HBW	153
9339M3	AA5423	166	ALG	0.5000	NORM	B	HBW	158	
8952M3	AA5421	166	ALG	0.5000	NORM	B	HBW	153	
8952M3	AA5422	166	ALG	0.5000	NORM	B	HBW	153	

LIMITS OF UNSPECIFIED ELEMENTS PER ASME SECTION II (SA-20)

CU + Ni + CR + MO = 0.22  
 CR + MO = 0.03

Q.C.I. N.D.

Certification of Material - Per ASME  
 HT# 8952M3-56  
 Qualifies for all requirements of SA 516-GR70 per Sect. II, Edition II, Addenda

P.O. # 11760  
 Mat. # 26  
 TRK. # 2517  
 P.O. # 13-0220

Q.C.I. N.D.

K. UGHADPAGA P.O.

MILL TEST REPORTS APPROVED BY Q.C.

MANAGER METALLURGICAL SERVICES

Q.C.I. E.V.

MAR 27 2013

279

1, 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 CALCULATION) AS REPRESENTING THE ACTUAL STRENGTH OF SUCH STEEL.



# QUALITY PLATES & PROFILES LIMITED

20 Nicholas Lane, R.R.#3 (Aberfoyle), Guelph, ON N1H 6H9  
 ALL-WELD COMPANY LIMITED  
 PO/Rel: 13-0220  
 PLATE CPL 516N 1/2" x DWG# 1176-4-4 TAG 1176-26

# Certificate of Mill Test Results

Contact: HELENE/BRIAN  
 Inv: I055184 Date: 03/19/2013  
 Heat: 8952M3



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

SO No., Item & Date:	8003926 000020 2012/10/18	Shipment No. & Date:	1000011159 2012/10/18	TC No., Date & Time:	ESA-19141 2012/10/19 - 07:59:10							
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:	P007192/2							
Customer Specification:	HR STEEL PLATE Carbon Multi Cert ASTM A516 GR 70 (10) / ASME SA516 GR 70 (11A) Meets NACE MR 0103 latest Ed., NACE MR 0175 latest Ed., BHN < 200, D.O.CEQ .43 max. Inclusion Shape Control Calcium Treated Normalized Temp 1670 °F 17 min CVNL Req. 15/12 FT-LBF at -50.0 F Std Thickness Tol PVQ Top and Bottom Standard Surface No Weld Repair Flatness 1/2 A20 Latest Ed. + Addenda of ASME Niobium max 0.015 Sum-Nb+V max 0.030 Vanadium max 0.020			BOL NO.:	1000011159							
Supplementary Instructions:	Test Cert 1:519-837-2227			Cust, Part No.:	NATIONAL TRANSPORTATION - 0695(1009) REV							
Insp T/R:	Test Report As Per Spec			Carrier:								
ESSAR STEEL ALGOMA INC. HEREBY CERTIFIES THAT THE MATERIAL, HEREIN DESCRIBED WAS MADE AND TESTED IN ACCORDANCE WITH THE RULES OF THE SPECIFICATION SHOWN. ALL RESULTS ARE RETAINED IN ACCORDANCE WITH THE COMPANY'S STANDARD RECORD KEEPING PRACTICES. THIS MILL TEST REPORT MAY NOT BE REPRODUCED EXCEPT IN FULL WITHOUT WRITTEN APPROVAL OF ESSAR STEEL ALGOMA INC. IF YOU RECEIVE THIS DOCUMENT AND ARE NOT THE INTENDED RECEIVER, PLEASE CALL (705)945-1065 FOR INSTRUCTIONS ON METHOD OF DISPOSAL.												
MEETS EN 10294:2004 TYPE 3.1 ISO QUALITY AND ENVIRONMENTAL CERTIFICATES AVAILABLE AT WWW.ESSARSTEELALGOMA.COM												
***** MECHANICAL PROPERTIES *****												
Hardness Tests												
Heat No.	Batch No.	SRCE	LAB	GAUGE	COND	LOC	MTHD	HARDNESS				
8520M	AA5660	166"	ALG	0.5000	NORM	B	HBW	164				
Impact Tests												
Heat No.	Batch No.	SRCE	LAB	GAUGE	COND	METH	DIR	LOC	SIZE	TEMP(°F)	ENERGY(H-lbf)	ENERGY AVG(ft-lbf)
9339M3	AA5423	166"	ALG	0.5000	NORM	CVN	L	B	FULL	-50	74 89 95	86
8952M3	AA5421	166"	ALG	0.5000	NORM	CVN	L	B	FULL	-50	79 79 63	74
8952M3	AA5422	166"	ALG	0.5000	NORM	CVN	L	B	FULL	-50	90 92 88	90
8520M	AA5660	166"	ALG	0.5000	NORM	CVN	L	B	FULL	-50	80 70 93	81
Tensile Tests												
Heat No.	Batch No.	SRCE	LAB	GAUGE	COND	METH	DIR	LOC	YIELD(KSI)	TENSILE(KSI)	EL SCALE	ELONG(%)
9339M3	AA5423	166"	ALG	0.5000	NORM	2	T	B	52	75	8"	28
8952M3	AA5421	166"	ALG	0.5000	NORM	2	T	B	50	75	8"	26

MAR 27 2013

Velocity America  
 APR 1, 2013  
 279

Q.C.I.  
 E.Y.

APR 03 2013

Q.C.I.  
 N.D.

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.

# QUALITY PLATES & PROFILES LIMITED

20 Nicholas Ave Road, R.R.#3 (Aberfoyle), Guelph, ON N1H 6H9  
 ALL-WELD COMPANY LIMITED  
 PO/Rel: 13-0220  
 PLATE CPL 516N 1/2" x DWG# 1176-4-4 TAG 1176-26

# Certificate of Mill Test Results

Inv: 1055184 Date: 03/19/2013  
 Contact: HELENE/BRIAN Heat: 8952M3



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

SO No., Item & Date.: 8003926 000020 2012/10/18	Shipment No. & Date.: 1000011159 2012/10/18	TC No., Date & Time : ESA-19141 2012/10/19 - 07:59:10
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: P007192 / 2 BOL NO.: 1000011159 Cust.Part No.: Carrier : NATIONAL TRANSPORTATION - 0695(1009) REV
Customer Specification : HR STEEL PLATE Carbon Multi Cert ASTM A516 GR 70 (10) / ASME SA516 GR 70 (11A) Meets NACE MR 0103 latest Ed., BHN < 200, D.O.CEQ .43 max, Inclusion Shape Control Calcium Treated Normalized Temp 1670 °F 17 min CVNL Req. 15 / 12 FT-LBF at -50.0 F Sid Thickness Tol PVQ Top and Bottom Standard Surface No Weld Repair Flatness 1/2 A20 Latest Ed.+Addenda of ASME Niobium max 0.015 Sum-Nb+V max 0.030 Vanadium max 0.020		

Supplementary Instructions : Test Cert 1:519-837-2227  
 Insp T/R : Test Report As Per Spec  
 Cust Use : PVQ

ESSAR STEEL ALGOMA INC. HEREBY CERTIFIES THAT THE MATERIAL HEREIN DESCRIBED WAS MADE AND TESTED IN ACCORDANCE WITH THE RULES OF THE SPECIFICATION SHOWN. ALL RESULTS ARE RETAINED IN ACCORDANCE WITH THE COMPANY'S STANDARD RECORD KEEPING PRACTICES.  
 THIS MILL TEST REPORT MAY NOT BE REPRODUCED EXCEPT IN FULL WITHOUT WRITTEN APPROVAL OF ESSAR STEEL ALGOMA INC. IF YOU RECEIVE THIS DOCUMENT AND ARE NOT THE INTENDED RECEIVER, PLEASE CALL (705)945-4095 FOR INSTRUCTIONS ON METHOD OF DISPOSAL OF DOCUMENT.

MEETS EN 10204:2004 TYPE 3.1  
 ISO QUALITY AND ENVIRONMENTAL CERTIFICATES AVAILABLE AT WWW.ESSARSTEELALGOMA.COM

Tensile Tests		MECHANICAL PROPERTIES										
Heat No.	Batch No.	SRCE	LAB	GAUGE	COND	METH	DIR	LOC	YIELD(KSI)	TENSILE(KSI)	EL SCALE	ELONG(%)
8952M3	AA5422	166*	ALG	0.5000	NORM	.2	T	B	51	75	8"	27
8520M	AA5660	166*	ALG	0.5000	NORM	.2	T	B	55	79	8"	25

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.



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

Page 1 of 1  
REPORT NUMBER 73175

DATE 3/25/2013

FCI ORDER NUMBER 59801

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

CUSTOMER ORDER NUMBER 13-0216  
SOLD/SHIPPED TO ALL-WELD CO., LTD.  
49 PASSMORE AVE.

SCARBOROUGH ONT MIV 4T1 CANADA

Item Quantity Description

1 2 2" X 900 X 11.75" LG RTJ LWN

ITEM# 1176-34

HEAT NUMBER:  
G820

MATERIAL TYPE:  
SA350LF2CL1

Manufactured in  
USA

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

CHEMICAL ANALYSIS

PHYSICAL PROPERTIES

C .191 ✓  
Mn .993 ✓  
P .0270 ✓  
S .0240 ✓  
Si .243 ✓  
Cr .131 ✓  
Mo .007 ✓  
V .002 ✓  
Cu .048 ✓  
Ni .035 ✓  
Cb .001 ✓

Yield PSI 49,366 ✓  
Tensile PSI 71,634 ✓  
Elongation 32 ✓  
Reduction of Area 67 ✓  
Hardness 144/150 HBW ✓  
CVN @ -58 °F FT LBS 28/27/29 ✓  
% Shear  
MLE

**N4**  
Certification of Material - Per ASME  
HT# G820  
Qualifies to all requirements of  
SA350-LF2 CL1 per  
Sect. II 10 Edition 11 Addenda

W.O. # 1176Q  
M.L. # 34(6/2)  
THK. # 1.697  
P.O. # 13-0216

Q.C.I.  
N.D.

APR 03 2013

Q.C.I.  
E.Y.

CE .39

Heat Treatment NORMALIZED ✓  
Temperature 1670 °F  
Time at Temperature 1/2 HR/IN THK MIN  
Cooling Media AIR

LIMITS OF UNSPECIFIED  
ELEMENTS PER ASME  
SECTION II (SA-20)  
CU + Ni + CR + MO = .227  
CR+MO = .138

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

*Helen Fielder*

Name: Helen Fielder

Title: QA Representative

Reviewed  
*RHS*  
Apr 15, 2013  
V  
279

**CERTIFICADO DE INSPECCION**  
 Inspection Certificate - Certificat de Reception

CLIENTE - Customer - Client  
**COMCO PIPE&SUPPLY COMPANY-ONTAR**  
 A DIVISION OF RUSSELL METALS  
 14 KERR CRESCENT  
 PUSLUNCH, ONTARIO  
 NOB 3J0 - CANADA

CLIENTE - Customer - Client  
 SGT 600998\* ULLM - FORJA - S COOP  
 Calle 14, #208, 14  
 C.R.E. Comercio S.A. S.P.A.  
 Tel: 78-545 70852  
 Fax: 34-53 78196  
 E-mail: info@ulma.com  
 Page: ng List 100331

SGI 600920  
 SGI 193716

PRODUCTO / Article - Article  
 FLANGES / Flanges  
 ASME B16.5  
 25/02/2013 155347 07/06/2012  
 MATERIAL CORRESPONDIENTE / ASTM A516-11 A - SA304  
 \*MATERIALES CORRESPONDIENTES / \*MATERIALES CORRESPONDIENTES  
 \*MODO DE FUSION / \*MODO DE FUSION  
 \*MATERIALES CORRESPONDIENTES / \*MATERIALES CORRESPONDIENTES  
 \*MODO DE FUSION / \*MODO DE FUSION  
 \*MATERIALES CORRESPONDIENTES / \*MATERIALES CORRESPONDIENTES  
 \*MODO DE FUSION / \*MODO DE FUSION

DESCRIPTION / DESCRIPCION  
 393 532 338 25,00 51,20 14 45 39 40 50 151 152  
 393 532 338 25,00 51,20 14 45 39 40 50 151 152

APR 17 2013

COMPOSICION QUIMICA - STEEL MAKER'S LADLE ANALYSIS - ANALYSE CHIMIQUE

Element	Symbol	Unit	Value	Limit
C	Carbon	%	0.25	0.25
Mn	Manganese	%	0.30	0.30
P	Phosphorus	%	0.008	0.008
S	Sulfur	%	0.005	0.005
Si	Silicon	%	0.03	0.03
Al	Aluminum	%	0.005	0.005
N	Nitrogen	%	0.001	0.001
O	Oxygen	%	0.001	0.001
Fe	Iron	%	100	100

W.O. # 1176  
 M.S. # 39  
 T.I.K. #  
 P.O. # 13-0293-REV1

Certification of Material - Per ASME  
 HT# A39V3  
 Qualifies to all requirements of  
 SA350 LF2 CL1 per  
 Sect. II, Edition 11 Addenda



ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SPM OFF SHORE  
 Print Name: MANESH SATHI  
 Signature: [Signature]  
 Date: July 10/13  
 Valost America LLC



Order#: 266245 - B Seq: 7 PO#: 13-0249 Heat#: J2L9676 Mill: Sumitomo  
 Part#: PC 8 STD S3 112IN Part Desc: Crop Pipe 8 STD SMLS SA/A333-6 112IN



NIPPON STEEL & SUMITOMO METAL CORPORATION  
 WAKAYAMA WORKS  
 1850, MINATO, WAKAYAMA, JAPAN

INSPECTION CERTIFICATE

CERTIFICATE NO. : WYK1969-02 PAGE : 1/2 DATE : 2012-11-04

CUSTOMER : COMCO PIPE AND SUPPLY LTD.  
 ORDER NO. : E1-3125 ITEM NO. 18  
 SHIPPER : SUMITOMO CORPORATION 057 KEQ 0809/2 2P17S243710  
 COMMODITY : SEAMLESS HOT FINISHED CARBON STEEL PIPE WITH BEVELED ENDS  
 STANDARD : ASTM A333M-10 / ASME 2010 (A1) SA-333M GR. 6 CSA Z245.1-07 CAT. II GR. 359  
 SPECIFICATION :  
 MILL WORK NO. : WYK1969 O. D. : NPSS W. I. : STD LENGTH: 40feet QUANTITY: 3pcs. MASS: 1554kg

HEAT NO. : J2KA102 J2L9676  
 PRODUCTS PCS. : 1 2  
 HEAT TREATMENT : QUENCHED & TEMPERED (950° C X 5min. W.Q. & 650° C X 30min. A.C.)  
 MELTING : BASIC OXYGEN  
 DEOXIDATION : KILLED

W.O. # 1176  
 M.L. # 4076  
 THK. # 342  
 P.O. # 13-0249

CHEMICAL COMPOSITION (%)

		#1	C	Si	Mn	P	S	Cu	Cr	Ni	Mo	Ti	V	Nb	B *CEQ	
						#3	#3			#2					#3	
SPEC.	MIN.	L	-	10	29	-	-	-	-	-	-	-	-	-	-	
	MAX.	L	26	50	106	25	25	-	-	10	-	11	11	11	1	40
	MIN.	P	-	-	-	-	-	-	-	-	-	-	-	-	-	
	MAX.	P	26	50	200	30	35	-	-	10	-	11	11	11	1	40
HEAT NO. J2KA102 J2L9676		L	6	26	130	10	2	2	9	0	3	1	0	0	0	20
		P	7	28	129	10	2	2	10	0	3	1	0	0	0	21
		L	7	25	125	9	2	1	9	0	1	1	0	0	0	20
		P	7	25	125	9	2	1	9	0	1	1	0	0	0	21
		P	7	25	125	9	2	1	9	0	1	1	0	0	0	21

APR 04 2013



\*1 L:LADLE ANALYSIS P:PRODUCT ANALYSIS \*2:X10 \*3:X1000 OTHER:X1000  
 \*CEQ: C+F (Mn/6+Si/24+Cu/15+Ni/20+(Cr+Mo+V+Nb)/5+5B) F=COEFFICIENT BY CSA STANDARD

FOR EACH REDUCTION OF 0.01% CARBON BELOW 0.30%, AN INCREASE OF 0.05% MANGANESE ABOVE 1.06% IS PERMITTED TO A MAXIMUM OF 1.35% MANGANESE.

TENSILE TEST

		#1 #2	YS	TS	EL
			#3	#3	%
SPEC.	MIN.	L B	M 359	M 455	30
	MAX.	L B	M 530	M 625	-
HEAT NO. J2KA102 J2L9676		L B	M 485	M 552	33
		L B	M 428	M 515	40
		L B	M 419	M 506	40

Certification of Material per ASME  
 HT# J2L9676  
 Qualifies to all requirements of  
 SA333 GR 6 per  
 Sect. II 10 Edition II Addenda



TYPE OF SPECIMEN: STRIP 38mm WIDTH \*1 SAMPLING DIRECTION L: LONGITUDINAL \*2 SAMPLING POSITION B: BASE METAL  
 \*3 UNIT M: MPa GAUGE LENGTH: 50.0mm KIND OF YS: 0.5% EXTENSION UNDER LOAD

ALL Checked  
 April 5 2013  
 Velosi America  
 279

WE HEREBY CERTIFY THAT THE MATERIAL DESCRIBED HEREIN HAS BEEN MADE IN ACCORDANCE WITH THE RULES OF THE CONTRACT.

T. Kondo

HEAD OF DEPARTMENT  
 QUALITY ASSURANCE DEPARTMENT

<An Important Message To Our Customers>  
 This certification is intended only for products listed. Modification to or unauthorized use of this certification is strictly prohibited. Offences may be regarded as forgery of documents and be subject to criminal prosecution. If you have any questions on this certification, you can contact us by facsimile or e-mail as shown below;  
 Fax. No. : +81-3-6867-4926 E-mail: pipe-ipp@jp.nssmc.com NO. 173609W12

Order#: 266245 - B Seq: 7 PO#: 13-0249 Heat#: J2L9676 Mill: Sumitomo  
 Part#: PC 8 STD S3 112IN Part Desc: Crop Pipe 8 STD SMLS SA/A333-6 112IN



NIPPON STEEL & SUMITOMO METAL CORPORATION  
 WAKAYAMA WORKS  
 1850, MINATO, WAKAYAMA, JAPAN

**INSPECTION CERTIFICATE**

CERTIFICATE NO. : WYK1969-02 PAGE : 2/2 DATE : 2012-11-04

**HARDNESS TEST ( HBW )**

	#1 #2	#3			
SPEC. MIN.	B C	-			
MAX.	B C	200			
HEAT NO.		(1) (2) (3)			
J2KA102	B C	169 172 174			
J2L9676 ✓	B C	158 157 158			
	B C	157 158 158			

#1 SAMPLING POSITION B:BASE METAL #2 LOCATION C:CROSS SECTION #3 EACH

**IMPACT TEST (-50.0°C 2mm V-Notch 10X6.67)**

	#1 #2	#3 #4	AVG		
SPEC. MIN.	L B	E J #5	9/12	12	
MAX.	L B	E J	-/-	-	
			[1] [2] [3]		
HEAT NO.					
J2KA102	L B	E J	267 270 270 269		
J2L9676	L B	E J	270 270 270 270		

[1] [2] [3]: SPECIMEN NO. TYPE OF SPECIMEN:NONFLATTENED  
 ABSORBED ENERGY #5:VALUE OF ONE PIECE/EACH VALUE OF TWO PIECES AVG:AVERAGE VALUE OF ONE SET (3 PIECES)  
 #1 SAMPLING DIRECTION L:LONGITUDINAL #2 SAMPLING POSITION B:BASE METAL #3 E:ABSORBED ENERGY #4 UNIT J:Joule

**IMPACT TEST (-45.0°C 2mm V-Notch 10X6.70)**

	#1 #2	#3 #4	AVG			#3 #4	AVG		
SPEC. MIN.	T B	E J #5	-	18	S % #6	50	60		
MAX.	T B	E J	-	-	S %	-	-		
			[1] [2] [3]			[1] [2] [3]			
HEAT NO.									
J2KA102	T B	E J	260 260 260 260	S %	100 100 100 100				
J2L9676	T B	E J	255 252 258 255	S %	100 100 100 100				

[1] [2] [3]: SPECIMEN NO. TYPE OF SPECIMEN:NONFLATTENED  
 ABSORBED ENERGY #5:VALUE OF ONE PIECE AVG:AVERAGE VALUE OF ONE SET (3 PIECES)  
 SHEAR AREA #6:VALUE OF ONE PIECE AVG:AVERAGE VALUE OF ONE SET (3 PIECES)  
 #1 SAMPLING DIRECTION T:TRANSVERSE #2 SAMPLING POSITION B:BASE METAL #3 E:ABSORBED ENERGY S:SHEAR AREA  
 #4 UNIT J:Joule %%

FLATTENING TEST: ACCEPTABLE  
 VISUAL & DIMENSIONS: ACCEPTABLE  
 HYDROSTATIC TEST 20. MPaX5sec.: ACCEPTABLE  
 ULTRASONIC EXAMINATION: ACCEPTABLE  
 RESIDUAL MAGNETISM (EACH READING MAX. 3.5mT / AVG. OF 4 READINGS MAX. 3.0mT): ACCEPTABLE

EN 10201 3.1 ✓

SOUR SERVICE (SSV)

NACE MR0175 ISO 15156-2 (2009) ANNEX A.2 REGION 3 AND NACE MR0103 (2010) SEC. 2.1: ACCEPTABLE



APR 04 2013

WE HEREBY CERTIFY THAT THE MATERIAL DESCRIBED HEREIN HAS BEEN MADE IN ACCORDANCE WITH THE RULES OF THE CONTRACT.

*Handwritten signature and date: April 5, 2013*



*Handwritten signature: T. Kondo*

HEAD OF DEPARTMENT  
 QUALITY ASSURANCE DEPARTMENT

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 Fax. No. : +81-3-6867-4926 E-mail: pipe-ipp@jp.nssmc.com

NO. 173609W12

# BENTELER

Steel/Tube

Blatt: 1 / 6  
 Page: Page:

Prüf-Nr.: 65-689506/001/P

Inspection No.:  
 No. du certificat:

Dokument-Nr.:  
 Document No.:

ABNAHMEPRÜFZEUGNIS EN 10204-3.1  
 INSPECTION CERTIFICATE EN 10204-3.1  
 CERTIFICAT DE RECEPTION EN 10204-3.1  
 EN 10204:2005-01

Hersteller:  
 Manufacturer:  
 Producteur:

Hersteller:  
 Manufacturer:  
 Producteur:

Kunden-Bestell-Nr.:  
 Purchase Order No.:

Benteler Steel/Tube GmbH - Postfach 1340 - 33043 Paderborn - Deutschland  
 BENTELER STEEL & TUBE CORP.  
 2121 ARGENTIA ROAD, SUITE # 101  
 MISSISSAUGA ON L5N 2X4  
 CANADA

Hersteller:  
 Manufacturer:  
 Producteur:

Benteler Auftrags-Nr.:  
 Benteler Order No.:

Wärmehrohrwerk Dinslaken  
 DIN EN 9001:2008 TÜV CERT 44100090381-003  
 PED 97/23/EC TÜV CERT 07-202-1411-2-1193/8/D

Stempel des Abnahmebeauftragten:  
 Stamp of the inspection representative:

Versandanzzeigen-Nr.:  
 Dispatch Note No.:

Stahlschmelzungsverfahren:  
 Steelmaking process:  
 Procédé d'élaboration de l'acier:

Stahlschmelzungsverfahren:  
 Steelmaking process:  
 Procédé d'élaboration de l'acier:

Produkt:  
 Product:

ASME SA-106, ASME Section II Part A Edition 2010 Addenda 2011a, S6, ASTM-A 106-2010, S6, ASTM-A 333-2010-HF, ASME SA-333-HF, ASME Section II Part A Edition 2010 Addenda 2011a, CSA Standard Z245.1-07 Category II, Sour Service, ANSI/NACE MR0175/ISO 15156-1: 2009, ANSI/NACE MR0175/ISO 15156-2: 2009

Lieferbedingungen:  
 Terms of delivery:  
 Conditions de livraison:

ASME SA-106, ASME Section II Part A Edition 2010 Addenda 2011a, S6, ASTM-A 106-2010, S6, ASTM-A 333-2010-HF, ASME SA-333-HF, ASME Section II Part A Edition 2010 Addenda 2011a, CSA Standard Z245.1-07 Category II, Sour Service, ANSI/NACE MR0175/ISO 15156-1: 2009, ANSI/NACE MR0175/ISO 15156-2: 2009

Maße - Toleranzen:  
 Dimensions-tolerances:  
 Dimensions-tolérances:

ASME B36.10M-2004, ASME SA-999 ASME Section II Part A Edition 2010, ASTM-A 999-2011

Stahlsorte:  
 Steel grade:  
 Nuance d'acier:

GRADE 6, GRADE B, GRADE C, GRADE 359

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

Lieferzustand:  
 Delivery condition:  
 État de livraison:

Normalized

APR 05 2013

APR 06 2013

Produktkennzeichnung:  
 Product marking:

FS: BENTELER Z.245.1 - A/SA-333 - A/SA 106 6/359/B/C CATEGORIE 2 HEAT-NO. M45C SS SMLS HN  
 DIMENSIONS WEIGHT CLASS WA GERMANY PO NO G1-2943

Marquage du produit:

AEZ = Ätzstrahlbeschriftung, Etching ink marking, Gravure à l'encre  
 FK = Farbstrahlbeschriftung, Colour marking, marquage par couleur  
 FS = Farbschablonenzeichnung, colour stencilling, marquage par peinture  
 FSD = Farbschablonenzeichnung, Colour ink printer, imprimante à jet d'encre de couleur  
 LK = Laserkennzeichnung, Laser marking, Marquage laser  
 PKE = Etikettenkennzeichnung, tag marking, marquage sur étiquette  
 PS = Prägestempel, die stamp, marquage par poinçonnage  
 TS = Tintenstrahlkennzeichnung, ink jet spray marking, imprimante à jet d'encre



Benteler Steel/Tube GmbH  
 Postfach 13 40  
 33043 Paderborn  
 Deutschland  
 Tel.: +49-5254-81-0 Fax: +49-5254-13666

ABNAHMEPRÜFZEUGNIS EN 10204-3.1  
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Dokument-Nr.: 65-689506/001/P  
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Pos.	Stück	Maße	Länge	Gewicht	Schmelzen-Nr.	Prüfdruck	Rohr-Nr.-Gruppe	Vielfachlängen
Item	Number	Dimensions	Length	Weight	Heat No.	Test pressure	Tube number group	Multiple lengths
Poste	Nombre	Dimensions	Longueur	Poids	No. de coulée	Pression d'épreuve	Série de no. des tubes	Longueurs multiples
			feet	lbs		bar		
0020	105	2" NPS * XS 20 FT - 22 FT	2305,35	11579	570747	172	5	
0030	56	2" NPS * XS 38 FT - 42 FT	2296,82	11616	570747	172	5	

Schmelzenanalyse [%] / Heat analysis [%] / Analyse sur coulée [%]

Pos.	Schmelzen-Nr.	C	SI	MN	P	S	CR	MO	NI	CU	V	NB	TI	B
Item	Heat No.													
Poste	No. de coulée													
0020	570747	0,120	0,320	1,23	0,008	0,002	0,17	0,07	0,19	0,08	0,064	0,031	0,003	0,0002
0030	570747	0,120	0,320	1,23	0,008	0,002	0,17	0,07	0,19	0,08	0,064	0,031	0,003	0,0002

- 1. Formel:  $CE_{IIW} = C + (Mn/6) + ((Cr + Mo + V)/5) + ((Cu + Ni)/15) < = 0,45 \%$
- 2. Formel:  $CEV = C + F * ((Mn/6) + (Si/24) + (Cu/15) + (Ni/20) + ((Cr + Mo + V + Nb)/5) + (5 * B)) < = 0,40$
- 3. Formel:  $Mn/C > = 3/1$
- 4. Formel:  $Cr + Cu + Mo + Ni + V < = 1,00 \%$

Formelergebnisse / Formula results / Résultats des formules

Pos.	Schmelzen-Nr.	1. Formel	2. Formel	3. Formel	4. Formel
Item	Heat No.	1. Formula	2. Formula	3. Formula	4. Formula
Poste	No. de coulée	1. Formule	2. Formule	3. Formule	4. Formule
0020	570747	0,404	0,346	10,250	0,574
0030	570747	0,404	0,346	10,250	0,574

Produktanlyse [%] / Product analysis [%] / Analyse sur produit [%]

Pos.	Schmelzen-Nr.	C	SI	MN	P	S	CR	MO	NI	CU	V	NB	TI	B
Item	Heat No.													
Poste	No. de coulée													
0020	570747	0,120	0,310	1,23	0,008	0,002	0,17	0,07	0,19	0,07	0,064	0,031	0,003	0,0002
0030	570747	0,120	0,310	1,23	0,008	0,002	0,17	0,07	0,19	0,07	0,064	0,031	0,003	0,0002

Certification of Material - Per ASME  
 HT# 570747  
 Qualifies to all requirements of  
 SA333-GR 6 per  
 Sect. II Edition II Addenda

Q.C.I.  
 N.D.

APR 0 6 2013

W.O. # 11769  
 M.L. # 4(C316,46)  
 TRK. # 2219  
 PO # 13-0249

Q.C.I.  
 E.Y.

APR 0 5 2013







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**ABNAHMEPRÜFZEUGNIS EN 10204-3.1**  
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- 1. Formel:  $CE_{IIV} = C + (Mn/6) + ((Cr + Mo + V)/5) + ((Cu + Ni)/15) < = 0,45 \%$
- 2. Formel:  $CEV = C + F * ((Mn/6) + (Si/24) + (Cu/15) + (Ni/20) + ((Cr + Mo + V + Nb)/5) + (5 * B)) < = 0,40$
- 3. Formel:  $Mn/C > = 3/1$
- 4. Formel:  $Cr + Cu + Mo + Ni + V < = 1,00 \%$

Formelerggebnisse / Formula results / Résultats des formules

Pos.	Schmelzen-Nr	1. Formel	2. Formel	3. Formel	4. Formel
Item	Heat No.	1. Formula	2. Formula	3. Formula	4. Formula
Poste	No. de coulée	1. Formule	2. Formule	3. Formule	4. Formule
0020	570747	0,403	0,345	1,0,250	0,564
0030	570747	0,403	0,345	1,0,250	0,564



*Renewal*  
*APR 5 2013*

**APR 05 2013**

Prüfergebnisse / Test results / Résultats des essais

Die Rohre sind auf Dichtheit geprüft durch: Hydrostatic test: acc. to CSA Z245.1, holding time min 5 seconds, Test  
 The tubes have been submitted to a leak tightness test by: pressure/Time-record  
 Les tubes ont passé un contrôle d'étanchéité par:

Die Rohre wurden zerstörungsfrei geprüft: ET-test: acc. to CSA Z245.1; for imperfections; drilled hole: 3,20 mm  
 The tubes are non destructive tested:  
 Les tubes ont passé un essai non destructif:

Augensichtkontrolle: PASSED Biegeversuch: PASSED Maßkontrolle: PASSED  
 Visual inspection: Bending test: Dimensions examination:  
 Examen visuel: Essai de cintrage: Vérification des dimensions:

Ringfaltversuch: PASSED  
 Flattening test:  
 Essai d'aplatissement:

Ergebnisse der mechanischen Prüfung / Results of mechanical testing / Résultats des essais mécaniques

Die Probenahme erfolgte an Vielfachlängen.  
 The sampling was carried out on multiple lengths.  
 L'échantillonnage était réalisé aux longueurs multiples.



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 CERTIFICAT DE RECEPTION EN 10204-3.1

Zugversuch längs Streifenprobe / Tensile test longitudinal Strip test specimen / Essai de traction longitudinale Bande decoupee sur tube

Pos.	Proben-Nr.	Schmelzen-Nr.	Probenabmessung	Streckgrenze	Zugfestigkeit	Dehnung	Einschnürung
Item	Specimen No.	Heat No.	Specimen dimensions	Yield strength	Tensile strength	Elongation	Area reduction
Poste	No. de l'éprouvette	No. de coulée	Dimensions de l'éprouv.	Limite élastique	Résistance à la traction	Allongement	Coefficient de striction
Anforderungen	ReH	Rm	A2"	1. Formel			
Requirements	MPa	MPa	%	1. Formula			
Exigences	359-530	455-625	MIN 26	1. Formule			
0020	000001	570747	19,00 X 5,55	458	582	34	
0020	000002	570747	19,00 X 5,55	460	585	34	
0030	000001	570747	19,00 X 5,50	458	585	34	
0030	000002	570747	19,00 X 5,80	461	582	34	

Härteprüfung / Hardness test / Essai de dureté

Pos.	Proben-Nr.	Schmelzen-Nr.	Härte	HB	HV	HRB	HBW
Item	Specimen No.	Heat No.	Hardness	MAX 200			
Poste	No. de l'éprouv.	No. de coulée	Dureté				
Anforderungen	HRC	HB	HV	HRB	HBW		
Requirements							
Exigences							
0020	000001	570747		170			
0020	000002	570747		169			
0020	000003	570747		168			
0030	000001	570747		170			
0030	000002	570747		168			
0030	000003	570747		168			

Q.C.I. E.Y.  
 APR 05 2013  
 APR 05 2013  
 APR 05 2013  
 APR 05 2013

Q.C.I. N.D.

APR 05 2013



Steel/Tube

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65-689506/001/P

ABNAHMEPRÜFZEUGNIS EN 10204-3.1  
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Kerbschlagbiegeversuch Notched bar impact test / Essai de flexion par choc (résilience) [1 CHARPY\_V]

Pos. Item	Proben-Nr. Specimen No.	Schmelz-Nr. Heat No.	Probenabmessung Specimen dimensions		Prütemperatur Test temperature	Kerbschlagarbeit Absorbed energy		Kerbschlagzähigkeit Impact strength	Verf.-Bruchanteil Shear fracture
			Länge Length	Breite Width		Höhe Height	Energie absorbierte Energie absorbée		
Anforderungen Requirements	Exigences	No. de l'éprouv. No. de coulée	Länge Length	Breite Width	Höhe Height	einzel single	mittel average	einzel single	single average
			mm	mm	mm	individuelle moyenne	individuelle moyenne	individuelle moyenne	single average
0020 000001	570747	55	4,00	4,00	10,00	64	70	85	85
0030 000001	570747	55	4,00	4,00	10,00	68	71	85	85

GRAD

°C

MIN 011

J

J

J/cm<sup>2</sup>

%

°C

L

-54

64

70

85

%

°C

L

-54

68

72

85

%

°C

L

-54

71

70

85

%

Wärmebehandlung / Heat treatment / Traitement thermique

Rolling temperature: 870°C - 1000°C / Cooling: air

Restmagnetismus / Demagnetize / Démagnétiser

demagnetized tubes; 1 measurement per 4 hours on both tube ends Two readings 180° apart around the circumference. Average value max 3.0 Millitesla (24 A/cm), individual value max 3.5 Millitesla (28 A/cm)

Vermerk / Remark / Remarque

NACE Standard: Hardness acc. to ANSI/NACE MR0175/ISO 15156: HRC max 22., The material meets the requirements of NACE MRO103; Certificate remarks: Sour Service, The Material is Aluminium deoxidized and inclusion shape controlled with Calcium-Silicon treatment. This is to confirm that the seamless linepipe supplied by Benteler and verified to CSA Standard Z245.1-07 meets the requirement for micro hardness of max. 248 HV 500 gf., No weld repair has been carried out; Bend test: mandrel diameter 12D. Bending angle: 90°

Grain size determination: acc. to ASTM-E 112, Grain size 6 and finer

Verkäufer(in) / Salesman/ woman in charge / Personne chargée : Mrs Schöneweis, Tel.: 05254/81-4234, Fax: 4289



APR 05 2013

APR 06 2013

ACCEPTED BY REVIEWS RELEASED  
 for and on behalf of: S35M OFF SHORE  
 Print name: G. A. VESIL S. A. H. K.  
 Signature: [Signature]  
 Date: APR 06 2013  
 046  
 Atplus VELOSI  
 Velosi America LLC

**BENTELER**  
Steel/Tube

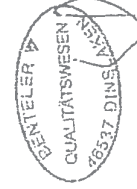
Benteler Steel/Tube GmbH  
Postfach 13 40  
33043 Paderborn  
Deutschland  
Tel.: +49.5254.81-0 Fax: +49.5254.13666

**ABNAHMEPRÜFZEUGNIS EN 10204-3.1**  
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No. du certificat:

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Abnahmebeauftragter  
Inspection representative

Contrôleur

DR. BASEL KEITA / Thei

Dinslaken, 17.04.2012, TEL.: 02064.623-537 FAX: 02064.623-539

Es wird bestätigt, daß die gelieferten Erzeugnisse den techn. Lieferbedingungen des Auftrages entsprechen. Dieses Dokument wurde mittels EDV erstellt und ist ohne Unterschrift rechtsgültig.  
We certify that the supplied products comply with the order specification. This document was prepared by means of electronic data processing and is valid without signature.  
Nous attestons que les produits livrés sont conformes aux stipulations de la commande. Ce document a été établi par traitement électronique de l'information et est valide sans signature.





Manufacturer of Piping and Pressure Vessel Components

4404 Haygood St - Houston, TX 77022  
 Phone: 713-695-3653 Fax: 713-695-3526  
 A Bonney Forge Company

Sold To: COMCO PIPE & SUPPLY  
 (PUSLINCH)  
 14 KERR CRESCENT  
 PUSLINCH ON, NOB 210

MTR #: 250.800

PO #: G1-269324-GK

Sales Order #: C001305091

Date: 04/04/2013

This product has not come in direct contact with mercury or any of its compounds, nor with any mercury-containing device employing a single boundary of containment. No welding performed.

We certify that the contents of this report are correct and accurate, and that all test results and operations performed by WFI or its subcontractors are in compliance with the material specification and requirements of the referenced code or standard, and that the material conforms to the dimensional requirements of the order. This document is in accordance with EN10204 3.1.

Certified Material Test Report

Heat Code: 58494

Material: A5A350 00a LF2 CL1

Item	Quantity	Description
1	16	16 - 8 X 2.3M HP SA350 LF2 CL1 LAW NAUF MR 175,2009

Chemical Composition

Ladle	C	CR	CU	MN	MO	NB	NI	P
	0.200	0.04	0.070	1.02	0.000	0.015	0.02	0.008
	S	SI	V					
	0.022	0.19	0.004					
Carbon Equivalency:	Ladle			0.39				

Product	Tensile PSI	Yield PSI	Elong %	RA %	Hardness
	72,500	48,750	30.10	64.70	150 BHN
Charpy V-Notch Properties:			Test Temperature:	-50 F	
F11BS: 17/21/45	% Shear: NB/NB/NB		ME: NB/NB/NB		
Normalized					

Certification of Material - Per ASME  
 HT# 58494  
 Qualifies to all requirements of  
 SA350 LF2 CL1 per  
 Sect. II 7C Edition 11 Addenda

W.O. # 11760  
 M.L. # 42(5/6)  
 THK. #  
 P.O. # 13-0293

ACCEPTED/REVIEWED/RELEASED 046  
 for and on behalf of: SAM OFF STORE  
 Print Name: SIA NRESH SAHA  
 Signature: [Signature]  
 Date: July 10/13  
 Q.C.I. APPROVED VELOSI  
 Velosi America LLC  
 APR 25 2013

Q.C.I. N.D.

Marie Dehmer  
 Marie Dehmer  
 Quality Assurance Representative

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

0006010

SO No. Item & Date	8005968 00010 2013 01 15	Shipment No. & Date	100005410 2013 01 15	TC No. Date & Time	ESA 41597 2013 01 15 22:23 45
Sold to Customer Name and Address		Ship to Customer Name and Address		Customer PO No. Item	
QUALITY PLATES & PROFILES LTD		QUALITY PLATES & PROFILES LTD		F0078-2-1	
NICHOLAS BEAVER ROAD RR#3 20		NICHOLAS BEAVER ROAD RR#3 20		100005410-E	
ABERFOYLE Ontario Canada		ABERFOYLE Ontario Canada		Cust Part No	
N14-6H9		N14-6H9		Lentrol	
Customer Specification		Customer Specification		NATIONAL TRANSPORTATION - 1213 1127	
H.R. STEEL PLATE Carbon Manganese Steel 50 ksi min. Yield, 60 ksi min. Tensile, 18 min. Charpy, 1570 F min. CVN, Req. 15 min. Flattening, 100% Edge Cracks, 100% Edge Cracks, 100% Standard Surface Flatness, P 40 Late 1.0 - Addenda 1 - 5		ASTM A 572 GR 50		Cust Use	
Supplementary Instructions		Test Cert's 319 837-228		2VQ	
Inqy Tkt		Test Report As Per Spec			

Heat No. (wt%)	C	Mn	P	S	SI	Cr	Ni	Mo	Cu	Al	Nb	TI	DD	Heat No.-MS	Quantity	No of Pcs
2259P3	0.19	1.10	0.005	0.005	0.330	0.04	0.07	0.04	0.004	0.004	0.000	0.015	0.000	2259P3 56	5880 LB	3
Dimensions (T x W x L) C 2500" x 96 000" x 288 00" C 2500" x 96 000" x 4288 00" Heat No. MS 2259P3 56 2259P3 56 Batch No ABBE16 ABBE17																

**LIMITS OF UNSPECIFIED ELEMENTS PER ASME SECTION II (SA-20) CU + Ni + CR + MO = 0.24. CR+MO = 0.05**

**CERTIFICATION OF MATERIAL - PER ASME HT# 2259P3-56**

**Quantities to all requirements of SA 516 GR 70 per Sect. II 10 Edition 11 Addenda**

**Q.C.I. N.D.**

Velosi America 279

MANAGER METALLURGICAL SERVICES K. UGHADPAGA

MAR 27 2013

Q.C.I. E.Y.

APR 03 2013

W.O. # 11760  
 M.L. # 43 (4/k)  
 TIK. # - 256  
 P.O. # 13-0039

MILL TEST REPORTS APPROVED BY Q.C.

P.O.

WARNING: This report is prepared by the manufacturer and is not a substitute for the original test results. The manufacturer does not accept any liability for the accuracy of the information provided in this report. The user of this report is advised to verify the accuracy of the information provided in this report.

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

SO No. Item & Date		803568 000010 2013-01-14		TC No. Date & Time		ESA 41597 2013-01-15 22:23:45	
Sold to Customer Name and Address		Ship to Customer Name and Address		Customer PO No. Item		PC07612 1	
QUALITY PLATES & PROFILES LTD		QUALITY PLATES & PROFILES LTD		BOL NO		1000025416	
NICHOLAS BEAVER ROAD #4120		NICHOLAS BEAVER ROAD RR#3 20		Cust Part No		NATIONAL TRANSPORTATION 1013 110*	
ABERFOYLE Ontario Canada		ABERFOYLE Ontario Canada		Cust Part No			
N.P.H. 6H9		N.P.H. 6H9		Cust Part No			
Customer Specification		HPI STEEL PLATE Carbon Multi Core ASTM A516 GR 70 (10) ASME SA516 GR 70 (10) Max. NACE MR 015 latest Ed. BRIN. 200 CO COE 43 max. Inclusion Shaps Control Calcium treated Normalized Temp. 570 F. 8 min CVN. Req. 15 ft x 10 ft L.P.F. at 50 F. Cyclic Stress of PVQ Top and Bottom Standard Surmise Fatness 1:2 490 Latest Ed + Addenda of ASME Code section II part 2 applies Time Grain Size fully rolled No Weld Repair		Customer PO No. Item			
Supplementary Instructions		Test Cert 1519 R37 2927		Customer PO No. Item			
Insp TRF		Test Report As Per Spec		Customer PO No. Item			
ESSAR STEEL ALGOMA INC. 105 WEST STREET SAULT STE MARIE ONTARIO CANADA P6A 7B4		ESSAR STEEL ALGOMA INC. 105 WEST STREET SAULT STE MARIE ONTARIO CANADA P6A 7B4		Customer PO No. Item			
CUSTOMER CONTACT INFORMATION		CUSTOMER CONTACT INFORMATION		Customer PO No. Item			
NAME: NICHOLAS BEAVER		NAME: NICHOLAS BEAVER		Customer PO No. Item			
ADDRESS: NICHOLAS BEAVER ROAD #4120		ADDRESS: NICHOLAS BEAVER ROAD #4120		Customer PO No. Item			
CITY: SAULT STE MARIE		CITY: SAULT STE MARIE		Customer PO No. Item			
PROVINCE: ONTARIO		PROVINCE: ONTARIO		Customer PO No. Item			
COUNTRY: CANADA		COUNTRY: CANADA		Customer PO No. Item			
PHONE: (705) 938-2000		PHONE: (705) 938-2000		Customer PO No. Item			
FAX: (705) 938-2000		FAX: (705) 938-2000		Customer PO No. Item			
EMAIL: nicholas.beaver@qualityplates.com		EMAIL: nicholas.beaver@qualityplates.com		Customer PO No. Item			
WEBSITE: www.qualityplates.com		WEBSITE: www.qualityplates.com		Customer PO No. Item			

APR 03 2013  
 Q.C.I. E.Y.  
 Q.C.I. N.D.  
 K. UGHADPAGA  
 MANAGER METALURGICAL SERVICES  
 Date: 2013/01/28 Time: 16:23:51 Page no: 2 of 2

Impact Tests	Heat No	Batch No	SRCF	LAB	GAUGE	COND	METH	DIR	LOC	SIZE	TEMP (F)	ENERGY (ft-lbf)	ENERGY AVG(ft-lbf)
2259P3	AB8626		166	ALG	0.2500	N	VV	H		50	69.116	72	
2259P3	AB8630		166	ALG	0.2500	N	VV	B		50	90.848	83	
2259P3	AB8631		166	ALG	0.2500	N	VV	B		5	73.80	7	
0712 0515	Batch No		SRCF	LAB	GAUGE	COND	METH	DIR	LOC	SIZE	TEMP (F) <td>ENERGY (ft-lbf) <td>ENERGY AVG(ft-lbf) </td></td>	ENERGY (ft-lbf) <td>ENERGY AVG(ft-lbf) </td>	ENERGY AVG(ft-lbf)
0712 0515	Batch No		SRCF	LAB	GAUGE	COND	METH	DIR	LOC	SIZE	TEMP (F) <td>ENERGY (ft-lbf) <td>ENERGY AVG(ft-lbf) </td></td>	ENERGY (ft-lbf) <td>ENERGY AVG(ft-lbf) </td>	ENERGY AVG(ft-lbf)
0712 0515	Batch No		SRCF	LAB	GAUGE	COND	METH	DIR	LOC	SIZE	TEMP (F) <td>ENERGY (ft-lbf) <td>ENERGY AVG(ft-lbf) </td></td>	ENERGY (ft-lbf) <td>ENERGY AVG(ft-lbf) </td>	ENERGY AVG(ft-lbf)

REVERSE  
 April 1, 2013  
 279  
 K. UGHADPAGA  
 MANAGER METALURGICAL SERVICES  
 Date: 2013/01/28 Time: 16:23:51 Page no: 2 of 2



# QUALITY PLATES & PROFILES LIMITED

20 Nicholas Ave Road, R.R.#3 (Aberfoyle), Guelph, ON N1H 6H9  
 ALL-WELD COMPANY LIMITED  
 PO/Rel: 13-0239  
 PLATE CPL 516N 1/4" x 2-3/16" DIA.

# Certificate of Mill Test Results

Contact: BRIAN WEEDON  
 Inv: 1055234 Date: 03/25/2013  
 Heat: 8888L

## ESSAR Steel Algoma Inc.

105 West St., Sault Ste. Marie, Ontario, Canada, P6A 7B4

0005097

CUSTOMER PURCHASE ORDER NUMBER P005643	ENTRY DATE 2011/08/29	CREATE DATE 2011/10/17	TALLY NUMBER 246425	SHIPPERS NUMBER -	CARRIER W.J. DEANS TRANSPORTATION - 2221 A/B	MILL ORDER 10816
---	--------------------------	---------------------------	------------------------	----------------------	---	---------------------

SHIP TO CUSTOMER NAME & ADDRESS  
 QUALITY PLATES & PROFILES LTD.  
 20 NICHOLAS BEAVER ROAD RR#3  
 ABERFOYLE, ON  
 N1H 6H9

CUSTOMER SPECIFICATION  
 HR PLATE - CARBON - ASME SA516 GR 70 (10) - CVNL 15/12 FT LBS AT -50 F - C .23  
 MAX, DO CE 0.43 MAX, V 0.02% MAX, NB 0.02% MAX, V+NB 0.03% MAX - FINE GRAIN  
 - MEETS ASME SECTION II LATEST ADDENDA - PVQ - NORMALIZED - FLATNESS 1/2 A-20

### MILL TEST REPORTS

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.

K. UGHADPAGA  
 MANAGER, METALLURGICAL SERVICES

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)945-2624 COLLECT FOR INSTRUCTIONS ON METHOD OF DISPOSAL OF DOCUMENT.

### SUPPLEMENTARY INSTRUCTIONS

TEST CERT 1: MICHELLE CRAVEIRO 519-837-2227 TEST CERT 2: PLAT  
 E TEST COUPON:

INSPI T/R TEST REPORTS REQUIRED 2000200546 PF  
 CUST USE RESALE 2011/10/17 18:27

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

PLATE NUMBER	HEAT-MS	NO. PIECES	NO. WEIGHT	PLATE NUMBER	HEAT-MS	PIECES	NO. WEIGHT
38621	8888L-04	3	5880	8888L-04	8888L-04	3	5880
38623	8888L-04	3	5880	8888L-05	8888L-05	3	5880

CUSTOMER ITEM 00001 OUR ITEM 002 DIMENSIONS .250 X 96 X 288 " P R O D U C T S H I P P E D \* \* \* \* \*  
 APR 03 2013

### TENSILE TESTS:

PLATE NUMBER	SRC	SAMPLE GAUGE	COND METH	DIR	TEST * DIR	YIELD KSI	TENSILE KSI	% ELONG
38621	166"	.2500	N	.2	T	54.0	74.0	26 (8")
38622	166"	.2500	N	.2	T	51.0	74.0	24 (8")
38623	166"	.2500	N	.2	T	53.2	74.0	26 (8")
38624	166"	.2500	N	.2	T	54.2	74.4	25 (8")
38625	166"	.2500	N	.2	T	54.0	74.4	27 (8")
38627	166"	.2500	N	.2	T	54.4	75.0	25 (8")

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

\*\*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 CHEMICAL 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.



# QUALITY PLATES & PROFILES LIMITED

20 Nicholas Beaver Road, R.R.#3 (Aberfoyle), Guelph, ON N1H 6H9  
 ALL-WELD COMPANY LIMITED  
 PO/Rel: 13-0239  
 PLATE CPL 516N 1/4" x 2-3/16" DIA.

# Certificate of Mill Test Results

Contact: BRIAN WEEDON  
 Inv: 1055234  
 Heat: 8888L  
 Date: 03/25/2013

<b>ESSAR Steel Algoma Inc.</b>		<b>105 West St., Sault Ste. Marie, Ontario, Canada, P6A 7B4</b>		MILL ORDER
CUSTOMER PURCHASE ORDER NUMBER <b>P005643</b>	ENTRY DATE 2011/08/29	CREATE DATE 2011/10/17	TALLY NUMBER 246425	CARRIER
SHIP TO CUSTOMER NAME & ADDRESS QUALITY PLATES & PROFILES LTD. 20 NICHOLAS BEAVER ROAD RR#3 ABERFOYLE, ON NIH 6H9	SHIP TO CUSTOMER NAME & ADDRESS QUALITY PLATES & PROFILES LTD. 20 NICHOLAS BEAVER ROAD RR#3 ABERFOYLE, ON		W.J. DEANS TRANSPORTATION - 2221 A/B	

**CHARGE TO CUSTOMER NAME & ADDRESS**  
 QUALITY PLATES & PROFILES LTD.  
 20 NICHOLAS BEAVER ROAD RR#3  
 ABERFOYLE, ON  
 NIH 6H9

**CUSTOMER SPECIFICATION**  
 HR PLATE - ASME SA516 GR 70 (10) - CVNL 15/12 FT LBS AT -50 F - C .23  
 MAX, DO CE 0.43 MAX, V 0.02% MAX, NB 0.02% MAX, V+NB 0.03% MAX - FINE GRAIN  
 - MEETS ASME SECTION II LATEST ADDENDA - PVQ - NORMALIZED

**MILL TEST REPORTS**  
 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.

**K. UGHADPAGA**  
 MANAGER METALLURGICAL SERVICES

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)945-2424 COLLECT FOR INSTRUCTIONS ON METHOD OF DISPOSAL OF DOCUMENT.

**SUPPLEMENTARY INSTRUCTIONS**  
 TEST CERT 1: MICHELLE CRAVEIRO 519-837-2227 TEST CERT 2: PLAT  
 E TEST COUPON:

INSP T/R TEST REPORTS REQUIRED 2000200546 PF  
 2011/10/17 18:27

CUST USE RESALE

HEAT	SRCE	GAUGE	COND	METH	DIR	TEST	SIZE	TEMP	FULL	ENERGY	PRO	PER	T	IES	TEST	RES	REPORTS	
8888L	166"	2500	N	CVN	L	1/2	104	-50F	112	110	CU	MO	AL	CB	V	0.000	0.001	0.002
8888L	166"	2500	N	CVN	L	1/2	73	-50F	68	90	CU	MO	AL	CB	V	0.000	0.001	0.002
8888L	166"	2500	N	CVN	L	1/2	76	-50F	81	77	CU	MO	AL	CB	V	0.000	0.001	0.002
8888L	166"	2500	N	CVN	L	1/2	76	-50F	81	77	CU	MO	AL	CB	V	0.000	0.001	0.002
8888L	166"	2500	N	CVN	L	1/2	76	-50F	81	77	CU	MO	AL	CB	V	0.000	0.001	0.002

**IMPACT TESTS:**  
 HEAT 8888L 38621  
 HEAT 8888L 38622  
 HEAT 8888L 38623  
 HEAT 8888L 38624  
 HEAT 8888L 38625  
 HEAT 8888L 38627

W.O. # 1176Q  
 M.L. # 43(76)  
 TIK. # 25(76)  
 P.O. # 13-0237

**Q.C.I. E.Y.**  
 APR 03 2013

**Q.C.I. N.D.**

**LIMITS OF UNSPECIFIED ELEMENTS PER ASME SECTION II (SA-20)**  
 CU + Ni + CR + MO = 68  
 CR + MO = 63

**CERTIFICATION OF MATERIAL - Per ASME IT# 8888L-38623**  
 Qualifies to all requirements of SA516-GR70 per Sect. II - Edition 11 Addenda

**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 CHEMICAL 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.

Signature: [Handwritten Signature]  
 Velocity America 279  
 5/2013

PAGE 2 OF 2



# Cambridge

materials testing limited

1177 Franklin Boulevard,  
Cambridge, Ontario N1R 7W4  
Tel: (519) 621-6600 Fax: (519) 621-6082  
www.cambridgematerials.com

ISO17025 Accredited

Report for: Quality Plates & Profiles Ltd.  
20 Nicholas Beaver Road  
R. R. # 3  
ABERFOYLE, Ontario  
N1H 6H9  
Phone: 1-800-268-2853  
Fax: 1-519-837-2224

Laboratory No. 598087-2012

Report Date: January 24, 2012  
Received Date: January 19, 2012

Customer P.O.#: P006311

Attention: Dave Braga

Specimen: Material: ASME SA516 - 70 Normalized  
.25" Thick x 3" x 3", Algoma Heat # 8888L-38625

## ROCKWELL HARDNESS TEST REPORT

80,79,79 HRBW

ACCEPTED/REVIEWED/RELEASED 046  
for and on behalf of: SIM OFFSHORE  
Print Name: GANESH SAH  
Signature: [Signature]  
Date: APR 15 2013  
Applus® VELOSI  
Velosi America LLC

NACE MR0175/ISO 15156-2 (A.2.1.2) Rockwell Hardness Requirement:  
22 HRC maximum

Conclusion: Pass

Testing performed according to  
NACE MR0175/ISO 15156-2:2009/Cir.1:2011(E), ISO 6508-1:1999(E),  
ASME Boiler and Pressure Vessel Code Section II, Part A, SA-370  
(2010 Edition, 2011 Addenda) and ASTM E18-08b.



Page 1 of 1

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

Per [Signature]  
Quality Assurance  
Per Matthew Links  
Technician

# Certificate of Mill Test Results

**QUALITY PLATES & PROFILES LIMITED**  
 20 Nicholas Road, R.R.#3 (Aberfoyle), Guelph, ON N1H 6H9  
 ALL-WELD COMPANY LIMITED  
 PO/Rel: 13-0239  
 PLATE CPL 516N 1" x 2" x 2"

Contact: BRIAN WEEDON  
 Inv: 1055234  
 Date: 03/25/2013  
 Heat: 2797P3



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

0005981

SO No., Item & Date:	8006515 000020 2013/01/05	Shipment No. & Date:	100023647 2013/01/06	TC No., Date & Time:	ESA-39932 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:	P00775512 1000023647
Customer Specification:	HR STEEL PLATE Carbon Multi Cert ASTM A516 GR 70 (10) / ASME SA516 GR 70 (1A) Meqts NACE MR0103 latest Ed. NACE MR 0175 latest Ed. BHN < 200. D.O.CEQ. 43 max. Inclusion Shape Control Calcium Treated Normalized temp. 1670. F 34 min. C.V.N. Req. 1.5/12 FT LBF at 0-50 FT. Std thickness 101 PVQ Top and Bottom Standard Surface Finishness 1/2 A20 Latest Ed 4-Addenda of ASME Code section II part A applies Fine Grain Fully Killed No Weld Repair	Carrier:	ROBINSON TRANSPORT LTD - 205(661)		

Supplementary instructions: Test Cert 1-519-837-2227  
 Insp ITR: Test Report As Per Spec

ESSAR STEEL ALGOMA INC. HEREBY CERTIFIES THAT THE MATERIAL REPRESENTED 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 WITHIN THE APPROVAL OF ESSAR STEEL ALGOMA INC. IF YOU RECEIVE THIS DOCUMENT AND ARE NOT THE INTENDED RECEIVER PLEASE CALL (705) 465-4046 FOR INSTRUCTIONS ON METHOD OF DISPOSAL OF DOCUMENT.

ALL HEATS FULLY KILLED  
 HEATS INDICATED WITH (1) NE-DRAWN  
 HEATS INDICATED WITH (2) MADE IN CANADA WITH DOMESTIC AND/OR NORTH AMERICAN MATERIALS

Dimensions (T x W x L)	Heat No.-MS	Quantity	No of Pcs	Dimensions (T x W x L)	Batch No.	Quantity	No of Pcs
1.0000" x 120.000" x 384.00"	AB8769	13 068 LB	1	1.0000" x 120.000" x 384.00"	AB8770	13 068 LB	1
1.0000" x 120.000" x 384.00"	AB8771	13 068 LB	1				

Heat No. (wt%)	C	Mn	P	S	Si	Cr	Ni	Cu	Mo	Al	Nb	V	B	TI	DO
2606P3	0.19	1.09	0.009	0.005	0.310	0.02	0.15	0.01	0.02	0.027	0.000	0.014	0.0003	0.002	0.4000
2797P3	0.19	1.09	0.009	0.005	0.310	0.02	0.15	0.01	0.02	0.027	0.000	0.014	0.0003	0.002	0.3900

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

W.O. # 11768  
 M.S. # 46627245(9/2)  
 THK. # 1-027  
 P.O. # 13-0239

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

**LIMITS OF UNSPECIFIED ELEMENTS PER ASME SECTION II (SA-20) CU + NI + CR + MO = 0.02**

Certification of Material - Per ASME HT# 2797P3-05  
 Qualifies to fill requirements of ASME SECTION II per Addenda Sect. II 10 Edition 11



K. UGHADPAGA  
 MANAGER METALLURGICAL SERVICES

MAR 27 2013

APR 03 2013

Date: 2013/01/07 Time: 12:25:32 Page no: 1 of 2

WARNING: THE TEST RESULTS AND VALUES REPORTED HEREIN ARE VALID ONLY IF THE PART IS AS SUPPLIED AND THE ANALYSIS AND PHYSICAL PROPERTIES OF SUCH STEEL ARE IN CONFORMANCE WITH THE REQUIREMENTS OF THE SPECIFICATION APPLIED TO THE PART. THE PART IS NOT TO BE USED TO QUALIFY THE STEEL FOR ANY SPECIFICATION OTHER THAN THE ONE INDICATED ON THE TEST REPORT. (EXCEPT FOR STEEL WHICH IS SPECIFICALLY IDENTIFIED AS BEING A STANDARD OF SUCH STEEL)



# Certificate of Mill Test Results

**QUALITY PLATES & PROFILES LIMITED**  
 20 Nicholas Ave Road, R.R.#3 (Aberfoyle), Guelph, ON N1H 6H9  
 ALL-WELD COMPANY LIMITED  
 PO/Rel: 13-0239  
 PLATE CPL 516N 1" x 2" x 2"

Inv: 1055234 Date: 03/25/2013  
 Contact: BRIAN WEEDON Heat: 2797P3

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

SO No. / Item & Date:	8006515 000020 2013J01/05	Shipment No. & Date:	1000203647 2013/01/06	TC No., Date & Time:	ESA 38929 2013/01/07 10:15:07							
Sold to Customer Name and Address:		Ship to Customer Name and Address:		Customer PO NO./Item:	P007755/2							
QUALITY PLATES & PROFILES LTD NICHOLAS BEAVER ROAD RR#3 20 ABERFOYLE, Ontario Canada N1H 6H9		QUALITY PLATES & PROFILES LTD NICHOLAS BEAVER ROAD RR#3 20 ABERFOYLE, Ontario Canada N1H 6H9		BOL NO.:	1000023647							
Customer Specification:		Customer Specification:		Cust Part No.:	ROBINSON TRANSPORT LTD - 205(661)							
HR STEEL PLATE Carbon Multi Cert ASTM A516 GR 70 (10) / ASME SA516 GR 70 (10) Meets NACE MR 0103 latest Ed. NACE MR 0175 latest Ed. BHN < 200. D.O.C.E.O. 43 max Inclusion Shape Control Calcium Treated. Normalized Temp. 1670. P.04. C.V.N.L. 0.05. 12 FT. L.B.F. at 0.50 0 F. Std Thickness Tol PVC Top and Bottom Standard Surface Finishness 1/2 A20 Latest Ed + Addenda of ASME Code section II part A applies. Fine Grain Fully Killed. No Weld Repair.				Carrier:								
Supplementary Instructions: Test Cert 1519-837-2227												
Insp TIR: Test Report As Per Spec												
ESSAR STEEL ALGOMA AND 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 USED IN ANY MANNER WITHOUT THE WRITTEN APPROVAL OF ESSAR STEEL ALGOMA. IF YOU RECEIVE THIS DOCUMENT AND ARE NOT THE INTENDED RECEIVER, PLEASE CALL 1709-846-4029 FOR INSTRUCTIONS ON METHOD OF DISPOSAL OF DOCUMENT.												
SHEETS EN 10204 2004 TYPE 3.1 ISO QUALITY AND ENVIRONMENTAL CERTIFICATES AVAILABLE AT WWW.ESSARSTEELALGOMA.COM												
MECHANICAL PROPERTIES												
Impact Tests	Batch No	SRCE	LAB	GAUGE	COND	METH	DIR	LOC	SIZE	TEMP(°F)	ENERGY (ft-lbf)	ENERGY AVG(ft-lbf)
2606P3	AB8760	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	75
Tensile Tests	Batch 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

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

**APR 03 2013**

*Revised*  
*April 1, 2013*

**Q.C.I. N.D.**

**MAR 27 2013**

K. UGHADPAGA  
 MANAGER METALLURGICAL SERVICES

**\*\*WARNING\*\*** THE TEST RESULTS AND VALUES INDICATED HEREIN INDICATE ONLY THAT (1) THE MATERIAL WAS 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 USED IN ANY MANNER WITHOUT THE WRITTEN APPROVAL OF ESSAR STEEL ALGOMA. IF YOU RECEIVE THIS DOCUMENT AND ARE NOT THE INTENDED RECEIVER, PLEASE CALL 1709-846-4029 FOR INSTRUCTIONS ON METHOD OF DISPOSAL OF DOCUMENT.





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

Page 1 of 1  
REPORT NUMBER 73595  
DATE 4/5/2013

FCI ORDER NUMBER 60029

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

CUSTOMER ORDER NUMBER 13-0279 ADD  
ORDER/SHIPPED TO ALL-WELD CO., LTD.  
49 PASSMORE AVE.

SCARBOROUGH ONT MIV 4T1 CANADA

Item Quantity Description

2 2 2" X 900 RTJ WN S/160

ITEM# 1176-7

HEAT NUMBER:  
B859

MATERIAL TYPE:  
SA350LF2CL1

Material Origin: USA  
Manufactured in USA

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

CHEMICAL ANALYSIS

PHYSICAL PROPERTIES

PRODUCT

C	.180	.181
Mn	1.160	1.176
P	.0080	.0000
S	.0030	.0000
Si	.220	.232
Cr	.070	.076
Mo	.020	.022
V	.020	.014
Cu	.130	.140
Ni	.060	.063
Co	.001	.002
Sn	.0103	.008

Yield PSI	46,300
Tensile PSI	73,900
Elongation	27
Reduction of Area	70
Hardness	149 HBW
CVN @ -50 °F FT LBS	58/55/54
% Shear	
MLE	

MAY 27 2013



Ti	.0010	
Al	.029	.030
B	.0002	
C E	41	410

**NI**  
Certification of Material - Per ASME  
HT# B859  
Qualifies to all requirements of  
SA350 LF2CL1 per  
Sect. II 10 Edition 11 Addenda

W.O. # 11766  
M.L. # 47(1/2)  
THK. # .462  
P.O. # 13-0279

**LIMITS OF UNSPECIFIED ELEMENTS PER ASME SECTION II (SA-20)**  
CU + Ni + CR + MO = .28  
CR + MO = .09

Heat Treatment NORMALIZED  
Temperature 1650 °F  
Time at Temperature 1/2 HR / IN THK MIN  
Cooling Media AIR

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 Helen Fielder  
Name: Helen Fielder Title: QA Representative

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of SBM OFF STORE  
Print Name: CHANDRESH SAH  
Signature: [Signature]  
Date: July 10/13  
Applus<sup>®</sup> VELOSI  
Velosi America LLC

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



SO No., Item & Date:	8010079 000010 2013/04/30	Shipment No. & Date:	1000045592 2013/05/06	TC No., Date & Time:	ESA-71132 2013/05/08 - 22:33:08
Sold to Customer Name and Address:	CANADIAN PLATE AND PROFILES IN KAMATO ROAD 920 MISSISSAUGA, Ontario, Canada	Ship to Customer Name and Address:	CANADIAN PLATE AND PROFILES IN KAMATO ROAD 920 MISSISSAUGA, Ontario, Canada	Customer PO NO./Item:	19748-STK / 1
	L4W 2R6		L4W 2R6	BOL NO.:	1000045592
				Cust. Part No.:	
				Carrier:	LOCOMOTE SYSTEM INC - RTA341 (891030)

**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, ISO 15156, PER EN 10204 3.1, SULPHIDE SHAPE CONTROL, CALCIUM TREATED, NO WELD REPAIR HAS BEEN PERFORMED ON THIS MATERIAL Normalized Temp 1670 °F 17 min CVNL Req. 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 Fine Grain Fully Killed

**Supplementary Instructions:** Test Cert 1: drafting@canadianplate.com Test Cert 2: 905-206-1370

**Insp T/R:** Test Report As Per Spec

**Cust Use:** PVQ

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

THIS MILL TEST REPORT MAY NOT BE REPRODUCED EXCEPT IN FULL WITHOUT WRITTEN APPROVAL OF ESSAR STEEL ALGOMA INC. IF YOU RECEIVE THIS DOCUMENT AND ARE NOT THE INTENDED RECEIVER, PLEASE CALL (705)947-0995 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)	Heat No.-MS	Quantity	Pcs
0.5000" x 96.000" x 480.00"	6396P3-01	13,068 LB	2

Batch No.	AD7572
-----------	--------

Heat No. (wt%)	C	Mn	P	S	Si	Cr	Ni	Cu	Mo	Al	Nb	V	B	Ti	DO
6396P3*	0.20	1.06	0.012	0.005	0.340	0.01	0.14	0.02	0.00	0.030	0.000	0.015	0.0002	0.003	0.39

Hardness Tests	SRCE	LAB	GAUGE	COND	LOC	MTHD	HARDNESS
Heat No.	AD7572	166"	ALG	0.5000	N	B	HBW
6396P3							158

Impact Tests	SRCE	LAB	GAUGE	COND	METH	DIR	LOC	SIZE	TEMP (°F)	FULLENERGY (ft-lbf)	FULL AVG (ft-lbf)
Heat No.	AD7572	166"	ALG	0.5000	N	CVN	L	B	FULL	-50	82 81 87
6396P3										83	
	AD7572	166"	ALG	0.5000	N	CVN	L	B	FULL	-50	88 79 67
										78	

**LIMITS OF UNSPECIFIED ELEMENTS PER ASME SECTION II (SA-20)**  
**CU + Ni + CR + MO = .17**  
**CR + MO = .01**

Certification of Material - Per ASME  
 HT# 6396P3-01  
 Qualified per requirements of  
 SA 516 GR 70 per  
 Sect. II 10 Edition 4 Addenda

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: Sam Coffey  
 Print Name: GIANESSI SAMIT  
 Signature: [Signature]  
 Date: Aug 2013  
 Appius®  
 Velosi America LLC

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

W.O.# 11769  
 M.O.# 53(272)54(272)576  
 P.O.# 130770

K. UGHADPAGA  
 MANAGER METALLURGICAL SERVICES

**\*\*WARNING\*\*** THE TEST RESULTS AND VALUES REPORTED HEREIN INDICATE ONLY THAT (1) THE PARTICULAR STEEL FOR WHICH THIS CERTIFICATE IS ISSUED MEETS THE MINIMUM SPECIFIED YIELD STRENGTH AND (2) THE ANALYSIS AND PHYSICAL PROPERTIES OF SUCH STEEL ARE IN CONFORMANCE WITH THE REQUIREMENTS OF THE SPECIFICATION INDICATED. THE RESULTS OR VALUES REPORTED HEREIN CAN NOT BE USED TO QUALIFY THE STEEL FOR ANY SPECIFICATION OTHER THAN THE ONE INDICATED AND CAN NOT BE RELIED UPON FOR ANY PURPOSE (INCLUDING DESIGN OR CALCULATIONS) AS REPRESENTING THE ACTUAL STRENGTH OF SUCH STEEL.



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

SO No., Item & Date:	8010079 000010 2013/04/30	Shipment No. & Date:	1000045592 2013/05/06	TC No., Date & Time :	ESA-71132 2013/05/08 - 22:33:08							
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:	19748-STK / 1							
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, ISO15156, PER EN 10204 3.1, SULPHIDE SHAPE CONTROL CALCIUM TREATED, NO WELDREPAIR HAS BEEN PERFORMED ON THIS MATERIAL. Normalized Temp 1670 °F 17 min CVNL Req. 15 / 12 FT-LBF at -50.0 F Sld Thickness Tol PVQ Top and Bottom Standard Surface Flatness 1/2 A20 Latest Ed. + Addenda of ASME Fine Grain Fully Killed			BOL NO.:	1000045592							
				Cust.Part No.:								
				Carrier :	LOCOMOTE SYSTEM INC - RTA341 (891030)							
Supplementary Instructions : Test Cert 1: drafting@canadianplate.com Test Cert 2: 905-206-1370												
Insp T/R : Test Report As Per Spec												
Cust Use : PVQ												
ESSAR STEEL ALGOMA INC. HEREBY CERTIFIES THAT THE MATERIAL HEREIN DESCRIBED WAS MADE AND TESTED IN ACCORDANCE WITH THE RULES OF THE SPECIFICATION SHOWN. ALL RESULTS ARE RETAINED IN ACCORDANCE WITH THE COMPANY'S STANDARD RECORD KEEPING PRACTICES. THIS MILL TEST REPORT MAY NOT BE REPRODUCED EXCEPT IN FULL WITHOUT WRITTEN APPROVAL OF ESSAR STEEL ALGOMA INC. IF YOU RECEIVE THIS DOCUMENT AND ARE NOT THE INTENDED RECEIVER, PLEASE CALL (705) 945-4095 FOR INSTRUCTIONS ON METHOD OF DISPOSAL OF DOCUMENT.												
MEETS EN 10204-2004 TYPE 3.1 ISO QUALITY AND ENVIRONMENTAL CERTIFICATES AVAILABLE AT WWW.ESSARSTEELALGOMA.COM												
***** MECHANICAL PROPERTIES *****												
Tensile Tests												
Heat No.	Batch No.	SRCE	LAB	GAUGE	COND	METH	DIR	LOC	YIELD(KSI)	TENSILE(KSI)	EL SCALE	ELONG(%)
6396P3	AD7572	166"	ALG	0.5000	N	.2	T	B	53.0	77.0	8"	24
6396P3	AD7572	166"	ALG	0.5000	N	.2	T	B	54.0	78.0	8"	24

**Q.C.I.  
E.Y.  
AUG 20 2013**

046  
 ✓ **ACCEPTED/REVIEWED/RELEASED**  
 for and on behalf of: SOM OFF SHORE  
GAMESH SAHJ  
**Appius®**  
**VELOSI**  
 Print Name: \_\_\_\_\_ Signature: \_\_\_\_\_ Date: \_\_\_\_\_  
 Velosi America LLC

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.





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

SO No., Item & Date:	8007677 000021 2013/02/22	Shipment No. & Date:	1000033668 2013/03/05	TC No., Date & Time:	ESA-53909 2013/03/06 - 06:21:28
Sold to Customer Name and Address:	CANADIAN PLATE AND PROFILES IN KAMATO ROAD 920 MISSISSAUGA, Ontario, Canada	Ship to Customer Name and Address:	CANADIAN PLATE AND PROFILES IN KAMATO ROAD 920 MISSISSAUGA, Ontario, Canada	Customer PO NO./Item:	19396-STK / 2
				BOL NO.:	1000033668
				Cust. Part No.:	LOCOMOTE SYSTEM INC - na341 (89103) rev
				Carrier:	

Customer Specification: HR STEEL PLATE Carbon Multi Cert ASTM A516 GR 70 (10) ASME SA516 GR 70 (11A) Meets NACE MR 0175 latest Ed., NACE MR 0103 latest Ed., BHN <200, Calcium Treated for Sulphide Shape Control Normalized Temp. 1670 - F 8 min CVNL Req. 15 x 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 Fine Grain Fully Killed No Weld Repair

Supplementary Instructions: Test Cert 1: drafting@canadianplate.com Test Cert 2: 905-206-1370

Insp TIR : Test Report As Per Spec Cust Use : PVQ

ESSAR STEEL ALGOMA INC. HEREBY CERTIFIES THAT THE MATERIAL HEREIN DESCRIBED WAS MADE AND TESTED IN ACCORDANCE WITH THE RULES OF THE SPECIFICATION SHOWN. ALL RESULTS ARE RETAINED IN ACCORDANCE WITH THE COMPANY'S STANDARD RECORD KEEPING PRACTICES. THIS MILL TEST REPORT MAY NOT BE REPRODUCED EXCEPT IN FULL WITHOUT WRITTEN APPROVAL OF ESSAR STEEL ALGOMA INC. IF YOU RECEIVE THIS DOCUMENT AND ARE NOT THE INTENDED RECEIVER, PLEASE CALL (705) 945-4095 FOR INSTRUCTIONS ON METHOD OF DISPOSAL OF DOCUMENT.

MEETS EN 10204/2004 TYPE 3.1 ISO QUALITY AND ENVIRONMENTAL CERTIFICATES AVAILABLE AT WWW.ESSARSTEELALGOMA.COM

ALL HEATS FULLY KILLED  
HEATS INDICATED WITH (\*) FINE GRAINED  
HEATS INDICATED WITH (+) MADE IN CANADA WITH DOMESTIC AND NORTH AMERICAN MATERIALS

Dimensions (T x W x L)	Batch No.	Heat No-MS	Quantity	No. of Pcs	Dimensions (T x W x L)	Batch No.	Heat No-MS	Quantity	No. of Pcs						
0.2500" x 120.000" x 480.00"	AC5976	4019P3-52	4,084 LB	1	0.2500" x 120.000" x 480.00"	AC5977	4019P3-52	4,084 LB	1						
Heat No. (wt%)	C	Mn	P	S	Si	Cr	Ni	Cu	Mo	Al	Nb	V	Ti	B	DO
4019P3*	0.19	1.07	0.011	0.004	0.310	0.02	0.15	0.026	0.000	0.014	0.0002	0.003	0.3900		
MECHANICAL PROPERTIES															
HARDNESS															
Heat No.	Batch No.	SRCE	LAB	GAUGE	COND	LOC	MTHD								
4019P3	AC5976	166"	ALG	0.2500	N	B	HBW	161							
4019P3	AC5977	166"	ALG	0.2500	N	B	HBW	162							

LIMITS OF UNSPECIFIED ELEMENTS PER ASME SECTION II (SA-20) CU + Ni + CR + MO = 0.19 CR + MO = 0.02

Q.C.I. N.D.

W.O. # 11769 (26/2)  
M.L. # 55 (25/2, 26/2)  
THK. # 259  
P.O. # 13-072e

Certification of Material - Per ASME  
HT# 4019P3-52  
Qualifies to all requirements of SA 516 GR 70N per Sect. II Edition II Addenda

ML# 65 (19/2)

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 CHEMICAL AND MECHANICAL PROPERTIES OF THIS 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 OTHER APPLICATIONS OR CALCULATIONS AS REPRESENTING THE ACTUAL STRENGTH OF SUCH STEEL.

ACCEPTED FOR AND ON BEHALF OF: SAM OFFSHORE  
Print Name: GAMESH SAH  
Signature: SAM  
Applus VELOSI





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

SO No., Item & Date:	8007577 000021 2013/02/22	Shipment No. & Date:	1000033668 2013/03/05	TC No., Date & Time:	ESA-53909 2013/03/06 - 06:21:28
Sold to Customer Name and Address:	CANADIAN PLATE AND PROFILES IN KAMATO ROAD 920 MISSISSAUGA, Ontario, Canada	Ship to Customer Name and Address:	CANADIAN PLATE AND PROFILES IN KAMATO ROAD 920 MISSISSAUGA, Ontario, Canada L4W 2R6	Customer PO NO./Item:	19396-STK/2
				BOL NO.:	1000033668
				Cust.Part No.:	LOCOMOTE SYSTEM INC - rta341 (89103) rev
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 Sulfide Shape Control Normalized Temp 1670 °F 8 min CVN Req 15 / 12 FT-LBF at -50 °F Sid Thickness Tol PVQ Top and Bottom Standard Surface Flatness 1/2 A20 Latest Ed. + Addenda of ASME Fine Grain Fully Killed No Weld Repair			Carrier:	

Supplementary Instructions : Test Cert 1:drafling@canadianplate.com Test Cert 2: 905-206-1370  
 Insp TIR : Test Report As Per Spec  
 Cust Use : PVQ  
 ESSAR STEEL ALGOMA INC. HEREBY CERTIFIES THAT THE MATERIAL HEREIN DESCRIBED WAS MADE AND TESTED IN ACCORDANCE WITH THE RULES OF THE SPECIFICATION SHOWN. ALL RESULTS ARE RETAINED IN ACCORDANCE WITH THE COMPANY'S STANDARD RECORD KEEPING PRACTICES. THIS MILL TEST REPORT MAY NOT BE REPRODUCED EXCEPT IN FULL WITHOUT WRITTEN APPROVAL OF ESSAR STEEL ALGOMA INC. IF YOU RECEIVE THIS DOCUMENT AND ARE NOT THE INTENDED RECEIVER, PLEASE CALL (705)945-1095 FOR INSTRUCTIONS ON METHOD OF DISPOSAL OF DOCUMENT.  
 MEETS EN 10048-2004 TYPE 3.1  
 ISO QUALITY AND ENVIRONMENTAL CERTIFICATES AVAILABLE AT WWW.ESSARSTEELALGOMA.COM

MECHANICAL PROPERTIES													
Impact Test	Heat No.	SRCE	LAB	GAUGE	COND	METH	DIR	LOC	SIZE	TEMP(°F)	FULL ENERGY (ft-lbf)	FULL AVG (ft-lbf)	
	4019P3	AC5976	166"	ALG	0.2500	N	CVN	L	B	1/2	-50	75 73 68	72
	4019P3	AC5977	166"	ALG	0.2500	N	CVN	L	B	1/2	-50	71 67 63	67
Tensile Test													
Heat No.	SRCE	LAB	GAUGE	COND	METH	DIR	LOC	YIELD(KSI)	TENSILE(KSI)	EL SCALE	ELONG(%)		
4019P3	AC5976	166"	ALG	0.2500	N	2	T B	56.0	77.0	8"	21		
4019P3	AC5977	166"	ALG	0.2500	N	2	T B	56.0	76.0	8"	23		

Q.C.I.  
E.Y.

AUG 20 2013

046

ACCEPTED/REVIEWED/RELEASED

for and on behalf of: SJM OFF SHORE

Print Name: YAMRISH SAHA

Signature: [Signature]

Date: July 23/13


AFPlus®  
VFLCSI  
Velo3i America LLC

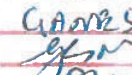
K. UGHADPAGA  
MANAGER METALLURGICAL SERVICES

**\*\*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.

160-2 County Court Blvd. Suite # 205, Brampton, ON, L6W 4V1  
 Tel: 416-473-8207 Fax-905-455-7844  
 Email: n.g@hitechnode.com

**ULTRASONIC INSPECTION REPORT**

Client: Canadian Plate & Profiles Inc				Report No: 05/13				
PO #: 19945				Part Description: Plate				
WO #: 2427				Procedure: UT/GP/101				
Heat No: See below				Client Specifications: ASME Sec V Art - 23, 2010 addenda 2011, SA578, Level- 'C'				
Material: SA516, Gr 70MT, NACE				Technique: 'A' Scan contact				
Thickness: See below				Cal. Block: IIW-1 & BW itself		SI. # -		
Surface: As Rolled/Rough				Couplant: Water		Batch # -		
Type of Fabrication: Plate				Time Base: As required				
Dwg. No: -				Gain: As Required				
Work Location: Kamato Road, Mississauga				Scanning Speed: 6" per sec.				
Customer: -				Test Date: Apr 24, 2013				
UT EQUIPMENT				TRANSDUCER				
Make	Model	Sl. #	Date	Valid	Angle	Size	Frequency	SI. #
Panametrics	Epoch-IV	03155409	Nov, 2012	Nov 2013	0°	1"	2.25 Mhz	43629
Scope: To inspect the following plate for lamination scan before flame cut:								
QTY		SIZE			HEAT #			
1 Plate		0.2500" X 48" X 120" D/L 102" X 129"			4019P3-AC5977			
1 Plate		0.3750" X 120" X 304"			4582P3-AC7419			
1 Plate		0.5000" X 120" X 191"			4927P3-AD0156			
1 Plate		0.6250" X 120" X 289"			2259P3-AB6514			
1 Plate		0.7500" X 96" X 94" D.L 43"X179"			4582P3-AC7352			
1 Plate		1.0000" X 96" X 171" D/L 70"X79"			4582P3-AC7350			
1 Plate		1.2500" X 120" X 240"			1966P3-AB5386			
1 Plate		1.5000" X 120" X 288"			5441P3-AD1562			
1 Plate		2.0000" X 120" X 151"			5441P3-AD1559			
<b>Results:</b>								
1. 100% plate area scanned with normal probe.								
2. No reject able indication detected during inspection.								
3. The plates inspected meet the requirement of ASTM SA578, Level- 'C'.								
Total Parts Examined			Parts Accepted			Parts Rejected		
9			9			0		
Name & Signature of Inspector			Certification		Representative		Dated	
N. WRAICH 			CGSB Level-II- [✓] SNT - Level-II [✓] ACCP- Level-III [✓]		Hi-Tech NDE Inc		Apr 24, 2013	
CLIENT REPRESENTATIVE:			Name		Signature		Date	

ACCEPTED/REVIEWED/RELEASED 046  
 for and on behalf of: SAM OFF SHORE  
 Print Name: ANURSH SAHA  
 Signature:   
 Date: July 23/13  
 Applus® VELOSI  
 Velosi America LLC





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

**Customer Specification:** HR STEEL PLATE Carbon Multi Cert ASTM A516 GR 70 (11A) Meets NACE MR 0103 latest Ed., NACE MR 0175 latest Ed., BHN < 200, Calcium Treated for Sulphide Shape Control Normalized Temp 1670 °F 34 min CVNL Req. 15/12 FT-LBF at -50.0 F Sid Thickness Tol PVQ Top and Bottom Standard Surface Flatness 1/2 A20 Latest Ed. +Addenda of ASME Code section II part A applies Fine Grain Fully Killed No Weld Repair

**Supplementary Instructions:** Test Cert 1: drafting@canadianplate.com Test Cert 2: 905-206-1370

Insp TR: Test Report As Per Spec  
Cust Use: PVQ  
ESSAR STEEL ALGOMA INC. HEREBY CERTIFIES THAT THE MATERIAL HEREIN DESCRIBED WAS MADE AND TESTED IN ACCORDANCE WITH THE RULES OF THE SPECIFICATION SHOWN. ALL RESULTS ARE RETAINED IN ACCORDANCE WITH THE COMPANY'S STANDARD RECORD KEEPING PRACTICES.  
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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 (v) 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	Cu	Mo	Al	Nb	B	TI	DO
0811P3*	0.19	1.08	0.009	0.004	0.330	0.05	0.16	0.04	0.01	0.030	0.000	0.002	0.003	0.4000

Hardness Tests	Batch No.	SRCE	LAB	GAUGE	COND	LOC	MTHD	HARDNESS
	AB0907	166"	ALG	1,0000	N	B	HBW	153
	AB0908	166"	ALG	1,0000	N	B	HBW	150

LIMITS OF UNSPECIFIED ELEMENTS PER ASME SECTION II (SA-20)  
CU + NI + CR + MO = 2.6  
CR + MO = 0.06

Certification of Material - Per ASME III  
0811P3-02  
Quantities to all test results of SA516-GR 70 per Sect. II Edition II Addenda

W.O. # 11769  
M.L. # 56 (7/3)  
I.I.K. # 1  
P.O. # 13-0720

Q.C.I. N.D.  
Q.C.I. E.Y.  
AUG 20 2013

K. UGHADPAGA  
MANAGER METALLURGICAL SERVICES

ACCEPTED FOR 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 CHEMICAL 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 OTHER APPLICATION OTHER THAN THAT SPECIFIED AND CAN NOT BE RELIED UPON FOR ANY PURPOSE (INCLUDING DESIGN OR CALCULATIONS) AS REPRESENTING THE ACTUAL STRENGTH OF SUCH STEEL.  
Print Name: S.B.M. G. SHARMA  
Signature: [Signature] Affplus VELOSI



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

SO No., Item & Data.: 8004571 000010 2012/10/27		Shipment No. & Date.: 1000012968 2012/10/29		TC No., Date & Time : ESA-22183 2012/10/30 - 20:30:57						
Sold to Customer Name and Address : CANADIAN PLATE AND PROFILES IN KAMATO ROAD 920 MISSISSAUGA, Ontario, Canada L4W 2R6		Ship to Customer Name and Address: CANADIAN PLATE AND PROFILES IN KAMATO ROAD 920 MISSISSAUGA, Ontario, Canada L4W 2R6		Customer PO NO./Item: 18651-STK / 1 BOL NO.: 1000012968 Cust. Part No.: Carrier: TRIPLE K TRANSPORT LTD - 35099 (250						
Customer Specification : HR STEEL PLATE Carbon Multi Cert ASTM A516 GR 70 (10) / ASME SA516 GR 70 (11A) Meets NACE MR 0103 latest Ed., BHN < 200, Calcium Treated for Sulphide Shape Control Normalized Temp 1670 °F 34 min CVNL Req. 15 1/2 FT-LBF at -50.0 F Sid Thickness Tol PVQ Top and Bottom Standard Surface Flatness 1/2 A20 Latest Ed. → Addenda of ASME Code section II part A applies Fine Grain Fully Killed No Weld Repair										
Supplementary Instructions : Test Cert 1: drafting@canadianplate.com Test Cert 2: 905-206-1370										
Insp T/R : Test Report As Per Spec		Cust Use : PVQ								
ESSAR STEEL ALGOMA INC. HEREBY CERTIFIES THAT THE MATERIAL HEREIN DESCRIBED WAS MADE AND TESTED IN ACCORDANCE WITH THE RULES OF THE SPECIFICATION SHOWN. ALL RESULTS ARE RETAINED IN ACCORDANCE WITH THE COMPANY'S STANDARD RECORD KEEPING PRACTICES. THIS MILL TEST REPORT MAY NOT BE REPRODUCED EXCEPT IN FULL WITHOUT WRITTEN APPROVAL OF ESSAR STEEL ALGOMA INC. IF YOU RECEIVE THIS DOCUMENT AND ARE NOT THE INTENDED RECEIVER, PLEASE CALL (705)945-4095 FOR INSTRUCTIONS ON METHOD OF DISPOSAL OF DOCUMENT.										
MEETS EN 10204-2004 TYPE 3.1 ISO QUALITY AND ENVIRONMENTAL CERTIFICATES AVAILABLE AT WWW.ESSARSTEELALGOMA.COM										
..... MECHANICAL PROPERTIES .....										
<b>Impact Tests</b>										
Heat No.	SRCE	LAB	GAUGE	COND	METH DIR LOC SIZE	TEMP (°F)	FULLENERGY (ft-lbf)	FULL AVG (ft-lbf)		
0811P3	AB0907	166"	ALG	1.0000	N CVN L B FULL	-50	101 74 89	88		
0811P3	AB0908	166"	ALG	1.0000	N CVN L B FULL	-50	89 108 107	101		
<b>Tensile Tests</b>										
Heat No.	Batch No.	SRCE	LAB	GAUGE	COND	METH DIR LOC	YIELD (KSI)	TENSILE (KSI)	EL SCALE	ELONG (%)
0811P3	AB0907	166"	ALG	1.0000	N	.2 T B	50.5	75.5	2"	36
0811P3	AB0908	166"	ALG	1.0000	N	.2 T B	50.0	77.0	2"	37

AUG 20 2013

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

✓ ACCU-TEST REVIEWED/RELEASED 046  
for and on behalf of: SAM OFF STORE  
Print Name: CIAMERH SAHIT  
Signature: [Signature]  
Date: Aug 22/13  
**Applus®**  
VELOSI  
Velosi America LLC

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 RELEAD 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:	8008924 000020 2013/03/15	Shipment No. & Date:	1000038482 2013/03/29	TC No., Date & Time:	ESA-60867 2013/03/30 - 08:47:26
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:	19609-STK / 2
				BOL NO.:	1000038482
				Cust.Part No.:	
				Carrier:	GBS & SONS TRUCKING LTD. - 413(1034)

**Customer Specification:** HR STEEL PLATE Carbon Multi Cert ASTM A516 GR 70 (1A) Meets NACE MR 0103 latest Ed., NACE MR 0175 latest Ed., BHN < 200, D.O.CEQ. 43 max, Inclusion Shape Control Calcium Treated Normalized Normalize Temp 1670 F 12 min CVNL Req. 15 / 12 FT-LBF at -50.0 F Sid Thickness Tol PVQ Top and Bottom Standard Surface Flatness 1/2 A20 Fine Grain Fully Killed

**Supplementary Instructions:** Test Cert 1: drafting@canadianplate.com Test Cert 2: 905-206-1370

**Insp TIR:** Test Report As Per Spec

ESSAR STEEL ALGOMA INC. HEREBY CERTIFIES THAT THE MATERIAL HEREIN DESCRIBED WAS MADE AND TESTED IN ACCORDANCE WITH THE RULES OF THE SPECIFICATION SHOWN. ALL RESULTS ARE RETAINED IN ACCORDANCE WITH THE COMPANY'S STANDARD RECORD KEEPING PRACTICES. THIS WILL 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)945-4065 FOR INSTRUCTIONS ON METHOD OF DISPOSAL OF DOCUMENT.

MEETS EN 10201:2004 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
0.3750" x 120.000" x 480.00"	AD0158	4927P3-04	12,252 LB	2	0.3750" x 120.000" x 480.00"	AD0159	4927P3-04	12,252 LB	2
0.3750" x 120.000" x 480.00"	AD0160	4927P3-52	12,252 LB	2					

Heat No. (wt%)	C	Min	P	S	Si	Gr	Ni	Cu	Mo	Al	Nb	V	B	Ti	DO
4927P3*	0.20	1.07	0.009	0.003	0.330	0.01	0.15	0.02	0.00	0.025	0.000	0.015	0.0002	0.003	0.39

Hardness Tests

Heat No.	Batch No.	SRCE	LAB	GAUGE	COND	LOC	MTHD	HARDNESS
4927P3	AD0160	166"	ALG	0.3750	N	B	HBW	155
4927P3	AD0159	166"	ALG	0.3750	N	B	HBW	156
4927P3	AD0158	166"	ALG	0.3750	N	B	HBW	157

Certification of Material - Per ASME  
 ITW 4927P3-04  
 Q.C.I. N.D.  
 Q.C.I. E.Y.  
 AUG 20 2013

Qualifies to all requirements of  
 SASIBERTON per  
 Sect. II 10 Edition II Addenda

**LIMITS OF UNSPECIFIED ELEMENTS PER ASME SECTION II (SA-20)**  
 CR + Ni + CR + MO = 0.18  
 CR + MO = 0.1

MANAGER METALLURGICAL SERVICES  
 K. UGHADPAGA

Date: 2013/03/30 Time: 12:05:24 Page no: 1 of 2

APPROVED FOR SALE  
 for and on behalf of  
 Print Name: *[Signature]*  
 Signature: *[Signature]*  
 Date: 2/23/13

046  
 APPLUS®  
 VELOSI  
 Velosi America LLC



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

SO No./Item & Date:	8008924 000020 2013/03/15	Shipment No. & Date:	1000038482 2013/03/29	TC No., Date & Time:	ESA-60867 2013/03/30 - 08:47:26
Sold to Customer Name and Address:	CANADIAN PLATE AND PROFILES IN KAMATO ROAD 920 MISSISSAUGA, Ontario, Canada	Ship to Customer Name and Address:	CANADIAN PLATE AND PROFILES IN KAMATO ROAD 920 MISSISSAUGA, Ontario, Canada	Customer PO NO./Item:	19609-STK / 2
	L4W 2R6		L4W 2R6	BOL NO.:	1000038482
				Cust. Part No.:	GBS & SONS TRUCKING LTD. - 413(1034)
Customer Specification:	HR STEEL PLATE Carbon Multi Cert ASTM A516 GR 70 (10) / ASME SA516 GR 70 (11A) Meets NACE MR 0103 latest Ed., BHN < 200, D.O.CEQ. 43 max, Inclusion Shape Control Calcium Treated Normalized Normalize Temp 1670 °F 12 min CVNL Req. 15 / 12 FT-LBF at -50.0 F Sid Thickness Tol PVQ Top and Bottom Standard Surface Flatness 1/2 A20 Fine Grain Fully Killed			Carrier:	

Supplementary Instructions : Test Cert 1:drafting@canadianplate.com Test Cert 2: 905-206-1370

Insp TIR : Test Report As Per Spec

ESSAR STEEL ALGOMA INC. HEREBY CERTIFIES THAT THE MATERIAL HEREIN DESCRIBED WAS MADE AND TESTED IN ACCORDANCE WITH THE RULES OF THE SPECIFICATION SHOWN. ALL RESULTS ARE RETAINED IN ACCORDANCE WITH THE COMPANY'S STANDARD RECORD KEEPING PRACTICES. THIS MILL TEST REPORT MAY NOT BE REPRODUCED EXCEPT IN FULL WITHOUT WRITTEN APPROVAL OF ESSAR STEEL ALGOMA INC. IF YOU RECEIVE THIS DOCUMENT AND ARE NOT THE INTENDED RECEIVER, PLEASE CALL (705)945-4095 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		FULL AVG (ft-lbf)										
Heat No.	Batch No.	SRCE	LAB	GAUGE	COND	METH	DIR	LOC	SIZE	TEMP (°F)	FULLENERGY (ft-lbf)	ELONG (%)
4927P3	AD0160	166"	ALG	0.3750	N	CVN	L	B	3/4	-50	82 145 94	107
4927P3	AD0159	166"	ALG	0.3750	N	CVN	L	B	3/4	-50	89 87 89	88
4927P3	AD0158	166"	ALG	0.3750	N	CVN	L	B	3/4	-50	88 112 67	95
Tensile Tests		ELONG (%)										
Heat No.	Batch No.	SRCE	LAB	GAUGE	COND	METH	DIR	LOC	YIELD (KSI)	TENSILE (KSI)	EL SCALE	ELONG (%)
4927P3	AD0160	166"	ALG	0.3750	N	.2	T	B	55.0	77.0	8"	26
4927P3	AD0159	166"	ALG	0.3750	N	.2	T	B	55.0	76.0	8"	24
4927P3	AD0158	166"	ALG	0.3750	N	.2	T	B	53.0	75.0	8"	23

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: SAM OFF SHORE  
Print Name: GANESH SAHA  
Signature: [Signature]  
Date: Aug 23/13  
APPIUS®  
VELOSI  
Velosi America LLC

Q.C.I. N.D.  
Q.C.I. E.V.

Aug 20 2013

K. UGHADPAGA  
MANAGER METALLURGICAL SERVICES

**WARNING\*** THE TEST RESULTS AND VALUES REPORTED HEREIN INDICATE ONLY THAT (1) THE PARTICULAR STEEL FOR WHICH THIS CERTIFICATE IS ISSUED MEETS THE MINIMUM SPECIFIED YIELD STRENGTH AND (2) THE ANALYSIS AND PHYSICAL PROPERTIES OF SUCH STEEL ARE IN CONFORMANCE WITH THE REQUIREMENTS OF THE SPECIFICATION INDICATED. THE RESULTS OR VALUES REPORTED HEREIN CAN NOT BE USED TO QUALIFY THE STEEL FOR ANY SPECIFICATION OTHER THAN THE ONE INDICATED AND CAN NOT BE RELIED UPON FOR ANY PURPOSE (INCLUDING DESIGN OR CALCULATIONS) AS REPRESENTING THE ACTUAL STRENGTH OF SUCH STEEL.



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

SO No., Item & Date: 8005805 000020 2012/12/17  
 Shipment No. & Date: 1000021035 2012/12/17  
 TC No., Date & Time: ESA-34474 2012/12/17 - 10:18:00

Sold to Customer Name and Address:  
 CANADIAN PLATE AND PROFILES IN  
 KAMATO ROAD 920  
 MISSISSAUGA, Ontario Canada

Ship to Customer Name and Address:  
 CANADIAN PLATE AND PROFILES IN  
 KAMATO ROAD 920  
 MISSISSAUGA, Ontario Canada

Customer PD NO./Item: 18996-SJK / 2  
 BOL. NO.: 12729abc  
 Cust. Part No.:  
 Carrier: Locomote System Inc.

Customer Specification: HR STEEL PLATE Carbon Multi Cert ASTM A516 GR 70 (10) ASME SA516 GR 70 (10) Meets NACE MR 0103 latest Ed. NACE MR 0175 latest Ed. BHN < 200. Calcium Treated for Sulphide Shrap Control Normalized temp 1570 ± 50 min per inch CWALL Req 15 ± 2 FFLBF at -50.0 F Std Thickness Tol PVQ Top and Bottom Standard Surface Flatness 1/2 A50 Fine Grain Fully Killed No Weld Repair.

Supplementary Instructions: Test Cert 1: drating@canadianplate.com Test Cert 2: 905-206-1370  
 Insp T/R: Test Report As Per Spec  
 Cust Use: PVQ

ESSAR STEEL ALGOMA INC HEREBY CERTIFIES THAT THE MATERIAL HEREIN DESCRIBED WAS MADE AND TESTED IN ACCORDANCE WITH THE RULES OF THE SPECIFICATION SHOWN. ALL RESULTS ARE RETAINED IN ACCORDANCE WITH THE COMPANY'S STANDARD RECORD KEEPING PRACTICES.  
 THIS MILL TEST REPORT MAY NOT BE REPRODUCED EXCEPT IN FULL WITHOUT WRITTEN APPROVAL OF ESSAR STEEL ALGOMA INC. IF YOU RECEIVE THIS DOCUMENT AND ARE NOT THE INTENDED RECEIVER, PLEASE CALL (416)949-4094 OR INSTRUCTIONS ON METHOD OF DISPOSAL OF DOCUMENT.

MEETS EN 10224 Z38 TYPE J1  
 ISO QUALITY AND ENVIRONMENTAL CERTIFICATES AVAILABLE AT WWW.ESSARSTEELALGOMA.COM

Dimensions (T x W x L)	Heat No.	Heat No.-Ms	Quantity	Pcs
1 5000" x 120 000" x 48 000"	AB5383	1966P3-04	24 500 LB	1

Heat No. (wt%)	CHEMICAL PROPERTIES														
	C	Mn	P	S	Si	Cr	Ni	Cu	Mb	Al	Nb	V	B	TI	DD
1966P3*	0.20	1.10	0.010	0.006	0.330	0.03	0.15	0.03	0.01	0.039	0.000	0.014	0.0003	0.002	0.4100

Heat No.	SRCE	LAB	GAUGE	COND	METH	DIR	LOC	SIZE	TEMP (-F)	ENERGY (ft-lb)	ENERGY AVG (ft-lb)
1966P3	AB5383	166"	ALG	1 5000	NORM	B	HBW	148			
1966P3	AB5383	166"	ALG	1 5000	NORM	CVN	L B	FULL	-50	85 79 87	83

**LIMITS OF UNSPECIFIED ELEMENTS PER ASME SECTION II (SA-20)**  
 CR+MO = 0.64  
 CU + Ni + CR + MO = 0.72

W.O. # 11769  
 M. # 58 (9/13)  
 THK. # 1 1/2"  
 P.O. # 13-0720

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

Certification of Material - Per ASME  
 H1# 1966P3-04  
 Qualifies to all requirements of  
 SA516-GR70 per  
 Sect. II 10 Edition 11 Addenda

K. UGHADPAGA  
 MANAGER METALLURGICAL SERVICES

ALL HEATS FULLY KILLED  
 HEATS INDICATED WITH (1) IN COLUMNS  
 HEATS INDICATED WITH (2) MADE IN CANADA WITH DOMESTIC AND NORTH AMERICAN MATERIALS

FOR AND ON BEHALF OF: S B M OFFSHORE  
 CLARESH SAHA  
 Signature: *Syana*  
 Print Name: CLARESH SAHA  
 Applus®

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

SO No., Item & Date: 8005805 000020 2012/12/17		Shipment No. & Date: 1000021035 2012/12/17		TC No., Date & Time: ESA-34474 2012/12/17 - 10:18:00						
Sold to Customer Name and Address: CANADIAN PLATE AND PROFILES IN KAMATO ROAD 920 MISSISSAUGA, Ontario, Canada		Ship to Customer Name and Address: CANADIAN PLATE AND PROFILES IN KAMATO ROAD 920 MISSISSAUGA, Ontario, Canada		Customer PO NO./Item: 18926-STK / 2 12728abc						
L4W 2R6		L4W 2R6		Cust.Part No.: Carrier: LOCOMOTE SYSTEM INC.						
Customer Specification: HR STEEL PLATE Carbon Milled 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 Stress Control Normalized Normalizing Temp 1670 °F 30 min per inch CVNL Req 15 / 12 FT-LBF at -50.0 F Std Thickness Tol PVQ Top and Bottom Standard Surface Flatness 1/2 A20 Fine Grain Fully Killed No Weld Repair										
Supplementary Instructions: Test Cert 1: drafting@canadianplate.com Test Cert 2: 905-208-1370										
Insp T/R: Test Report As Per Spec										
ESSAR STEEL ALGOMA INC HERBY 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)946-4895 FOR INSTRUCTIONS ON METHOD OF DISPOSAL OF DOCUMENT.										
MEETS EN 10284 2004 TYPE 31 ISO QUALITY AND ENVIRONMENTAL CERTIFICATES AVAILABLE AT WWW.ESSARSTEELALGOMA.COM										
. . . . . MECHANICAL PROPERTIES . . . . .										
Tensile Tests		SRICE LAB GAUGE COND METH DIR LOC YIELD(KSI) TENSILE(KSI) EL SCALE		ELONG(%)						
Heat No. T066P3	Batch No. AB5383	166"	ALG	15000	NORM 2	T B	48	77	2"	33

AUG 20 2013  
 Q.C.I. E.Y.  
 Q.C.I. N.D.

046  
 ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SJM OFF SHORE  
 Print Name: W FAYE SII SAH  
 Signature: [Signature]  
 Date: 08/22/13  
**APPLUS®**  
**VELOSI**  
 Velosi America LLC

K. UGHADPAGA  
 MANAGER METALLURGICAL SERVICES

\*\*WARNING\*\* THE TEST RESULTS AND VALUES REPORTED HEREIN INDICATE ONLY THAT IN THE PARTICULAR STEEL FROM WHICH THIS CERTIFICATE IS ISSUED MEETS THE MINIMUM SPECIFIED YIELD STRENGTH AND IN THE ANALYSES AND PHYSICAL PROPERTIES OF SUCH STEEL ARE IN CONFORMANCE WITH THE REQUIREMENTS OF THE SPECIFICATION INDICATED. THE RESULTS OR VALUES REPORTED HEREIN MAY NOT BE USED TO QUALIFY THE STEEL FOR ANY APPLICATION OTHER THAN THAT FOR WHICH IT WAS SPECIFICALLY DESIGNED. THIS CERTIFICATE IS VALID ONLY FOR THE PARTICULAR STEEL FROM WHICH THIS CERTIFICATE IS ISSUED. THIS CERTIFICATE IS NOT VALID FOR ANY OTHER TYPE OF STEEL.





Blatt: 1 / 5  
 Page: Page:

Prüf.-Nr.: 65-714417/001/P  
 Inspection No.:  
 No. du certificat:  
 Warmrohrwerk Dinslaken  
 (DIN EN ISO 9001, ISO/TS-16949 CERTIFIED BY TÜV NORD CERT)  
 (PED 97/23/EC CERTIFIED BY TÜV NORD SYSTEM S)

Dokument-Nr.:  
 Document No.:  
 No. du document:  
 Kunden-Bestell-Nr.: BST 12-5572 / Comco G1-3426 Hersteller:  
 Purchase Order No.:  
 No. de commande du client:  
 Herstellerzeichen:  
 Manufacturer's brand:  
 Marque du producteur:  
 Benteler Auftrags-Nr.: 1577798  
 Benteler Order No.:  
 No. de commande Benteler:  
 Versandanzeigen-Nr.: 6570440  
 Dispatch Note No.:  
 No. d'avis d'expédition:

ABNAHMEPRÜFZEUGNIS EN 10204-3.1  
 INSPECTION CERTIFICATE EN 10204-3.1  
 CERTIFICAT DE RECEPTION EN 10204-3.1  
 EN 10204:2005-01  
 Benteler Steel/Tube GmbH - Postfach 1340 - 33043 Paderborn - Deutschland  
 COMCO PIPE & SUPPLY CO.  
 R.R. # 3  
 GUELPH, ON N1H 6H9  
 CANADA

Stahlschmelzungsverfahren: ELEKTROSTAHL  
 Steelmaking process: ELECTRIC FURNACE  
 Procédé d'élaboration de l'acier: FOUR ELECTRIQUE

Produkt: NAHTLOSE STAHLROHRE  
 Product: SEAMLESS STEEL TUBES  
 Produit: TUBES D'ACIER SANS SOUDURE

ASME SA-106, ASME Section II Part A Edition 2010 Addenda 2011a, S6, ASTM-A 106-2011, S6, ASTM-A 333-2010-HF, ASME SA-333-HF, ASME Section II Part A Edition 2010 Addenda 2011a, CSA Standard Z245.1-07 Category II, Sour Service, ANSI/NACE MR0175/ISO 15156-1: 2009, ANSI/NACE MR0175/ISO 15156-2: 2009  
 ASME B36.10M-2004, ASME SA-999 ASME Section II Part A Edition 2010, ASTM-A 999-2011

Q.C.I.  
 E.Y.

GRADE 6, GRADE B, GRADE C, GRADE 359

Normalized

FS: BENTELER Z.245.1 - A/SA-333 - A/SA 106 6/359/B/C CATEGORIE 2 HEAT-NO. M45C SS SMLS HN  
 DIMENSIONS SCHEDULE WA GERMANY PO NO G1-3426

Marquage du produit:  
 AZZ = Ätzzeichenbeschriftung, Etching ink marking, Gravure à l'encre  
 PK = Farbklebenzeichnung, Colour marking, marquage par couleur  
 FS = Farbschablonenfräse, Paint stencilling, marquage par poinçuro  
 FSD = Farbstrahlendruck, Colour jet printer, imprimante à jet d'encre de couleur  
 LX = Laserkennzeichnung, Laser marking, marquage laser  
 PKE = Etikettenkennzeichnung, Tag marking, marquage sur étiquette  
 PS = Prägestempel, die stamp, marquage par poinçonnage  
 TS = Trichterstrahlkennzeichnung, Ink jet spray marking, imprimante à jet d'encre

Pos.	Stück	Maße	Länge	Gewicht	Schmelzen-Nr.	Prüfdruck	Rohr-Nr.-Gruppe	Vielfachlängen
Item	Number	Dimensions	Length	Weight	Heat No.	Test pressure	Tube number group	Multiple lengths
Poste	Nombre	Dimensions	Longueur	Poids	No. de coulée	Pression d'épreuve	Série de no. des tubes	Longueurs multiples
			feet	lbs		PSI	S	
0004	66	2" NPS * Sched. 160 20 FT - 22 FT	1444,88	10935	573636	3000	5	

ACCEPTED/RECEIVED/RELEASÉ  
 for and on behalf of:  
 \$GM GHT SHORE  
 L'OMBSH SAHD  
 Signature: [Signature]  
 Date: 02/23/13  
 Veldot America LLC



Steel/Tube

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Inspection No.:  
No. du certificat:

Dokument-Nr.:  
Document No.:  
No. du document:

65-714417/001/P

ABNAHMERÜFZEUGNIS EN 10204-3.1  
INSPECTION CERTIFICATE EN 10204-3.1  
CERTIFICAT DE RECEPTION EN 10204-3.1

Benteler Steel/Tube GmbH  
Postfach 13 40  
33043 Paderborn  
Deutschland  
Tel.: + 49-5254-81-0 Fax: + 49-5254-13666

Schmelzenanalyse [%] / Heat analysis [%] / Analyse sur coulée [%]

Pos. / Schmelzen-Nr.	C	SI	MN	P	S	CR	MO	NI	CU	V	NB	TI	B
0004 573636	0,150	0,220	1,17	0,008	0,002	0,09	0,02	0,07	0,09	0,038	0,013	0,002	0,0001

1. Formel:  $CE_{IIW} = C + (Mn/6) + ((Cr + Mo + V)/5) + ((Cu + Ni)/15) \leq 0,45 \%$
2. Formel:  $CEV = C + F + ((Mn/6) + (Si/24) + (Cu/15) + (Ni/20) + ((Cr + Mo + V + Nb)/5) + (5 * B)) \leq 0,40$
3. Formel:  $Mn/C \geq 3/1$
4. Formel:  $Cr + Cu + Mo + Ni + V \leq 1,00 \%$

W.O. # 11760  
M.L. # 64(19/2)  
P.K. # 342  
D.O. # 13-6/98

C.C.I.  
E.Y.

AUG 11 2013

C.C.I.  
N.D.

Formelergbnisse / Formula results / Résultats des formules

Pos. / Schmelzen-Nr.	1. Formel	2. Formel	3. Formel	4. Formel
0004 573636	0,385	0,367	7,800	0,308

Produktanalyse [%] / Product analysis [%] / Analyse sur produit [%]

Pos. / Schmelzen-Nr.	C	SI	MN	P	S	CR	MO	NI	CU	V	NB	TI	B
0004 573636	0,150	0,210	1,17	0,008	0,003	0,08	0,02	0,08	0,09	0,038	0,014	0,002	0,0001

1. Formel:  $CE_{IIW} = C + (Mn/6) + ((Cr + Mo + V)/5) + ((Cu + Ni)/15) \leq 0,45 \%$
2. Formel:  $CEV = C + F + ((Mn/6) + (Si/24) + (Cu/15) + (Ni/20) + ((Cr + Mo + V + Nb)/5) + (5 * B)) \leq 0,40$
3. Formel:  $Mn/C \geq 3/1$
4. Formel:  $Cr + Cu + Mo + Ni + V \leq 1,00 \%$

Certification of Material Per ASME  
HT# 573636  
Qualification requirements of SA 333-6 per Sect. II, Edition II Addenda

Formelergbnisse / Formula results / Résultats des formules

Pos. / Schmelzen-Nr.	1. Formel	2. Formel	3. Formel	4. Formel
0004 573636	0,383	0,365	7,800	0,298

ACCEPTED/REVIEWED/RELEASED  
for and on behalf of: 515M OFF SHORE  
Print Name: CLANESH SAMA  
Signature: [Signature]  
Date: 08/23/13  
Applus® VELOSI  
Velosi America LLC





Steel/Tube

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Prüfergebnisse / Test results / Résultats des essais

Die Rohre sind auf Dichtheit geprüft durch:

The tubes have been submitted to a leak tightness test by:

Les tubes ont passé un contrôle d'étanchéité par:

Die Rohre wurden zerstörungsfrei geprüft:

The tubes are non destructive tested:

Les tubes ont passé un essai non destructif:

Augensichtkontrolle: PASSED

Visual inspection:

Examen visuel: PASSED

Ringfaltversuch: PASSED

Flattening test:

Essai d'aplatissement: PASSED

Q.C.I.  
 N.D.

Ergebnisse der mechanischen Prüfung / Results of mechanical testing / Résultats des essais mécaniques

Die Probenahme erfolgte an Vielfachlängen.

The sampling was carried out on multiple lengths.

L'échantillonnage était réalisé aux longueurs multiples.

Zugversuch längs Streifenprobe / Tensile test longitudinal Strip test specimen / Essai de traction longit udinale Bande decoupee sur tube

Pos.	Proben-Nr.	Schmelzen-Nr.	Probendimensionen	Streckgrenze	Zugfestigkeit	Dehnung	Einschnürung
Item	Specimen No.	Heat No.	Dimensions de l'éprouv.	Yield strength	Tensile strength	Elongation	Area reduction
Poste	No. de l'éprouvette	No. de coulée	Dimensions de l'éprouv.	Limite élastique	Résistance à la traction	Allongement	Coefficient de striction
			mm	ReH	Rm	A2 <sup>h</sup>	
				PSI	PSI	%	
				52069-76870	65992-90649	MIN 30	
				53654	73399	40	
				8,40	74114	38	
				8,40	73534	38	
				8,70	72519	40	

1. Formel  
 1. Formula  
 1. Formule

Q.C.I.  
 E.Y.

AUG 20 2013

046  
 ACCEPTED FOR REVIEW/RELEASSED  
 for and on behalf of: SAM OFFSHORE  
 Print Name: YANESH SAHA  
 Signature: YANESH SAHA  
 Date: Aug 23/13  
 APPIUS<sup>®</sup>  
 VELOSI  
 Velosi America LLC

AUG 20 2013



Benteler Steel/Tube GmbH  
 Postfach 13 40  
 33043 Paderborn  
 Deutschland  
 Tel.: + 49.5254.81-0 Fax: + 49.5254.13666

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Härteprüfung / Hardness test / Essai de dureté

Pos. Item Poste	Proben-Nr. Specimen No.	Schmelzen-Nr. Heat No.	Härte Hardness Dureté	HB	HV	HRB	HBW
				MAX 200			
0004	000001	573636		144			
0004	000002	573636		146			
0004	000003	573636		143			
0004	000004	573636		145			

Kerbschlagbiegeversuch Notched bar impact test / Essai de flexion par choc (resilience) [1 CHARPY\_V]

Pos. Item Poste	Proben-Nr. Specimen No.	Schmelzen-Nr. Heat No.	Probenabmessung Specimen dimensions Dimensions de l'éprouvette	Prüftemperatur Test temperature Température d'essai	Kerbschlagarbeit Absorbed energy Energie absorbée		Laterale Breitung Lateral expansion Expansion latérale	Verf.-Bruchanteil Shear fracture Rupture ductile
					einzel single	mittel average		
				MIN 020	J	J	mm	%
0004	000001	573636	Länge mm 55	GRAD °C -45	183	191	1,42	80
			Breite mm 7,50	-45	183	186		80
			Höhe mm 10,00					80
			quer (Q) transversal (Q)					
			longitudinal (L)					
			longitudinal (L)					
			min. 0.38					
			1,42					
			186					
			80					
			80					
			80					
			80					

Wärmebehandlung / Heat treatment / Traitement thermique  
 Rolling temperature: 870°C - 1.000°C / Cooling: Air

Restmagnetismus / Demagnetize / Démagnétiser

demagnetized tubes; 1 measurement per 4 hours on both tube ends Two readings 180° apart around the circumference. Average value  
 max 3.0 Millitesia (24 A/cm), individual value max 3.5 Millitesia (28 A/cm)

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SAM OPR SHONE  
 Print Name: GABRIEL SAHA  
 Signature: [Signature]  
 Date: 04/24/13  
 Affplus VELOS  
 Veloc America LLC





Steel/Tube

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 Inspection No.:  
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Vermerk / Remark / Remarque

NA CE Standard: Hardness acc. to ANSI/NA CE MR0175/ISO 15156: HRC max 22., The material meets the requirements of NACE MR0103, Region 3, in accordance to Figure 1 and Appendix A.2, ANSI/NA CE MR0175/ISO 15156-2:2009; Certificate remarks: Sour Service, The Material is Aluminium deoxidized and Inclusion shape controlled with Calcium-Silicon treatment, it is the end user's responsibility to ensure that all environmental requirements as well as the requirements regarding engineering, construction and operation of facilities are fulfilled in the country of use. Fit for purpose of the parts as well as homologation is not the scope of this contract., This is to confirm that the seamless linepipe supplied by Benteler and verified to CSA Standard Z245.1-07 meets the requirement for micro hardness of max. 248 HV 500 gf., No weld repair has been carried out; Bend test: mandrel diameter 12D; Bending angle: 90° ✓  
 Grain size: acc. to ASTM-E 112, Grain size 6 and finer

Verkäufer(in) / Salesman/ woman in charge / Personne chargée : Mrs Schöneweis, Tel.: 052.54/81-4234, Fax: 4289

046

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SAM OFFSHORE  
 Print Name: GAMSI SAHIT **APIUS®**  
 Signature: [Signature] **VELOSI**  
 Date: Aug 23/13 **Velosi America LLC**



Abnahmebeauftragter  
 Inspection representative

Contrôleur

DR. BASEL KEITA / Thei

Es wird bestätigt, daß die gelieferten Erzeugnisse den techn. Lieferbedingungen des Auftrages entsprechen. Dieses Dokument wurde mittels EDV erstellt und ist ohne Unterschrift rechtsgültig.  
 We certify that the supplied products comply with the order specification. This document was prepared by means of electronic data processing and is valid without signature.  
 Nous attestons que les produits livrés sont conformes aux stipulations de la commande. Ce document a été établi par traitement électronique et est valide sans signature.

Dinslaken, 17.09.2012, TEL.: 02064.623-537 FAX: 02064.623-539

Sold To: SALIT STEEL SERVICE CENTRE  
 DIVISION OF MYER SALIT LTD  
 PO BOX 837  
 NIAGARA FALLS ON L2E 6V6  
 CANADA  
 (905) 354-5691

Ship To: SALIT STEEL PP - NF  
 7771 STANLEY AVE  
 NIAGARA FALLS ON L2E 6V6  
 CANADA  
 (905) 354-5691  
 Fax: (905) 356-0809

Customer P.O.	46911	Sales Order	296351.5
Product Group	Merchant Bar Quality	Part Number	2020025024004W0
Grade	A36/A529gr50/CSA44W/50W	Lot #	AU1310159402
Size	2x2x1/4 Angle	Heat #	AU13101594
Product	2x2x1/4 Angle 20' A36/A52950/CSA44W/50W	B.L. Number	Y1-423553
Description	A36/A529gr50/CSA44W/50W	Load Number	Y1-170457
Customer Spec		Customer Part #	

I hereby certify that the material described herein has been manufactured in accordance with the specifications and standards listed above and that it satisfies those requirements.

Roll Date: 4/5/2013 Melt Date: 3/18/2013 Qty Shipped LBS: 15,504 Qty Shipped Pcs: 243

ASTM A36/A36M-08, A709/709M-11 GR36, ASME SA36-10 Ed '11 Ad.  
 ASME SA36-2007 EDITION-2011 ADDENDA  
 ASTM A709/A709M-11 GR 36 [250]

C	Mn	P	S	Si	Cu	Ni	Cr	Mo
0.14%	0.91%	0.016%	0.032%	0.13%	0.32%	0.10%	0.13%	0.022%

Yield 1: 54,500psi (376MPa) Tensile 1: 75,800psi (523MPa) Elongation: 30.1% in 8"(% in 203.3mm)  
 Yield 2: 53,900psi (372MPa) Tensile 2: 75,800psi (523MPa) Elongation 30.9% in 8"(% in 203.3mm)

Specification Comments: MEETS OR EXCEEDS THE REQUIREMENTS OF ASTM A36/A36M-08, A529/A529M-05 GR50(345),  
 A709/A709M-10 GR36(250), A709 GR50(345) CSA G40.21-04 GR44W(300W)&GR50W(350W) AASHTO M270/270M-10 GR36(270)  
 ASME SA36/SA36M-10

ALL MANUFACTURING PROCESSES OF THE STEEL MATERIALS IN THIS PRODUCT, INCLUDING MELTING, HAVE OCCURRED WITHIN THE UNITED STATES. ALL PRODUCTS PRODUCED ARE WELD FREE. MERCURY, IN ANY FORM, HAS NOT BEEN USED IN THE PRODUCTION OR TESTING OF THIS MATERIAL.

W.O. # 1176Q  
 M.L. # 67(3/1, 4/1, 7/1, 11/1)  
 THK. # .750  
 P.O. # 13-0768

Certification of Material - Per ASME  
 HT# AU13101594  
 Qualifies to all requirements of  
 SA 36 per  
 Sect. II 10 Edition 11 Addenda

Q.C.I.  
 N.D.

AUG 20 2013

ACCEPTED/REVIEWED/RELEASED  
 for and on behalf of: SBM OFFSHORE 046  
 Print Name: C. JAMES H SA #11  
 Signature: [Signature]  
 Date: Aug 23/13  
 Applus® VELOSI  
 Velosi America LLC

[Signature]

Jim Biernat  
 Division Metallurgist

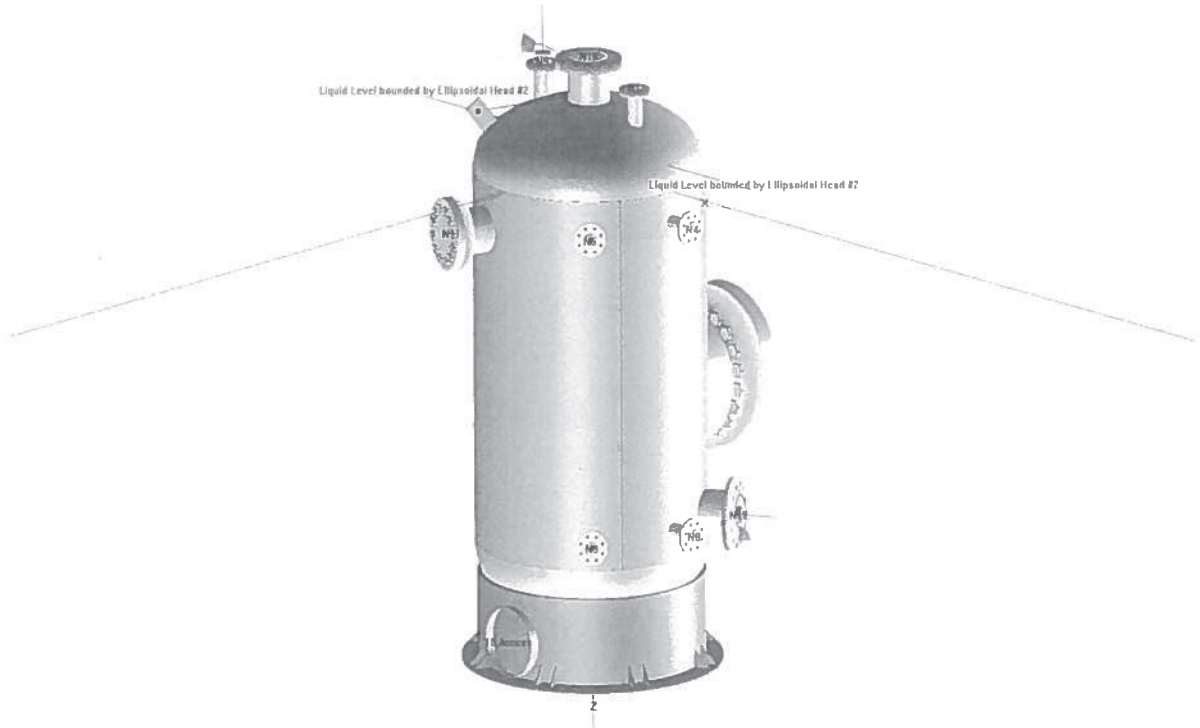
# ALL-WELD COMPANY LIMITED

49 Passmore Avenue,

Toronto, Ontario,

Canada M1V 4T1

[www.allweld.ca](http://www.allweld.ca)



## COMPRESS Pressure Vessel Design Calculations

**Item:** 60" ID Vertical Carbon Steel H<sub>2</sub>S Contactor  
**Vessel No:** 772-VECO-102 and 202  
**Customer:** Ultrafab Industries Limited  
**Designer:** Todd Clark, P. Eng.  
**Date:** Tuesday, July 16, 2013



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31. 60 ID BOTTOM SE HEAD
32. Bottom Drain (N1)
33. 63-1/4" OD Skirt
34. Tail lug
35. Skirt Base Ring
36. Liquid Level bounded by Ellipsoidal Head #2





### Nozzle Schedule

Nozzle mark	Service	Size	Materials		Impact Tested	Normalized	Fine Grain	Flange	Blind
<u>N1</u>	Bottom Drain	NPS 2 Sch 160	Nozzle	SA-333 1 Wld & smls pipe	No	No	No	NPS 2 Class 900 WN A350 LF2	No
<u>N10</u>	Outlet	11.75 OD x 1.875	Nozzle	SA-350 LF2 Cl 1	No	No	No	NPS 8 Class 900 LWN A350 LF2 Cl.1	No
<u>N11</u>	Inspection Nozzle	11.75 OD x 1.875	Nozzle	SA-350 LF2 Cl 1	No	No	No	NPS 8 Class 900 LWN A350 LF2 Cl.1	NPS 8 Class 900 A350 LF2 Cl.1
<u>N12</u>	Inlet Nozzle	11.75 OD x 1.875	Nozzle	SA-350 LF2 Cl 1	No	No	No	NPS 8 Class 900 LWN A350 LF2 Cl.1	No
<u>N13</u>	Manway	35 OD x 5.5	Nozzle	SA-350 LF2 Cl 1	No	No	No	NPS 24 Class 900 V2 A350 LF2 Cl.1	NPS 24 Class 900 A350 LF2 Cl.1
<u>N2</u>	Purge	4.12 OD x 1.06	Nozzle	SA-350 LF2 Cl 1	No	No	No	NPS 2 Class 900 LWN A350 LF2 Cl.1	No
<u>N3</u>	Level Bridal Low	4.12 OD x 1.06	Nozzle	SA-350 LF2 Cl 1	No	No	No	NPS 2 Class 900 LWN A350 LF2 Cl.1	No
<u>N4</u>	Diff Press High	4.12 OD x 1.06	Nozzle	SA-350 LF2 Cl 1	No	No	No	NPS 2 Class 900 LWN A350 LF2 Cl.1	No
<u>N5</u>	Level Bridal High	4.12 OD x 1.06	Nozzle	SA-350 LF2 Cl 1	No	No	No	NPS 2 Class 900 LWN A350 LF2 Cl.1	No
<u>N6</u>	Fil/ Water Flush	4.12 OD x 1.06	Nozzle	SA-350 LF2 Cl 1	No	No	No	NPS 2 Class 900 LWN A350 LF2 Cl.1	No
<u>N7</u>	Vent	4.12 OD x 1.06	Nozzle	SA-350 LF2 Cl 1	No	No	No	NPS 2 Class 900 LWN A350 LF2 Cl.1	No
<u>N8</u>	Diff press Low	4.12 OD x 1.06	Nozzle	SA-350 LF2 Cl 1	No	No	No	NPS 2 Class 900 LWN A350 LF2 Cl.1	No
<u>N9</u>	Corrosion Coupon	5 OD x 1	Nozzle	SA-350 LF2 Cl 1	No	No	No	NPS 3 Class 900 LWN A350 LF2 Cl.1	No

### Nozzle Summary

Nozzle mark	OD (In)	$t_n$ (In)	Req $t_n$ (In)	A <sub>1</sub> ?	A <sub>2</sub> ?	Shell			Reinforcement Pad		Corr (In)	A <sub>a</sub> /A <sub>r</sub> (%)
						Nom t (In)	Design t (In)	User t (In)	Width (In)	$t_{pad}$ (In)		
<u>N1</u>	2.375	0.344	0.2969	Yes	Yes	2.491*	N/A		N/A	N/A	0.125	Exempt
<u>N10</u>	11.75	1.875	0.5057	Yes	Yes	2.491*	1.9983		N/A	N/A	0.125	109.5
<u>N11</u>	11.75	1.875	0.5501	Yes	Yes	2.5	2.2916		N/A	N/A	0.125	101.6
<u>N12</u>	11.75	1.875	0.5501	Yes	Yes	2.5	2.2965		N/A	N/A	0.125	101.1
<u>N13</u>	35	5.5	1.3828	Yes	Yes	2.5	2.2952		N/A	N/A	0.125	110.3
<u>N2</u>	4.12	1.06	0.3324	Yes	Yes	2.5	N/A		N/A	N/A	0.125	Exempt
<u>N3</u>	4.12	1.06	0.3324	Yes	Yes	2.5	N/A		N/A	N/A	0.125	Exempt
<u>N4</u>	4.12	1.06	0.3324	Yes	Yes	2.5	N/A		N/A	N/A	0.125	Exempt
<u>N5</u>	4.12	1.06	0.3324	Yes	Yes	2.5	N/A		N/A	N/A	0.125	Exempt
<u>N6</u>	4.12	1.06	0.3324	Yes	Yes	2.5	N/A		N/A	N/A	0.125	Exempt
<u>N7</u>	4.12	1.06	0.3324	Yes	Yes	2.491*	2.491		N/A	N/A	0.125	136.5
<u>N8</u>	4.12	1.06	0.3324	Yes	Yes	2.5	N/A		N/A	N/A	0.125	Exempt
<u>N9</u>	5	1	0.3508	Yes	Yes	2.491*	2.3917		N/A	N/A	0.125	100.0

- $t_n$ : 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<sub>a</sub>: Area available per UG-37, governing condition
- A<sub>r</sub>: Area required per UG-37, governing condition
- Corr: Corrosion allowance on nozzle wall
- \* Head minimum thickness after forming

## Pressure Summary

### Pressure Summary for Chamber bounded by 60 ID BOTTOM SE HEAD and 60 ID TOP SE HEAD

Identifier	P Design (psi)	T Design (°F)	MAWP (psi)	MAEP (psi)	T <sub>e</sub> external (°F)	MDMT (°F)	MDMT Exemption	Impact Tested
<u>60 ID TOP SE HEAD</u>	1,378	140	1,566.92	750.1	140	-32.9	Note 1	Yes
<u>Straight Flange on 60 ID TOP SE HEAD</u>	1,378	140	1,572.94	876.28	140	-32.9	Note 2	Yes
<u>60 ID SHELL</u>	1,378	140	1,501.48	838.94	140	-28.6	Note 3	Yes
<u>Straight Flange on 60 ID BOTTOM SE HEAD</u>	1,378	140	1,569.04	876.28	140	-32.7	Note 5	Yes
<u>60 ID BOTTOM SE HEAD</u>	1,378	140	1,562.35	750.1	140	-32.7	Note 4	Yes
<u>Bottom Drain (N1)</u>	1,378	140	1,378	750.1	140	-55	Note 6	No
<u>Outlet (N10)</u>	1,378	140	1,378	750.1	140	-55	Note 7	No
<u>Inspection Nozzle (N11)</u>	1,378	140	1,378	838.94	140	-55	Note 7	No
<u>Inlet Nozzle (N12)</u>	1,378	140	1,378	838.94	140	-55	Note 7	No
<u>Manway (N13)</u>	1,378	140	1,378	838.94	140	-55	Note 8	No
<u>Purge (N2)</u>	1,378	140	1,378	838.94	140	-55	Note 7	No
<u>Level Bridal Low (N3)</u>	1,378	140	1,378	838.94	140	-55	Note 7	No
<u>Diff Press High (N4)</u>	1,378	140	1,378	838.94	140	-55	Note 7	No
<u>Level Bridal High (N5)</u>	1,378	140	1,378	838.94	140	-55	Note 7	No
<u>Fill/ Water Flush (N6)</u>	1,378	140	1,378	838.94	140	-55	Note 7	No
<u>Vent (N7)</u>	1,378	140	1,378	750.1	140	-55	Note 7	No
<u>Diff press Low (N8)</u>	1,378	140	1,378	838.94	140	-55	Note 7	No
<u>Corrosion Coupon (N9)</u>	1,378	140	1,378	718.17	140	-55	Note 7	No

Chamber design MDMT is -20 °F

Chamber rated MDMT is -28.6 °F @ 1,378 psi

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 718.17 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.	Straight Flange governs MDMT	
2.	Material is impact tested per UG-84 to -20 °F	UCS-66(i) reduction of 12.9 °F applied (ratio = 0.8707).
3.	Material is impact tested per UG-84 to -20 °F	UCS-66(i) reduction of 8.6 °F applied (ratio = 0.9144).
4.	Straight Flange governs MDMT	
5.	Material is impact tested per UG-84 to -20 °F	UCS-66(i) reduction of 12.7 °F applied (ratio = 0.8733).
6.	Nozzle is impact tested to -50 °F with an additional 5 °F reduction per UCS-66(g)	UCS-66 governing thickness = 0.301 in.
7.	Flange rating governs:	UCS-66(b)(1)(b)
8.	Nozzle is impact tested to -50 °F with an additional 5 °F reduction per UCS-66(g)	UCS-66 governing thickness = 2.5 in.

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:	HT

### 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>60 ID TOP SE HEAD</u>	SA-516 70	60 ID	17.491	2.491*	2.2038	0.125	1.00	Internal
<u>Straight Flange on 60 ID TOP SE HEAD</u>	SA-516 70	60 ID	2	2.612	2.2906	0.125	1.00	Internal
<u>60 ID SHELL</u>	SA-516 70	60 ID	96	2.5	2.2968	0.125	1.00	Internal
<u>Straight Flange on 60 ID BOTTOM SE HEAD</u>	SA-516 70	60 ID	2	2.612	2.297	0.125	1.00	Internal
<u>60 ID BOTTOM SE HEAD</u>	SA-516 70	60 ID	17.491	2.491*	2.2108	0.125	1.00	Internal
<u>63-1/4" OD Skirt</u>	SA-516 70	63.25 OD	23.25	0.75	0.0557	0	0.55	Seismic

Nominal t: Vessel wall nominal thickness

Design t: Required vessel thickness due to governing loading + corrosion

Joint E: Longitudinal seam joint efficiency

\* Head minimum thickness after forming

Load

internal: Circumferential stress due to internal pressure governs

external: External pressure governs

Wind: Combined longitudinal stress of pressure + weight + wind governs

Seismic: Combined longitudinal stress of pressure + weight + seismic governs

## Weight Summary

Component	Weight ( lb) Contributed by Vessel Elements										Surface Area ft <sup>2</sup>
	Metal New*	Metal Corroded*	Insulation	Insulation Supports	Lining	Piping + Liquid	Operating Liquid		Test Liquid		
							New	Corroded	New	Corroded	
60 ID TOP SE HEAD	3,428	3,272.2	0	0	0	0	714.6	720.8	1,239.6	1,259.7	37
60 ID SHELL	12,445.3	11,848.4	0	0	0	0	10,913.1	11,008.3	9,921	10,007.5	127
60 ID BOTTOM SE HEAD	3,524.5	3,363.9	0	0	0	0	1,347.6	1,368.4	1,225.1	1,244	38
63-1.4" OD Skirt	927.3	927.3	0	0	0	0	0	0	0	0	64
Skirt Base Ring	451	451	0	0	0	0	0	0	0	0	27
<b>TOTAL:</b>	<b>20,776.2</b>	<b>19,862.7</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>12,975.3</b>	<b>13,097.5</b>	<b>12,385.7</b>	<b>12,511.2</b>	<b>294</b>

\* Shells with attached nozzles have weight reduced by material cut out for opening.

Component	Weight ( lb) Contributed by Attachments										Surface Area ft <sup>2</sup>
	Body Flanges		Nozzles & Flanges		Packed Beds	Ladders & Platforms	Trays	Tray Supports	Rings & Clips	Vertical Loads	
	New	Corroded	New	Corroded							
60 ID TOP SE HEAD	0	0	452.8	435.8	0	0	0	0	32.3	0	7
60 ID SHELL	0	0	7,439.9	7,333.4	0	0	0	0	0	0	52
60 ID BOTTOM SE HEAD	0	0	29	27.7	0	0	0	0	0	0	1
63-1.4" OD Skirt	0	0	85.3	85.3	0	0	0	0	15.8	0	1
<b>TOTAL:</b>	<b>0</b>	<b>0</b>	<b>8,007.1</b>	<b>7,882.2</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>48.1</b>	<b>0</b>	<b>61</b>

Vessel operating weight, Corroded: 40,891 lb  
Vessel operating weight, New: 41,807 lb  
Vessel empty weight, Corroded: 27,793 lb  
Vessel empty weight, New: 28,831 lb  
Vessel test weight, New: 41,217 lb  
Vessel test weight, Corroded: 40,304 lb  
Vessel surface area: 355 ft<sup>2</sup>

### Vessel center of gravity location - from datum - lift condition

Vessel Lift Weight, New: 28,831 lb  
Center of Gravity: 52.5931"

### Vessel Capacity

Vessel Capacity\*\* (New): 1,469 US gal  
Vessel Capacity\*\* (Corroded): 1,483 US gal

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



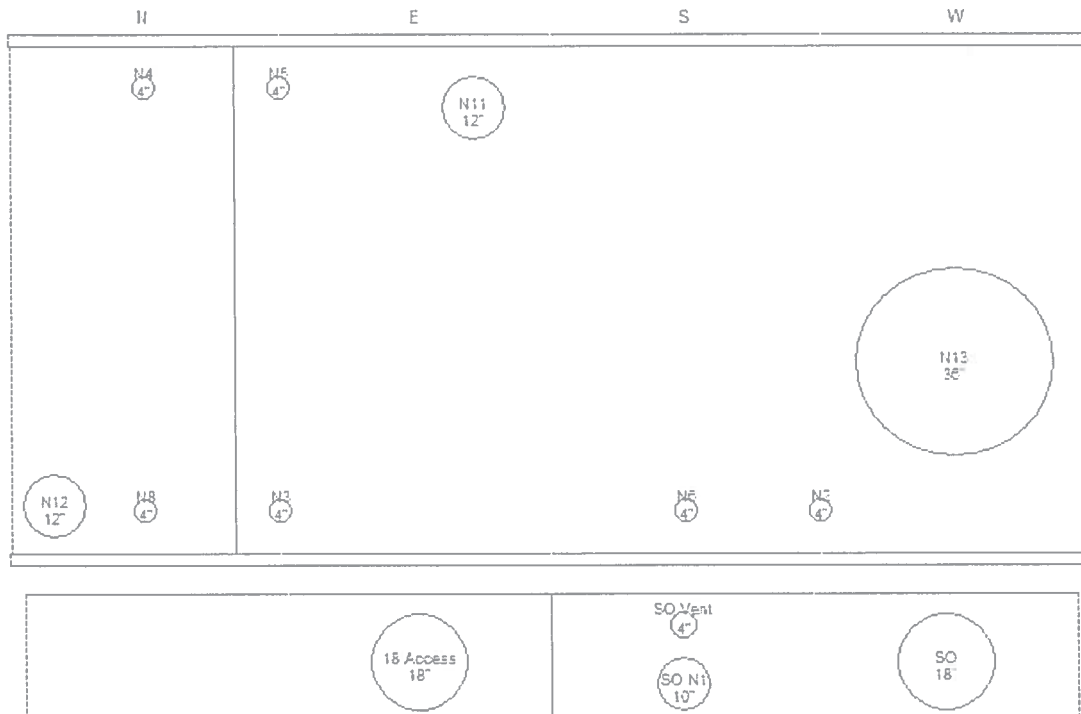
## Long Seam Summary

Shell Long Seam Angles	
Component	Seam 1
60 ID SHELL	30°
63 1/4" OD Skirt	135°

Shell Plate Lengths		
Component	Starting Angle	Plate 1
60 ID SHELL	30°	196.3495"
63 1/4" OD Skirt	135°	196.3495"

\*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 60 ID BOTTOM SE HEAD and 60 ID 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
60 ID TOP SE HEAD (1)	1,793.945	2.545	1	1.30
Straight Flange on 60 ID TOP SE HEAD	1,793.945	2.545	1	1.30
60 ID SHELL	1,793.945	2.545	1	1.30
Straight Flange on 60 ID BOTTOM SE HEAD	1,793.945	2.545	1	1.30
60 ID BOTTOM SE HEAD	1,793.945	2.545	1	1.30
Bottom Drain (N1)	1,792.892	1.492	1	1.30
Corrosion Coupon (N9)	1,793.566	2.166	1	1.30
Diff Press High (N4)	1,791.689	0.289	1	1.30
Diff press Low (N8)	1,791.689	0.289	1	1.30
Fill/ Water Flush (N6)	1,794.324	2.924	1	1.30
Inlet Nozzle (N12)	1,791.918	0.518	1	1.30
Inspection Nozzle (N11)	1,793.522	2.122	1	1.30
Level Bridal High (N5)	1,792.058	0.658	1	1.30
Level Bridal Low (N3)	1,792.058	0.658	1	1.30
Manway (N13)	1,793.295	1.895	1	1.30
Outlet (N10)	1,793.006	1.606	1	1.30
Purge (N2)	1,793.921	2.521	1	1.30
Vent (N7)	1,792.248	0.848	1	1.30

**Notes:**

- (1) 60 ID 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 60 ID BOTTOM SE HEAD and 60 ID TOP SE HEAD.

The test temperature of 50 °F is warmer than the minimum recommended temperature of 1.4 °F so the brittle fracture provision of UG-99(h) has been met.

### Vacuum Summary

Component	Line of Support	Elevation above Datum (in)	Length Le (in)
<u>60 ID TOP SE HEAD</u>	-	-19.491	N/A
-	<u>1/3 depth of 60 ID TOP SE HEAD</u>	-7.0417	N/A
<u>Straight Flange on 60 ID TOP SE HEAD Top</u>	-	-2	110.0833
<u>Straight Flange on 60 ID TOP SE HEAD Bottom</u>	-	0	110.0833
<u>60 ID SHELL Top</u>	-	0	110.0833
<u>60 ID SHELL Bottom</u>	-	96	110.0833
<u>Straight Flange on 60 ID BOTTOM SE HEAD Top</u>	-	96	110.0833
<u>Straight Flange on 60 ID BOTTOM SE HEAD Bottom</u>	-	98	110.0833
-	<u>1/3 depth of 60 ID BOTTOM SE HEAD</u>	103.0417	N/A
<u>60 ID BOTTOM SE HEAD</u>	-	115.491	N/A

<b>Note</b>
For main components, the listed value of 'Le' is the largest unsupported length for the component.



## Engineering Notes

1. External loads have not been considered in the flange pressure rating.
2. The minimum thickness of the top and bottom heads are from the readings taken by KV Inspection Services. Reports dated February 26, 2013.
3. The style of lifting lug analysed here is only analysed for vertical lifting only. The software will not complete a "rigging analyses" on this style of lifting lug.
4. The Compress software does not analyse the seismic and wind loads simultaneously so this information is not contained within this report. The magnitude of the wind loading in comparison to the motion "seismic" loads is miniscule when compared to the motion loads. The total wind load on this vessel equates to a force of 660 pounds acting on one side of the vessel.

## Seismic Code

<b>Method of seismic analysis:</b>	<b>User-defined</b>
Base Shear Multiplier	0.5000
Portion at Top	0.0700
Vertical Accelerations Considered:	Yes
Force Multiplier:	= 1.4738
Minimum Weight Multiplier:	= 1.0000

### Vessel Characteristics

Vessel height: 12.1832 ft

Vessel Weight:

Operating, Corroded: 40,891 lb

Empty, Corroded: 27,793 lb

Vacuum, Corroded: 40,891 lb

### Period of Vibration Calculation

Fundamental Period, T:

Operating, Corroded: 0.018 sec (f = 56.5 Hz)

Empty, Corroded: 0.015 sec (f = 68.3 Hz)

Vacuum, Corroded: 0.018 sec (f = 57.0 Hz)

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

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

$W_i$  is the weight of the  $i^{\text{th}}$  lumped mass, and

$y_i$  is its deflection when the system is treated as a cantilever beam.

### Seismic Shear Reports:

Operating, Corroded

Empty, Corroded

Vacuum, Corroded

Base Shear Calculations

**Seismic Shear Report: Operating, Corroded**

Component	Elevation of bottom above base (in)	Elastic modulus E (10 <sup>6</sup> psi)	Inertia I (ft <sup>4</sup> )	Seismic shear at Bottom (lbf)	Bending Moment at Bottom (lbf-ft)
60 ID TOP SE HEAD	126.7075	29.1	*	5,197	5,392
60 ID SHELL	30.7075	29.1	11.0628	19,545	135,547
60 ID BOTTOM SE HEAD (top)	23.25	29.1	*	19,897	147,809
63-1/4" OD Skirt	0	29.1	3.468	20,445	187,180

\*Moment of Inertia I varies over the length of the component

**Seismic Shear Report: Empty, Corroded**

Component	Elevation of bottom above base (in)	Elastic modulus E (10 <sup>6</sup> psi)	Inertia I (ft <sup>4</sup> )	Seismic shear at Bottom (lbf)	Bending Moment at Bottom (lbf-ft)
60 ID TOP SE HEAD	126.7075	29.4	*	4,178	4,509
60 ID SHELL	30.7075	29.4	11.0628	13,220	101,019
60 ID BOTTOM SE HEAD (top)	23.25	29.4	*	13,437	109,306
63-1/4" OD Skirt	0	29.4	3.468	13,897	136,015

\*Moment of Inertia I varies over the length of the component

**Seismic Shear Report: Vacuum, Corroded**

Component	Elevation of bottom above base (in)	Elastic modulus E (10 <sup>6</sup> psi)	Inertia I (ft <sup>4</sup> )	Seismic shear at Bottom (lbf)	Bending Moment at Bottom (lbf-ft)
60 ID TOP SE HEAD	126.7075	29.1	*	5,197	5,392
60 ID SHELL	30.7075	29.1	11.0628	19,545	135,547
60 ID BOTTOM SE HEAD (top)	23.25	29.1	*	19,897	147,809
63-1/4" OD Skirt	0	29.8	3.468	20,445	187,180

\*Moment of Inertia I varies over the length of the component

**Vertical Acceleration Term,  $V_{Accel}$**

Factor is applied to dead load.

Compressive Side: = 1.0 +  $V_{Accel}$

<b><math>V_{Accel}</math> Term is:</b>				
<b>greater of (Force Mult * Base Shear / Weight) or (Min. Weight Mult.)</b>				
Force multiplier = 1.4738		Minimum Weight Multiplier = 1.0000		
Condition	Base Shear ( lbf)	Weight ( lb)	<u>Force Mult * Shear</u> Weight	$V_{Accel}$
Operating, Corroded	20,445	40,890.5	0.7369	1
Operating, New	20,903	41,806.6	0.7369	1
Empty, Corroded	13,897	27,793	0.7369	1
Empty, New	14,416	28,831.4	0.7369	1
Vacuum, Corroded	20,445	40,890.5	0.7369	1

## Base Shear Calculations

Operating, Corroded

Empty, Corroded

Vacuum, Corroded

### Base Shear Calculations: Operating, Corroded

$$\begin{aligned} V &= \text{Base Shear Multiplier} * W \\ &= 0.5000 * 40,890.5156 \\ &= 20,445.26 \text{ lb} \end{aligned}$$

### Base Shear Calculations: Empty, Corroded

$$\begin{aligned} V &= \text{Base Shear Multiplier} * W \\ &= 0.5000 * 27,793.0352 \\ &= 13,896.52 \text{ lb} \end{aligned}$$

### Base Shear Calculations: Vacuum, Corroded

$$\begin{aligned} V &= \text{Base Shear Multiplier} * W \\ &= 0.5000 * 40,890.5156 \\ &= 20,445.26 \text{ lb} \end{aligned}$$



## 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: 12.1832 ft  
 Vessel Minimum Diameter  
     Operating, Corroded: 5.4167 ft  
     Empty, Corroded: 5.4167 ft  
 Fundamental Frequency,  $n_1$   
     Operating, Corroded: 56.4765 Hz  
     Empty, Corroded: 68.3053 Hz  
 Damping coefficient,  $\beta$   
     Operating, Corroded: 0.0250  
     Empty, Corroded: 0.0200

### Wind Deflection Reports:

[Operating, Corroded](#)  
[Empty, Corroded](#)  
[Vacuum, Corroded](#)  
[Wind Pressure Table](#)

### Wind Deflection Report: Operating, Corroded

Component	Elevation of bottom above base (in)	Effective OD (ft)	Elastic modulus E (10 <sup>6</sup> psi)	Inertia I (ft <sup>4</sup> )	Platform wind shear at Bottom (lbf)	Total wind shear at Bottom (lbf)	bending moment at Bottom (lbf-ft)	Deflection at top (in)
60 ID TOP SE HEAD	126.7075	5.43	29.1	*	0	88	79	0.0007
60 ID SHELL	30.7075	5.42	29.1	11.06	0	625	25,969	0.0006
60 ID BOTTOM SE HEAD (top)	23.25	5.43	29.1	*	0	667	26,371	0.0001
63-1/4" OD Skirt	0	5.27	29.1	3.468	0	793	27,785	0
*Moment of Inertia I varies over the length of the component								

**Wind Deflection Report: Empty, Corroded**

Component	Elevation of bottom above base (In)	Effective OD (ft)	Elastic modulus E (10 <sup>6</sup> psi)	Inertia I (ft <sup>4</sup> )	Platform wind shear at Bottom (lbf)	Total wind shear at Bottom (lbf)	bending moment at Bottom (lbf-ft)	Deflection at top (In)
60 ID TOP SE HEAD	126.7075	5.43	29.4	*	0	88	79	0.0007
60 ID SHELL	30.7075	5.42	29.4	11.06	0	625	25,969	0.0006
60 ID BOTTOM SE HEAD (top)	23.25	5.43	29.4	*	0	667	26,371	0.0001
63-1/4" OD Skirt	0	5.27	29.4	3.468	0	793	27,785	0
*Moment of Inertia I varies over the length of the component								

**Wind Deflection Report: Vacuum, Corroded**

Component	Elevation of bottom above base (In)	Effective OD (ft)	Elastic modulus E (10 <sup>6</sup> psi)	Inertia I (ft <sup>4</sup> )	Platform wind shear at Bottom (lbf)	Total wind shear at Bottom (lbf)	bending moment at Bottom (lbf-ft)	Deflection at top (In)
60 ID TOP SE HEAD	126.7075	5.43	29.1	*	0	88	79	0.0007
60 ID SHELL	30.7075	5.42	29.1	11.06	0	625	25,969	0.0006
60 ID BOTTOM SE HEAD (top)	23.25	5.43	29.1	*	0	667	26,371	0.0001
63-1/4" OD Skirt	0	5.27	29.8	3.468	0	793	27,785	0
*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.

## 60 ID TOP SE HEAD

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

Component: Ellipsoidal Head  
Material Specification: SA-516 70 (II-D p.18, In. 19)  
Straight Flange governs MDMT

Internal design pressure:  $P = 1,378 \text{ psi @ } 140 \text{ }^\circ\text{F}$   
External design pressure:  $P_e = 15 \text{ psi @ } 140 \text{ }^\circ\text{F}$

#### Static liquid head:

$P_s = 0.18 \text{ psi (SG=1.1, } H_s=4.5\text{'' Operating head)}$   
 $P_{th} = 2.54 \text{ psi (SG=1, } H_s=70.5\text{'' Horizontal test head)}$

Corrosion allowance: Inner C = 0.125" Outer C = 0"

Design MDMT =  $-20^\circ\text{F}$  Impact test performed  
Rated MDMT =  $-32.9^\circ\text{F}$  Material is normalized  
Material is not produced to fine grain practice  
PWHT is 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 = 3,428 lb corr = 3,272.2 lb  
Capacity\*: new = 146.9 US gal corr = 149.1 US gal  
\* includes straight flange

Inner diameter = 60"  
Minimum head thickness = 2.491"  
Head ratio D/2h = 2 (new)  
Head ratio D/2h = 1.9917 (corroded)  
Straight flange length  $L_{sf}$  = 2"  
Nominal straight flange thickness  $t_{sf}$  = 2.612"

#### Results Summary

The governing condition is internal pressure.  
Minimum thickness per UG-16 =  $0.0625\text{''} + 0.125\text{''} = 0.1875\text{''}$   
Design thickness due to internal pressure (t) = 2.2038''  
Design thickness due to external pressure ( $t_e$ ) = 0.2819''  
Maximum allowable working pressure (MAWP) = 1,566.92 psi  
Maximum allowable external pressure (MAEP) = 750.1 psi

#### K (Corroded)

$$K = (1/6) * [2 + (D / (2*h))^2] = (1/6) * [2 + (60.25 / (2*15.125))^2] = 0.994502$$

#### K (New)

$$K = (1/6) * [2 + (D / (2*h))^2] = (1/6) * [2 + (60 / (2*15))^2] = 1$$

**Design thickness for internal pressure, (Corroded at 140 °F) Appendix 1-4(c)**

$$\begin{aligned}t &= P \cdot D \cdot K / (2 \cdot S \cdot E - 0.2 \cdot P) + \text{Corrosion} \\ &= 1,378.18 \cdot 60.25 \cdot 0.994502 / (2 \cdot 20,000 \cdot 1 - 0.2 \cdot 1,378.18) + 0.125 \\ &= 2.2038''\end{aligned}$$

The head internal pressure design thickness is 2.2038".

**Maximum allowable working pressure, (Corroded at 140 °F) Appendix 1-4(c)**

$$\begin{aligned}P &= 2 \cdot S \cdot E \cdot t / (K \cdot D + 0.2 \cdot t) - P_s \\ &= 2 \cdot 20,000 \cdot 1 \cdot 2.366 / (0.994502 \cdot 60.25 + 0.2 \cdot 2.366) - 0.18 \\ &= 1,566.92 \text{ psi}\end{aligned}$$

The maximum allowable working pressure (MAWP) is 1,566.92 psi.

**Design thickness for external pressure, (Corroded at 140 °F) UG-33(d)**

Equivalent outside spherical radius ( $R_o$ )

$$\begin{aligned}R_o &= K_o \cdot D_o \\ &= 0.8359 \cdot 64.982 \\ &= 54.3193 \text{ in}\end{aligned}$$

$$\begin{aligned}A &= 0.125 / (R_o / t) \\ &= 0.125 / (54.3193 / 0.156888) \\ &= 0.000361\end{aligned}$$

From Table CS-2:  $B = 5,193.454$  psi

$$\begin{aligned}P_a &= B / (R_o / t) \\ &= 5,193.454 / (54.3193 / 0.1569) \\ &= 15 \text{ psi}\end{aligned}$$

$$t = 0.1569'' + \text{Corrosion} = 0.1569'' + 0.125'' = 0.2819''$$

Check the external pressure per UG-33(a)(1) Appendix 1-4(c)

$$\begin{aligned}t &= 1.67 \cdot P_e \cdot D \cdot K / (2 \cdot S \cdot E - 0.2 \cdot 1.67 \cdot P_e) + \text{Corrosion} \\ &= 1.67 \cdot 15 \cdot 60.25 \cdot 0.994502 / (2 \cdot 20,000 \cdot 1 - 0.2 \cdot 1.67 \cdot 15) + 0.125 \\ &= 0.1625''\end{aligned}$$

The head external pressure design thickness ( $t_e$ ) is 0.2819".

**Maximum Allowable External Pressure, (Corroded at 140 °F) UG-33(d)**

Equivalent outside spherical radius ( $R_o$ )

$$\begin{aligned}R_o &= K_o \cdot D_o \\ &= 0.8359 \cdot 64.982 \\ &= 54.3193 \text{ in}\end{aligned}$$

$$\begin{aligned}A &= 0.125 / (R_o / t) \\ &= 0.125 / (54.3193 / 2.366) \\ &= 0.005445\end{aligned}$$

From Table CS-2:  $B = 17,220.94$  psi



$$\begin{aligned} P_a &= B / (R_o / t) \\ &= 17,220.94 / (54.3193 / 2.366) \\ &= 750.0974 \text{ psi} \end{aligned}$$

**Check the Maximum External Pressure, UG-33(a)(1) Appendix 1-4(c)**

$$\begin{aligned} P &= 2 * S * E * t / ((K * D + 0.2 * t) * 1.67) - P_{s2} \\ &= 2 * 20,000 * 1 * 2.366 / ((0.994502 * 60.25 + 0.2 * 2.366) * 1.67) - 0 \\ &= 938.38 \text{ psi} \end{aligned}$$

The maximum allowable external pressure (MAEP) is 750.1 psi.

**% Extreme fiber elongation - UCS-79(d)**

$$\begin{aligned} EFE &= (75 * t / R_i) * (1 - R_i / R_o) \\ &= (75 * 2.612 / 11.506) * (1 - 11.506 / \infty) \\ &= 17.0259\% \end{aligned}$$

## Straight Flange on 60 ID TOP SE HEAD

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

Component: Straight Flange  
Material specification: SA-516 70 (II-D p. 18, In. 19)  
Material is impact tested per UG-84 to -20 °F  
UCS-66(i) reduction of 12.9 °F applied (ratio = 0.8707).

Internal design pressure:  $P = 1,378$  psi @ 140 °F  
External design pressure:  $P_e = 15$  psi @ 140 °F

#### Static liquid head:

$P_s = 0.26$  psi (SG = 1.1,  $H_s = 6.5$ " , Operating head)  
 $P_{th} = 2.54$  psi (SG = 1,  $H_s = 70.5$ " , Horizontal test head)

Corrosion allowance      Inner C = 0.125"      Outer C = 0"

Design MDMT = -20 °F      Impact test performed  
Rated MDMT = -32.9 °F      Material is normalized  
Material is not produced to Fine Grain Practice  
PWHT is performed

Radiography:      Longitudinal joint -      Seamless No RT  
Circumferential joint -      Full UW-11(a) Type 1

Estimated weight New = 290.8 lb      corr = 277.4 lb  
Capacity      New = 24.48 US gal      corr = 24.68 US gal

ID = 60"  
Length = 2"  
 $L_c$   
t = 2.612"

#### Design thickness, (at 140 °F) UG-27(c)(1)

t =  $P \cdot R / (S \cdot E - 0.60 \cdot P) + \text{Corrosion}$   
=  $1,378.26 \cdot 30.125 / (20,000 \cdot 1.00 - 0.60 \cdot 1,378.26) + 0.125$   
= 2.2906"

#### Maximum allowable working pressure, (at 140 °F) UG-27(c)(1)

P =  $S \cdot E \cdot t / (R + 0.60 \cdot t) - P_s$   
=  $20,000 \cdot 1.00 \cdot 2.487 / (30.125 + 0.60 \cdot 2.487) - 0.26$   
= 1,572.94 psi

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

$L / D_o = 110.0833 / 65.224 = 1.6878$   
 $D_o / t = 65.224 / 0.2616 = 249.3220$   
From table G: A = 0.000195  
From table CS-2: B = 2,804.8786 psi

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

$$= 4 \cdot 2,804.88 / (3 \cdot (65.224 / 0.2616))$$
$$= 15 \text{ psi}$$

**Design thickness for external pressure  $P_a = 15$  psi**

$$t_a = t + \text{Corrosion} = 0.2616 + 0.125 = 0.3866''$$

**Maximum Allowable External Pressure, (Corroded & at 140 °F) UG-28(c)**

$$L / D_o = 110.0833 / 65.224 = 1.6878$$

$$D_o / t = 65.224 / 2.487 = 26.2260$$

$$\text{From table G: } A = 0.005788$$

$$\text{From table CS-2: } B = 17,236.009 \text{ psi}$$

$$P_a = 4 \cdot B / (3 \cdot (D_o / t))$$
$$= 4 \cdot 17,236.01 / (3 \cdot (65.224 / 2.487))$$
$$= 876.28 \text{ psi}$$

**% Extreme fiber elongation - UCS-79(d)**

$$\text{EFE} = (50 \cdot t / R_t) \cdot (1 - R_t / R_o)$$
$$= (50 \cdot 2.612 / 31.306) \cdot (1 - 31.306 / \infty)$$
$$= 4.1717\%$$

The extreme fiber elongation does not exceed 5%.

**Design thickness = 2.2906''**

The governing condition is due to internal pressure.

The cylinder thickness of 2.612'' is adequate.

### Thickness Required Due to Pressure + External Loads

Condition	Pressure P (psi)	Allowable Stress Before UG-23 Stress Increase (psi)		Temperature (°F)	Corrosion C (in)	Load	Req'd Thk Due to Tension (in)	Req'd Thk Due to Compression (in)
		S <sub>t</sub>	S <sub>c</sub>					
<u>Operating, Hot &amp; Corroded</u>	1,378	20,000	<u>17,359</u>	140	0.125	Wind	<u>0.8542</u>	<u>0.8542</u>
						Seismic	<u>0.8551</u>	<u>0.8526</u>
<u>Operating, Hot &amp; New</u>	1,378	20,000	<u>17,371</u>	140	0	Wind	<u>0.8507</u>	<u>0.8506</u>
						Seismic	<u>0.8515</u>	<u>0.8489</u>
<u>Hot Shut Down, Corroded</u>	0	20,000	<u>17,359</u>	140	0.125	Wind	<u>0.0009</u>	<u>0.0009</u>
						Seismic	<u>0.0001</u>	<u>0.0028</u>
<u>Hot Shut Down, New</u>	0	20,000	<u>17,371</u>	140	0	Wind	<u>0.0009</u>	<u>0.001</u>
						Seismic	<u>0.0001</u>	<u>0.0029</u>
<u>Empty, Corroded</u>	0	20,000	<u>17,359</u>	70	0.125	Wind	<u>0.0009</u>	<u>0.0009</u>
						Seismic	<u>0.0001</u>	<u>0.0027</u>
<u>Empty, New</u>	0	20,000	<u>17,371</u>	70	0	Wind	<u>0.0009</u>	<u>0.001</u>
						Seismic	<u>0.0001</u>	<u>0.0028</u>
<u>Vacuum</u>	-15	20,000	<u>17,359</u>	140	0.125	Wind	<u>0.0117</u>	<u>0.0116</u>
						Seismic	<u>0.0108</u>	<u>0.0137</u>
<u>Hot Shut Down, Corroded, Weight &amp; Eccentric Moments Only</u>	0	20,000	<u>17,359</u>	140	0.125	Weight	<u>0.0011</u>	<u>0.0011</u>

#### Allowable Compressive Stress, Hot and Corroded- S<sub>CHC</sub>, (table CS-2)

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (32.612 / 2.487) \\
 &= 0.009533 \\
 B &= 17,359 \text{ psi} \\
 S &= 20,000 / 1.00 = 20,000 \text{ psi} \\
 S_{CHC} &= \min(B, S) = \underline{17,359 \text{ psi}}
 \end{aligned}$$

#### Allowable Compressive Stress, Hot and New- S<sub>CHN</sub>, (table CS-2)

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (32.612 / 2.612) \\
 &= 0.010012 \\
 B &= 17,371 \text{ psi} \\
 S &= 20,000 / 1.00 = 20,000 \text{ psi} \\
 S_{CHN} &= \min(B, S) = \underline{17,371 \text{ psi}}
 \end{aligned}$$

#### Allowable Compressive Stress, Cold and New- S<sub>CCN</sub>, (table CS-2)

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (32.612 / 2.612) \\
 &= 0.010012 \\
 B &= 17,371 \text{ psi} \\
 S &= 20,000 / 1.00 = 20,000 \text{ psi} \\
 S_{CCN} &= \min(B, S) = \underline{17,371 \text{ psi}}
 \end{aligned}$$



**Allowable Compressive Stress, Cold and Corroded-  $S_{cCC}$ , (table CS-2)**

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (32.612 / 2.487) \\
 &= 0.009533 \\
 B &= 17,359 \text{ psi} \\
 S &= 20,000 / 1.00 = 20,000 \text{ psi} \\
 S_{cCC} &= \min(B, S) = \underline{17.359 \text{ psi}}
 \end{aligned}$$

**Allowable Compressive Stress, Vacuum and Corroded-  $S_{cVC}$ , (table CS-2)**

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (32.612 / 2.487) \\
 &= 0.009533 \\
 B &= 17,359 \text{ psi} \\
 S &= 20,000 / 1.00 = 20,000 \text{ psi} \\
 S_{cVC} &= \min(B, S) = \underline{17.359 \text{ psi}}
 \end{aligned}$$

**Operating, Hot & Corroded, Wind, Bottom Seam**

$$\begin{aligned}
 t_p &= P \cdot R / (2 \cdot S_t \cdot K_s \cdot E_c + 0.40 \cdot |P|) && \text{(Pressure)} \\
 &= 1,378 \cdot 30.125 / (2 \cdot 20,000 \cdot 1.20 \cdot 1.00 + 0.40 \cdot |1,378|) \\
 &= 0.855"
 \end{aligned}$$

$$\begin{aligned}
 t_m &= M / (\pi \cdot R_m^2 \cdot S_t \cdot K_s \cdot E_c) && \text{(bending)} \\
 &= 949 / (\pi \cdot 31.3685^2 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\
 &= 0"
 \end{aligned}$$

$$\begin{aligned}
 t_w &= W / (2 \cdot \pi \cdot R_m \cdot S_t \cdot K_s \cdot E_c) && \text{(Weight)} \\
 &= 3,740.2 / (2 \cdot \pi \cdot 31.3685 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\
 &= 0.0008"
 \end{aligned}$$

$$\begin{aligned}
 t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\
 &= 0.855 + 0 - (0.0008) \\
 &= \underline{0.8542"}
 \end{aligned}$$

$$\begin{aligned}
 t_c &= |t_{mc} + t_{wc} - t_{pc}| && \text{(total, net tensile)} \\
 &= |0 + (0.0008) - (0.855)| \\
 &= \underline{0.8542"}
 \end{aligned}$$

**Maximum allowable working pressure, Longitudinal Stress**

$$\begin{aligned}
 P &= 2 \cdot S_t \cdot K_s \cdot E_c \cdot (t - t_m + t_w) / (R - 0.40 \cdot (t - t_m + t_w)) \\
 &= 2 \cdot 20,000 \cdot 1.20 \cdot 1.00 \cdot (2.487 - 0 + (0.0008)) / (30.125 - 0.40 \cdot (2.487 - 0 + (0.0008))) \\
 &= 4,099.34 \text{ psi}
 \end{aligned}$$

**Operating, Hot & New, Wind, Bottom Seam**

$$\begin{aligned}
 t_p &= P \cdot R / (2 \cdot S_t \cdot K_s \cdot E_c + 0.40 \cdot |P|) && \text{(Pressure)} \\
 &= 1,378 \cdot 30 / (2 \cdot 20,000 \cdot 1.20 \cdot 1.00 + 0.40 \cdot |1,378|) \\
 &= 0.8515"
 \end{aligned}$$

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

$$= 970 / (\pi 31.306^2 20,000 1.20 1.00)$$

$$= 0"$$

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

$$= 3,913.1 / (2 \pi 31.306 20,000 1.20 1.00)$$

$$= 0.0008"$$

$$t_t = t_p + t_m - t_w \quad (\text{total required, tensile})$$

$$= 0.8515 + 0 - (0.0008)$$

$$= \underline{0.8507}"$$

$$t_c = |t_{mc} + t_{wc} - t_{pc}| \quad (\text{total, net tensile})$$

$$= |0 + (0.0008) - (0.8515)|$$

$$= \underline{0.8506}"$$

### Maximum allowable working pressure, Longitudinal Stress

$$P = 2 S_t K_s E_c (t - t_m + t_w) / (R - 0.40 (t - t_m + t_w))$$

$$= 2 20,000 1.20 1.00 (2.612 - 0 + (0.0008)) / (30 - 0.40 (2.612 - 0 + (0.0008)))$$

$$= 4,331.4 \text{ psi}$$

### Hot Shut Down, Corroded, Wind, Bottom Seam

$$t_p = 0" \quad (\text{Pressure})$$

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

$$= 949 / (\pi 31.3685^2 17,359.27 1.20)$$

$$= 0"$$

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

$$= 3,740.2 / (2 \pi 31.3685 17,359.27 1.20)$$

$$= 0.0009"$$

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

$$= |0 + 0 - (0.0009)|$$

$$= \underline{0.0009}"$$

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

$$= 0 + (0.0009) - (0)$$

$$= \underline{0.0009}"$$

### Hot Shut Down, New, Wind, Bottom Seam

$$t_p = 0" \quad (\text{Pressure})$$

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

$$= 970 / (\pi 31.306^2 17,371.43 1.20)$$

$$= 0"$$

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

$$= 3,913.1 / (2 \pi 31.306 17,371.43 1.20)$$

$$= 0.001"$$

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

$$= |0 + 0 - (0.001)|$$

$$= \underline{0.0009}"$$

$$\begin{aligned}
 t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\
 &= 0 + (0.001) - (0) \\
 &= \underline{0.001"}
 \end{aligned}$$

**Empty, Corroded, Wind, Bottom Seam**

$$\begin{aligned}
 t_p &= 0" && \text{(Pressure)} \\
 t_m &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\
 &= 949 / (\pi * 31.3685^2 * 17,359.27 * 1.20) \\
 &= 0" \\
 t_w &= W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\
 &= 3,740.2 / (2 * \pi * 31.3685 * 17,359.27 * 1.20) \\
 &= 0.0009" \\
 t_t &= |t_p + t_m - t_w| && \text{(total, net compressive)} \\
 &= |0 + 0 - (0.0009)| \\
 &= \underline{0.0009"} \\
 t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\
 &= 0 + (0.0009) - (0) \\
 &= \underline{0.0009"}
 \end{aligned}$$

**Empty, New, Wind, Bottom Seam**

$$\begin{aligned}
 t_p &= 0" && \text{(Pressure)} \\
 t_m &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\
 &= 970 / (\pi * 31.306^2 * 17,371.43 * 1.20) \\
 &= 0" \\
 t_w &= W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\
 &= 3,913.1 / (2 * \pi * 31.306 * 17,371.43 * 1.20) \\
 &= 0.001" \\
 t_t &= |t_p + t_m - t_w| && \text{(total, net compressive)} \\
 &= |0 + 0 - (0.001)| \\
 &= \underline{0.0009"} \\
 t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\
 &= 0 + (0.001) - (0) \\
 &= \underline{0.001"}
 \end{aligned}$$

**Vacuum, Wind, Bottom Seam**

$$\begin{aligned}
 t_p &= P * R / (2 * S_c * K_s + 0.40 * |P|) && \text{(Pressure)} \\
 &= -15 * 30.125 / (2 * 17,359.27 * 1.20 + 0.40 * |15|) \\
 &= -0.0108" \\
 t_m &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\
 &= 949 / (\pi * 31.3685^2 * 17,359.27 * 1.20) \\
 &= 0" \\
 t_w &= W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\
 &= 3,740.2 / (2 * \pi * 31.3685 * 17,359.27 * 1.20) \\
 &= 0.0009"
 \end{aligned}$$

$$\begin{aligned}
 t_t &= |t_p + t_m - t_w| && \text{(total, net compressive)} \\
 &= |-0.0108 + 0 - (0.0009)| \\
 &= \underline{0.0117"}
 \end{aligned}$$

$$\begin{aligned}
 t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\
 &= 0 + (0.0009) - (-0.0108) \\
 &= \underline{0.0118"}
 \end{aligned}$$

### Maximum Allowable External Pressure, Longitudinal Stress

$$\begin{aligned}
 P &= 2*S_c*K_s*(t - t_{mc} - t_{wc}) / (R - 0.40*(t - t_{mc} - t_{wc})) \\
 &= 2*17,359.27*1.20*(2.487 - 0 - 0.0009) / (30.125 - 0.40*(2.487 - 0 - 0.0009)) \\
 &= 3,555.56 \text{ psi}
 \end{aligned}$$

### Hot Shut Down, Corroded. Weight & Eccentric Moments Only, Bottom Seam

$$\begin{aligned}
 t_p &= 0" && \text{(Pressure)} \\
 t_m &= M / (\pi*R_m^2*S_c*K_s) && \text{(bending)} \\
 &= 213 / (\pi*31.3685^2*17,359.27*1.00) \\
 &= 0"
 \end{aligned}$$

$$\begin{aligned}
 t_w &= W / (2*\pi*R_m*S_c*K_s) && \text{(Weight)} \\
 &= 3,740.2 / (2*\pi*31.3685*17,359.27*1.00) \\
 &= 0.0011"
 \end{aligned}$$

$$\begin{aligned}
 t_t &= |t_p + t_m - t_w| && \text{(total, net compressive)} \\
 &= |0 + 0 - (0.0011)| \\
 &= \underline{0.0011"}
 \end{aligned}$$

$$\begin{aligned}
 t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\
 &= 0 + (0.0011) - (0) \\
 &= \underline{0.0011"}
 \end{aligned}$$

### Operating, Hot & Corroded, Seismic, Bottom Seam

$$\begin{aligned}
 t_p &= P*R / (2*S_t*K_s*E_c + 0.40*|P|) && \text{(Pressure)} \\
 &= 1,378*30.125 / (2*20,000*1.20*1.00 + 0.40*|1,378|) \\
 &= 0.855"
 \end{aligned}$$

$$\begin{aligned}
 t_m &= M / (\pi*R_m^2*S_t*K_s*E_c) && \text{(bending)} \\
 &= 64,702 / (\pi*31.3685^2*20,000*1.20*1.00) \\
 &= 0.0009"
 \end{aligned}$$

$$\begin{aligned}
 t_w &= W / (2*\pi*R_m*S_t*K_s*E_c) && \text{(Weight)} \\
 &= 3,740.2 / (2*\pi*31.3685*20,000*1.20*1.00) \\
 &= 0.0008"
 \end{aligned}$$

$$\begin{aligned}
 t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\
 &= 0.855 + 0.0009 - (0.0008) \\
 &= \underline{0.8551"}
 \end{aligned}$$

$$\begin{aligned}
 t_{wc} &= (1 + V\text{Accel})*W / (2*\pi*R_m*S_t*K_s*E_c) && \text{(Weight)} \\
 &= 2.00*3,740.2 / (2*\pi*31.3685*20,000*1.20*1.00) \\
 &= 0.0016"
 \end{aligned}$$

$$t_c = |t_{mc} + t_{wc} - t_{pc}| \quad \text{(total, net tensile)}$$



$$= |0.0009 + (0.0016) - (0.855)|$$

$$= \underline{0.8526''}$$

### Maximum allowable working pressure, Longitudinal Stress

$$P = 2 * S_t * K_s * E_c * (t - t_m + t_w) / (R - 0.40 * (t - t_m + t_w))$$

$$= 2 * 20,000 * 1.20 * 1.00 * (2.487 - 0.0009 + (0.0008)) / (30.125 - 0.40 * (2.487 - 0.0009 + (0.0008)))$$

$$= 4,097.88 \text{ psi}$$

### Operating, Hot & New, Seismic, Bottom Seam

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

$$= 1,378 * 30 / (2 * 20,000 * 1.20 * 1.00 + 0.40 * |1,378|)$$

$$= 0.8515''$$

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

$$= 66,830 / (\pi * 31.306^2 * 20,000 * 1.20 * 1.00)$$

$$= 0.0009''$$

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

$$= 3,913.1 / (2 * \pi * 31.306 * 20,000 * 1.20 * 1.00)$$

$$= 0.0008''$$

$$t_t = t_p + t_m - t_w \quad (\text{total required, tensile})$$

$$= 0.8515 + 0.0009 - (0.0008)$$

$$= \underline{0.8515''}$$

$$t_{wc} = (1 + V_{\text{Accel}}) * W / (2 * \pi * R_m * S_t * K_s * E_c) \quad (\text{Weight})$$

$$= 2.00 * 3,913.1 / (2 * \pi * 31.306 * 20,000 * 1.20 * 1.00)$$

$$= 0.0017''$$

$$t_c = |t_{mc} + t_{wc} - t_{pc}| \quad (\text{total, net tensile})$$

$$= |0.0009 + (0.0017) - (0.8515)|$$

$$= \underline{0.8489''}$$

### Maximum allowable working pressure, Longitudinal Stress

$$P = 2 * S_t * K_s * E_c * (t - t_m + t_w) / (R - 0.40 * (t - t_m + t_w))$$

$$= 2 * 20,000 * 1.20 * 1.00 * (2.612 - 0.0009 + (0.0008)) / (30 - 0.40 * (2.612 - 0.0009 + (0.0008)))$$

$$= 4,329.87 \text{ psi}$$

### Hot Shut Down, Corroded, Seismic, Bottom Seam

$$t_p = 0'' \quad (\text{Pressure})$$

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

$$= 64,702 / (\pi * 31.3685^2 * 20,000 * 1.20 * 1.00)$$

$$= 0.0009''$$

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

$$= 3,740.2 / (2 * \pi * 31.3685 * 20,000 * 1.20 * 1.00)$$

$$= 0.0008''$$

$$t_t = t_p + t_m - t_w \quad (\text{total required, tensile})$$

$$= 0 + 0.0009 - (0.0008)$$

$$= \underline{0.0001''}$$

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

$$= 64,702 / (\pi * 31.3685^2 * 17,359.27 * 1.20)$$

$$= 0.001''$$

$$t_{wc} = (1 + V_{Accel}) * W / (2 * \pi * R_m * S_c * K_s) \quad (\text{Weight})$$

$$= 2.00 * 3,740.2 / (2 * \pi * 31.3685 * 17,359.27 * 1.20)$$

$$= 0.0018''$$

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

$$= 0.001 + (0.0018) - (0)$$

$$= \underline{0.0028''}$$

#### Hot Shut Down, New, Seismic, Bottom Seam

$$t_p = 0'' \quad (\text{Pressure})$$

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

$$= 66,830 / (\pi * 31.306^2 * 20,000 * 1.20 * 1.00)$$

$$= 0.0009''$$

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

$$= 3,913.1 / (2 * \pi * 31.306 * 20,000 * 1.20 * 1.00)$$

$$= 0.0008''$$

$$t_t = t_p + t_m - t_w \quad (\text{total required, tensile})$$

$$= 0 + 0.0009 - (0.0008)$$

$$= \underline{0.0001''}$$

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

$$= 66,830 / (\pi * 31.306^2 * 17,371.43 * 1.20)$$

$$= 0.001''$$

$$t_{wc} = (1 + V_{Accel}) * W / (2 * \pi * R_m * S_c * K_s) \quad (\text{Weight})$$

$$= 2.00 * 3,913.1 / (2 * \pi * 31.306 * 17,371.43 * 1.20)$$

$$= 0.0019''$$

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

$$= 0.001 + (0.0019) - (0)$$

$$= \underline{0.0029''}$$

#### Empty, Corroded, Seismic, Bottom Seam

$$t_p = 0'' \quad (\text{Pressure})$$

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

$$= 54,112 / (\pi * 31.3685^2 * 17,359.27 * 1.20)$$

$$= 0.0008''$$

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

$$= 3,740.2 / (2 * \pi * 31.3685 * 17,359.27 * 1.20)$$

$$= 0.0009''$$

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

$$= |0 + 0.0008 - (0.0009)|$$

$$= \underline{0.0001''}$$

$$t_{wc} = (1 + VAccel) * W / (2 * \pi * R_m * S_c * K_s) \quad (\text{Weight})$$

$$= 2.00 * 3,740.2 / (2 * \pi * 31.3685 * 17,359.27 * 1.20)$$

$$= 0.0018''$$

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

$$= 0.0008 + (0.0018) - (0)$$

$$= \underline{0.0027''}$$

#### Empty, New, Seismic, Bottom Seam

$$t_p = 0'' \quad (\text{Pressure})$$

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

$$= 56,321 / (\pi * 31.306^2 * 17,371.43 * 1.20)$$

$$= 0.0009''$$

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

$$= 3,913.1 / (2 * \pi * 31.306 * 17,371.43 * 1.20)$$

$$= 0.001''$$

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

$$= |0 + 0.0009 - (0.001)|$$

$$= \underline{0.0001''}$$

$$t_{wc} = (1 + VAccel) * W / (2 * \pi * R_m * S_c * K_s) \quad (\text{Weight})$$

$$= 2.00 * 3,913.1 / (2 * \pi * 31.306 * 17,371.43 * 1.20)$$

$$= 0.0019''$$

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

$$= 0.0009 + (0.0019) - (0)$$

$$= \underline{0.0028''}$$

#### Vacuum, Seismic, Bottom Seam

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

$$= -15 * 30.125 / (2 * 17,359.27 * 1.20 + 0.40 * |15|)$$

$$= -0.0108''$$

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

$$= 64,702 / (\pi * 31.3685^2 * 17,359.27 * 1.20)$$

$$= 0.001''$$

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

$$= 3,740.2 / (2 * \pi * 31.3685 * 17,359.27 * 1.20)$$

$$= 0.0009''$$

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

$$= |-0.0108 + 0.001 - (0.0009)|$$

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

$$t_{wc} = (1 + VAccel) * W / (2 * \pi * R_m * S_c * K_s) \quad (\text{Weight})$$

$$= 2.00 * 3,740.2 / (2 * \pi * 31.3685 * 17,359.27 * 1.20)$$

$$= 0.0018''$$

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

$$= 0.001 + (0.0018) - (-0.0108)$$

$$= \underline{0.0137''}$$

### Maximum Allowable External Pressure, Longitudinal Stress

$$\begin{aligned} P &= 2 \cdot S_c \cdot K_s \cdot (t - t_{mc} - t_{wc}) / (R - 0.40 \cdot (t - t_{mc} - t_{wc})) \\ &= 2 \cdot 17,359.27 \cdot 1.20 \cdot (2.487 - 0.001 - 0.0018) / (30.125 - 0.40 \cdot (2.487 - 0.001 - 0.0018)) \\ &= 3,552.75 \text{ psi} \end{aligned}$$

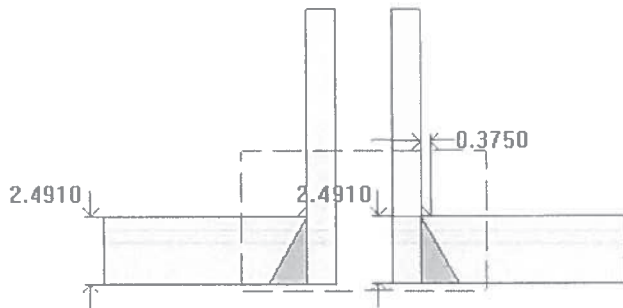


## Vent (N7)

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$$t_{w(\text{lower})} = 2.491 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

### Location and Orientation

Located on:	60 ID TOP SE HEAD
Orientation:	0°
End of nozzle to datum line:	-24.5 in
Calculated as hillside:	Yes
Distance to head center, R:	18 in
Passes through a Category A joint:	No

### Nozzle

Access opening:	No
Material specification:	SA-350 LF2 Cl 1 (II-D p. 18, ln. 10)
Inside diameter, new:	2 in
Nominal wall thickness:	1.06 in
Corrosion allowance:	0.125 in
Opening chord length:	2.3928 in
Projection available outside vessel, Lpr:	5.5086 in
Projection available outside vessel to flange face, Lf:	7.2586 in
Local vessel minimum thickness:	2.491 in
Liquid static head included:	0 psi
Longitudinal joint efficiency:	1

### ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 LWN A350 LF2 Cl.1
Bolt Material:	SA-193 B7 Bolt <= 2 1/2 (II-D p. 334, ln. 32)
Blind included:	No
Rated MDMT:	-55°F per UCS-66(b)(1)(b)
Liquid static head:	0 psi
MAWP rating:	2,146 psi @ 140°F
MAP rating:	2,220 psi @ 50°F
Hydrotest rating:	3,350 psi @ 50°F

PWHT performed:

Yes



**Reinforcement Calculations for Chamber MAWP**

<b>UG-37 Area Calculation Summary (in<sup>2</sup>)</b> For P = 1,378 psi @ 140 °F The opening is adequately reinforced							<b>UG-45 Nozzle Wall Thickness Summary (in)</b> The nozzle passes UG-45	
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
4.4824	7.3864	3.2529	3.9929	--	--	0.1406	0.3324	1.06

<b>UG-41 Weld Failure Path Analysis Summary</b>
The nozzle is exempt from weld strength calculations per UW-15(b)(1)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	0.25	0.2625	weld size is adequate

**Calculations for internal pressure 1,378 psi @ 140 °F**

Nozzle is impact test exempt to -155 °F per UCS-66(b)(3) (coincident ratio = 0.0865).

Nozzle UCS-66 governing thk: 1.06 in

Nozzle rated MDMT: -155 °F

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.3928, 1.1964 + (1.06 - 0.125) + (2.491 - 0.125)) \\
 &= 4.4974 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(2.491 - 0.125), 2.5*(1.06 - 0.125) + 0) \\
 &= 2.3375 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_n &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 1.125 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.0809 \text{ in}
 \end{aligned}$$

**Required thickness t<sub>r</sub> from UG-37(a)(c)**

$$\begin{aligned}
 t_r &= P \cdot K_1 \cdot D / (2 \cdot S \cdot E - 0.2 \cdot P) \\
 &= 1,378 \cdot 0.8963 \cdot 60.25 / (2 \cdot 20,000 \cdot 1 - 0.2 \cdot 1,378)
 \end{aligned}$$

$$= 1.8733 \text{ in}$$

### Area required per UG-37(c)

Allowable stresses:  $S_n = 20,000$ ,  $S_v = 20,000$  psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$\begin{aligned} A &= d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1}) \\ &= 2.3928 \cdot 1.8733 \cdot 1 + 2 \cdot 0.935 \cdot 1.8733 \cdot 1 \cdot (1 - 1) \\ &= \underline{4.4824} \text{ in}^2 \end{aligned}$$

### Area available from FIG. UG-37.1

$$A_1 = \text{larger of the following} = \underline{3.2529} \text{ in}^2$$

$$\begin{aligned} &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2.3928 \cdot (1 \cdot 2.366 - 1 \cdot 1.8733) - 2 \cdot 0.935 \cdot (1 \cdot 2.366 - 1 \cdot 1.8733) \cdot (1 - 1) \\ &= 1.179 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2 \cdot (2.366 + 0.935) \cdot (1 \cdot 2.366 - 1 \cdot 1.8733) - 2 \cdot 0.935 \cdot (1 \cdot 2.366 - 1 \cdot 1.8733) \cdot (1 - 1) \\ &= 3.2529 \text{ in}^2 \end{aligned}$$

$$A_2 = \text{smaller of the following} = \underline{3.9929} \text{ in}^2$$

$$\begin{aligned} &= 2 \cdot (t_n - t_m) \cdot f_{r2} \cdot L_{pr} \\ &= 2 \cdot (0.935 - 0.0809) \cdot 1 \cdot 5.5086 \\ &= 9.4098 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (0.935 - 0.0809) \cdot 1 \cdot 0.935 \\ &= 3.9929 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} A_{41} &= \text{Leg}^2 \cdot f_{r2} \\ &= 0.375^2 \cdot 1 \\ &= \underline{0.1406} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_{41} \\ &= 3.2529 + 3.9929 + 0.1406 \\ &= \underline{7.3864} \text{ in}^2 \end{aligned}$$

As Area  $\geq$  A the reinforcement is adequate.



### UW-16(c) Weld Check

Fillet weld:  $t_{\min}$  = lesser of 0.75 or  $t_n$  or  $t = 0.75$  in

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

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

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

Interpretation VIII-1-83-66 has been applied.

$$\begin{aligned} t_{a \text{ UG-27}} &= P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion} \\ &= 1,378 \cdot 1.125 / (20,000 \cdot 1 - 0.6 \cdot 1,378) + 0.125 \\ &= 0.2059 \text{ in} \end{aligned}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.2059, 0 ] \\ &= 0.2059 \text{ in} \end{aligned}$$

$$t_{b1} = 2.2035 \text{ in}$$

$$\begin{aligned} t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 2.2035, 0.1875 ] \\ &= 2.2035 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.3324, 2.2035 ] \\ &= 0.3324 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.2059, 0.3324 ] \\ &= 0.3324 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06$  in

The nozzle neck thickness is adequate.

## Reinforcement Calculations for MAEP

<b>UG-37 Area Calculation Summary (in<sup>2</sup>)</b> For Pe = 750.1 psi @ 140 °F The opening is adequately reinforced							<b>UG-45 Nozzle Wall Thickness Summary (in)</b> The nozzle passes UG-45	
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
2.8278	3.8609	--	3.7203	--	--	0.1406	0.3324	1.06

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	0.25	0.2625	weld size is adequate

Calculations for external pressure 750.1 psi @ 140 °F

### Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.3904, 1.1952 + (1.06 - 0.125) + (2.491 - 0.125)) \\
 &= 4.4962 \text{ in}
 \end{aligned}$$

### Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(2.491 - 0.125), 2.5*(1.06 - 0.125) + 0) \\
 &= 2.3375 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28  $t_{rn} = 0.1392 \text{ in}$

From UG-37(d)(1) required thickness  $t_r = 2.366 \text{ in}$

### Area required per UG-37(d)(1)

Allowable stresses:  $S_n = 20,000$ ,  $S_v = 20,000 \text{ psi}$

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$A = 0.5*(d*t_r*F + 2*t_n*t_r*F*(1 - f_{r1}))$$

$$\begin{aligned}
 &= 0.5*(2.3904*2.366*1 + 2*0.935*2.366*1*(1 - 1)) \\
 &= \underline{2.8278} \text{ in}^2
 \end{aligned}$$

#### Area available from FIG. UG-37.1

$A_1$  = larger of the following = 0 in<sup>2</sup>

$$\begin{aligned}
 &= d*(E_1*t - F*t_r) - 2*t_n*(E_1*t - F*t_r)*(1 - f_{r1}) \\
 &= 2.3904*(1*2.366 - 1*2.366) - 2*0.935*(1*2.366 - 1*2.366)*(1 - 1) \\
 &= 0 \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 &= 2*(t + t_n)*(E_1*t - F*t_r) - 2*t_n*(E_1*t - F*t_r)*(1 - f_{r1}) \\
 &= 2*(2.366 + 0.935)*(1*2.366 - 1*2.366) - 2*0.935*(1*2.366 - 1*2.366)*(1 - 1) \\
 &= 0 \text{ in}^2
 \end{aligned}$$

$A_2$  = smaller of the following = 3.7203 in<sup>2</sup>

$$\begin{aligned}
 &= 2*(t_n - t_{rn})*f_{r2}*L_{pr} \\
 &= 2*(0.935 - 0.1392)*1*5.5086 \\
 &= 8.7672 \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 &= 5*(t_n - t_{rn})*f_{r2}*t_n \\
 &= 5*(0.935 - 0.1392)*1*0.935 \\
 &= 3.7203 \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 A_{41} &= \text{Leg}^2*f_{r2} \\
 &= 0.375^2*1 \\
 &= \underline{0.1406} \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 \text{Area} &= A_1 + A_2 + A_{41} \\
 &= 0 + 3.7203 + 0.1406 \\
 &= \underline{3.8609} \text{ in}^2
 \end{aligned}$$

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

Interpretation VIII-1-83-66 has been applied.

$$t_{a \text{ UG-28}} = 0.2642 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.2642, 0 ] \\ &= 0.2642 \text{ in} \end{aligned}$$

$$t_{b2} = 1.2529 \text{ in}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2}, t_{b \text{ UG16}} ] \\ &= \max[ 1.2529, 0.1875 ] \\ &= 1.2529 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b2} ] \\ &= \min[ 0.3324, 1.2529 ] \\ &= 0.3324 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.2642, 0.3324 ] \\ &= 0.3324 \text{ in} \end{aligned}$$

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)

$$\begin{aligned} L / D_o &= 8.7407 / 4.12 = 2.1215 \\ D_o / t &= 4.12 / 0.1392 = 29.5928 \\ \text{From table G: } A &= 0.003723 \\ \text{From table CS-2: } B &= 16,648.1137 \text{ psi} \end{aligned}$$

$$\begin{aligned} P_a &= 4*B / (3*(D_o / t)) \\ &= 4*16,648.11 / (3*(4.12 / 0.1392)) \\ &= 750.1 \text{ psi} \end{aligned}$$

**Design thickness for external pressure  $P_a = 750.1 \text{ psi}$**

$$t_a = t + \text{Corrosion} = 0.1392 + 0.125 = 0.2642''$$

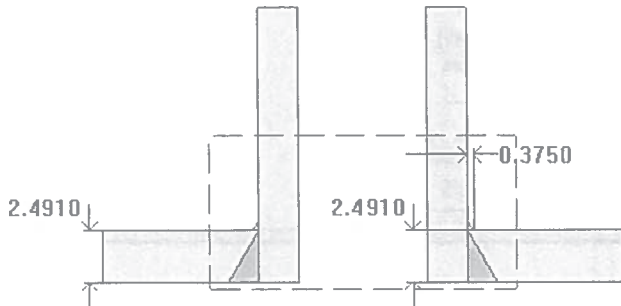


## Outlet (N10)

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$$t_{w(\text{lower})} = 2.491 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

### Location and Orientation

Located on:	60 ID TOP SE HEAD
Orientation:	0°
End of nozzle to datum line:	-29.1875 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-350 LF2 Cl 1 (II-D p. 18, In. 10)
Inside diameter, new:	8 in
Nominal wall thickness:	1.875 in
Corrosion allowance:	0.125 in
Projection available outside vessel, L <sub>pr</sub> :	7.2348 in
Projection available outside vessel to flange face, L <sub>f</sub> :	9.9848 in
Local vessel minimum thickness:	2.491 in
Liquid static head included:	0 psi
Longitudinal joint efficiency:	1

### ASME B16.5-2009 Flange

Description:	NPS 8 Class 900 LWN A350 LF2 Cl.1
Bolt Material:	SA-193 B7 Bolt <= 2 1/2 (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55°F per UCS-66(b)(1)(b)
Liquid static head:	0 psi
MAWP rating:	2,146 psi @ 140°F
MAP rating:	2,220 psi @ 50°F
Hydrotest rating:	3,350 psi @ 50°F
PWHT performed:	Yes

## Reinforcement Calculations for Chamber MAWP

UG-37 Area Calculation Summary (in <sup>2</sup> ) 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 <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
15.4546	16.9236	4.0649	12.7181	--	--	0.1406	0.4531	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 <sub>41</sub> )	0.25	0.2625	weld size is adequate

### Calculations for internal pressure 1,378 psi @ 140 °F

Nozzle is impact test exempt to -155 °F per UCS-66(b)(3) (coincident ratio = 0.1694).

Nozzle UCS-66 governing thk: 1.875 in

Nozzle rated MDMT: -155 °F

### Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(8.25, 4.125 + (1.875 - 0.125) + (2.491 - 0.125)) \\
 &= 8.25 \text{ in}
 \end{aligned}$$

### Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(2.491 - 0.125), 2.5*(1.875 - 0.125) + 0) \\
 &= 4.375 \text{ in}
 \end{aligned}$$

### Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 4.125 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.2965 \text{ in}
 \end{aligned}$$

### Required thickness t<sub>r</sub> from UG-37(a)(c)

$$\begin{aligned}
 t_r &= P \cdot K_1 \cdot D / (2 \cdot S \cdot E - 0.2 \cdot P) \\
 &= 1,378 \cdot 0.8963 \cdot 60.25 / (2 \cdot 20,000 \cdot 1 - 0.2 \cdot 1,378) \\
 &= 1.8733 \text{ in}
 \end{aligned}$$

### Area required per UG-37(c)

Allowable stresses:  $S_n = 20,000$ ,  $S_v = 20,000$  psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$\begin{aligned} A &= d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1}) \\ &= 8.25 \cdot 1.8733 \cdot 1 + 2 \cdot 1.75 \cdot 1.8733 \cdot 1 \cdot (1 - 1) \\ &= \underline{15.4546} \text{ in}^2 \end{aligned}$$

### Area available from FIG. UG-37.1

$A_1 = \text{larger of the following} = \underline{4.0649} \text{ in}^2$

$$\begin{aligned} &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 8.25 \cdot (1 \cdot 2.366 - 1 \cdot 1.8733) - 2 \cdot 1.75 \cdot (1 \cdot 2.366 - 1 \cdot 1.8733) \cdot (1 - 1) \\ &= 4.0649 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2 \cdot (2.366 + 1.75) \cdot (1 \cdot 2.366 - 1 \cdot 1.8733) - 2 \cdot 1.75 \cdot (1 \cdot 2.366 - 1 \cdot 1.8733) \cdot (1 - 1) \\ &= 4.0561 \text{ in}^2 \end{aligned}$$

$A_2 = \text{smaller of the following} = \underline{12.7181} \text{ in}^2$

$$\begin{aligned} &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t \\ &= 5 \cdot (1.75 - 0.2965) \cdot 1 \cdot 2.366 \\ &= 17.1949 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (1.75 - 0.2965) \cdot 1 \cdot 1.75 \\ &= 12.7181 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} A_{41} &= \text{Leg}^2 \cdot f_{r2} \\ &= 0.375^2 \cdot 1 \\ &= \underline{0.1406} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_{41} \\ &= 4.0649 + 12.7181 + 0.1406 \\ &= \underline{16.9236} \text{ in}^2 \end{aligned}$$

As Area  $\geq$  A the reinforcement is adequate.

### UW-16(c) Weld Check

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

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

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

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

Interpretation VIII-1-83-66 has been applied.

$$\begin{aligned}t_{a \text{ UG-27}} &= P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion} \\ &= 1,378 \cdot 4.125 / (20,000 \cdot 1 - 0.6 \cdot 1,378) + 0.125 \\ &= 0.4215 \text{ in}\end{aligned}$$

$$\begin{aligned}t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.4215, 0 ] \\ &= 0.4215 \text{ in}\end{aligned}$$

$$t_{b1} = 2.2035 \text{ in}$$

$$\begin{aligned}t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 2.2035, 0.1875 ] \\ &= 2.2035 \text{ in}\end{aligned}$$

$$\begin{aligned}t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.4531, 2.2035 ] \\ &= 0.4531 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.4215, 0.4531 ] \\ &= 0.4531 \text{ in}\end{aligned}$$

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 <sup>2</sup> ) For Pe = 750.1 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 <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
9.7598	12.1224	--	11.9818	--	--	0.1406	0.5057	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 <sub>41</sub> )	0.25	0.2625	weld size is adequate

Calculations for external pressure 750.1 psi @ 140 °F

### Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(8.25, 4.125 + (1.875 - 0.125) + (2.491 - 0.125)) \\
 &= 8.25 \text{ in}
 \end{aligned}$$

### Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(2.491 - 0.125), 2.5*(1.875 - 0.125) + 0) \\
 &= 4.375 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28  $t_{rn} = 0.3807$  in

From UG-37(d)(1) required thickness  $t_r = 2.366$  in

### Area required per UG-37(d)(1)

Allowable stresses:  $S_n = 20,000$ ,  $S_v = 20,000$  psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$\begin{aligned}
 A &= 0.5*(d*t_r*F + 2*t_n*t_r*F*(1 - f_{r1})) \\
 &= 0.5*(8.25*2.366*1 + 2*1.75*2.366*1*(1 - 1))
 \end{aligned}$$

$$= \underline{9.7598} \text{ in}^2$$

### Area available from FIG. UG-37.1

$A_1 =$  larger of the following =  $\underline{0}$  in<sup>2</sup>

$$\begin{aligned} &= d(E_1 t - F t_r) - 2 t_n (E_1 t - F t_r) (1 - f_{r1}) \\ &= 8.25(1 \cdot 2.366 - 1 \cdot 2.366) - 2 \cdot 1.75(1 \cdot 2.366 - 1 \cdot 2.366)(1 - 1) \\ &= 0 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 2(t + t_n)(E_1 t - F t_r) - 2 t_n (E_1 t - F t_r) (1 - f_{r1}) \\ &= 2(2.366 + 1.75)(1 \cdot 2.366 - 1 \cdot 2.366) - 2 \cdot 1.75(1 \cdot 2.366 - 1 \cdot 2.366)(1 - 1) \\ &= 0 \text{ in}^2 \end{aligned}$$

$A_2 =$  smaller of the following =  $\underline{11.9818}$  in<sup>2</sup>

$$\begin{aligned} &= 5(t_n - t_m) f_{r2} t \\ &= 5(1.75 - 0.3807) \cdot 1 \cdot 2.366 \\ &= 16.1993 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 5(t_n - t_m) f_{r2} t_n \\ &= 5(1.75 - 0.3807) \cdot 1 \cdot 1.75 \\ &= 11.9818 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} A_{41} &= \text{Leg}^2 f_{r2} \\ &= 0.375^2 \cdot 1 \\ &= \underline{0.1406} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_{41} \\ &= 0 + 11.9818 + 0.1406 \\ &= \underline{12.1224} \text{ in}^2 \end{aligned}$$

As Area  $\geq$  A the reinforcement is adequate.

### UW-16(c) Weld Check

Fillet weld:  $t_{\min} =$  lesser of 0.75 or  $t_n$  or  $t = 0.75$  in

$t_{c(\min)} =$  lesser of 0.25 or  $0.7 \cdot t_{\min} = \underline{0.25}$  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.

$$t_{a \text{ UG-28}} = 0.5057 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.5057, 0 ] \\ &= 0.5057 \text{ in} \end{aligned}$$

$$t_{b2} = 1.2529 \text{ in}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2}, t_{b \text{ UG16}} ] \\ &= \max[ 1.2529, 0.1875 ] \\ &= 1.2529 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b2} ] \\ &= \min[ 0.4531, 1.2529 ] \\ &= 0.4531 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.5057, 0.4531 ] \\ &= 0.5057 \text{ in} \end{aligned}$$

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)

$$L / D_o = 9.9848 / 11.75 = 0.8498$$

$$D_o / t = 11.75 / 0.3807 = 30.8677$$

From table G: A = 0.009769

From table CS-2: B = 17,365.3559 psi

$$\begin{aligned} P_a &= 4*B / (3*(D_o / t)) \\ &= 4*17,365.36 / (3*(11.75 / 0.3807)) \\ &= 750.1 \text{ psi} \end{aligned}$$

**Design thickness for external pressure  $P_a = 750.1 \text{ psi}$**

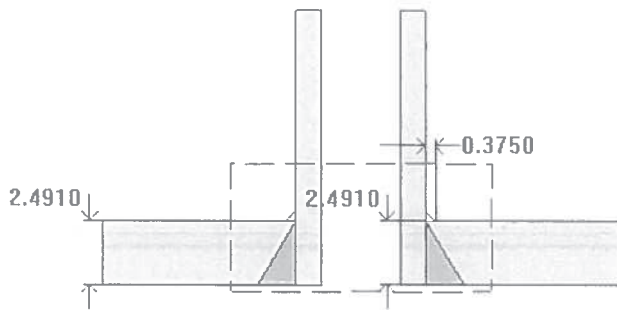
$$t_a = t + \text{Corrosion} = 0.3807 + 0.125 = 0.5057''$$

## Corrosion Coupon (N9)

ASME Section VIII Division 1, 2010 Edition, A11 Addenda

$$t_{w(\text{lower})} = 2.491 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

### Location and Orientation

Located on:	60 ID TOP SE HEAD
Orientation:	180°
End of nozzle to datum line:	-24.5 in
Calculated as hillside:	Yes
Distance to head center, R:	18 in
Passes through a Category A joint:	No

### Nozzle

Access opening:	No
Material specification:	SA-350 LF2 Cl 1 (II-D p. 18, ln. 10)
Inside diameter, new:	3 in
Nominal wall thickness:	1 in
Corrosion allowance:	0.125 in
Opening chord length:	3.4569 in
Projection available outside vessel, L <sub>pr</sub> :	5.3776 in
Projection available outside vessel to flange face, L <sub>f</sub> :	7.1276 in
Local vessel minimum thickness:	2.491 in
Liquid static head included:	0 psi
Longitudinal joint efficiency:	1

### ASME B16.5-2009 Flange

Description:	NPS 3 Class 900 LWN A350 LF2 Cl.1
Bolt Material:	SA-193 B7 Bolt ≤ 2 1/2 (II-D p. 334, ln. 32)
Blind included:	No
Rated MDMT:	-55°F per UCS-66(b)(1)(b)
Liquid static head:	0 psi
MAWP rating:	2,146 psi @ 140°F
MAP rating:	2,220 psi @ 50°F
Hydrotest rating:	3,350 psi @ 50°F



PWHT performed:

Yes



**Reinforcement Calculations for Chamber MAWP**

<b>UG-37 Area Calculation Summary (in<sup>2</sup>)</b> For P = 1,378 psi @ 140 °F The opening is adequately reinforced							<b>UG-45 Nozzle Wall Thickness Summary (in)</b> The nozzle passes UG-45	
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
6.4757	6.6515	3.1938	3.3171	--	--	0.1406	0.3508	1

<b>UG-41 Weld Failure Path Analysis Summary</b>
The nozzle is exempt from weld strength calculations per UW-15(b)(1)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	0.25	0.2625	weld size is adequate

**Calculations for internal pressure 1,378 psi @ 140 °F**

Nozzle is impact test exempt to -155 °F per UCS-66(b)(3) (coincident ratio = 0.1335).

Nozzle UCS-66 governing thk: 1 in

Nozzle rated MDMT: -155 °F

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(3.4569, 1.7285 + (1 - 0.125) + (2.491 - 0.125)) \\
 &= 4.9695 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(2.491 - 0.125), 2.5*(1 - 0.125) + 0) \\
 &= 2.1875 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378 \cdot 1.625 / (20,000 \cdot 1 - 0.6 \cdot 1,378) \\
 &= 0.1168 \text{ in}
 \end{aligned}$$

**Required thickness t<sub>r</sub> from UG-37(a)(c)**

$$\begin{aligned}
 t_r &= P \cdot K_1 \cdot D / (2 \cdot S \cdot E - 0.2 \cdot P) \\
 &= 1,378 \cdot 0.8963 \cdot 60.25 / (2 \cdot 20,000 \cdot 1 - 0.2 \cdot 1,378)
 \end{aligned}$$

$$= 1.8733 \text{ in}$$

### Area required per UG-37(c)

Allowable stresses:  $S_n = 20,000$ ,  $S_v = 20,000$  psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$\begin{aligned} A &= d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1}) \\ &= 3.4569 \cdot 1.8733 \cdot 1 + 2 \cdot 0.875 \cdot 1.8733 \cdot 1 \cdot (1 - 1) \\ &= \underline{6.4757} \text{ in}^2 \end{aligned}$$

### Area available from FIG. UG-37.1

$$A_1 = \text{larger of the following} = \underline{3.1938} \text{ in}^2$$

$$\begin{aligned} &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 3.4569 \cdot (1 \cdot 2.366 - 1 \cdot 1.8733) - 2 \cdot 0.875 \cdot (1 \cdot 2.366 - 1 \cdot 1.8733) \cdot (1 - 1) \\ &= 1.7033 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2 \cdot (2.366 + 0.875) \cdot (1 \cdot 2.366 - 1 \cdot 1.8733) - 2 \cdot 0.875 \cdot (1 \cdot 2.366 - 1 \cdot 1.8733) \cdot (1 - 1) \\ &= 3.1938 \text{ in}^2 \end{aligned}$$

$$A_2 = \text{smaller of the following} = \underline{3.3171} \text{ in}^2$$

$$\begin{aligned} &= 2 \cdot (t_n - t_m) \cdot f_{r2} \cdot L_{pr} \\ &= 2 \cdot (0.875 - 0.1168) \cdot 1 \cdot 5.3776 \\ &= 8.1546 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (0.875 - 0.1168) \cdot 1 \cdot 0.875 \\ &= 3.3171 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} A_{41} &= \text{Leg}^2 \cdot f_{r2} \\ &= 0.375^2 \cdot 1 \\ &= \underline{0.1406} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_{41} \\ &= 3.1938 + 3.3171 + 0.1406 \\ &= \underline{6.6515} \text{ in}^2 \end{aligned}$$

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.

$$\begin{aligned} t_{a \text{ UG-27}} &= P * R / (S * E - 0.6 * P) + \text{Corrosion} \\ &= 1,378 * 1.625 / (20,000 * 1 - 0.6 * 1,378) + 0.125 \\ &= 0.2418 \text{ in} \end{aligned}$$

$$t_{a \text{ UG-22}} = 0.2384 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.2418, 0.2384 ] \\ &= 0.2418 \text{ in} \end{aligned}$$

$$t_{b1} = 2.2035 \text{ in}$$

$$\begin{aligned} t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 2.2035, 0.1875 ] \\ &= 2.2035 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.3508, 2.2035 ] \\ &= 0.3508 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.2418, 0.3508 ] \\ &= 0.3508 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1 \text{ in}$

The nozzle neck thickness is adequate.



## Applied Loads

Radial load:  $P_r = 642 \text{ lb}_f$   
Circumferential moment:  $M_1 = 8,629 \text{ lb}_f\text{-in}$   
Circumferential shear:  $V_2 = 787 \text{ lb}_f$   
Longitudinal moment:  $M_2 = 8,629 \text{ lb}_f\text{-in}$   
Longitudinal shear:  $V_1 = 787 \text{ lb}_f$   
Torsion moment:  $M_t = 12,214 \text{ lb}_f\text{-in}$   
Internal pressure:  $P = 1,378 \text{ psi}$   
Head yield stress:  $S_y = 36,200 \text{ psi}$

### Maximum stresses due to the applied loads at the nozzle OD (includes pressure)

Mean dish radius  $R_m = 55.578 \text{ in}$

$U = r_o / \text{Sqr}(R_m * t) = 0.218$

Pressure stress intensity factor,  $I = 1$  (derived from PVP-Vol. 399, pages 77-82)

Local pressure stress =  $I * P * R_i / (2 * t) = 15,840 \text{ psi}$

Maximum combined stress ( $P_L + P_b + Q$ ) =  $16,538 \text{ psi}$

Allowable combined stress ( $P_L + P_b + Q$ ) =  $\pm 3 * S = \pm 60,000 \text{ psi}$

The maximum combined stress ( $P_L + P_b + Q$ ) is within allowable limits.

Maximum local primary membrane stress ( $P_L$ ) =  $15,839 \text{ psi}$

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	A <sub>u</sub>	A <sub>i</sub>	B <sub>u</sub>	B <sub>i</sub>	C <sub>u</sub>	C <sub>i</sub>	D <sub>u</sub>	D <sub>i</sub>
SR-2*	0.2178	-25	-25	-25	-25	-25	-25	-25	-25
SR-2	0.1824	-126	126	-126	126	-126	126	-126	126
SR-3*	0.1614	0	0	0	0	-22	-22	22	22
SR-3	0.6952	0	0	0	0	-561	561	561	-561
SR-3*	0.1614	-22	-22	22	22	0	0	0	0
SR-3	0.6952	-561	561	561	-561	0	0	0	0
Pressure stress*		15,840	15,840	15,840	15,840	15,840	15,840	15,840	15,840
Total O <sub>x</sub> stress		15,106	16,480	16,272	15,402	15,106	16,480	16,272	15,402
Membrane O <sub>x</sub> stress*		15,793	15,793	15,837	15,837	15,793	15,793	15,837	15,837
SR-2*	0.0675	-8	-8	-8	-8	-8	-8	-8	-8
SR-2	0.0544	-37	37	-37	37	-37	37	-37	37
SR-3*	0.0487	0	0	0	0	-7	-7	7	7
SR-3	0.202	0	0	0	0	-163	163	163	-163
SR-3*	0.0487	-7	-7	7	7	0	0	0	0
SR-3	0.202	-163	163	163	-163	0	0	0	0
Pressure stress*		15,840	15,840	15,840	15,840	15,840	15,840	15,840	15,840
Total O <sub>y</sub> stress		15,625	16,025	15,965	15,713	15,625	16,025	15,965	15,713
Membrane O <sub>y</sub> stress*		15,825	15,825	15,839	15,839	15,825	15,825	15,839	15,839
Shear from M <sub>i</sub>		131	131	131	131	131	131	131	131
Shear from V <sub>1</sub>		0	0	0	0	-42	-42	42	42
Shear from V <sub>2</sub>		42	42	-42	-42	0	0	0	0
Total Shear stress		173	173	89	89	89	89	173	173
Combined stress (P <sub>L</sub> +P <sub>b</sub> +Q)		15,677	16,538	16,296	15,737	15,640	16,497	16,350	15,790

Notes: (1) \* denotes primary stress.

(2) The nozzle is assumed to be a rigid (solid) attachment.

### Longitudinal stress in the nozzle wall due to internal pressure + external loads

$$\begin{aligned}\sigma_{n(P_m)} &= P \cdot R_i / (2 \cdot t_n) - P_r / (\pi \cdot (R_o^2 - R_i^2)) + M \cdot R_o / I \\ &= 1,378 \cdot 1.625 / (2 \cdot 0.875) - 642 / (\pi \cdot (2.5^2 - 1.625^2)) + 12,203.2 \cdot 2.5 / 25.2031 \\ &= 2,433 \text{ psi}\end{aligned}$$

The average primary stress P<sub>m</sub> (see Division 2 5.6.a.1) across the nozzle wall due to internal pressure + external loads is acceptable ( ≤ S = 20,000 psi)

### Shear stress in the nozzle wall due to external loads

$$\begin{aligned}\sigma_{\text{shear}} &= (V_L^2 + V_C^2)^{0.5} / (\pi \cdot R_i \cdot t_n) \\ &= (787^2 + 787^2)^{0.5} / (\pi \cdot 1.625 \cdot 0.875) \\ &= 249 \text{ psi}\end{aligned}$$

$$\begin{aligned}\sigma_{\text{torsion}} &= M_t / (2 \cdot \pi \cdot R_i^2 \cdot t_n) \\ &= 12,214 / (2 \cdot \pi \cdot 1.625^2 \cdot 0.875) \\ &= 841 \text{ psi}\end{aligned}$$

$$\begin{aligned}\sigma_{\text{total}} &= \sigma_{\text{shear}} + \sigma_{\text{torsion}} \\ &= 249 + 841 \\ &= 1,090 \text{ psi}\end{aligned}$$

UG-45: The total combined shear stress (1,090 psi) is below than the allowable ( $0.7 \cdot S_n = 0.7 \cdot 20,000 = 14,000$  psi)

## Reinforcement Calculations for MAEP

<b>UG-37 Area Calculation Summary (in<sup>2</sup>)</b> For $P_e = 718.17 \text{ psi @ } 140 \text{ }^\circ\text{F}$ The opening is adequately reinforced							<b>UG-45 Nozzle Wall Thickness Summary (in)</b> The nozzle passes UG-45	
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
3.9146	3.9146	0.6438	3.1302	--	--	0.1406	0.3508	1

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	<u>0.25</u>	0.2625	weld size is adequate

Calculations for external pressure 718.17 psi @ 140 °F

### Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(3.454, 1.727 + (1 - 0.125) + (2.491 - 0.125)) \\
 &= 4.968 \text{ in}
 \end{aligned}$$

### Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(2.491 - 0.125), 2.5*(1 - 0.125) + 0) \\
 &= 2.1875 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28  $t_{rn} = 0.1595 \text{ in}$

From UG-37(d)(1) required thickness  $t_r = 2.2667 \text{ in}$

### Area required per UG-37(d)(1)

Allowable stresses:  $S_n = 20,000$ ,  $S_v = 20,000 \text{ psi}$

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$A = 0.5*(d*t_r*F + 2*t_n*t_r*F*(1 - f_{r1}))$$

$$= 0.5*(3.454*2.2667*1 + 2*0.875*2.2667*1*(1 - 1))$$

$$= \underline{3.9146} \text{ in}^2$$

#### Area available from FIG. UG-37.1

$$A_1 = \text{larger of the following} = \underline{0.6438} \text{ in}^2$$

$$= d*(E_1*t - F*t_r) - 2*t_n*(E_1*t - F*t_r)*(1 - f_{r1})$$

$$= 3.454*(1*2.366 - 1*2.2667) - 2*0.875*(1*2.366 - 1*2.2667)*(1 - 1)$$

$$= 0.3431 \text{ in}^2$$

$$= 2*(t + t_n)*(E_1*t - F*t_r) - 2*t_n*(E_1*t - F*t_r)*(1 - f_{r1})$$

$$= 2*(2.366 + 0.875)*(1*2.366 - 1*2.2667) - 2*0.875*(1*2.366 - 1*2.2667)*(1 - 1)$$

$$= 0.6438 \text{ in}^2$$

$$A_2 = \text{smaller of the following} = \underline{3.1302} \text{ in}^2$$

$$= 2*(t_n - t_m)*f_{r2}*L_{pr}$$

$$= 2*(0.875 - 0.1595)*1*5.3776$$

$$= 7.6951 \text{ in}^2$$

$$= 5*(t_n - t_m)*f_{r2}*t_n$$

$$= 5*(0.875 - 0.1595)*1*0.875$$

$$= 3.1302 \text{ in}^2$$

$$A_{41} = \text{Leg}^2*f_{r2}$$

$$= 0.375^2*1$$

$$= \underline{0.1406} \text{ in}^2$$

$$\text{Area} = A_1 + A_2 + A_{41}$$

$$= 0.6438 + 3.1302 + 0.1406$$

$$= \underline{3.9146} \text{ in}^2$$

As Area  $\geq$  A the reinforcement is adequate.

#### UW-16(c) Weld Check

Fillet weld:  $t_{\min}$  = lesser of 0.75 or  $t_n$  or  $t = 0.75$  in

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

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

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

Interpretation VIII-1-83-66 has been applied.

$$t_{a \text{ UG-28}} = 0.2845 \text{ in}$$

$$t_{a \text{ UG-22}} = 0.2031 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.2845, 0.2031 ] \\ &= 0.2845 \text{ in} \end{aligned}$$

$$t_{b2} = 1.2047 \text{ in}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2}, t_{b \text{ UG16}} ] \\ &= \max[ 1.2047, 0.1875 ] \\ &= 1.2047 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b2} ] \\ &= \min[ 0.3508, 1.2047 ] \\ &= 0.3508 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.2845, 0.3508 ] \\ &= 0.3508 \text{ in} \end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1 \text{ in}$

The nozzle neck thickness is adequate.

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

$$L / D_o = 8.93 / 5 = 1.7860$$

$$D_o / t = 5 / 0.1595 = 31.3435$$

From table G:  $A = 0.004190$

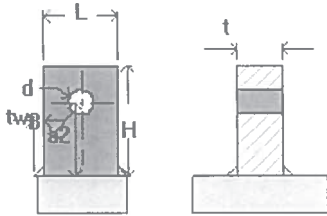
From table  
CS-2:  $B = 16,882.5165 \text{ psi}$

$$\begin{aligned} P_a &= 4*B / (3*(D_o / t)) \\ &= 4*16,882.52 / (3*(5 / 0.1595)) \\ &= 718.17 \text{ psi} \end{aligned}$$

**Design thickness for external pressure  $P_a = 718.17 \text{ psi}$**

$$t_a = t + \text{Corrosion} = 0.1595 + 0.125 = 0.2845''$$

## Lifting Lug #1



### Geometry Inputs

Attached To	60 ID TOP SE HEAD
Material	A36
Orientation	Longitudinal
Distance of Lift Point From Datum	-15"
Angular Position	135.00 °
Length of Lug, L	5"
Height of Lug, H	7.5"
Thickness of Lug, t	1.5"
Hole Diameter, d	1.5625"
Pin Diameter, D <sub>p</sub>	1.5"
Load Eccentricity, a <sub>1</sub>	0"
Distance from Load to Shell or Pad, a <sub>2</sub>	5"
Weld Size, t <sub>w</sub>	0.75"
Load Angle Normal to Vessel, β	139.0635 °
Load Angle from Vertical, φ	98.1270 °

### Intermediate Values

Load Factor	1.5000
Vessel Weight (new, incl. Load Factor), W	43247 lb
Lug Weight (new), $W_{lug}$	16 lb
Distance from Center of Gravity to Top Lug, $l_1$	67.5931"
Distance from Center of Gravity to Tail Lug, $l_2$	70.6144"
Distance from Vessel Center Line to Tail Lug, $l_3$	36.625"
Allowable Stress, Tensile, $\sigma_t$	19980 psi
Allowable Stress, Shear, $\sigma_s$	13320 psi
Allowable Stress, Bearing, $\sigma_p$	29970 psi
Allowable Stress, Bending, $\sigma_b$	22201 psi
Allowable Stress, Weld Shear, $\tau_{allowable}$	13320 psi
Allowable Stress set to 1/3 Sy per ASME B30.20	No

### Summary Values

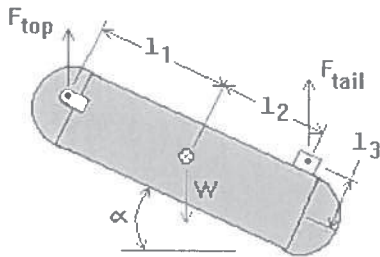
Required Lift Pin Diameter, $d_{reqd}$	1.0166"
Required Lug Thickness, $t_{reqd}$	0.481"
Lug Stress Ratio, $\sigma_{ratio}$	0.4
Weld Shear Stress Ratio, $\tau_{ratio}$	0.48
Lug Design	Acceptable
Local Stresses	Acceptable

### Lift Forces

Lift force on lugs during rotational lift ( $0^\circ \leq \alpha \leq 90^\circ$ ):

$$2 * F_{top} = W * (l_2 * \cos(\alpha) + l_3 * \sin(\alpha)) / (l_1 * \cos(\alpha) + l_2 * \cos(\alpha) + l_3 * \sin(\alpha))$$

$$F_{tail} = W - (2 * F)$$



$\alpha$ [°]	$F_{top}$ [lbf]	$F_{tail}$ [lbf]
0	11,048	21,151
15	11,749	19,749
30	12,451	18,344
45	13,264	16,720
60	14,375	14,497
75	16,307	10,634
90	21,624	0
90 <sup>1</sup>	21,624	0
90 <sup>2</sup>	21,624	0
<sup>1</sup> Lift angle at maximum lug stress.		
<sup>2</sup> Lift angle at maximum weld stress.		
Shell angle at lift lug	229.06°	

### Lug Pin Diameter - Shear stress

$$d_{reqd} = (2F_r / (\pi\sigma_s))^{0.5}$$

$$= (2*21,624 / (\pi*13,320))^{0.5} = \underline{1.0166"}$$

$$d_{reqd} / D_p = 1.0166 / 1.5 = 0.68 \quad \text{Acceptable}$$

$$\sigma = F_r / A$$

$$= F_r / (2*(0.25*\pi*D_p^2))$$

$$= 21,624 / (2*(0.25*\pi*1.5^2)) = 6,118 \text{ psi}$$

$$\sigma / \sigma_s = 6,118 / 13,320 = 0.46 \quad \text{Acceptable}$$

### Lug Thickness - Tensile stress

$$t_{reqd} = F_r / ((L - d)*\sigma_t)$$

$$= 21,624 / ((5 - 1.5625)*19,980) = 0.3148"$$

$$t_{reqd} / t = 0.3148 / 1.5 = 0.21 \quad \text{Acceptable}$$

$$\sigma = F_r / A$$

$$= F_r / ((L - d)*t)$$

$$= 21,624 / ((5 - 1.5625)*1.5) = 4,194 \text{ psi}$$

$$\sigma / \sigma_t = 4,194 / 19,980 = 0.21 \quad \text{Acceptable}$$

### Lug Thickness - Bearing stress

$$t_{reqd} = F_v / (D_p*\sigma_p)$$

$$= 21,624 / (1.5*29,970) = \underline{0.481"}$$

$$t_{reqd} / t = 0.481 / 1.5 = 0.32 \quad \text{Acceptable}$$

$$\begin{aligned} \sigma &= F_v / A_{bearing} \\ &= F_v / (D_p * t) \\ &= 21,624 / (1.5 * (1.5)) = 9,610 \text{ psi} \end{aligned}$$

$$\sigma / \sigma_p = 9,610 / 29,970 = 0.32 \quad \text{Acceptable}$$

### Lug Thickness - Shear stress

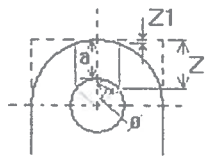
$$\begin{aligned} t_{reqd} &= [F_v / \sigma_s] / (2 * L_{shear}) \\ &= (21,624 / 13,320) / (2 * 2.0153) = \underline{0.4028"} \end{aligned}$$

$$t_{reqd} / t = 0.4028 / 1.5 = 0.27 \quad \text{Acceptable}$$

$$\begin{aligned} \tau &= F_v / A_{shear} \\ &= F_v / (2 * t * L_{shear}) \\ &= 21,624 / (2 * 1.5 * 2.0153) = 3,577 \text{ psi} \end{aligned}$$

$$\tau / \sigma_s = 3,577 / 13,320 = 0.27 \quad \text{Acceptable}$$

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



$$\begin{aligned} \phi &= 55 * D_p / d \\ &= 55 * 1.5 / 1.5625 \\ &= 52.8^\circ \end{aligned}$$

$$\begin{aligned} L_{shear} &= (H - a_2 - 0.5 * d) + 0.5 * D_p * (1 - \cos(\phi)) \\ &= (7.5 - 5 - 0.5 * 1.5625) + 0.5 * 1.5 * (1 - \cos(52.8)) \\ &= 2.0153" \end{aligned}$$

### Lug Plate Stress

Lug stress tensile + bending during lift:

$$\begin{aligned} \sigma_{ratio} &= [F_{ten} / (A_{ten} * \sigma_t)] + [M_{bend} / (Z_{bend} * \sigma_b)] \leq 1 \\ &= [(F_r * \cos(\alpha)) / (t * L * \sigma_t)] + [(6 * \text{abs}(F_r * \sin(\alpha) * \text{Hght} - F_r * \cos(\alpha) * a_1)) / (t * L^2 * \sigma_b)] \leq 1 \\ &= (21,624 * \cos(139.1)) / (1.5 * 5 * 19,980) + (6 * \text{abs}(21,624 * \sin(139.1) * 5 - 21,624 * \cos(139.1) * 0)) / (1.5 * 5^2 * 22,201) \\ &= \underline{0.40} \quad \text{Acceptable} \end{aligned}$$



## Weld Stress

Weld stress, tensile, bending and shear during lift:

Direct shear:

Shear stress at lift angle 139.06°; lift force = 21,624 lbf

$$A_{\text{weld}} = 2 \cdot (0.707) \cdot t_w \cdot (L + t)$$

$$= 2 \cdot (0.707) \cdot 0.75 \cdot (5 + 1.5) = 6.8933 \text{ in}^2$$

$$\tau_t = F_r \cdot \cos(\alpha) / A_{\text{weld}}$$

$$= 21,624 \cdot \cos(139.1) / 6.8933 = -2,370 \text{ psi}$$

$$\tau_s = F_r \cdot \sin(\alpha) / A_{\text{weld}}$$

$$= 21,624 \cdot \sin(139.1) / 6.8933 = 2,055 \text{ psi}$$

$$\tau_b = M \cdot c / I$$

$$= \frac{3 \cdot (F_r \cdot \sin(\alpha) \cdot \text{Hght} - F_r \cdot \cos(\alpha) \cdot a_1)}{(0.707 \cdot h \cdot L \cdot (3 \cdot t + L))}$$

$$= \frac{3 \cdot \text{abs}(21,624 \cdot \sin(139.1) \cdot 5 - 21,624 \cdot \cos(139.1) \cdot (0))}{(25.1869)}$$

$$= 8,438 \text{ psi}$$

$$\tau_{\text{ratio}} = \text{sqr}((\tau_t + \tau_b)^2 + \tau_s^2) / \tau_{\text{allowable}} \leq 1$$

$$= \text{sqr}((-2,370 + 8,438)^2 + (2,055)^2) / 13,320$$

$$= 0.48 \quad \text{Acceptable}$$

## EN 13445 Lift Lug Procedure

### Geometry Inputs - EN13445

Nominal Vessel Thickness, $e_n$	2.491"
Pad Thickness, $e_2$	0"
Length of Lug, $b_1$	5"
Width of Pad, $b_2$	0"
Length of Pad, $b_3$	0"

### Intermediate Values - EN13445

Equivalent Diameter of Vessel at Lug, $ID_{\text{eq}}$	36.2456"
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, $F_r$	<u>21.624 lbf</u>
Maximum Allowable Load, $F_{Rmax}$	<u>135.388 lbf</u>
Load Acceptance Ratio, $F_R / F_{Rmax}$	<b>0.1597</b>
Lug Design	Acceptable

### Equivalent Inner Diameter

$$ID_{eq} = D_i \cdot \sqrt{1 - 3 \cdot (x / D_i)^2}$$

$$ID_{eq} = 60 \cdot \sqrt{1 - 3 \cdot (27.6059 / 60)^2}$$

$$ID_{eq} = 36.2456''$$

where 'x' is the distance between the axis of semi-ellipsoidal head and the center of the lug

### Applied Force

$F_r$  = force on vessel at lug

$$F_r = [W / \cos(\phi_1)] \cdot (1 - x_1 / (x_1 + x_2))$$

$$= (43,247) / \cos(98.1270) \cdot (1 - 0 / (0 + 0))$$

$$= \underline{21.624 \text{ lbf}}$$

where ' $x_1$ ' is the distance between this lug and the center of gravity

' $x_2$ ' is the distance between the second lift lug and the center of gravity

### Lug factors

$\lambda$  = line load factor

$$\lambda = b / \sqrt{ID_{eq} \cdot e_n}$$

$$= 5 / \sqrt{36.2456 \cdot 2.491}$$

$$= 0.526$$

$v_1$  = ratio between local membrane stress and local bending stress

$$v_1 = \min(0.08 \cdot \lambda, 0.2)$$

$$= 0.042$$

$\sigma_m$  = global membrane stress

$$\sigma_m = P \cdot ID_{eq} / (2 \cdot e_n)$$

$$= 0 \cdot 36.2456 / (2 \cdot 2.491)$$

$$= 0.0000 \text{ psi}$$

$v_2$  = ratio between global membrane stress and allowable stress

$$v_2 = \sigma_m / (K_2 \cdot f)$$

$$= 0 / (1.25 \cdot 20,000)$$

$$= 0$$

$$K_{13} = 1 / (1.2 \cdot \sqrt{1 + 0.06 \cdot \lambda^2})$$

$$= 1 / (1.2 \cdot \sqrt{1 + 0.06 \cdot 0.526^2})$$

$$= 0.8265$$

$$\begin{aligned} K_{14} &= 1 / (0.6 * \text{sqr}(1 + 0.03 * \lambda^2)) \\ &= 1 / (0.6 * \text{sqr}(1 + 0.03 * 0.5262^2)) \\ &= 1.6598 \end{aligned}$$

### Bending Limit Stress

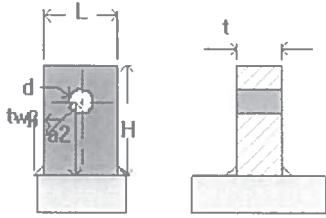
$$\begin{aligned} K_1 &= (1 - v_2^2) / ( (1/3 + v_1 * v_2) + \text{sqr}( (1/3 + v_1 * v_2)^2 + (1 - v_2^2) * v_1^2 ) ) \\ &= (1 - 0^2) / ( (1/3 + 0.0421 * 0) + \text{sqr}( (1/3 + 0.0421 * 0)^2 + (1 - 0^2) * 0.0421^2 ) ) \\ &= 1.4941 \end{aligned}$$

$$\begin{aligned} \sigma_b &= K_1 * K_2 * f \\ &= 1.4941 * 1.25 * 20,000 \\ &= 37,352 \text{ psi} \end{aligned}$$

### Maximum Allowable Load

$$\begin{aligned} F_{Rmax} &= \sigma_b * e_n^2 / (K_{13} * |\cos(\beta)| + K_{14} * |a_2 * \sin(\beta) - a_1 * \cos(\beta)| / b_1) \\ &= 37,352 * (2.491)^2 / (0.8265 * |\cos(139.0635)| + 1.6598 * |5 * \sin(139.0635) - 0 * \cos(139.0635)| / 5) \\ &= \underline{135,388 \text{ lbf}} \end{aligned}$$

## Lifting Lug #2



### Geometry Inputs

Attached To	60 ID TOP SE HEAD
Material	A36
Orientation	Longitudinal
Distance of Lift Point From Datum	-13.5"
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, D <sub>p</sub>	1.5"
Load Eccentricity, a <sub>1</sub>	0"
Distance from Load to Shell or Pad, a <sub>2</sub>	5"
Weld Size, t <sub>w</sub>	0.75"
Load Angle Normal to Vessel, β	133.8604 °
Load Angle from Vertical, φ	87.7207 °

### Intermediate Values

Load Factor	1.5000
Vessel Weight (new, incl. Load Factor), W	43247 lb
Lug Weight (new), $W_{lug}$	16 lb
Distance from Center of Gravity to Top Lug, $l_1$	67.5931"
Distance from Center of Gravity to Tail Lug, $l_2$	70.6144"
Distance from Vessel Center Line to Tail Lug, $l_3$	36.625"
Allowable Stress, Tensile, $\sigma_t$	19980 psi
Allowable Stress, Shear, $\sigma_s$	13320 psi
Allowable Stress, Bearing, $\sigma_p$	29970 psi
Allowable Stress, Bending, $\sigma_b$	22201 psi
Allowable Stress, Weld Shear, $\tau_{allowable}$	13320 psi
Allowable Stress set to 1/3 Sy per ASME B30.20	No

### Summary Values

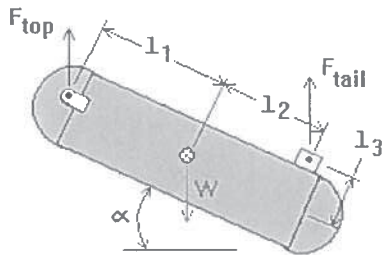
Required Lift Pin Diameter, $d_{reqd}$	1.0166"
Required Lug Thickness, $t_{reqd}$	0.481"
Lug Stress Ratio, $\sigma_{ratio}$	0.46
Weld Shear Stress Ratio, $\tau_{ratio}$	0.56
Lug Design	Acceptable
Local Stresses	Acceptable

### Lift Forces

Lift force on lugs during rotational lift ( $0^\circ \leq \alpha \leq 90^\circ$ ):

$$2 * F_{top} = W * (l_2 * \cos(\alpha) + l_3 * \sin(\alpha)) / (l_1 * \cos(\alpha) + l_2 * \cos(\alpha) + l_3 * \sin(\alpha))$$

$$F_{tail} = W - (2 * F)$$





$\alpha$ [°]	$F_{top}$ [lbf]	$F_{tail}$ [lbf]
0	11,048	21,151
15	11,749	19,749
30	12,451	18,344
45	13,264	16,720
60	14,375	14,497
75	16,307	10,634
90	21,624	0
90 <sup>1</sup>	21,624	0
90 <sup>2</sup>	21,624	0
<sup>1</sup> Lift angle at maximum lug stress.		
<sup>2</sup> Lift angle at maximum weld stress.		
Shell angle at lift lug	223.86°	

### Lug Pin Diameter - Shear stress

$$d_{reqd} = (2F_r / (\pi\sigma_s))^{0.5}$$

$$= (2 \cdot 21,624 / (\pi \cdot 13,320))^{0.5} = \underline{1.0166"}$$

$$d_{reqd} / D_p = 1.0166 / 1.5 = 0.68 \quad \text{Acceptable}$$

$$\sigma = F_r / A$$

$$= F_r / (2 \cdot (0.25 \cdot \pi \cdot D_p^2))$$

$$= 21,624 / (2 \cdot (0.25 \cdot \pi \cdot 1.5^2)) = 6,118 \text{ psi}$$

$$\sigma / \sigma_s = 6,118 / 13,320 = 0.46 \quad \text{Acceptable}$$

### Lug Thickness - Tensile stress

$$t_{reqd} = F_r / ((L - d) \cdot \sigma_t)$$

$$= 21,624 / ((5 - 1.5625) \cdot 19,980) = 0.3148"$$

$$t_{reqd} / t = 0.3148 / 1.5 = 0.21 \quad \text{Acceptable}$$

$$\sigma = F_r / A$$

$$= F_r / ((L - d) \cdot t)$$

$$= 21,624 / ((5 - 1.5625) \cdot 1.5) = 4,194 \text{ psi}$$

$$\sigma / \sigma_t = 4,194 / 19,980 = 0.21 \quad \text{Acceptable}$$

### Lug Thickness - Bearing stress

$$t_{reqd} = F_v / (D_p \cdot \sigma_p)$$

$$= 21,624 / (1.5 \cdot 29,970) = \underline{0.481"}$$

$$t_{\text{reqd}} / t = 0.481 / 1.5 = 0.32 \quad \text{Acceptable}$$

$$\begin{aligned} \sigma &= F_v / A_{\text{bearing}} \\ &= F_v / (D_p * t) \\ &= 21,624 / (1.5 * 1.5) = 9,610 \text{ psi} \end{aligned}$$

$$\sigma / \sigma_p = 9,610 / 29,970 = 0.32 \quad \text{Acceptable}$$

### Lug Thickness - Shear stress

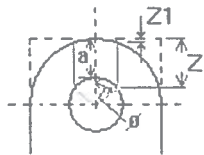
$$\begin{aligned} t_{\text{reqd}} &= [F_v / \sigma_s] / (2 * L_{\text{shear}}) \\ &= (21,624 / 13,320) / (2 * 2.0153) = \underline{0.4028"} \end{aligned}$$

$$t_{\text{reqd}} / t = 0.4028 / 1.5 = 0.27 \quad \text{Acceptable}$$

$$\begin{aligned} \tau &= F_v / A_{\text{shear}} \\ &= F_v / (2 * t * L_{\text{shear}}) \\ &= 21,624 / (2 * 1.5 * 2.0153) = 3,577 \text{ psi} \end{aligned}$$

$$\tau / \sigma_s = 3,577 / 13,320 = 0.27 \quad \text{Acceptable}$$

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



$$\begin{aligned} \phi &= 55 * D_p / d \\ &= 55 * 1.5 / 1.5625 \\ &= 52.8^\circ \end{aligned}$$

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

### Lug Plate Stress

Lug stress tensile + bending during lift:

$$\begin{aligned} \sigma_{\text{ratio}} &= [F_{\text{ten}} / (A_{\text{ten}} * \sigma_t)] + [M_{\text{bend}} / (Z_{\text{bend}} * \sigma_b)] \leq 1 \\ &= [(F_r * \cos(\alpha)) / (t * L * \sigma_t)] + [(6 * \text{abs}(F_r * \sin(\alpha) * \text{Hght} - F_r * \cos(\alpha) * a_r)) / (t * L^2 * \sigma_b)] \leq 1 \\ &= 21,624 * \cos(133.9) / (1.5 * 5 * 19,980) + 6 * \text{abs}(21,624 * \sin(133.9) * 5 - 21,624 * \cos(133.9) * 0) / (1.5 * 5^2 * 22,201) \\ &= \underline{0.46} \quad \text{Acceptable} \end{aligned}$$

## Weld Stress

Weld stress, tensile, bending and shear during lift:

Direct shear:

Shear stress at lift angle 133.86°; lift force = 21,624 lbf

$$A_{\text{weld}} = 2 \cdot (0.707) \cdot t_w \cdot (L + t)$$

$$= 2 \cdot (0.707) \cdot 0.75 \cdot (5 + 1.5) = 6.8933 \text{ in}^2$$

$$\tau_t = F_r \cdot \cos(\alpha) / A_{\text{weld}}$$

$$= 21,624 \cdot \cos(133.9) / 6.8933 = -2,174 \text{ psi}$$

$$\tau_s = F_r \cdot \sin(\alpha) / A_{\text{weld}}$$

$$= 21,624 \cdot \sin(133.9) / 6.8933 = 2,262 \text{ psi}$$

$$\tau_b = \frac{M \cdot c}{I}$$

$$= \frac{3 \cdot (F_r \cdot \sin(\alpha) \cdot \text{Hght} - F_r \cdot \cos(\alpha) \cdot a_1)}{(0.707 \cdot h \cdot L \cdot (3 \cdot t + L))}$$

$$= \frac{3 \cdot \text{abs}(21,624 \cdot \sin(133.9) \cdot 5 - 21,624 \cdot \cos(133.9) \cdot (0))}{(25.1869)}$$

$$= 9,285 \text{ psi}$$

$$\tau_{\text{ratio}} = \frac{\text{sqr}((\tau_t + \tau_b)^2 + \tau_s^2)}{\tau_{\text{allowable}}} \leq 1$$

$$= \frac{\text{sqr}((-2,174 + 9,285)^2 + (2,262)^2)}{13,320}$$

$$= \underline{0.56} \quad \text{Acceptable}$$

## EN 13445 Lift Lug Procedure

### Geometry Inputs - EN13445

Nominal Vessel Thickness, $e_n$	2.491"
Pad Thickness, $e_2$	0"
Length of Lug, $b_1$	5"
Width of Pad, $b_2$	0"
Length of Pad, $b_3$	0"

### Intermediate Values - EN13445

Equivalent Diameter of Vessel at Lug, $ID_{\text{eq}}$	<u>33.1911"</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, $F_r$	21.624 lbf
Maximum Allowable Load, $F_{Rmax}$	131.003 lbf
Load Acceptance Ratio, $F_R / F_{Rmax}$	0.1651
Lug Design	Acceptable

### Equivalent Inner Diameter

$$ID_{eq} = D_i \cdot \sqrt{1 - 3 \cdot (x / D_i)^2}$$

$$ID_{eq} = 60 \cdot \sqrt{1 - 3 \cdot (28.858 / 60)^2}$$

$$ID_{eq} = 33.1911''$$

where 'x' is the distance between the axis of semi-ellipsoidal head and the center of the lug

### Applied Force

$$F_r = \text{force on vessel at lug}$$

$$F_r = [W / \cos(\phi_1)] \cdot (1 - x_1 / (x_1 + x_2))$$

$$= (43,247) / \cos(87.7207) \cdot (1 - 0 / (0 + 0))$$

$$= 21.624 \text{ lbf}$$

where 'x<sub>1</sub>' is the distance between this lug and the center of gravity

'x<sub>2</sub>' is the distance between the second lift lug and the center of gravity

### Lug factors

$$\lambda = \text{line load factor}$$

$$\lambda = b / \sqrt{ID_{eq} \cdot e_n}$$

$$= 5 / \sqrt{33.1911 \cdot 2.491}$$

$$= 0.55$$

$$v_1 = \text{ratio between local membrane stress and local bending stress}$$

$$v_1 = \min(0.08 \cdot \lambda, 0.2)$$

$$= 0.044$$

$$\sigma_m = \text{global membrane stress}$$

$$\sigma_m = P \cdot ID_{eq} / (2 \cdot e_n)$$

$$= 0 \cdot 33.1911 / (2 \cdot 2.491)$$

$$= 0.0000 \text{ psi}$$

$$v_2 = \text{ratio between global membrane stress and allowable stress}$$

$$v_2 = \sigma_m / (K_2 \cdot f)$$

$$= 0 / (1.25 \cdot 20,000)$$

$$= 0$$

$$K_{13} = 1 / (1.2 \cdot \sqrt{1 + 0.06 \cdot \lambda^2})$$

$$= 1 / (1.2 \cdot \sqrt{1 + 0.06 \cdot 0.5499^2})$$

$$= 0.8259$$

$$\begin{aligned} K_{14} &= 1 / (0.6 * \text{sqr}(1 + 0.03 * \lambda^2)) \\ &= 1 / (0.6 * \text{sqr}(1 + 0.03 * 0.5499^2)) \\ &= 1.6592 \end{aligned}$$

### Bending Limit Stress

$$\begin{aligned} K_1 &= (1 - v_2^2) / ( (1/3 + v_1 * v_2) + \text{sqr}( (1/3 + v_1 * v_2)^2 + (1 - v_2^2) * v_1^2 ) ) \\ &= (1 - 0^2) / ( (1/3 + 0.044 * 0) + \text{sqr}( (1/3 + 0.044 * 0)^2 + (1 - 0^2) * 0.044^2 ) ) \\ &= 1.4935 \end{aligned}$$

$$\begin{aligned} \sigma_b &= K_1 * K_2 * f \\ &= 1.4935 * 1.25 * 20,000 \\ &= 37,338 \text{ psi} \end{aligned}$$

### Maximum Allowable Load

$$\begin{aligned} F_{Rmax} &= \sigma_b * e_n^2 / (K_{13} * |\cos(\beta)| + K_{14} * |a_2 * \sin(\beta) - a_1 * \cos(\beta)| / b_1) \\ &= 37,338 * (2.491)^2 / (0.8259 * |\cos(133.8604)| + 1.6592 * |5 * \sin(133.8604) - 0 * \cos(133.8604)| / 5) \\ &= \underline{131.003 \text{ lbf}} \end{aligned}$$



## 60 ID SHELL

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

Component: Cylinder  
Material specification: SA-516 70 (II-D p. 18, In. 19)  
Material is impact tested per UG-84 to -20 °F  
UCS-66(i) reduction of 8.6 °F applied (ratio = 0.9144).

Internal design pressure:  $P = 1,378$  psi @ 140 °F  
External design pressure:  $P_e = 15$  psi @ 140 °F

#### Static liquid head:

$P_s = 4.07$  psi (SG = 1.1,  $H_s = 102.5$ ", Operating head)  
 $P_{th} = 2.54$  psi (SG = 1,  $H_s = 70.5$ ", Horizontal test head)

Corrosion allowance Inner C = 0.125" Outer C = 0"

Design MDMT = -20 °F Impact test performed  
Rated MDMT = -28.6 °F Material is normalized  
Material is not produced to Fine Grain Practice  
PWHT is 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 = 12,445.3 lb corr = 11,848.4 lb  
Capacity New = 1,175.04 US gal corr = 1,184.85 US gal

ID = 60"  
Length = 96"  
 $L_c$   
t = 2.5"

#### Design thickness, (at 140 °F) UG-27(c)(1)

$t = P \cdot R / (S \cdot E - 0.60 \cdot P) + \text{Corrosion}$   
 $= 1,382.07 \cdot 30.125 / (20,000 \cdot 1.00 - 0.60 \cdot 1,382.07) + 0.125$   
 $= 2.2968$ "

#### Maximum allowable working pressure, (at 140 °F) UG-27(c)(1)

$P = S \cdot E \cdot t / (R + 0.60 \cdot t) - P_s$   
 $= 20,000 \cdot 1.00 \cdot 2.375 / (30.125 + 0.60 \cdot 2.375) - 4.07$   
 $= 1,501.48$  psi

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

$L / D_o = 110.0833 / 65 = 1.6936$   
 $D_o / t = 65 / 0.261 = 249.0199$   
From table G: A = 0.000195  
From table CS-2: B = 2,801.4783 psi

$$\begin{aligned}
 P_a &= 4*B / (3*(D_o / t)) \\
 &= 4*2,801.48 / (3*(65 / 0.261)) \\
 &= 15 \text{ psi}
 \end{aligned}$$

**Design thickness for external pressure  $P_a = 15$  psi**

$$t_a = t + \text{Corrosion} = 0.261 + 0.125 = 0.386''$$

**Maximum Allowable External Pressure, (Corroded & at 140 °F) UG-28(c)**

$$\begin{aligned}
 L / D_o &= 110.0833 / 65 = 1.6936 \\
 D_o / t &= 65 / 2.375 = 27.3684 \\
 \text{From table G: } A &= 0.005433 \\
 \text{From table CS-2: } B &= 17,220.3969 \text{ psi}
 \end{aligned}$$

$$\begin{aligned}
 P_a &= 4*B / (3*(D_o / t)) \\
 &= 4*17,220.4 / (3*(65 / 2.375)) \\
 &= 838.94 \text{ psi}
 \end{aligned}$$

**% Extreme fiber elongation - UCS-79(d)**

$$\begin{aligned}
 \text{EFE} &= (50*t / R_f) * (1 - R_f / R_o) \\
 &= (50*2.5 / 31.25) * (1 - 31.25 / \infty) \\
 &= 4\%
 \end{aligned}$$

The extreme fiber elongation does not exceed 5%.

**External Pressure + Weight + Wind Loading Check (Bergman, ASME paper 54-A-104)**

$$\begin{aligned}
 P_v &= W / (2*\pi*R_m) + M / (\pi*R_m^2) \\
 &= 22,922.1 / (2*\pi*31.3125) + 311,627 / (\pi*31.3125^2) \\
 &= 217.6776 \text{ lb/in} \\
 \alpha &= P_v / (P_e * D_o) \\
 &= 217.6776 / (15*65) \\
 &= 0.2233 \\
 n &= 3 \\
 m &= 1.23 / (L / D_o)^2 \\
 &= 1.23 / (110.0833 / 65)^2 \\
 &= 0.4288 \\
 \text{Ratio } P_e &= (n^2 - 1 + m + m*\alpha) / (n^2 - 1 + m) \\
 &= (3^2 - 1 + 0.4288 + 0.4288*0.2233) / (3^2 - 1 + 0.4288) \\
 &= 1.0114
 \end{aligned}$$

Ratio  $P_e * P_e \leq$  MAEP design cylinder thickness is satisfactory.

**External Pressure + Weight + Seismic Loading Check (Bergman, ASME paper 54-A-104)**

$$\begin{aligned}
 P_v &= (1 + V\text{Accel}) * W / (2*\pi*R_m) + M / (\pi*R_m^2) \\
 &= 2.00*22,922.1 / (2*\pi*31.3125) + 1,626,562 / (\pi*31.3125^2) \\
 &= 761.0786 \text{ lb/in}
 \end{aligned}$$

$$\begin{aligned}
 \alpha &= P_v / (P_e * D_o) \\
 &= 761.0786 / (15 * 65) \\
 &= 0.7806 \\
 n &= 3 \\
 m &= 1.23 / (L / D_o)^2 \\
 &= 1.23 / (110.0833 / 65)^2 \\
 &= 0.4288 \\
 \text{Ratio } P_e &= (n^2 - 1 + m + m * \alpha) / (n^2 - 1 + m) \\
 &= (3^2 - 1 + 0.4288 + 0.4288 * 0.7806) / (3^2 - 1 + 0.4288) \\
 &= 1.0397
 \end{aligned}$$

Ratio  $P_e * P_e \leq$  MAEP design cylinder thickness is satisfactory.

**Design thickness = 2.2968"**

The governing condition is due to internal pressure.

The cylinder thickness of 2.5" is adequate.

### Thickness Required Due to Pressure + External Loads

Condition	Pressure P (psi)	Allowable Stress Before UG-23 Stress Increase (psi)		Temperature (°F)	Corrosion C (in)	Load	Req'd Thk Due to Tension (in)	Req'd Thk Due to Compression (in)
		S <sub>t</sub>	S <sub>c</sub>					
<u>Operating, Hot &amp; Corroded</u>	1,378	20,000	<u>17,349</u>	140	0.125	Wind	<u>0.8544</u>	<u>0.846</u>
						Seismic	<u>0.8722</u>	<u>0.8233</u>
<u>Operating, Hot &amp; New</u>	1,378	20,000	<u>17,361</u>	140	0	Wind	<u>0.8507</u>	<u>0.8422</u>
						Seismic	<u>0.869</u>	<u>0.8188</u>
<u>Hot Shut Down, Corroded</u>	0	20,000	<u>17,349</u>	140	0.125	Wind	<u>0.0007</u>	<u>0.0105</u>
						Seismic	<u>0.0171</u>	<u>0.0366</u>
<u>Hot Shut Down, New</u>	0	20,000	<u>17,361</u>	140	0	Wind	<u>0.0009</u>	<u>0.0107</u>
						Seismic	<u>0.0175</u>	<u>0.0377</u>
<u>Empty, Corroded</u>	0	20,000	<u>17,349</u>	70	0.125	Wind	<u>0.0007</u>	<u>0.0105</u>
						Seismic	<u>0.0115</u>	<u>0.0301</u>
<u>Empty, New</u>	0	20,000	<u>17,361</u>	70	0	Wind	<u>0.0009</u>	<u>0.0107</u>
						Seismic	<u>0.012</u>	<u>0.0312</u>
<u>Vacuum</u>	-15	20,000	<u>17,349</u>	140	0.125	Wind	<u>0.0116</u>	<u>0.0213</u>
						Seismic	<u>0.0077</u>	<u>0.0474</u>
<u>Hot Shut Down, Corroded, Weight &amp; Eccentric Moments Only</u>	0	20,000	<u>17,349</u>	140	0.125	Weight	<u>0.0015</u>	<u>0.0119</u>

#### Allowable Compressive Stress, Hot and Corroded- S<sub>CHC</sub>, (table CS-2)

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (32.5 / 2.375) \\
 &= 0.009135 \\
 B &= 17,349 \text{ psi} \\
 S &= 20,000 / 1.00 = 20,000 \text{ psi} \\
 S_{CHC} &= \min(B, S) = \underline{17,349 \text{ psi}}
 \end{aligned}$$

#### Allowable Compressive Stress, Hot and New- S<sub>CHN</sub>, (table CS-2)

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (32.5 / 2.5) \\
 &= 0.009615 \\
 B &= 17,361 \text{ psi} \\
 S &= 20,000 / 1.00 = 20,000 \text{ psi} \\
 S_{CHN} &= \min(B, S) = \underline{17,361 \text{ psi}}
 \end{aligned}$$

#### Allowable Compressive Stress, Cold and New- S<sub>CCN</sub>, (table CS-2)

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (32.5 / 2.5) \\
 &= 0.009615 \\
 B &= 17,361 \text{ psi} \\
 S &= 20,000 / 1.00 = 20,000 \text{ psi} \\
 S_{CCN} &= \min(B, S) = \underline{17,361 \text{ psi}}
 \end{aligned}$$

**Allowable Compressive Stress, Cold and Corroded-  $S_{cCC}$ , (table CS-2)**

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (32.5 / 2.375) \\
 &= 0.009135 \\
 B &= 17,349 \text{ psi} \\
 S &= 20,000 / 1.00 = 20,000 \text{ psi} \\
 S_{cCC} &= \min(B, S) = \underline{17.349 \text{ psi}}
 \end{aligned}$$

**Allowable Compressive Stress, Vacuum and Corroded-  $S_{cVC}$ , (table CS-2)**

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (32.5 / 2.375) \\
 &= 0.009135 \\
 B &= 17,349 \text{ psi} \\
 S &= 20,000 / 1.00 = 20,000 \text{ psi} \\
 S_{cVC} &= \min(B, S) = \underline{17.349 \text{ psi}}
 \end{aligned}$$

**Operating, Hot & Corroded, Wind, Bottom Seam**

$$\begin{aligned}
 t_p &= P \cdot R / (2 \cdot S_t \cdot K_s \cdot E_c + 0.40 \cdot |P|) && \text{(Pressure)} \\
 &= 1,378 \cdot 30.125 / (2 \cdot 20,000 \cdot 1.20 \cdot 1.00 + 0.40 \cdot |1,378|) \\
 &= 0.855"
 \end{aligned}$$

$$\begin{aligned}
 t_m &= M / (\pi \cdot R_m^2 \cdot S_t \cdot K_s \cdot E_c) && \text{(bending)} \\
 &= 311,627 / (\pi \cdot 31.3125^2 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\
 &= 0.0042"
 \end{aligned}$$

$$\begin{aligned}
 t_w &= W / (2 \cdot \pi \cdot R_m \cdot S_t \cdot K_s \cdot E_c) && \text{(Weight)} \\
 &= 22,922.1 / (2 \cdot \pi \cdot 31.3125 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\
 &= 0.0049"
 \end{aligned}$$

$$\begin{aligned}
 t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\
 &= 0.855 + 0.0042 - (0.0049) \\
 &= \underline{0.8544"}
 \end{aligned}$$

$$\begin{aligned}
 t_c &= |t_{mc} + t_{wc} - t_{pc}| && \text{(total, net tensile)} \\
 &= |0.0042 + (0.0049) - (0.855)| \\
 &= \underline{0.846"}
 \end{aligned}$$

**Maximum allowable working pressure, Longitudinal Stress**

$$\begin{aligned}
 P &= 2 \cdot S_t \cdot K_s \cdot E_c \cdot (t - t_m + t_w) / (R - 0.40 \cdot (t - t_m + t_w)) \\
 &= 2 \cdot 20,000 \cdot 1.20 \cdot 1.00 \cdot (2.375 - 0.0042 + (0.0049)) / (30.125 - 0.40 \cdot (2.375 - 0.0042 + (0.0049))) \\
 &= 3,908.54 \text{ psi}
 \end{aligned}$$

**Operating, Hot & New, Wind, Bottom Seam**

$$\begin{aligned}
 t_p &= P \cdot R / (2 \cdot S_t \cdot K_s \cdot E_c + 0.40 \cdot |P|) && \text{(Pressure)} \\
 &= 1,378 \cdot 30 / (2 \cdot 20,000 \cdot 1.20 \cdot 1.00 + 0.40 \cdot |1,378|) \\
 &= 0.8515"
 \end{aligned}$$



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

$$= 314,448 / (\pi 31.25^2 20,000 * 1.20 * 1.00)$$

$$= 0.0043"$$

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

$$= 23,798.4 / (2 \pi 31.25 * 20,000 * 1.20 * 1.00)$$

$$= 0.0051"$$

$$t_t = t_p + t_m - t_w \quad (\text{total required, tensile})$$

$$= 0.8515 + 0.0043 - (0.0051)$$

$$= \underline{0.8507}"$$

$$t_c = |t_{mc} + t_{wc} - t_{pc}| \quad (\text{total, net tensile})$$

$$= |0.0043 + (0.0051) - (0.8515)|$$

$$= \underline{0.8422}"$$

### Maximum allowable working pressure, Longitudinal Stress

$$P = 2 S_t K_s E_c (t - t_m + t_w) / (R - 0.40 (t - t_m + t_w))$$

$$= 2 * 20,000 * 1.20 * 1.00 (2.5 - 0.0043 + (0.0051)) / (30 - 0.40 (2.5 - 0.0043 + (0.0051)))$$

$$= 4,139.27 \text{ psi}$$

### Hot Shut Down, Corroded, Wind, Bottom Seam

$$t_p = 0" \quad (\text{Pressure})$$

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

$$= 311,627 / (\pi 31.3125^2 17,348.7 * 1.20)$$

$$= 0.0049"$$

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

$$= 22,922.1 / (2 \pi 31.3125 * 17,348.7 * 1.20)$$

$$= 0.0056"$$

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

$$= |0 + 0.0049 - (0.0056)|$$

$$= \underline{0.0007}"$$

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

$$= 0.0049 + (0.0056) - (0)$$

$$= \underline{0.0105}"$$

### Hot Shut Down, New, Wind, Bottom Seam

$$t_p = 0" \quad (\text{Pressure})$$

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

$$= 314,448 / (\pi 31.25^2 17,361.41 * 1.20)$$

$$= 0.0049"$$

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

$$= 23,798.4 / (2 \pi 31.25 * 17,361.41 * 1.20)$$

$$= 0.0058"$$

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

$$= |0 + 0.0049 - (0.0058)|$$

$$= \underline{0.0009}"$$

$$\begin{aligned}
 t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\
 &= 0.0049 + (0.0058) - (0) \\
 &= \underline{0.0107"}
 \end{aligned}$$

#### Empty, Corroded, Wind, Bottom Seam

$$\begin{aligned}
 t_p &= 0" && \text{(Pressure)} \\
 t_m &= M / (\pi R_m^2 S_c K_s) && \text{(bending)} \\
 &= 311,627 / (\pi * 31.3125^2 * 17,348.7 * 1.20) \\
 &= 0.0049" \\
 t_w &= W / (2 * \pi R_m S_c K_s) && \text{(Weight)} \\
 &= 22,922.1 / (2 * \pi * 31.3125 * 17,348.7 * 1.20) \\
 &= 0.0056" \\
 t_t &= |t_p + t_m - t_w| && \text{(total, net compressive)} \\
 &= |0 + 0.0049 - (0.0056)| \\
 &= \underline{0.0007"} \\
 t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\
 &= 0.0049 + (0.0056) - (0) \\
 &= \underline{0.0105"}
 \end{aligned}$$

#### Empty, New, Wind, Bottom Seam

$$\begin{aligned}
 t_p &= 0" && \text{(Pressure)} \\
 t_m &= M / (\pi R_m^2 S_c K_s) && \text{(bending)} \\
 &= 314,448 / (\pi * 31.25^2 * 17,361.41 * 1.20) \\
 &= 0.0049" \\
 t_w &= W / (2 * \pi R_m S_c K_s) && \text{(Weight)} \\
 &= 23,798.4 / (2 * \pi * 31.25 * 17,361.41 * 1.20) \\
 &= 0.0058" \\
 t_t &= |t_p + t_m - t_w| && \text{(total, net compressive)} \\
 &= |0 + 0.0049 - (0.0058)| \\
 &= \underline{0.0009"} \\
 t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\
 &= 0.0049 + (0.0058) - (0) \\
 &= \underline{0.0107"}
 \end{aligned}$$

#### Vacuum, Wind, Bottom Seam

$$\begin{aligned}
 t_p &= P * R / (2 * S_c * K_s + 0.40 * |P|) && \text{(Pressure)} \\
 &= -15 * 30.125 / (2 * 17,348.7 * 1.20 + 0.40 * |15|) \\
 &= -0.0109" \\
 t_m &= M / (\pi R_m^2 S_c K_s) && \text{(bending)} \\
 &= 311,627 / (\pi * 31.3125^2 * 17,348.7 * 1.20) \\
 &= 0.0049" \\
 t_w &= W / (2 * \pi R_m S_c K_s) && \text{(Weight)} \\
 &= 22,922.1 / (2 * \pi * 31.3125 * 17,348.7 * 1.20) \\
 &= 0.0056"
 \end{aligned}$$

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

$$= |-0.0109 + 0.0049 - (0.0056)|$$

$$= \underline{0.0116''}$$

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

$$= 0.0049 + (0.0056) - (-0.0109)$$

$$= \underline{0.0213''}$$

### Maximum Allowable External Pressure, Longitudinal Stress

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

$$= 2 * 17,348.7 * 1.20 * (2.375 - 0.0049 - 0.0056) / (30.125 - 0.40 * (2.375 - 0.0049 - 0.0056))$$

$$= 3,374.06 \text{ psi}$$

### Hot Shut Down, Corroded, Weight & Eccentric Moments Only, Bottom Seam

$$t_p = 0'' \quad \text{(Pressure)}$$

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

$$= 276,644 / (\pi * 31.3125^2 * 17,348.7 * 1.00)$$

$$= 0.0052''$$

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

$$= 22,922.1 / (2 * \pi * 31.3125 * 17,348.7 * 1.00)$$

$$= 0.0067''$$

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

$$= |0 + 0.0052 - (0.0067)|$$

$$= \underline{0.0015''}$$

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

$$= 0.0052 + (0.0067) - (0)$$

$$= \underline{0.0119''}$$

### Operating, Hot & Corroded, Seismic, Bottom Seam

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

$$= 1,378 * 30.125 / (2 * 20,000 * 1.20 * 1.00 + 0.40 * |1,378|)$$

$$= 0.855''$$

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

$$= 1,626,562 / (\pi * 31.3125^2 * 20,000 * 1.20 * 1.00)$$

$$= 0.022''$$

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

$$= 22,922.1 / (2 * \pi * 31.3125 * 20,000 * 1.20 * 1.00)$$

$$= 0.0049''$$

$$t_t = t_p + t_m - t_w \quad \text{(total required, tensile)}$$

$$= 0.855 + 0.022 - (0.0049)$$

$$= \underline{0.8722''}$$

$$t_{wc} = (1 + V_{Accel}) * W / (2 * \pi * R_m * S_t * K_s * E_c) \quad \text{(Weight)}$$

$$= 2.00 * 22,922.1 / (2 * \pi * 31.3125 * 20,000 * 1.20 * 1.00)$$

$$= 0.0097''$$

$$t_c = |t_{mc} + t_{wc} - t_{pc}| \quad \text{(total, net tensile)}$$

$$= |0.022 + (0.0097) - (0.855)|$$

$$= \underline{0.8233"}$$

### Maximum allowable working pressure, Longitudinal Stress

$$P = 2 * S_t * K_s * E_c * (t - t_m + t_w) / (R - 0.40 * (t - t_m + t_w))$$

$$= 2 * 20,000 * 1.20 * 1.00 * (2.375 - 0.022 + (0.0049)) / (30.125 - 0.40 * (2.375 - 0.022 + (0.0049)))$$

$$= 3,878.33 \text{ psi}$$

### Operating, Hot & New, Seismic, Bottom Seam

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

$$= 1,378 * 30 / (2 * 20,000 * 1.20 * 1.00 + 0.40 * |1,378|)$$

$$= 0.8515"$$

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

$$= 1,662,898 / (\pi * 31.25^2 * 20,000 * 1.20 * 1.00)$$

$$= 0.0226"$$

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

$$= 23,798.4 / (2 * \pi * 31.25 * 20,000 * 1.20 * 1.00)$$

$$= 0.0051"$$

$$t_t = t_p + t_m - t_w \quad (\text{total required, tensile})$$

$$= 0.8515 + 0.0226 - (0.0051)$$

$$= \underline{0.869"}$$

$$t_{wc} = (1 + V_{\text{Accel}}) * W / (2 * \pi * R_m * S_t * K_s * E_c) \quad (\text{Weight})$$

$$= 2.00 * 23,798.4 / (2 * \pi * 31.25 * 20,000 * 1.20 * 1.00)$$

$$= 0.0101"$$

$$t_c = |t_{mc} + t_{wc} - t_{pc}| \quad (\text{total, net tensile})$$

$$= |0.0226 + (0.0101) - (0.8515)|$$

$$= \underline{0.8188"}$$

### Maximum allowable working pressure, Longitudinal Stress

$$P = 2 * S_t * K_s * E_c * (t - t_m + t_w) / (R - 0.40 * (t - t_m + t_w))$$

$$= 2 * 20,000 * 1.20 * 1.00 * (2.5 - 0.0226 + (0.0051)) / (30 - 0.40 * (2.5 - 0.0226 + (0.0051)))$$

$$= 4,107.92 \text{ psi}$$

### Hot Shut Down, Corroded, Seismic, Bottom Seam

$$t_p = 0" \quad (\text{Pressure})$$

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

$$= 1,626,562 / (\pi * 31.3125^2 * 20,000 * 1.20 * 1.00)$$

$$= 0.022"$$

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

$$= 22,922.1 / (2 * \pi * 31.3125 * 20,000 * 1.20 * 1.00)$$

$$= 0.0049"$$

$$t_t = t_p + t_m - t_w \quad (\text{total required, tensile})$$

$$= 0 + 0.022 - (0.0049)$$

$$= \underline{0.0171"}$$

$$\begin{aligned}
 t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\
 &= 1,626,562 / (\pi * 31.3125^2 * 17,348.7 * 1.20) \\
 &= 0.0254" \\
 t_{wc} &= (1 + V_{Accel}) * W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\
 &= 2.00 * 22,922.1 / (2 * \pi * 31.3125 * 17,348.7 * 1.20) \\
 &= 0.0112" \\
 t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\
 &= 0.0254 + (0.0112) - (0) \\
 &= \underline{0.0366"}
 \end{aligned}$$

#### Hot Shut Down. New. Seismic. Bottom Seam

$$\begin{aligned}
 t_p &= 0" && \text{(Pressure)} \\
 t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\
 &= 1,662,898 / (\pi * 31.25^2 * 20,000 * 1.20 * 1.00) \\
 &= 0.0226" \\
 t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\
 &= 23,798.4 / (2 * \pi * 31.25 * 20,000 * 1.20 * 1.00) \\
 &= 0.0051" \\
 t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\
 &= 0 + 0.0226 - (0.0051) \\
 &= \underline{0.0175"} \\
 t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\
 &= 1,662,898 / (\pi * 31.25^2 * 17,361.41 * 1.20) \\
 &= 0.026" \\
 t_{wc} &= (1 + V_{Accel}) * W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\
 &= 2.00 * 23,798.4 / (2 * \pi * 31.25 * 17,361.41 * 1.20) \\
 &= 0.0116" \\
 t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\
 &= 0.026 + (0.0116) - (0) \\
 &= \underline{0.0377"}
 \end{aligned}$$

#### Empty. Corroded. Seismic. Bottom Seam

$$\begin{aligned}
 t_p &= 0" && \text{(Pressure)} \\
 t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\
 &= 1,212,233 / (\pi * 31.3125^2 * 20,000 * 1.20 * 1.00) \\
 &= 0.0164" \\
 t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\
 &= 22,922.1 / (2 * \pi * 31.3125 * 20,000 * 1.20 * 1.00) \\
 &= 0.0049" \\
 t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\
 &= 0 + 0.0164 - (0.0049) \\
 &= \underline{0.0115"} \\
 t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\
 &= 1,212,233 / (\pi * 31.3125^2 * 17,348.7 * 1.20)
 \end{aligned}$$



$$= 0.0189''$$

$$\begin{aligned} t_{wc} &= (1 + V_{Accel}) * W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\ &= 2.00 * 22,922.1 / (2 * \pi * 31.3125 * 17,348.7 * 1.20) \\ &= 0.0112'' \end{aligned}$$

$$\begin{aligned} t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\ &= 0.0189 + (0.0112) - (0) \\ &= \underline{0.0301''} \end{aligned}$$

#### Empty, New, Seismic, Bottom Seam

$$\begin{aligned} t_p &= 0'' && \text{(Pressure)} \\ t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\ &= 1,252,311 / (\pi * 31.25^2 * 20,000 * 1.20 * 1.00) \\ &= 0.017'' \end{aligned}$$

$$\begin{aligned} t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\ &= 23,798.4 / (2 * \pi * 31.25 * 20,000 * 1.20 * 1.00) \\ &= 0.0051'' \end{aligned}$$

$$\begin{aligned} t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\ &= 0 + 0.017 - (0.0051) \\ &= \underline{0.012''} \end{aligned}$$

$$\begin{aligned} t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\ &= 1,252,311 / (\pi * 31.25^2 * 17,361.41 * 1.20) \\ &= 0.0196'' \end{aligned}$$

$$\begin{aligned} t_{wc} &= (1 + V_{Accel}) * W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\ &= 2.00 * 23,798.4 / (2 * \pi * 31.25 * 17,361.41 * 1.20) \\ &= 0.0116'' \end{aligned}$$

$$\begin{aligned} t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\ &= 0.0196 + (0.0116) - (0) \\ &= \underline{0.0312''} \end{aligned}$$

#### Vacuum, Seismic, Bottom Seam

$$\begin{aligned} t_p &= P * R / (2 * S_t * K_s * E_c + 0.40 * |P|) && \text{(Pressure)} \\ &= -15 * 30.125 / (2 * 20,000 * 1.20 * 1.00 + 0.40 * |15|) \\ &= -0.0094'' \end{aligned}$$

$$\begin{aligned} t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\ &= 1,626,562 / (\pi * 31.3125^2 * 20,000 * 1.20 * 1.00) \\ &= 0.022'' \end{aligned}$$

$$\begin{aligned} t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\ &= 22,922.1 / (2 * \pi * 31.3125 * 20,000 * 1.20 * 1.00) \\ &= 0.0049'' \end{aligned}$$

$$\begin{aligned} t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\ &= -0.0094 + 0.022 - (0.0049) \\ &= \underline{0.0077''} \end{aligned}$$

$$\begin{aligned} t_{pc} &= P * R / (2 * S_c * K_s + 0.40 * |P|) && \text{(Pressure)} \\ &= -15 * 30.125 / (2 * 17,348.7 * 1.20 + 0.40 * |15|) \end{aligned}$$

$$= -0.0109''$$

$$\begin{aligned}t_{mc} &= M / (\pi R_m^2 S_c K_s) && \text{(bending)} \\ &= 1,626,562 / (\pi 31.3125^2 17,348.7 1.20) \\ &= 0.0254''\end{aligned}$$

$$\begin{aligned}t_{wc} &= (1 + V_{\text{Accel}}) W / (2 \pi R_m S_c K_s) && \text{(Weight)} \\ &= 2.00 22,922.1 / (2 \pi 31.3125 17,348.7 1.20) \\ &= 0.0112''\end{aligned}$$

$$\begin{aligned}t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\ &= 0.0254 + (0.0112) - (-0.0109) \\ &= \underline{0.0474''}\end{aligned}$$

#### Maximum Allowable External Pressure, Longitudinal Stress

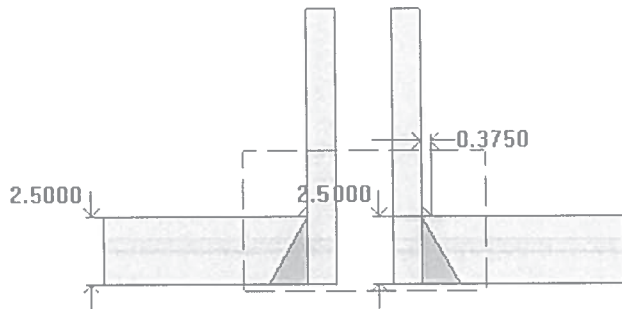
$$\begin{aligned}P &= 2 S_c K_s (t - t_{mc} - t_{wc}) / (R - 0.40 (t - t_{mc} - t_{wc})) \\ &= 2 17,348.7 1.20 (2.375 - 0.0254 - 0.0112) / (30.125 - 0.40 (2.375 - 0.0254 - 0.0112)) \\ &= 3,335.62 \text{ psi}\end{aligned}$$

## Purge (N2)

ASME Section VIII Division 1, 2010 Edition, A11 Addenda

$$t_{w(\text{lower})} = 2.5 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

### Location and Orientation

Located on:	60 ID SHELL
Orientation:	225°
Nozzle center line offset to datum line:	88 in
End of nozzle to shell center:	40.5 in
Passes through a Category A joint:	No

### Nozzle

Access opening:	No
Material specification:	SA-350 LF2 Cl 1 (II-D p. 18, ln. 10)
Inside diameter, new:	2 in
Nominal wall thickness:	1.06 in
Corrosion allowance:	0.125 in
Projection available outside vessel, L <sub>pr</sub> :	6.25 in
Projection available outside vessel to flange face, L <sub>f</sub> :	8 in
Local vessel minimum thickness:	2.5 in
Liquid static head included:	3.792 psi
Longitudinal joint efficiency:	1

### ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 LWN A350 LF2 Cl.1
Bolt Material:	SA-193 B7 Bolt <= 2 1/2 (II-D p. 334, ln. 32)
Blind included:	No
Rated MDMT:	-55°F per UCS-66(b)(1)(b)
Liquid static head:	3.7523 psi
MAWP rating:	2,146 psi @ 140°F
MAP rating:	2,220 psi @ 50°F
Hydrotest rating:	3,350 psi @ 50°F
PWHT performed:	Yes

**Reinforcement Calculations for Chamber MAWP**

<b>UG-37 Area Calculation Summary (in<sup>2</sup>)</b> For P = 1,381.79 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary (in)</b> The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.3324	1.06	

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

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	0.25	0.2625	weld size is adequate

**Calculations for internal pressure 1,381.79 psi @ 140 °F**

Nozzle is impact test exempt to -155 °F per UCS-66(b)(3) (coincident ratio = 0.0895). External nozzle loadings per UG-22 govern the coincident ratio used.

Nozzle UCS-66 governing thk: 1.06 in

Nozzle rated MDMT: -155 °F

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.25, 1.125 + (1.06 - 0.125) + (2.5 - 0.125)) \\
 &= 4.435 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(2.5 - 0.125), 2.5*(1.06 - 0.125) + 0) \\
 &= 2.3375 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_{rn} &= P * R_n / (S_n * E - 0.6 * P) \\
 &= 1,381.792 * 1.125 / (20,000 * 1 - 0.6 * 1,381.792) \\
 &= 0.0811 \text{ in}
 \end{aligned}$$

### Required thickness $t_r$ from UG-37(a)

$$\begin{aligned}t_r &= P \cdot R / (S \cdot E - 0.6 \cdot P) \\ &= 1,381.792 \cdot 30.125 / (20,000 \cdot 1 - 0.6 \cdot 1,381.792) \\ &= 2.1713 \text{ in}\end{aligned}$$

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

### UW-16(c) Weld Check

Fillet weld:  $t_{\min}$  = lesser of 0.75 or  $t_n$  or  $t = 0.75$  in

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

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

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$\begin{aligned}t_{a \text{ UG-27}} &= P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion} \\ &= 1,381.792 \cdot 1.125 / (20,000 \cdot 1 - 0.6 \cdot 1,381.792) + 0.125 \\ &= 0.2061 \text{ in}\end{aligned}$$

$$t_{a \text{ UG-22}} = 0.2087 \text{ in}$$

$$\begin{aligned}t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.2061, 0.2087 ] \\ &= 0.2087 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion} \\ &= 1,381.792 \cdot 30.125 / (20,000 \cdot 1 - 0.6 \cdot 1,381.792) + 0.125 \\ &= 2.2963 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 2.2963, 0.1875 ] \\ &= 2.2963 \text{ in}\end{aligned}$$

$$\begin{aligned}t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.3324, 2.2963 ] \\ &= 0.3324 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.2087, 0.3324 ] \\ &= 0.3324 \text{ in}\end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.06$  in

The nozzle neck thickness is adequate.



## Applied Loads

Radial load:	$P_r = 334$	$\text{lb}_f$
Circumferential moment:	$M_c = 2,965$	$\text{lb}_f\text{-in}$
Circumferential shear:	$V_c = 409$	$\text{lb}_f$
Longitudinal moment:	$M_L = 2,965$	$\text{lb}_f\text{-in}$
Longitudinal shear:	$V_L = 409$	$\text{lb}_f$
Torsion moment:	$M_t = 4,160$	$\text{lb}_f\text{-in}$
Internal pressure:	$P = 1,381.792$	psi
Mean shell radius:	$R_m = 31.3125$	in
Local shell thickness:	$t = 2.375$	in
Shell yield stress:	$S_y = 36,200$	psi

### Maximum stresses due to the applied loads at the nozzle OD (includes pressure)

$$R_m / t = 31.3125 / 2.375 = 13.1842$$

Pressure stress intensity factor,  $I = 1.08139$  (derived from PVP-Vol. 399, pages 77-82)

$$\text{Local circumferential pressure stress} = I * P * R_i / t = 18,954 \text{ psi}$$

$$\text{Local longitudinal pressure stress} = I * P * R_i / (2 * t) = 9,477 \text{ psi}$$

$$\text{Maximum combined stress } (P_L + P_b + Q) = 19,117 \text{ psi}$$

$$\text{Allowable combined stress } (P_L + P_b + Q) = \pm 3 * S = \pm 60,000 \text{ psi}$$

The maximum combined stress ( $P_L + P_b + Q$ ) is within allowable limits.

$$\text{Maximum local primary membrane stress } (P_L) = 18,952 \text{ psi}$$

$$\text{Allowable local primary membrane stress } (P_L) = \pm 1.5 * S = \pm 30,000 \text{ psi}$$

The maximum local primary membrane stress ( $P_L$ ) is within allowable limits.

Stresses at the nozzle OD per WRC Bulletin 107										
Figure	value	$\beta$	$A_u$	$A_l$	$B_u$	$B_l$	$C_u$	$C_l$	$D_u$	$D_l$
3C*	2.6447	0.0576	0	0	0	0	-12	-12	-12	-12
4C*	2.6412	0.0576	-12	-12	-12	-12	0	0	0	0
1C	0.2321	0.0576	0	0	0	0	-82	82	-82	82
2C-1	0.1957	0.0576	-70	70	-70	70	0	0	0	0
3A*	0.1019	0.0576	0	0	0	0	-2	-2	2	2
1A	0.1082	0.0576	0	0	0	0	-189	189	189	-189
3B*	0.4471	0.0576	-10	-10	10	10	0	0	0	0
1B-1	0.0651	0.0576	-114	114	114	-114	0	0	0	0
Pressure stress*			18,954	18,954	18,954	18,954	17,527	17,527	17,527	17,527
Total circumferential stress			18,748	19,116	18,996	18,908	17,242	17,784	17,624	17,410
Primary membrane circumferential stress*			18,932	18,932	18,952	18,952	17,513	17,513	17,517	17,517
3C*	2.6447	0.0576	-12	-12	-12	-12	0	0	0	0
4C*	2.6412	0.0576	0	0	0	0	-12	-12	-12	-12
1C-1	0.2327	0.0576	-83	83	-83	83	0	0	0	0
2C	0.1925	0.0576	0	0	0	0	-68	68	-68	68
4A*	0.1414	0.0576	0	0	0	0	-3	-3	3	3
2A	0.0642	0.0576	0	0	0	0	-112	112	112	-112
4B*	0.1101	0.0576	-2	-2	2	2	0	0	0	0
2B-1	0.1039	0.0576	-182	182	182	-182	0	0	0	0
Pressure stress*			8,764	8,764	8,764	8,764	9,477	9,477	9,477	9,477
Total longitudinal stress			8,485	9,015	8,853	8,655	9,282	9,642	9,512	9,424
Primary membrane longitudinal stress*			8,750	8,750	8,754	8,754	9,462	9,462	9,468	9,468
Shear from $M_l$			66	66	66	66	66	66	66	66
Circ shear from $V_c$			27	27	-27	-27	0	0	0	0
Long shear from $V_L$			0	0	0	0	-27	-27	27	27
Total Shear stress			93	93	39	39	39	39	93	93
Combined stress ( $P_L+P_b+Q$ )			18,749	19,117	18,996	18,908	17,242	17,784	17,625	17,411

Note: \* denotes primary stress.

#### Longitudinal stress in the nozzle wall due to internal pressure + external loads

$$\begin{aligned}\sigma_{n(P_m)} &= P \cdot R_i / (2 \cdot t_n) - P_r / (\pi \cdot (R_o^2 - R_i^2)) + M \cdot R_o / I \\ &= 1,381.79 \cdot 1.125 / (2 \cdot 0.935) - 334 / (\pi \cdot (2.06^2 - 1.125^2)) + 4,193.1 \cdot 2.06 / 12.8855 \\ &= 1,466 \text{ psi}\end{aligned}$$

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

$$\begin{aligned}\sigma_{\text{shear}} &= (V_L^2 + V_c^2)^{0.5} / (\pi \cdot R_i \cdot t_n) \\ &= (409^2 + 409^2)^{0.5} / (\pi \cdot 1.125 \cdot 0.935) \\ &= 175 \text{ psi}\end{aligned}$$

$$\begin{aligned}\sigma_{\text{torsion}} &= M_l / (2 \cdot \pi \cdot R_i^2 \cdot t_n) \\ &= 4,160 / (2 \cdot \pi \cdot 1.125^2 \cdot 0.935)\end{aligned}$$

= 560 psi

$$\begin{aligned}\sigma_{\text{total}} &= \sigma_{\text{shear}} + \sigma_{\text{torsion}} \\ &= 175 + 560 \\ &= 735 \text{ psi}\end{aligned}$$

UG-45: The total combined shear stress (735 psi) is below than the allowable ( $0.7 \cdot S_n = 0.7 \cdot 20,000 = 14,000$  psi)

**Reinforcement Calculations for MAEP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For Pe = 838.94 psi @ 140 °F							<b>UG-45</b> <b>Nozzle Wall</b> <b>Thickness</b> <b>Summary</b> (in) The nozzle passes UG-45	
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.3324	1.06

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (In)	Actual weld throat size (In)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	0.25	0.2625	weld size is adequate

Calculations for external pressure 838.94 psi @ 140 °F

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.25, 1.125 + (1.06 - 0.125) + (2.5 - 0.125)) \\
 &= 4.435 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(2.5 - 0.125), 2.5*(1.06 - 0.125) + 0) \\
 &= 2.3375 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28  $t_{rn} = 0.1518 \text{ in}$

From UG-37(d)(1) required thickness  $t_r = 2.375 \text{ in}$

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

$$t_{a \text{ UG-28}} = 0.2768 \text{ in}$$

$$t_{a \text{ UG-22}} = 0.1847 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.2768, 0.1847 ] \\ &= 0.2768 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion} \\ &= 838.9424 \cdot 30.125 / (20,000 \cdot 1 - 0.6 \cdot 838.9424) + 0.125 \\ &= 1.4213 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2}, t_{b \text{ UG16}} ] \\ &= \max[ 1.4213, 0.1875 ] \\ &= 1.4213 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b2} ] \\ &= \min[ 0.3324, 1.4213 ] \\ &= 0.3324 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.2768, 0.3324 ] \\ &= 0.3324 \text{ in} \end{aligned}$$

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)

$$L / D_o = 8.0654 / 4.12 = 1.9576$$

$$D_o / t = 4.12 / 0.1518 = 27.1437$$

From table G:  $A = 0.004676$

From table  
CS-2:  $B = 17,078.9811 \text{ psi}$

$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 17,078.98 / (3 \cdot (4.12 / 0.1518)) \\ &= 838.94 \text{ psi} \end{aligned}$$

**Design thickness for external pressure  $P_a = 838.94 \text{ psi}$**

$$t_a = t + \text{Corrosion} = 0.1518 + 0.125 = 0.2768''$$

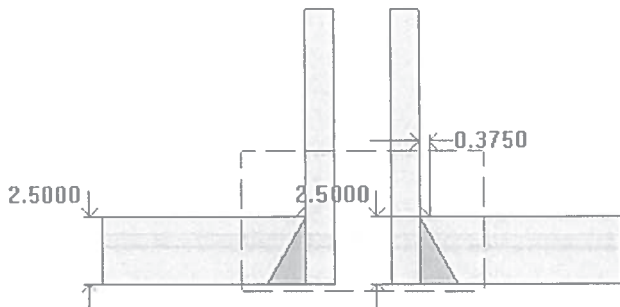


## Level Bridal Low (N3)

ASME Section VIII Division 1, 2010 Edition, A11 Addenda

$$t_{w(\text{lower})} = 2.5 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

### Location and Orientation

Located on:	60 ID SHELL
Orientation:	45°
Nozzle center line offset to datum line:	88 in
End of nozzle to shell center:	40.5 in
Passes through a Category A joint:	No

### Nozzle

Access opening:	No
Material specification:	SA-350 LF2 Cl 1 (II-D p. 18, ln. 10)
Inside diameter, new:	2 in
Nominal wall thickness:	1.06 in
Corrosion allowance:	0.125 in
Projection available outside vessel, Lpr:	6.25 in
Projection available outside vessel to flange face, Lf:	8 in
Local vessel minimum thickness:	2.5 in
Liquid static head included:	3.792 psi
Longitudinal joint efficiency:	1

### ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 LWN A350 LF2 Cl.1
Bolt Material:	SA-193 B7 Bolt ≤ 2 1/2 (II-D p. 334, ln. 32)
Blind included:	No
Rated MDMT:	-55°F per UCS-66(b)(1)(b)
Liquid static head:	3.7523 psi
MAWP rating:	2,146 psi @ 140°F
MAP rating:	2,220 psi @ 50°F
Hydrotest rating:	3,350 psi @ 50°F
PWHT performed:	Yes

**Reinforcement Calculations for Chamber MAWP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For P = 1,381.79 psl @ 140 °F							<b>UG-45</b> <b>Nozzle Wall</b> <b>Thickness</b> <b>Summary</b> (in) The nozzle passes UG-45	
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.3324	1.06

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

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (In)	Actual weld throat size (In)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	0.25	0.2625	weld size is adequate

Calculations for internal pressure 1,381.79 psi @ 140 °F

Nozzle is impact test exempt to -155 °F per UCS-66(b)(3) (coincident ratio = 0.0867).

Nozzle UCS-66 governing thk: 1.06 in

Nozzle rated MDMT: -155 °F

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.25, 1.125 + (1.06 - 0.125) + (2.5 - 0.125)) \\
 &= 4.435 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(2.5 - 0.125), 2.5*(1.06 - 0.125) + 0) \\
 &= 2.3375 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_{rn} &= P * R_n / (S_n * E - 0.6 * P) \\
 &= 1,381.792 * 1.125 / (20,000 * 1 - 0.6 * 1,381.792) \\
 &= 0.0811 \text{ in}
 \end{aligned}$$

**Required thickness t<sub>r</sub> from UG-37(a)**

$$t_r = P * R / (S * E - 0.6 * P)$$

$$= 1,381.792 \cdot 30.125 / (20,000 \cdot 1 - 0.6 \cdot 1,381.792)$$

$$= 2.1713 \text{ in}$$

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

### UW-16(c) Weld Check

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

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

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

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

$$t_{a \text{ UG-27}} = P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion}$$

$$= 1,381.792 \cdot 1.125 / (20,000 \cdot 1 - 0.6 \cdot 1,381.792) + 0.125$$

$$= 0.2061 \text{ in}$$

$$t_a = \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ]$$

$$= \max[ 0.2061, 0 ]$$

$$= 0.2061 \text{ in}$$

$$t_{b1} = P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion}$$

$$= 1,381.792 \cdot 30.125 / (20,000 \cdot 1 - 0.6 \cdot 1,381.792) + 0.125$$

$$= 2.2963 \text{ in}$$

$$t_{b1} = \max[ t_{b1}, t_{b \text{ UG16}} ]$$

$$= \max[ 2.2963, 0.1875 ]$$

$$= 2.2963 \text{ in}$$

$$t_b = \min[ t_{b3}, t_{b1} ]$$

$$= \min[ 0.3324, 2.2963 ]$$

$$= 0.3324 \text{ in}$$

$$t_{\text{UG-45}} = \max[ t_a, t_b ]$$

$$= \max[ 0.2061, 0.3324 ]$$

$$= 0.3324 \text{ in}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

**Reinforcement Calculations for MAEP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For Pe = 838.94 psl @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45	
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.3324	1.06

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (In)	Actual weld throat size (In)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	0.25	0.2625	weld size is adequate

Calculations for external pressure 838.94 psi @ 140 °F

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.25, 1.125 + (1.06 - 0.125) + (2.5 - 0.125)) \\
 &= 4.435 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(2.5 - 0.125), 2.5*(1.06 - 0.125) + 0) \\
 &= 2.3375 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28  $t_{rn} = 0.1518 \text{ in}$

From UG-37(d)(1) required thickness  $t_r = 2.375 \text{ in}$

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

$$t_{a \text{ UG-28}} = 0.2768 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.2768, 0 ] \\ &= 0.2768 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion} \\ &= 838.9424 \cdot 30.125 / (20,000 \cdot 1 - 0.6 \cdot 838.9424) + 0.125 \\ &= 1.4213 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2}, t_{b \text{ UG16}} ] \\ &= \max[ 1.4213, 0.1875 ] \\ &= 1.4213 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b2} ] \\ &= \min[ 0.3324, 1.4213 ] \\ &= 0.3324 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.2768, 0.3324 ] \\ &= 0.3324 \text{ in} \end{aligned}$$

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)

$$L / D_o = 8.0654 / 4.12 = 1.9576$$

$$D_o / t = 4.12 / 0.1518 = 27.1437$$

From table G:  $A = 0.004676$

From table  
CS-2:  $B = 17,078.9811 \text{ psi}$

$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 17,078.98 / (3 \cdot (4.12 / 0.1518)) \\ &= 838.94 \text{ psi} \end{aligned}$$

**Design thickness for external pressure  $P_a = 838.94 \text{ psi}$**

$$t_a = t + \text{Corrosion} = 0.1518 + 0.125 = 0.2768''$$

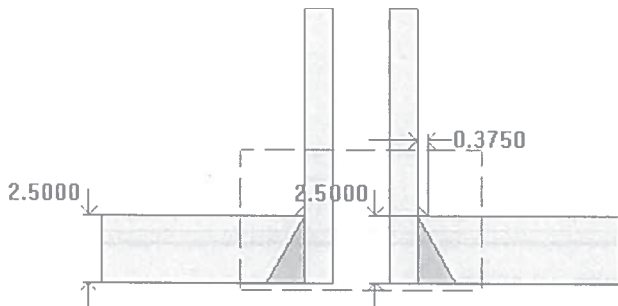


## Diff Press High (N4)

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$$t_{w(\text{lower})} = 2.5 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



Note: round inside edges per UG 76(c)

### Location and Orientation

Located on:	60 ID SHELL
Orientation:	0°
Nozzle center line offset to datum line:	8 in
End of nozzle to shell center:	40.5 in
Passes through a Category A joint:	No

### Nozzle

Access opening:	No
Material specification:	SA-350 LF2 Cl 1 (II-D p. 18, ln. 10)
Inside diameter, new:	2 in
Nominal wall thickness:	1.06 in
Corrosion allowance:	0.125 in
Projection available outside vessel, L <sub>pr</sub> :	6.25 in
Projection available outside vessel to flange face, L <sub>f</sub> :	8 in
Local vessel minimum thickness:	2.5 in
Liquid static head included:	0.6155 psi
Longitudinal joint efficiency:	1

### ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 LWN A350 LF2 Cl.1
Bolt Material:	SA-193 B7 Bolt ≤ 2 1/2 (II-D p. 334, ln. 32)
Blind included:	No
Rated MDMT:	-55 °F per UCS-66(b)(1)(b)
Liquid static head:	0.5757 psi
MAWP rating:	2,146 psi @ 140 °F
MAP rating:	2,220 psi @ 50 °F
Hydrotest rating:	3,350 psi @ 50 °F
PWHT performed:	Yes

**Reinforcement Calculations for Chamber MAWP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For P = 1,378.62 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.3324	1.06	

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

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (In)	Actual weld throat size (In)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	0.25	0.2625	weld size is adequate

**Calculations for internal pressure 1,378.62 psi @ 140 °F**

Nozzle is impact test exempt to -155 °F per UCS-66(b)(3) (coincident ratio = 0.0865).

Nozzle UCS-66 governing thk: 1.06 in

Nozzle rated MDMT: -155 °F

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.25, 1.125 + (1.06 - 0.125) + (2.5 - 0.125)) \\
 &= 4.435 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(2.5 - 0.125), 2.5*(1.06 - 0.125) + 0) \\
 &= 2.3375 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_{rn} &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378.6155 \cdot 1.125 / (20,000 \cdot 1 - 0.6 \cdot 1,378.6155) \\
 &= 0.0809 \text{ in}
 \end{aligned}$$

**Required thickness t<sub>r</sub> from UG-37(a)**

$$t_r = P \cdot R / (S \cdot E - 0.6 \cdot P)$$

$$= 1,378.6155 \cdot 30.125 / (20,000 \cdot 1 - 0.6 \cdot 1,378.6155)$$

$$= 2.1661 \text{ in}$$

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

### UW-16(c) Weld Check

Fillet weld:  $t_{\min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$   
 $t_{c(\min)} = \text{lesser of } 0.25 \text{ or } 0.7 \cdot t_{\min} = 0.25 \text{ in}$   
 $t_{c(\text{actual})} = 0.7 \cdot \text{Leg} = 0.7 \cdot 0.375 = 0.2625 \text{ in}$

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

$$t_{a \text{ UG-27}} = P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion}$$

$$= 1,378.6155 \cdot 1.125 / (20,000 \cdot 1 - 0.6 \cdot 1,378.6155) + 0.125$$

$$= 0.2059 \text{ in}$$

$$t_a = \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ]$$

$$= \max[ 0.2059, 0 ]$$

$$= 0.2059 \text{ in}$$

$$t_{b1} = P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion}$$

$$= 1,378.6155 \cdot 30.125 / (20,000 \cdot 1 - 0.6 \cdot 1,378.6155) + 0.125$$

$$= 2.2911 \text{ in}$$

$$t_{b1} = \max[ t_{b1}, t_{b \text{ UG16}} ]$$

$$= \max[ 2.2911, 0.1875 ]$$

$$= 2.2911 \text{ in}$$

$$t_b = \min[ t_{b3}, t_{b1} ]$$

$$= \min[ 0.3324, 2.2911 ]$$

$$= 0.3324 \text{ in}$$

$$t_{\text{UG-45}} = \max[ t_a, t_b ]$$

$$= \max[ 0.2059, 0.3324 ]$$

$$= 0.3324 \text{ in}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

**Reinforcement Calculations for MAEP**

<b>UG-37 Area Calculation Summary (in<sup>2</sup>)</b> For Pe = 838.94 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary (in)</b> The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.3324	1.06	

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (In)	Actual weld throat size (In)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	0.25	0.2625	weld size is adequate

Calculations for external pressure 838.94 psi @ 140 °F

**Parallel Limit of reinforcement per UG-40**

$$L_R = \text{MAX}(d, R_n + (t_n - C_n) + (t - C))$$

$$= \text{MAX}(2.25, 1.125 + (1.06 - 0.125) + (2.5 - 0.125))$$

$$= 4.435 \text{ in}$$

**Outer Normal Limit of reinforcement per UG-40**

$$L_H = \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e)$$

$$= \text{MIN}(2.5*(2.5 - 0.125), 2.5*(1.06 - 0.125) + 0)$$

$$= 2.3375 \text{ in}$$

Nozzle required thickness per UG-28 t<sub>rn</sub> = 0.1518 in

From UG-37(d)(1) required thickness t<sub>r</sub> = 2.375 in

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

**UW-16(c) Weld Check**

Fillet weld: t<sub>min</sub> = lesser of 0.75 or t<sub>n</sub> or t = 0.75 in

t<sub>c(min)</sub> = lesser of 0.25 or 0.7\*t<sub>min</sub> = 0.25 in

t<sub>c(actual)</sub> = 0.7\*Leg = 0.7\*0.375 = 0.2625 in

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check

$$t_{a \text{ UG-28}} = 0.2768 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.2768, 0 ] \\ &= 0.2768 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion} \\ &= 838.9424 \cdot 30.125 / (20,000 \cdot 1 - 0.6 \cdot 838.9424) + 0.125 \\ &= 1.4213 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2}, t_{b \text{ UG16}} ] \\ &= \max[ 1.4213, 0.1875 ] \\ &= 1.4213 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b2} ] \\ &= \min[ 0.3324, 1.4213 ] \\ &= 0.3324 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.2768, 0.3324 ] \\ &= 0.3324 \text{ in} \end{aligned}$$

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)

$$L / D_o = 8.0654 / 4.12 = 1.9576$$

$$D_o / t = 4.12 / 0.1518 = 27.1437$$

From table G:  $A = 0.004676$

From table  
CS-2:  $B = 17,078.9811 \text{ psi}$

$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 17,078.98 / (3 \cdot (4.12 / 0.1518)) \\ &= 838.94 \text{ psi} \end{aligned}$$

**Design thickness for external pressure  $P_a = 838.94 \text{ psi}$**

$$t_a = t + \text{Corrosion} = 0.1518 + 0.125 = 0.2768''$$

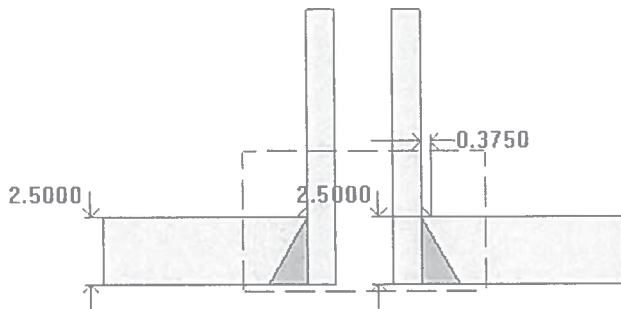


## Level Bridal High (N5)

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$$t_{w(\text{lower})} = 2.5 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

### Location and Orientation

Located on:	60 ID SHELL
Orientation:	45°
Nozzle center line offset to datum line:	8 in
End of nozzle to shell center:	40.5 in
Passes through a Category A joint:	No

### Nozzle

Access opening:	No
Material specification:	SA-350 LF2 Cl 1 (II-D p. 18, In. 10)
Inside diameter, new:	2 in
Nominal wall thickness:	1.06 in
Corrosion allowance:	0.125 in
Projection available outside vessel, L <sub>pr</sub> :	6.25 in
Projection available outside vessel to flange face, L <sub>f</sub> :	8 in
Local vessel minimum thickness:	2.5 in
Liquid static head included:	0.6155 psi
Longitudinal joint efficiency:	1

### ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 LWN A350 LF2 Cl.1
Bolt Material:	SA-193 B7 Bolt <= 2 1/2 (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55°F per UCS-66(b)(1)(b)
Liquid static head:	0.5757 psi
MAWP rating:	2,146 psi @ 140°F
MAP rating:	2,220 psi @ 50°F
Hydrotest rating:	3,350 psi @ 50°F
PWHT performed:	Yes

## Reinforcement Calculations for Chamber MAWP

UG-37 Area Calculation Summary (in <sup>2</sup> ) For P = 1,378.62 psi @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.3324	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 <sub>41</sub> )	0.25	0.2625	weld size is adequate

Calculations for internal pressure 1,378.62 psi @ 140 °F

Nozzle is impact test exempt to -155 °F per UCS-66(b)(3) (coincident ratio = 0.0865).

Nozzle UCS-66 governing thk: 1.06 in

Nozzle rated MDMT: -155 °F

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.25, 1.125 + (1.06 - 0.125) + (2.5 - 0.125)) \\
 &= 4.435 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(2.5 - 0.125), 2.5*(1.06 - 0.125) + 0) \\
 &= 2.3375 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,378.6155 \cdot 1.125 / (20,000 \cdot 1 - 0.6 \cdot 1,378.6155) \\
 &= 0.0809 \text{ in}
 \end{aligned}$$

**Required thickness t<sub>r</sub> from UG-37(a)**

$$t_r = P \cdot R / (S \cdot E - 0.6 \cdot P)$$

$$= 1,378.6155 \cdot 30.125 / (20,000 \cdot 1 - 0.6 \cdot 1,378.6155)$$

$$= 2.1661 \text{ in}$$

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

### UW-16(c) Weld Check

Fillet weld:  $t_{\min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$   
 $t_{c(\min)} = \text{lesser of } 0.25 \text{ or } 0.7 \cdot t_{\min} = 0.25 \text{ in}$   
 $t_{c(\text{actual})} = 0.7 \cdot \text{Leg} = 0.7 \cdot 0.375 = 0.2625 \text{ in}$

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

$$t_{a \text{UG-27}} = P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion}$$

$$= 1,378.6155 \cdot 1.125 / (20,000 \cdot 1 - 0.6 \cdot 1,378.6155) + 0.125$$

$$= 0.2059 \text{ in}$$

$$t_a = \max[ t_{a \text{UG-27}}, t_{a \text{UG-22}} ]$$

$$= \max[ 0.2059, 0 ]$$

$$= 0.2059 \text{ in}$$

$$t_{b1} = P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion}$$

$$= 1,378.6155 \cdot 30.125 / (20,000 \cdot 1 - 0.6 \cdot 1,378.6155) + 0.125$$

$$= 2.2911 \text{ in}$$

$$t_{b1} = \max[ t_{b1}, t_{b \text{UG16}} ]$$

$$= \max[ 2.2911, 0.1875 ]$$

$$= 2.2911 \text{ in}$$

$$t_b = \min[ t_{b3}, t_{b1} ]$$

$$= \min[ 0.3324, 2.2911 ]$$

$$= 0.3324 \text{ in}$$

$$t_{\text{UG-45}} = \max[ t_a, t_b ]$$

$$= \max[ 0.2059, 0.3324 ]$$

$$= 0.3324 \text{ in}$$

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 <sup>2</sup> ) For Pe = 838.94 psi @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.3324	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 <sub>41</sub> )	0.25	0.2625	weld size is adequate

Calculations for external pressure 838.94 psi @ 140 °F

### Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.25, 1.125 + (1.06 - 0.125) + (2.5 - 0.125)) \\
 &= 4.435 \text{ in}
 \end{aligned}$$

### Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(2.5 - 0.125), 2.5*(1.06 - 0.125) + 0) \\
 &= 2.3375 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28  $t_{rn} = 0.1518 \text{ in}$

From UG-37(d)(1) required thickness  $t_r = 2.375 \text{ in}$

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

### UW-16(c) Weld Check

$$\begin{aligned}
 \text{Fillet weld: } t_{\min} &= \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in} \\
 t_{c(\min)} &= \text{lesser of } 0.25 \text{ or } 0.7*t_{\min} = 0.25 \text{ in} \\
 t_{c(\text{actual})} &= 0.7*\text{Leg} = 0.7*0.375 = 0.2625 \text{ in}
 \end{aligned}$$

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

$$t_{a \text{ UG-28}} = 0.2768 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.2768, 0 ] \\ &= 0.2768 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion} \\ &= 838.9424 \cdot 30.125 / (20,000 \cdot 1 - 0.6 \cdot 838.9424) + 0.125 \\ &= 1.4213 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2}, t_{b \text{ UG16}} ] \\ &= \max[ 1.4213, 0.1875 ] \\ &= 1.4213 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b2} ] \\ &= \min[ 0.3324, 1.4213 ] \\ &= 0.3324 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.2768, 0.3324 ] \\ &= 0.3324 \text{ in} \end{aligned}$$

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)

$$L / D_o = 8.0654 / 4.12 = 1.9576$$

$$D_o / t = 4.12 / 0.1518 = 27.1437$$

From table G: A = 0.004676

From table  
CS-2: B = 17,078.9811 psi

$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 17,078.98 / (3 \cdot (4.12 / 0.1518)) \\ &= 838.94 \text{ psi} \end{aligned}$$

Design thickness for external pressure  $P_a = 838.94 \text{ psi}$

$$t_a = t + \text{Corrosion} = 0.1518 + 0.125 = 0.2768''$$

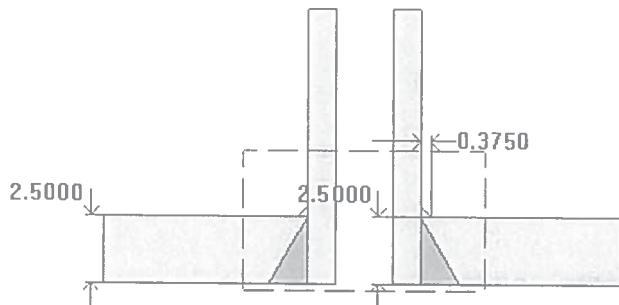


## Fill/ Water Flush (N6)

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$$t_{w(\text{lower})} = 2.5 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

### Location and Orientation

Located on:	60 ID SHELL
Orientation:	180°
Nozzle center line offset to datum line:	88 in
End of nozzle to shell center:	40.5 in
Passes through a Category A joint:	No

### Nozzle

Access opening:	No
Material specification:	SA-350 LF2 Cl 1 (II-D p. 18, ln. 10)
Inside diameter, new:	2 in
Nominal wall thickness:	1.06 in
Corrosion allowance:	0.125 in
Projection available outside vessel, L <sub>pr</sub> :	6.25 in
Projection available outside vessel to flange face, L <sub>f</sub> :	8 in
Local vessel minimum thickness:	2.5 in
Liquid static head included:	3.792 psi
Longitudinal joint efficiency:	1

### ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 LWN A350 LF2 Cl.1
Bolt Material:	SA-193 B7 Bolt <= 2 1/2 (II-D p. 334, ln. 32)
Blind included:	No
Rated MDMT:	-55°F per UCS-66(b)(1)(b)
Liquid static head:	3.7523 psi
MAWP rating:	2,146 psi @ 140°F
MAP rating:	2,220 psi @ 50°F
Hydrotest rating:	3,350 psi @ 50°F
PWHT performed:	Yes

**Reinforcement Calculations for Chamber MAWP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For P = 1,381.79 psi @ 140 °F							<b>UG-45</b> <b>Nozzle Wall</b> <b>Thickness</b> <b>Summary</b> (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.3324	1.06	

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

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	0.25	0.2625	weld size is adequate

**Calculations for internal pressure 1,381.79 psi @ 140 °F**

Nozzle is impact test exempt to -155 °F per UCS-66(b)(3) (coincident ratio = 0.0867).

Nozzle UCS-66 governing thk: 1.06 in

Nozzle rated MDMT: -155 °F

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.25, 1.125 + (1.06 - 0.125) + (2.5 - 0.125)) \\
 &= 4.435 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(2.5 - 0.125), 2.5*(1.06 - 0.125) + 0) \\
 &= 2.3375 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_{rn} &= P * R_n / (S_n * E - 0.6 * P) \\
 &= 1,381.792 * 1.125 / (20,000 * 1 - 0.6 * 1,381.792) \\
 &= 0.0811 \text{ in}
 \end{aligned}$$

**Required thickness t<sub>r</sub> from UG-37(a)**

$$t_r = P * R / (S * E - 0.6 * P)$$

$$= 1,381.792 * 30.125 / (20,000 * 1 - 0.6 * 1,381.792)$$

$$= 2.1713 \text{ in}$$

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

### UW-16(c) Weld Check

Fillet weld:  $t_{\min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$   
 $t_{c(\min)} = \text{lesser of } 0.25 \text{ or } 0.7 * t_{\min} = 0.25 \text{ in}$   
 $t_{c(\text{actual})} = 0.7 * \text{Leg} = 0.7 * 0.375 = 0.2625 \text{ in}$

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

$$t_{a \text{ UG-27}} = P * R / (S * E - 0.6 * P) + \text{Corrosion}$$

$$= 1,381.792 * 1.125 / (20,000 * 1 - 0.6 * 1,381.792) + 0.125$$

$$= 0.2061 \text{ in}$$

$$t_a = \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ]$$

$$= \max[ 0.2061, 0 ]$$

$$= 0.2061 \text{ in}$$

$$t_{b1} = P * R / (S * E - 0.6 * P) + \text{Corrosion}$$

$$= 1,381.792 * 30.125 / (20,000 * 1 - 0.6 * 1,381.792) + 0.125$$

$$= 2.2963 \text{ in}$$

$$t_{b1} = \max[ t_{b1}, t_{b \text{ UG16}} ]$$

$$= \max[ 2.2963, 0.1875 ]$$

$$= 2.2963 \text{ in}$$

$$t_b = \min[ t_{b3}, t_{b1} ]$$

$$= \min[ 0.3324, 2.2963 ]$$

$$= 0.3324 \text{ in}$$

$$t_{\text{UG-45}} = \max[ t_a, t_b ]$$

$$= \max[ 0.2061, 0.3324 ]$$

$$= 0.3324 \text{ in}$$

Available nozzle wall thickness new,  $t_n = 1.06 \text{ in}$

The nozzle neck thickness is adequate.

**Reinforcement Calculations for MAEP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For Pe = 838.94 psi @ 140 °F							<b>UG-45</b> <b>Nozzle Wall</b> <b>Thickness</b> <b>Summary</b> (in) The nozzle passes UG-45	
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.3324	1.06

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	0.25	0.2625	weld size is adequate

Calculations for external pressure 838.94 psi @ 140 °F

**Parallel Limit of reinforcement per UG-40**

$$L_R = \text{MAX}(d, R_n + (t_n - C_n) + (t - C))$$

$$= \text{MAX}(2.25, 1.125 + (1.06 - 0.125) + (2.5 - 0.125))$$

$$= 4.435 \text{ in}$$

**Outer Normal Limit of reinforcement per UG-40**

$$L_H = \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e)$$

$$= \text{MIN}(2.5*(2.5 - 0.125), 2.5*(1.06 - 0.125) + 0)$$

$$= 2.3375 \text{ in}$$

Nozzle required thickness per UG-28  $t_{rn} = 0.1518 \text{ in}$

From UG-37(d)(1) required thickness  $t_r = 2.375 \text{ in}$

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

$$t_{a \text{ UG-28}} = 0.2768 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.2768, 0 ] \\ &= 0.2768 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion} \\ &= 838.9424 \cdot 30.125 / (20,000 \cdot 1 - 0.6 \cdot 838.9424) + 0.125 \\ &= 1.4213 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2}, t_{b \text{ UG16}} ] \\ &= \max[ 1.4213, 0.1875 ] \\ &= 1.4213 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b2} ] \\ &= \min[ 0.3324, 1.4213 ] \\ &= 0.3324 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.2768, 0.3324 ] \\ &= 0.3324 \text{ in} \end{aligned}$$

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)

$$L / D_o = 8.0654 / 4.12 = 1.9576$$

$$D_o / t = 4.12 / 0.1518 = 27.1437$$

From table G: A = 0.004676

From table  
CS-2: B = 17,078.9811 psi

$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 17,078.98 / (3 \cdot (4.12 / 0.1518)) \\ &= 838.94 \text{ psi} \end{aligned}$$

**Design thickness for external pressure  $P_a = 838.94 \text{ psi}$**

$$t_a = t + \text{Corrosion} = 0.1518 + 0.125 = 0.2768''$$

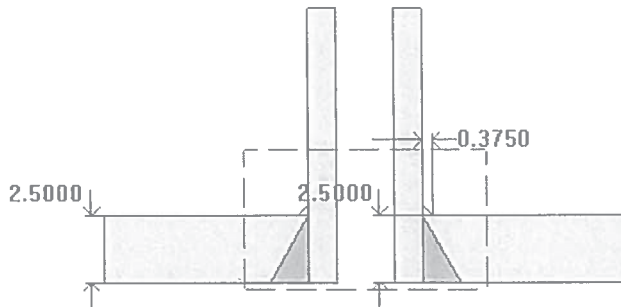


## Diff press Low (N8)

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$$t_{w(\text{lower})} = 2.5 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

#### Location and Orientation

Located on:	60 ID SHELL
Orientation:	0°
Nozzle center line offset to datum line:	88 in
End of nozzle to shell center:	40.5 in
Passes through a Category A joint:	No

#### Nozzle

Access opening:	No
Material specification:	SA-350 LF2 Cl 1 (II-D p. 18, ln. 10)
Inside diameter, new:	2 in
Nominal wall thickness:	1.06 in
Corrosion allowance:	0.125 in
Projection available outside vessel, Lpr:	6.25 in
Projection available outside vessel to flange face, Lf:	8 in
Local vessel minimum thickness:	2.5 in
Liquid static head included:	3.792 psi
Longitudinal joint efficiency:	1

#### ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 LWN A350 LF2 Cl.1
Bolt Material:	SA-193 B7 Bolt <= 2 1/2 (II-D p. 334, ln. 32)
Blind included:	No
Rated MDMT:	-55°F per UCS-66(b)(1)(b)
Liquid static head:	3.7523 psi
MAWP rating:	2,146 psi @ 140°F
MAP rating:	2,220 psi @ 50°F
Hydrotest rating:	3,350 psi @ 50°F
PWHT performed:	Yes

## Reinforcement Calculations for Chamber MAWP

UG-37 Area Calculation Summary (in <sup>2</sup> ) For P = 1,381.79 psi @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45		
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>	
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.3324	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 <sub>41</sub> )	0.25	0.2625	weld size is adequate

### Calculations for internal pressure 1,381.79 psi @ 140 °F

Nozzle is impact test exempt to -155 °F per UCS-66(b)(3) (coincident ratio = 0.0867).

Nozzle UCS-66 governing thk: 1.06 in

Nozzle rated MDMT: -155 °F

#### Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.25, 1.125 + (1.06 - 0.125) + (2.5 - 0.125)) \\
 &= 4.435 \text{ in}
 \end{aligned}$$

#### Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(2.5 - 0.125), 2.5*(1.06 - 0.125) + 0) \\
 &= 2.3375 \text{ in}
 \end{aligned}$$

#### Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,381.792 \cdot 1.125 / (20,000 \cdot 1 - 0.6 \cdot 1,381.792) \\
 &= 0.0811 \text{ in}
 \end{aligned}$$

#### Required thickness t<sub>r</sub> from UG-37(a)

$$t_r = P \cdot R / (S \cdot E - 0.6 \cdot P)$$

$$= 1,381.792 \times 30.125 / (20,000 \times 1 - 0.6 \times 1,381.792)$$

$$= 2.1713 \text{ in}$$

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

### UW-16(c) Weld Check

Fillet weld:  $t_{\min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in}$   
 $t_{c(\min)} = \text{lesser of } 0.25 \text{ or } 0.7 \times t_{\min} = 0.25 \text{ in}$   
 $t_{c(\text{actual})} = 0.7 \times \text{Leg} = 0.7 \times 0.375 = 0.2625 \text{ in}$

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

$$t_{a \text{ UG-27}} = P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion}$$

$$= 1,381.792 \times 1.125 / (20,000 \times 1 - 0.6 \times 1,381.792) + 0.125$$

$$= 0.2061 \text{ in}$$

$$t_a = \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ]$$

$$= \max[ 0.2061, 0 ]$$

$$= 0.2061 \text{ in}$$

$$t_{b1} = P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion}$$

$$= 1,381.792 \times 30.125 / (20,000 \times 1 - 0.6 \times 1,381.792) + 0.125$$

$$= 2.2963 \text{ in}$$

$$t_{b1} = \max[ t_{b1}, t_{b \text{ UG16}} ]$$

$$= \max[ 2.2963, 0.1875 ]$$

$$= 2.2963 \text{ in}$$

$$t_b = \min[ t_{b3}, t_{b1} ]$$

$$= \min[ 0.3324, 2.2963 ]$$

$$= 0.3324 \text{ in}$$

$$t_{\text{UG-45}} = \max[ t_a, t_b ]$$

$$= \max[ 0.2061, 0.3324 ]$$

$$= 0.3324 \text{ in}$$

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 <sup>2</sup> ) For Pe = 838.94 psi @ 140 °F							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.3324	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 <sub>41</sub> )	0.25	0.2625	weld size is adequate

Calculations for external pressure 838.94 psi @ 140 °F

### Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(2.25, 1.125 + (1.06 - 0.125) + (2.5 - 0.125)) \\
 &= 4.435 \text{ in}
 \end{aligned}$$

### Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(2.5 - 0.125), 2.5*(1.06 - 0.125) + 0) \\
 &= 2.3375 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28  $t_{rn} = 0.1518 \text{ in}$

From UG-37(d)(1) required thickness  $t_r = 2.375 \text{ in}$

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

### UW-16(c) Weld Check

$$\begin{aligned}
 \text{Fillet weld: } t_{\min} &= \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in} \\
 t_{c(\min)} &= \text{lesser of } 0.25 \text{ or } 0.7*t_{\min} = 0.25 \text{ in} \\
 t_{c(\text{actual})} &= 0.7*\text{Leg} = 0.7*0.375 = 0.2625 \text{ in}
 \end{aligned}$$

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

$$t_{a \text{ UG-28}} = 0.2768 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.2768, 0 ] \\ &= 0.2768 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion} \\ &= 838.9424 \cdot 30.125 / (20,000 \cdot 1 - 0.6 \cdot 838.9424) + 0.125 \\ &= 1.4213 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2}, t_{b \text{ UG16}} ] \\ &= \max[ 1.4213, 0.1875 ] \\ &= 1.4213 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b2} ] \\ &= \min[ 0.3324, 1.4213 ] \\ &= 0.3324 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.2768, 0.3324 ] \\ &= 0.3324 \text{ in} \end{aligned}$$

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)

$$L / D_o = 8.0654 / 4.12 = 1.9576$$

$$D_o / t = 4.12 / 0.1518 = 27.1437$$

From table G: A = 0.004676

From table  
CS-2: B = 17,078.9811 psi

$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 17,078.98 / (3 \cdot (4.12 / 0.1518)) \\ &= 838.94 \text{ psi} \end{aligned}$$

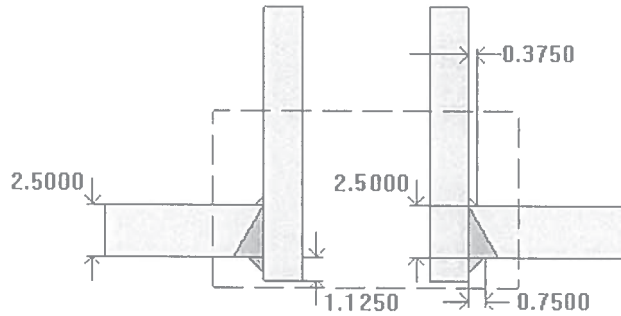
Design thickness for external pressure  $P_a = 838.94 \text{ psi}$

$$t_a = t + \text{Corrosion} = 0.1518 + 0.125 = 0.2768''$$



## Inspection Nozzle (N11)

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$$\begin{aligned}
 t_{w(\text{lower})} &= 2.5 \text{ in} \\
 \text{Leg}_{41} &= 0.375 \text{ in} \\
 \text{Leg}_{43} &= 0.75 \text{ in} \\
 h_{\text{new}} &= 1.125 \text{ in}
 \end{aligned}$$

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

### Location and Orientation

Located on:	60 ID SHELL
Orientation:	110°
Nozzle center line offset to datum line:	12 in
End of nozzle to shell center:	42.5 in
Passes through a Category A joint:	No

### Nozzle

Access opening:	No
Material specification:	SA-350 LF2 Cl 1 (II-D p. 18, In. 10)
Inside diameter, new:	8 in
Nominal wall thickness:	1.875 in
Corrosion allowance:	0.125 in
Projection available outside vessel, L <sub>pr</sub> :	7.25 in
Internal projection, h <sub>new</sub> :	1.125 in
Projection available outside vessel to flange face, L <sub>f</sub> :	10 in
Local vessel minimum thickness:	2.5 in
Liquid static head included:	0.8934 psi
Longitudinal joint efficiency:	1

### ASME B16.5-2009 Flange

Description:	NPS 8 Class 900 LWN A350 LF2 Cl.1
Bolt Material:	SA-193 B7 Bolt ≤ 2 1/2 (II-D p. 334, In. 32)
Blind included:	Yes
Rated MDMT:	-55°F per UCS-66(b)(1)(b)
Liquid static head:	0.7346 psi
MAWP rating:	2,146 psi @ 140°F
MAP rating:	2,220 psi @ 50°F
Hydrotest rating:	3,350 psi @ 50°F
PWHT performed:	Yes

**Reinforcement Calculations for Chamber MAWP**

<b>UG-37 Area Calculation Summary (in<sup>2</sup>)</b> For P = 1,378.89 psi @ 140 °F The opening is adequately reinforced							<b>UG-45 Nozzle Wall Thickness Summary (in)</b> The nozzle passes UG-45	
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
17.8743	18.153	1.7195	12.7164	3.25	--	0.4671	0.4531	1.875

<b>UG-41 Weld Failure Path Analysis Summary</b>
The nozzle is exempt from weld strength calculations per UW-15(b)(1)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	0.25	0.2625	weld size is adequate

**Calculations for internal pressure 1,378.89 psi @ 140 °F**

Nozzle is impact test exempt to -155 °F per UCS-66(b)(3) (coincident ratio = 0.1695).

Nozzle UCS-66 governing thk: 1.875 in  
 Nozzle rated MDMT: -155 °F

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(8.25, 4.125 + (1.875 - 0.125) + (2.5 - 0.125)) \\
 &= 8.25 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(2.5 - 0.125), 2.5*(1.875 - 0.125) + 0) \\
 &= 4.375 \text{ in}
 \end{aligned}$$

**Inner Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_I &= \text{MIN}(2.5*(t - C), 2.5*(t_i - C_n - C)) \\
 &= \text{MIN}(2.5*(2.5 - 0.125), 2.5*(1.875 - 0.125 - 0.125)) \\
 &= 4.0625 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_n &= P*R_n / (S_n*E - 0.6*P) \\
 &= 1,378.8934*4.125 / (20,000*1 - 0.6*1,378.8934) \\
 &= 0.2967 \text{ in}
 \end{aligned}$$

**Required thickness  $t_r$  from UG-37(a)**

$$\begin{aligned}
 t_r &= P \cdot R / (S \cdot E - 0.6 \cdot P) \\
 &= 1,378.8934 \cdot 30.125 / (20,000 \cdot 1 - 0.6 \cdot 1,378.8934) \\
 &= 2.1666 \text{ in}
 \end{aligned}$$

**Area required per UG-37(c)**

Allowable stresses:  $S_n = 20,000$ ,  $S_v = 20,000$  psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$\begin{aligned}
 A &= d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1}) \\
 &= 8.25 \cdot 2.1666 \cdot 1 + 2 \cdot 1.75 \cdot 2.1666 \cdot 1 \cdot (1 - 1) \\
 &= \underline{17.8743} \text{ in}^2
 \end{aligned}$$

**Area available from FIG. UG-37.1**

$A_1 = \text{larger of the following} = \underline{1.7195} \text{ in}^2$

$$\begin{aligned}
 &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\
 &= 8.25 \cdot (1 \cdot 2.375 - 1 \cdot 2.1666) - 2 \cdot 1.75 \cdot (1 \cdot 2.375 - 1 \cdot 2.1666) \cdot (1 - 1) \\
 &= 1.7195 \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\
 &= 2 \cdot (2.375 + 1.75) \cdot (1 \cdot 2.375 - 1 \cdot 2.1666) - 2 \cdot 1.75 \cdot (1 \cdot 2.375 - 1 \cdot 2.1666) \cdot (1 - 1) \\
 &= 1.7195 \text{ in}^2
 \end{aligned}$$

$A_2 = \text{smaller of the following} = \underline{12.7164} \text{ in}^2$

$$\begin{aligned}
 &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t \\
 &= 5 \cdot (1.75 - 0.2967) \cdot 1 \cdot 2.375 \\
 &= 17.2579 \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t_n \\
 &= 5 \cdot (1.75 - 0.2967) \cdot 1 \cdot 1.75 \\
 &= 12.7164 \text{ in}^2
 \end{aligned}$$

$A_3 = \text{smaller of the following} = \underline{3.25} \text{ in}^2$

$$\begin{aligned}
 &= 5 \cdot t_i \cdot f_{r2} \\
 &= 5 \cdot 2.375 \cdot 1.625 \cdot 1 \\
 &= \underline{19.2969} \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 &= 5 \cdot t_i \cdot f_{r2} \\
 &= 5 \cdot 1.625 \cdot 1.625 \cdot 1
 \end{aligned}$$

$$= \underline{13.2031} \text{ in}^2$$

$$\begin{aligned} &= 2 \cdot h \cdot t_1 \cdot f_{r2} \\ &= 2 \cdot 1 \cdot 1.625 \cdot 1 \\ &= \underline{3.25} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} A_{41} &= \text{Leg}^2 \cdot f_{r2} \\ &= 0.375^2 \cdot 1 \\ &= \underline{0.1406} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} A_{43} &= \text{Leg}^2 \cdot f_{r2} \\ &= 0.5714^2 \cdot 1 \\ &= \underline{0.3265} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_3 + A_{41} + A_{43} \\ &= 1.7195 + 12.7164 + 3.25 + 0.1406 + 0.3265 \\ &= \underline{18.153} \text{ in}^2 \end{aligned}$$

As Area  $\geq$  A the reinforcement is adequate.

#### UW-16(c) Weld Check

Fillet weld:  $t_{\min}$  = lesser of 0.75 or  $t_n$  or  $t = 0.75$  in

$t_{c(\min)}$  = lesser of 0.25 or  $0.7 \cdot t_{\min} = \underline{0.25}$  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

$$\begin{aligned} t_{a \text{ UG-27}} &= P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion} \\ &= 1,378.8934 \cdot 4.125 / (20,000 \cdot 1 - 0.6 \cdot 1,378.8934) + 0.125 \\ &= 0.4217 \text{ in} \end{aligned}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.4217, 0 ] \\ &= 0.4217 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion} \\ &= 1,378.8934 \cdot 30.125 / (20,000 \cdot 1 - 0.6 \cdot 1,378.8934) + 0.125 \\ &= 2.2916 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 2.2916, 0.1875 ] \\ &= 2.2916 \text{ in} \end{aligned}$$

$$\begin{aligned}t_b &= \min[ t_{b3} , t_{b1} ] \\ &= \min[ 0.4531 , 2.2916 ] \\ &= 0.4531 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{UG-45} &= \max[ t_a , t_b ] \\ &= \max[ 0.4217 , 0.4531 ] \\ &= 0.4531 \text{ in}\end{aligned}$$

Available nozzle wall thickness new,  $t_n = 1.875$  in

The nozzle neck thickness is adequate.



**Reinforcement Calculations for MAEP**

<p align="center"><b>UG-37 Area Calculation Summary (in<sup>2</sup>)</b>                  For Pe = 838.94 psi @ 140 °F                  The opening is adequately reinforced</p>							<p align="center"><b>UG-45 Nozzle Wall Thickness Summary (in)</b>                  The nozzle passes UG-45</p>	
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
9.7969	15.3104	--	11.5933	3.25	--	0.4671	0.5501	1.875

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	0.25	0.2625	weld size is adequate

Calculations for external pressure 838.94 psi @ 140 °F

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(8.25, 4.125 + (1.875 - 0.125) + (2.5 - 0.125)) \\
 &= 8.25 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(2.5 - 0.125), 2.5*(1.875 - 0.125) + 0) \\
 &= 4.375 \text{ in}
 \end{aligned}$$

**Inner Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_I &= \text{MIN}(2.5*(t - C), 2.5*(t_i - C_n - C)) \\
 &= \text{MIN}(2.5*(2.5 - 0.125), 2.5*(1.875 - 0.125 - 0.125)) \\
 &= 4.0625 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28 t<sub>n</sub> = 0.4251 in

From UG-37(d)(1) required thickness t<sub>r</sub> = 2.375 in

**Area required per UG-37(d)(1)**

Allowable stresses: S<sub>n</sub> = 20,000, S<sub>v</sub> = 20,000 psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$\begin{aligned} A &= 0.5(d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1})) \\ &= 0.5(8.25 \cdot 2.375 \cdot 1 + 2 \cdot 1.75 \cdot 2.375 \cdot 1 \cdot (1 - 1)) \\ &= \underline{9.7969} \text{ in}^2 \end{aligned}$$

**Area available from FIG. UG-37.1**

$$A_1 = \text{larger of the following} = \underline{0} \text{ in}^2$$

$$\begin{aligned} &= d(E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 8.25(1 \cdot 2.375 - 1 \cdot 2.375) - 2 \cdot 1.75(1 \cdot 2.375 - 1 \cdot 2.375)(1 - 1) \\ &= 0 \text{ in}^2 \\ &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2 \cdot (2.375 + 1.75) \cdot (1 \cdot 2.375 - 1 \cdot 2.375) - 2 \cdot 1.75 \cdot (1 \cdot 2.375 - 1 \cdot 2.375) \cdot (1 - 1) \\ &= 0 \text{ in}^2 \end{aligned}$$

$$A_2 = \text{smaller of the following} = \underline{11.5933} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t \\ &= 5 \cdot (1.75 - 0.4251) \cdot 1 \cdot 2.375 \\ &= 15.7337 \text{ in}^2 \\ &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (1.75 - 0.4251) \cdot 1 \cdot 1.75 \\ &= 11.5933 \text{ in}^2 \end{aligned}$$

$$A_3 = \text{smaller of the following} = \underline{3.25} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot t_i \cdot t_i \cdot f_{r2} \\ &= 5 \cdot 2.375 \cdot 1.625 \cdot 1 \\ &= \underline{19.2969} \text{ in}^2 \\ &= 5 \cdot t_i \cdot t_i \cdot f_{r2} \\ &= 5 \cdot 1.625 \cdot 1.625 \cdot 1 \\ &= \underline{13.2031} \text{ in}^2 \\ &= 2 \cdot h \cdot t_i \cdot f_{r2} \\ &= 2 \cdot 1 \cdot 1.625 \cdot 1 \\ &= \underline{3.25} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} A_{41} &= \text{Leg}^2 \cdot f_{r2} \\ &= 0.375^2 \cdot 1 \\ &= \underline{0.1406} \text{ in}^2 \end{aligned}$$

$$A_{43} = \text{Leg}^2 \cdot f_{r2}$$

$$= 0.5714^2 * 1$$

$$= \underline{0.3265 \text{ in}^2}$$

$$\text{Area} = A_1 + A_2 + A_3 + A_{41} + A_{43}$$

$$= 0 + 11.5933 + 3.25 + 0.1406 + 0.3265$$

$$= \underline{15.3104 \text{ in}^2}$$

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

$$t_{a \text{ UG-28}} = 0.5501 \text{ in}$$

$$t_a = \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ]$$

$$= \max[ 0.5501, 0 ]$$

$$= 0.5501 \text{ in}$$

$$t_{b2} = P * R / (S * E - 0.6 * P) + \text{Corrosion}$$

$$= 838.9424 * 30.125 / (20,000 * 1 - 0.6 * 838.9424) + 0.125$$

$$= 1.4213 \text{ in}$$

$$t_{b2} = \max[ t_{b2}, t_{b \text{ UG16}} ]$$

$$= \max[ 1.4213, 0.1875 ]$$

$$= 1.4213 \text{ in}$$

$$t_b = \min[ t_{b3}, t_{b2} ]$$

$$= \min[ 0.4531, 1.4213 ]$$

$$= 0.4531 \text{ in}$$

$$t_{\text{UG-45}} = \max[ t_a, t_b ]$$

$$= \max[ 0.5501, 0.4531 ]$$

$$= 0.5501 \text{ in}$$

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)**

$$L / D_o = 10.5354 / 11.75 = 0.8966$$

$$D_o / t = 11.75 / 0.4251 = 27.6434$$

From table G: A = 0.010937

From table  
CS-2: B = 17,393.3823 psi

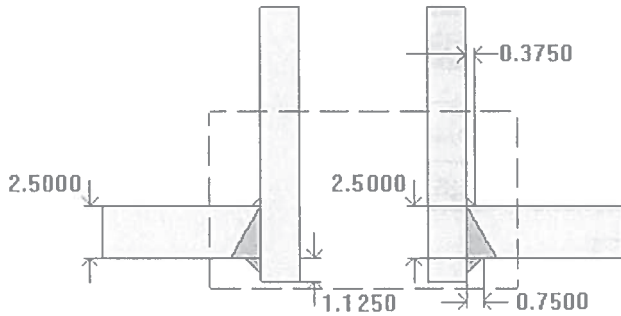
$$\begin{aligned} P_a &= 4*B / (3*(D_o / t)) \\ &= 4*17,393.38 / (3*(11.75 / 0.4251)) \\ &= 838.94 \text{ psi} \end{aligned}$$

**Design thickness for external pressure  $P_a = 838.94$  psi**

$$t_a = t + \text{Corrosion} = 0.4251 + 0.125 = 0.5501''$$

## Inlet Nozzle (N12)

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$$t_{w(\text{lower})} = 2.5 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$

$$\text{Leg}_{43} = 0.75 \text{ in}$$

$$h_{\text{new}} = 1.125 \text{ in}$$

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

### Location and Orientation

Located on:	60 ID SHELL
Orientation:	330°
Nozzle center line offset to datum line:	87 in
End of nozzle to shell center:	42.5 in
Passes through a Category A joint:	No

### Nozzle

Access opening:	No
Material specification:	SA-350 LF2 Cl 1 (II-D p. 18, In. 10)
Inside diameter, new:	8 in
Nominal wall thickness:	1.875 in
Corrosion allowance:	0.125 in
Projection available outside vessel, L <sub>pr</sub> :	7.25 in
Internal projection, h <sub>new</sub> :	1.125 in
Projection available outside vessel to flange face, L <sub>f</sub> :	10 in
Local vessel minimum thickness:	2.5 in
Liquid static head included:	3.8714 psi
Longitudinal joint efficiency:	1

### ASME B16.5-2009 Flange

Description:	NPS 8 Class 900 LWN A350 LF2 Cl.1
Bolt Material:	SA-193 B7 Bolt ≤ 2 1/2 (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55°F per UCS-66(b)(1)(b)
Liquid static head:	3.7126 psi
MAWP rating:	2,146 psi @ 140°F
MAP rating:	2,220 psi @ 50°F
Hydrotest rating:	3,350 psi @ 50°F
PWHT performed:	Yes



## Reinforcement Calculations for Chamber MAWP

UG-37 Area Calculation Summary (in <sup>2</sup> ) For P = 1,381.87 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 <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
17.9145	18.1074	1.6792	12.7111	3.25	--	0.4671	0.4531	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 <sub>41</sub> )	0.25	0.2625	weld size is adequate

Calculations for internal pressure 1,381.87 psi @ 140 °F

Nozzle is impact test exempt to -155 °F per UCS-66(b)(3) (coincident ratio = 0.1699).

Nozzle UCS-66 governing thk: 1.875 in

Nozzle rated MDMT: -155 °F

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(8.25, 4.125 + (1.875 - 0.125) + (2.5 - 0.125)) \\
 &= 8.25 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(2.5 - 0.125), 2.5*(1.875 - 0.125) + 0) \\
 &= 4.375 \text{ in}
 \end{aligned}$$

**Inner Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_I &= \text{MIN}(2.5*(t - C), 2.5*(t_i - C_n - C)) \\
 &= \text{MIN}(2.5*(2.5 - 0.125), 2.5*(1.875 - 0.125 - 0.125)) \\
 &= 4.0625 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_m &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,381.8714 \cdot 4.125 / (20,000 \cdot 1 - 0.6 \cdot 1,381.8714) \\
 &= 0.2973 \text{ in}
 \end{aligned}$$

### Required thickness $t_r$ from UG-37(a)

$$\begin{aligned}t_r &= P \cdot R / (S \cdot E - 0.6 \cdot P) \\&= 1,381.8714 \cdot 30.125 / (20,000 \cdot 1 - 0.6 \cdot 1,381.8714) \\&= 2.1715 \text{ in}\end{aligned}$$

### Area required per UG-37(c)

Allowable stresses:  $S_n = 20,000$ ,  $S_v = 20,000$  psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$\begin{aligned}A &= d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1}) \\&= 8.25 \cdot 2.1715 \cdot 1 + 2 \cdot 1.75 \cdot 2.1715 \cdot 1 \cdot (1 - 1) \\&= \underline{17.9145} \text{ in}^2\end{aligned}$$

### Area available from FIG. UG-37.1

$A_1 = \text{larger of the following} = \underline{1.6792} \text{ in}^2$

$$\begin{aligned}&= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\&= 8.25 \cdot (1 \cdot 2.375 - 1 \cdot 2.1715) - 2 \cdot 1.75 \cdot (1 \cdot 2.375 - 1 \cdot 2.1715) \cdot (1 - 1) \\&= 1.6792 \text{ in}^2 \\&= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\&= 2 \cdot (2.375 + 1.75) \cdot (1 \cdot 2.375 - 1 \cdot 2.1715) - 2 \cdot 1.75 \cdot (1 \cdot 2.375 - 1 \cdot 2.1715) \cdot (1 - 1) \\&= 1.6792 \text{ in}^2\end{aligned}$$

$A_2 = \text{smaller of the following} = \underline{12.7111} \text{ in}^2$

$$\begin{aligned}&= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t \\&= 5 \cdot (1.75 - 0.2973) \cdot 1 \cdot 2.375 \\&= 17.2508 \text{ in}^2 \\&= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t_n \\&= 5 \cdot (1.75 - 0.2973) \cdot 1 \cdot 1.75 \\&= 12.7111 \text{ in}^2\end{aligned}$$

$A_3 = \text{smaller of the following} = \underline{3.25} \text{ in}^2$

$$\begin{aligned}&= 5 \cdot t \cdot t_1 \cdot f_{r2} \\&= 5 \cdot 2.375 \cdot 1.625 \cdot 1 \\&= \underline{19.2969} \text{ in}^2 \\&= 5 \cdot t_1 \cdot t_1 \cdot f_{r2} \\&= 5 \cdot 1.625 \cdot 1.625 \cdot 1\end{aligned}$$

$$\begin{aligned}
 &= \underline{13.2031} \text{ in}^2 \\
 &= 2 \cdot h \cdot t_i \cdot f_{r2} \\
 &= 2 \cdot 1 \cdot 1.625 \cdot 1 \\
 &= \underline{3.25} \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 A_{41} &= \text{Leg}^2 \cdot f_{r2} \\
 &= 0.375^2 \cdot 1 \\
 &= \underline{0.1406} \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 A_{43} &= \text{Leg}^2 \cdot f_{r2} \\
 &= 0.5714^2 \cdot 1 \\
 &= \underline{0.3265} \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 \text{Area} &= A_1 + A_2 + A_3 + A_{41} + A_{43} \\
 &= 1.6792 + 12.7111 + 3.25 + 0.1406 + 0.3265 \\
 &= \underline{18.1074} \text{ in}^2
 \end{aligned}$$

As Area  $\geq$  A the reinforcement is adequate.

#### UW-16(c) Weld Check

Fillet weld:  $t_{\min}$  = lesser of 0.75 or  $t_n$  or  $t = 0.75$  in

$t_{c(\min)}$  = lesser of 0.25 or  $0.7 \cdot t_{\min} = \underline{0.25}$  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

$$\begin{aligned}
 t_{a \text{ UG-27}} &= P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion} \\
 &= 1,381.8714 \cdot 4.125 / (20,000 \cdot 1 - 0.6 \cdot 1,381.8714) + 0.125 \\
 &= 0.4223 \text{ in}
 \end{aligned}$$


$$t_{a \text{ UG-22}} = 0.3798 \text{ in}$$

$$\begin{aligned}
 t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\
 &= \max[ 0.4223, 0.3798 ] \\
 &= 0.4223 \text{ in}
 \end{aligned}$$

$$\begin{aligned}
 t_{b1} &= P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion} \\
 &= 1,381.8714 \cdot 30.125 / (20,000 \cdot 1 - 0.6 \cdot 1,381.8714) + 0.125 \\
 &= 2.2965 \text{ in}
 \end{aligned}$$

$$t_{b1} = \max[ t_{b1}, t_{b \text{ UG16}} ]$$

$$= \max[ 2.2965 , 0.1875 ]$$
$$= 2.2965 \text{ in}$$


$$t_b = \min[ t_{b3} , t_{b1} ]$$
$$= \min[ 0.4531 , 2.2965 ]$$
$$= 0.4531 \text{ in}$$

$$t_{UG-45} = \max[ t_a , t_b ]$$
$$= \max[ 0.4223 , 0.4531 ]$$
$$= 0.4531 \text{ in}$$

Available nozzle wall thickness new,  $t_n = 1.875 \text{ in}$

The nozzle neck thickness is adequate.

## Applied Loads

Radial load:	$P_r = 2,720$	$lb_f$
Circumferential moment:	$M_c = 92,535$	$lb_f\text{-in}$
Circumferential shear:	$V_c = 3,332$	$lb_f$
Longitudinal moment:	$M_L = 92,535$	$lb_f\text{-in}$
Longitudinal shear:	$V_L = 3,332$	$lb_f$
Torsion moment:	$M_t = 130,858$	$lb_f\text{-in}$
Internal pressure:	$P = 1,381.871$	psi
Mean shell radius:	$R_m = 31.3125$	in
Local shell thickness:	$t = 2.375$	in
Shell yield stress:	$S_y = 36,200$	psi

### Maximum stresses due to the applied loads at the nozzle OD (includes pressure)

$$R_m / t = 31.3125 / 2.375 = 13.1842$$

Pressure stress intensity factor,  $I = 1.18127$  (derived from PVP-Vol. 399, pages 77-82)

$$\text{Local circumferential pressure stress} = I * P * R_i / t = 20,705 \text{ psi}$$

$$\text{Local longitudinal pressure stress} = I * P * R_i / (2 * t) = 10,353 \text{ psi}$$

$$\text{Maximum combined stress } (P_L + P_b + Q) = 21,608 \text{ psi}$$

$$\text{Allowable combined stress } (P_L + P_b + Q) = + - 3 * S = + - 60,000 \text{ psi}$$

The maximum combined stress  $(P_L + P_b + Q)$  is within allowable limits.

$$\text{Maximum local primary membrane stress } (P_L) = 20,940 \text{ psi}$$

$$\text{Allowable local primary membrane stress } (P_L) = + - 1.5 * S = + - 30,000 \text{ psi}$$

The maximum local primary membrane stress  $(P_L)$  is within allowable limits.



Stresses at the nozzle OD per WRC Bulletin 107										
Figure	value	$\beta$	$A_u$	$A_l$	$B_u$	$B_l$	$C_u$	$C_l$	$D_u$	$D_l$
3C*	2.0727	0.1642	0	0	0	0	-76	-76	-76	-76
4C*	2.341	0.1642	-86	-86	-86	-86	0	0	0	0
1C	0.1247	0.1642	0	0	0	0	-361	361	-361	361
2C-1	0.0907	0.1642	-262	262	-262	262	0	0	0	0
3A*	0.3939	0.1642	0	0	0	0	-95	-95	95	95
1A	0.0981	0.1642	0	0	0	0	-1,878	1,878	1,878	-1,878
3B*	1.3281	0.1642	-321	-321	321	321	0	0	0	0
1B-1	0.0484	0.1642	-927	927	927	-927	0	0	0	0
Pressure stress*			20,705	20,705	20,705	20,705	17,528	17,528	17,528	17,528
Total circumferential stress			19,109	21,487	21,605	20,275	15,118	19,596	19,064	16,030
Primary membrane circumferential stress*			20,298	20,298	20,940	20,940	17,357	17,357	17,547	17,547
3C*	2.0727	0.1642	-76	-76	-76	-76	0	0	0	0
4C*	2.341	0.1642	0	0	0	0	-86	-86	-86	-86
1C-1	0.1264	0.1642	-366	366	-366	366	0	0	0	0
2C	0.0906	0.1642	0	0	0	0	-262	262	-262	262
4A*	0.5797	0.1642	0	0	0	0	-140	-140	140	140
2A	0.0562	0.1642	0	0	0	0	-1,076	1,076	1,076	-1,076
4B*	0.3835	0.1642	-93	-93	93	93	0	0	0	0
2B-1	0.0779	0.1642	-1,492	1,492	1,492	-1,492	0	0	0	0
Pressure stress*			8,764	8,764	8,764	8,764	10,353	10,353	10,353	10,353
Total longitudinal stress			6,737	10,453	9,907	7,655	8,789	11,465	11,221	9,593
Primary membrane longitudinal stress*			8,595	8,595	8,781	8,781	10,127	10,127	10,407	10,407
Shear from $M_l$			254	254	254	254	254	254	254	254
Circ shear from $V_c$			76	76	-76	-76	0	0	0	0
Long shear from $V_L$			0	0	0	0	-76	-76	76	76
Total Shear stress			330	330	178	178	178	178	330	330
Combined stress ( $P_L+P_b+Q$ )			19,118	21,497	21,608	20,278	15,123	19,600	19,078	16,047

Note: \* denotes primary stress.

### Longitudinal stress in the nozzle wall due to internal pressure + external loads

$$\begin{aligned} \sigma_{n(P_m)} &= P \cdot R_i / (2 \cdot t_n) - P_r / (\pi \cdot (R_o^2 - R_i^2)) + M \cdot R_o / I \\ &= 1,381.87 \cdot 4.125 / (2 \cdot 1.75) - 2,720 / (\pi \cdot (5.875^2 - 4.125^2)) + 130,864.3 \cdot 5.875 / 708.2696 \\ &= 2,665 \text{ psi} \end{aligned}$$

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

$$\begin{aligned} \sigma_{\text{shear}} &= (V_L^2 + V_c^2)^{0.5} / (\pi \cdot R_i \cdot t_n) \\ &= (3,332^2 + 3,332^2)^{0.5} / (\pi \cdot 4.125 \cdot 1.75) \\ &= 208 \text{ psi} \end{aligned}$$

$$\begin{aligned} \sigma_{\text{torsion}} &= M_t / (2 \cdot \pi \cdot R_i^2 \cdot t_n) \\ &= 130,858 / (2 \cdot \pi \cdot 4.125^2 \cdot 1.75) \end{aligned}$$

= 699 psi

$$\begin{aligned}\sigma_{\text{total}} &= \sigma_{\text{shear}} + \sigma_{\text{torsion}} \\ &= 208 + 699 \\ &= 907 \text{ psi}\end{aligned}$$

UG-45: The total combined shear stress (907 psi) is below than the allowable ( $0.7 \cdot S_n = 0.7 \cdot 20,000 = 14,000$  psi)

**Reinforcement Calculations for MAEP**

<b>UG-37 Area Calculation Summary (in<sup>2</sup>)</b> For Pe = 838.94 psi @ 140 °F The opening is adequately reinforced							<b>UG-45 Nozzle Wall Thickness Summary (in)</b> The nozzle passes UG-45	
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
9.7969	15.3104	--	11.5933	3.25	--	0.4671	0.5501	1.875

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (In)	Actual weld throat size (In)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	0.25	0.2625	weld size is adequate

Calculations for external pressure 838.94 psi @ 140 °F

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(8.25, 4.125 + (1.875 - 0.125) + (2.5 - 0.125)) \\
 &= 8.25 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(2.5 - 0.125), 2.5*(1.875 - 0.125) + 0) \\
 &= 4.375 \text{ in}
 \end{aligned}$$

**Inner Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_I &= \text{MIN}(2.5*(t - C), 2.5*(t_i - C_n - C)) \\
 &= \text{MIN}(2.5*(2.5 - 0.125), 2.5*(1.875 - 0.125 - 0.125)) \\
 &= 4.0625 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28 t<sub>n</sub> = 0.4251 in

From UG-37(d)(1) required thickness t<sub>r</sub> = 2.375 in

**Area required per UG-37(d)(1)**

Allowable stresses: S<sub>n</sub> = 20,000, S<sub>v</sub> = 20,000 psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$\begin{aligned} A &= 0.5(d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1})) \\ &= 0.5(8.25 \cdot 2.375 \cdot 1 + 2 \cdot 1.75 \cdot 2.375 \cdot 1 \cdot (1 - 1)) \\ &= \underline{9.7969} \text{ in}^2 \end{aligned}$$

**Area available from FIG. UG-37.1**

$$A_1 = \text{larger of the following} = \underline{0} \text{ in}^2$$

$$\begin{aligned} &= d(E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 8.25(1 \cdot 2.375 - 1 \cdot 2.375) - 2 \cdot 1.75(1 \cdot 2.375 - 1 \cdot 2.375)(1 - 1) \\ &= 0 \text{ in}^2 \\ &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\ &= 2 \cdot (2.375 + 1.75) \cdot (1 \cdot 2.375 - 1 \cdot 2.375) - 2 \cdot 1.75 \cdot (1 \cdot 2.375 - 1 \cdot 2.375) \cdot (1 - 1) \\ &= 0 \text{ in}^2 \end{aligned}$$

$$A_2 = \text{smaller of the following} = \underline{11.5933} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t \\ &= 5 \cdot (1.75 - 0.4251) \cdot 1 \cdot 2.375 \\ &= 15.7337 \text{ in}^2 \\ &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t_n \\ &= 5 \cdot (1.75 - 0.4251) \cdot 1 \cdot 1.75 \\ &= 11.5933 \text{ in}^2 \end{aligned}$$

$$A_3 = \text{smaller of the following} = \underline{3.25} \text{ in}^2$$

$$\begin{aligned} &= 5 \cdot t_i \cdot f_{r2} \\ &= 5 \cdot 2.375 \cdot 1.625 \cdot 1 \\ &= \underline{19.2969} \text{ in}^2 \\ &= 5 \cdot t_i \cdot t_i \cdot f_{r2} \\ &= 5 \cdot 1.625 \cdot 1.625 \cdot 1 \\ &= \underline{13.2031} \text{ in}^2 \\ &= 2 \cdot h \cdot t_i \cdot f_{r2} \\ &= 2 \cdot 1 \cdot 1.625 \cdot 1 \\ &= \underline{3.25} \text{ in}^2 \end{aligned}$$

$$\begin{aligned} A_{41} &= \text{Leg}^2 \cdot f_{r2} \\ &= 0.375^2 \cdot 1 \\ &= \underline{0.1406} \text{ in}^2 \end{aligned}$$

$$A_{43} = \text{Leg}^2 \cdot f_{r2}$$

$$= 0.5714^2 * 1$$

$$= \underline{0.3265 \text{ in}^2}$$

$$\text{Area} = A_1 + A_2 + A_3 + A_{41} + A_{43}$$

$$= 0 + 11.5933 + 3.25 + 0.1406 + 0.3265$$

$$= \underline{15.3104 \text{ in}^2}$$

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

$$t_{a \text{ UG-28}} = 0.5501 \text{ in}$$

$$t_{a \text{ UG-22}} = 0.3113 \text{ in}$$

$$t_a = \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ]$$

$$= \max[ 0.5501, 0.3113 ]$$

$$= 0.5501 \text{ in}$$

$$t_{b2} = P * R / (S * E - 0.6 * P) + \text{Corrosion}$$

$$= 838.9424 * 30.125 / (20,000 * 1 - 0.6 * 838.9424) + 0.125$$

$$= 1.4213 \text{ in}$$

$$t_{b2} = \max[ t_{b2}, t_{b \text{ UG16}} ]$$

$$= \max[ 1.4213, 0.1875 ]$$

$$= 1.4213 \text{ in}$$

$$t_b = \min[ t_{b3}, t_{b2} ]$$

$$= \min[ 0.4531, 1.4213 ]$$

$$= 0.4531 \text{ in}$$

$$t_{\text{UG-45}} = \max[ t_a, t_b ]$$

$$= \max[ 0.5501, 0.4531 ]$$

$$= 0.5501 \text{ in}$$

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)**

$$L / D_o = 10.5354 / 11.75 = 0.8966$$

$$D_o / t = 11.75 / 0.4251 = 27.6434$$

From table G: A = 0.010937

From table  
CS-2: B = 17,393.3823 psi

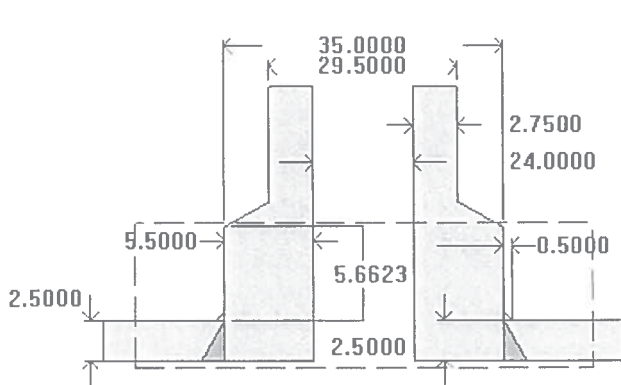
$$\begin{aligned} P_a &= 4*B / (3*(D_o / t)) \\ &= 4*17,393.38 / (3*(11.75 / 0.4251)) \\ &= 838.94 \text{ psi} \end{aligned}$$

**Design thickness for external pressure  $P_a = 838.94$  psi**

$$t_a = t + \text{Corrosion} = 0.4251 + 0.125 = 0.5501''$$

## Manway (N13)

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$$t_{w(\text{lower})} = 2.5 \text{ in}$$

$$\text{Leg}_{41} = 0.5 \text{ in}$$

Note: Per UW-16(b) minimum inside corner radius  $r_1 = \min [1/4t, 0.125 \text{ in}] = 0.125 \text{ in}$

### Location and Orientation

Located on:	60 ID SHELL
Orientation:	270°
Nozzle center line offset to datum line:	60 in
End of nozzle to shell center:	48.25 in
Passes through a Category A joint:	No

### Nozzle

Access opening:	Yes
Material specification:	SA-350 LF2 Cl 1 (II-D p. 18, In. 10)
Inside diameter, new:	24 in
Wall thickness, $t_n$ :	5.5 in
Minimum wall thickness:	2.75 in
Corrosion allowance:	0.125 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:	2.5 in
User input radial limit of reinforcement:	23 in
Liquid static head included:	3.117 psi
Longitudinal joint efficiency:	1

### ASME B16.5-2009 Flange

Description:	NPS 24 Class 900 V2 A350 LF2 Cl.1 (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 UCS-66(b)(1)(b)
Liquid static head:	2.6405 psi
MAWP rating:	2,146 psi @ 140°F
MAP rating:	2,220 psi @ 50°F

Hydrotest rating:  
PWHT performed:

3,350 psi @ 50°F  
Yes

**Reinforcement Calculations for Chamber MAWP**

<b>UG-37 Area Calculation Summary (in<sup>2</sup>)</b> For P = 1,381.12 psi @ 140 °F The opening is adequately reinforced							<b>UG-45 Nozzle Wall Thickness Summary (in)</b> The nozzle passes UG-45	
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
52.6281	58.0278	4.4537	53.3241	--	--	0.25	0.9985	2.75

<b>UG-41 Weld Failure Path Analysis Summary</b>
The nozzle is exempt from weld strength calculations per UW-15(b)(1)

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (In)	Actual weld throat size (In)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	0.25	0.35	weld size is adequate

**Calculations for internal pressure 1,381.12 psi @ 140 °F**

Nozzle is impact tested to -50 °F with an additional 5 °F reduction per UCS-66(g).

Nozzle UCS-66 governing thk: 2.5 in  
 Nozzle rated MDMT: -55 °F

**Parallel Limit of reinforcement per UG-40 and Fig. UG-40 sketch (e-1)**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(24.25, 12.125 + (2.75 - 0.125) + (2.5 - 0.125)) \\
 &= 24.25 \text{ in}
 \end{aligned}$$

$$L_R = 23 \text{ in (User Defined)}$$

**Outer Normal Limit of reinforcement per UG-40 and Fig. UG-40 sketch (e-1)**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(2.5 - 0.125), 2.5*(2.75 - 0.125) + 4.7631) \\
 &= 5.9375 \text{ in}
 \end{aligned}$$

$$\begin{aligned}
 t_e &= \text{MIN}( 5.6623 + 2.75*\tan(30) , 2.75*\tan(60) ) \\
 &= 4.7631 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_{rn} &= P*R_n / (S_n*E - 0.6*P) \\
 &= 1,381.117*12.125 / (20,000*1 - 0.6*1,381.117) \\
 &= 0.8735 \text{ in}
 \end{aligned}$$

**Required thickness  $t_r$  from UG-37(a)**

$$\begin{aligned}
 t_r &= P \cdot R / (S \cdot E - 0.6 \cdot P) \\
 &= 1,381.117 \cdot 30.125 / (20,000 \cdot 1 - 0.6 \cdot 1,381.117) \\
 &= 2.1702 \text{ in}
 \end{aligned}$$

**Area required per UG-37(c)**

Allowable stresses:  $S_n = 20,000$ ,  $S_v = 20,000$  psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$\begin{aligned}
 A &= d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1}) \\
 &= 24.25 \cdot 2.1702 \cdot 1 + 2 \cdot 5.375 \cdot 2.1702 \cdot 1 \cdot (1 - 1) \\
 &= \underline{52.6281} \text{ in}^2
 \end{aligned}$$

**Area available from FIG. UG-37.1**

$A_1$ : (specified limit governs) = 4.4537 in<sup>2</sup>

$$\begin{aligned}
 &= (2 \cdot \text{limits} - d) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\
 &= (2 \cdot 23 - 24.25) \cdot (1 \cdot 2.375 - 1 \cdot 2.1702) - 2 \cdot 5.375 \cdot (1 \cdot 2.375 - 1 \cdot 2.1702) \cdot (1 - 1) \\
 &= \underline{4.4537} \text{ in}^2
 \end{aligned}$$

$A_2$  = smaller of the following = 53.3241 in<sup>2</sup>

$$\begin{aligned}
 &= 5 \cdot (t_n - t_m) \cdot f_{r2} \cdot t - (\text{LIMIT} - L_{hb})^2 \cdot f_{r2} / \tan(30) \\
 &= 5 \cdot (5.375 - 0.8735) \cdot 1 \cdot 2.375 - (5.9375 - 5.6623)^2 \cdot 1 / \tan(30) \\
 &= 53.3241 \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 &= 2 \cdot (t_n - t_m) \cdot f_{r2} \cdot L_{pr} - [(t_n - t_p)^2 \cdot \tan(30) + 2 \cdot (\text{LIMIT} - L_{hb} - L_{slope}) \cdot (t_n - t_p)] \cdot f_{r2} \\
 &= 2 \cdot (5.375 - 0.8735) \cdot 1 \cdot 10 - [(5.375 - 2.625)^2 \cdot \tan(30) + 2 \cdot (10 - 5.6623 - 1.5877) \cdot (5.375 - 2.625)] \cdot 1 \\
 &= 70.5388 \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 A_{41} &= \text{Leg}^2 \cdot f_{r2} \\
 &= 0.5^2 \cdot 1 \\
 &= \underline{0.25} \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 \text{Area} &= A_1 + A_2 + A_{41} \\
 &= 4.4537 + 53.3241 + 0.25 \\
 &= \underline{58.0278} \text{ in}^2
 \end{aligned}$$

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)

$$\begin{aligned}t_{a \text{ UG-27}} &= P*R / (S*E - 0.6*P) + \text{Corrosion} \\ &= 1,381.117*12.125 / (20,000*1 - 0.6*1,381.117) + 0.125 \\ &= 0.9985 \text{ in}\end{aligned}$$

$$\begin{aligned}t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.9985, 0 ] \\ &= 0.9985 \text{ in}\end{aligned}$$

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

$$= 2 / 3 * A = (2 / 3) * 52.6281 = \underline{35.0854} \text{ in}^2$$

Area that is within 75 percent of the limits of reinforcement is:

$A_1 = \text{larger of } 3.1739 \text{ or}$

$$\begin{aligned}&= (2*\text{limits} - d)*(E_1*t - F*t_r) - 2*t_n*(E_1*t - F*t_r)*(1 - f_{r1}) \\ &= (2*18.1875 - 24.25)*(1*2.375 - 1*2.1702) - 2*5.375*(1*2.375 - 1*2.1702)*(1 - 1) \\ &= 2.4828 \text{ in}^2\end{aligned}$$

$$\begin{aligned}\text{Area} &= A_1 + A_2 + A_3 + A_{41} + A_{42} + A_{43} + A_5 \\ &= 3.1739 + 53.3241 + 0 + 0.25 + 0 + 0 + 0 \\ &= \underline{56.748} \text{ in}^2\end{aligned}$$

The area replacement requirements of Appendix 1-7(a) are satisfied.

### Check Large Opening per Appendix 1-7(b)

1-7(b)(1)(a)  $D_i = 60.25 \text{ in} > 60 \text{ in}$  True

1-7(b)(1)(b)  $d = 24.25 \text{ in} > 40 \text{ in}$  False

1-7(b)(1)(b)  $d = 24.25 \text{ in} > 3.4*(30.125*2.375)^{0.5} = 28.759 \text{ in}$  False



1-7(b)(1)(c)  $R_n / R = 12.125 / 30.125 = 0.4025 \leq 0.7$

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).

$R_n / R = 0.4025$  does not exceed 0.7 so a U-2(g) analysis is not required per 1-7(b)(1)(c).

## Reinforcement Calculations for MAEP

<b>UG-37 Area Calculation Summary (in<sup>2</sup>)</b> For Pe = 838.94 psi @ 140 °F The opening is adequately reinforced							<b>UG-45 Nozzle Wall Thickness Summary (in)</b> The nozzle passes UG-45	
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
28.7969	49.0106	--	48.7606	--	--	0.25	1.3828	2.75

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

UW-16 Weld Sizing Summary			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	0.25	0.35	weld size is adequate

Calculations for external pressure 838.94 psi @ 140 °F

Parallel Limit of reinforcement per UG-40 and Fig. UG-40 sketch (e-1)

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(24.25, 12.125 + (2.75 - 0.125) + (2.5 - 0.125)) \\
 &= 24.25 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40 and Fig. UG-40 sketch (e-1)

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(2.5 - 0.125), 2.5*(2.75 - 0.125) + 4.7631) \\
 &= 5.9375 \text{ in}
 \end{aligned}$$

$$\begin{aligned}
 t_e &= \text{MIN}(5.6623 + 2.75*\tan(30), 2.75*\tan(60)) \\
 &= 4.7631 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28  $t_{rn} = 1.2578 \text{ in}$

From UG-37(d)(1) required thickness  $t_r = 2.375 \text{ in}$

Area required per UG-37(d)(1)

Allowable stresses:  $S_n = 20,000$ ,  $S_v = 20,000 \text{ psi}$

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$\begin{aligned}
A &= 0.5*(d*t_r*F + 2*t_n*t_r*F*(1 - f_{r1})) \\
&= 0.5*(24.25*2.375*1 + 2*5.375*2.375*1*(1 - 1)) \\
&= \underline{28.7969} \text{ in}^2
\end{aligned}$$

**Area available from FIG. UG-37.1**

$$A_1 = \text{larger of the following} = \underline{0} \text{ in}^2$$

$$\begin{aligned}
&= d*(E_1*t - F*t_r) - 2*t_n*(E_1*t - F*t_r)*(1 - f_{r1}) \\
&= 24.25*(1*2.375 - 1*2.375) - 2*5.375*(1*2.375 - 1*2.375)*(1 - 1) \\
&= 0 \text{ in}^2 \\
&= 2*(t + t_n)*(E_1*t - F*t_r) - 2*t_n*(E_1*t - F*t_r)*(1 - f_{r1}) \\
&= 2*(2.375 + 5.375)*(1*2.375 - 1*2.375) - 2*5.375*(1*2.375 - 1*2.375)*(1 - 1) \\
&= 0 \text{ in}^2
\end{aligned}$$

$$A_2 = \text{smaller of the following} = \underline{48.7606} \text{ in}^2$$

$$\begin{aligned}
&= 5*(t_n - t_m)*f_{r2}*t - (\text{LIMIT} - L_{hb})^2*f_{r2} / \tan(30) \\
&= 5*(5.375 - 1.2578)*1*2.375 - (5.9375 - 5.6623)^2*1 / \tan(30) \\
&= 48.7606 \text{ in}^2 \\
&= 2*(t_n - t_m)*f_{r2}*L_{pr} - [(t_n - t_p)^2*\tan(30) + 2*(\text{LIMIT} - L_{hb} - L_{slope})*(t_n - t_p)]*f_{r2} \\
&= 2*(5.375 - 1.2578)*1*10 - [(5.375 - 2.625)^2*\tan(30) + 2*(10 - 5.6623 - 1.5877)*(5.375 - 2.625)]*1 \\
&= 62.8529 \text{ in}^2
\end{aligned}$$

$$\begin{aligned}
A_{41} &= \text{Leg}^2*f_{r2} \\
&= 0.5^2*1 \\
&= \underline{0.25} \text{ in}^2
\end{aligned}$$

$$\begin{aligned}
\text{Area} &= A_1 + A_2 + A_{41} \\
&= 0 + 48.7606 + 0.25 \\
&= \underline{49.0106} \text{ in}^2
\end{aligned}$$

As Area  $\geq$  A the reinforcement is adequate.

**UW-16(c) Weld Check**

$$\begin{aligned}
\text{Fillet weld: } t_{\min} &= \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.75 \text{ in} \\
t_{c(\min)} &= \text{lesser of } 0.25 \text{ or } 0.7*t_{\min} = \underline{0.25} \text{ in} \\
t_{c(\text{actual})} &= 0.7*\text{Leg} = 0.7*0.5 = 0.35 \text{ in}
\end{aligned}$$

The fillet weld size is satisfactory.

Weld strength calculations are not required for this detail which conforms to Fig. UW-16.1, sketch (c-e).

### UG-45 Nozzle Neck Thickness Check (Access Opening)

$$t_{a \text{ UG-28}} = 1.3828 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 1.3828, 0 ] \\ &= 1.3828 \text{ in} \end{aligned}$$

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  
 $= 2 / 3 * A = (2 / 3) * 28.7969 = \underline{19.1979} \text{ in}^2$

Area that is within 75 percent of the limits of reinforcement is:

$A_1 =$  larger of 0 or

$$\begin{aligned} &= (2 * \text{limits} - d) * (E_1 * t - F * t_r) - 2 * t_n * (E_1 * t - F * t_r) * (1 - f_{r1}) \\ &= (2 * 18.1875 - 24.25) * (1 * 2.375 - 1 * 2.375) - 2 * 5.375 * (1 * 2.375 - 1 * 2.375) * (1 - 1) \\ &= 0 \text{ in}^2 \end{aligned}$$

$$\begin{aligned} \text{Area} &= A_1 + A_2 + A_3 + A_{41} + A_{42} + A_{43} + A_5 \\ &= 0 + 48.7606 + 0 + 0.25 + 0 + 0 + 0 \\ &= \underline{49.0106} \text{ in}^2 \end{aligned}$$

The area replacement requirements of Appendix 1-7(a) are satisfied.

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

$$\begin{aligned} L / D_o &= 20.8639 / 35 = 0.5961 \\ D_o / t &= 35 / 1.2578 = 27.8265 \\ \text{From table G: } A &= 0.017365 \\ \text{From table CS-2: } B &= 17,508.6251 \text{ psi} \end{aligned}$$

$$\begin{aligned} P_a &= 4 * B / (3 * (D_o / t)) \\ &= 4 * 17,508.63 / (3 * (35 / 1.2578)) \\ &= 838.94 \text{ psi} \end{aligned}$$

**Design thickness for external pressure  $P_a = 838.94 \text{ psi}$**

$$t_a = t + \text{Corrosion} = 1.2578 + 0.125 = 1.3828''$$

## Straight Flange on 60 ID BOTTOM SE HEAD

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

Component: Straight Flange  
Material specification: SA-516 70 (II-D p. 18, In. 19)  
Material is impact tested per UG-84 to -20 °F  
UCS-66(i) reduction of 12.7 °F applied (ratio = 0.8733).

Internal design pressure:  $P = 1,378$  psi @ 140 °F  
External design pressure:  $P_e = 15$  psi @ 140 °F

#### Static liquid head:

$P_s = 4.15$  psi (SG = 1.1,  $H_s = 104.5$ ", Operating head)  
 $P_{th} = 2.54$  psi (SG = 1,  $H_s = 70.5$ ", Horizontal test head)

Corrosion allowance Inner C = 0.125" Outer C = 0"

Design MDMT = -20 °F Impact test performed  
Rated MDMT = -32.7 °F Material is normalized  
Material is not produced to Fine Grain Practice  
PWHT is performed

Radiography: Longitudinal joint - Seamless No RT  
Circumferential joint - Full UW-11(a) Type 1

Estimated weight New = 290.8 lb corr = 277.4 lb  
Capacity New = 24.48 US gal corr = 24.68 US gal

ID = 60"  
Length = 2"  
 $L_c$   
t = 2.612"

#### Design thickness, (at 140 °F) UG-27(c)(1)

$t = P \cdot R / (S \cdot E - 0.60 \cdot P) + \text{Corrosion}$   
 $= 1,382.15 \cdot 30.125 / (20,000 \cdot 1.00 - 0.60 \cdot 1,382.15) + 0.125$   
 $= 2.297$ "

#### Maximum allowable working pressure, (at 140 °F) UG-27(c)(1)

$P = S \cdot E \cdot t / (R + 0.60 \cdot t) - P_s$   
 $= 20,000 \cdot 1.00 \cdot 2.487 / (30.125 + 0.60 \cdot 2.487) - 4.15$   
 $= 1,569.04$  psi

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

$L / D_o = 110.0833 / 65.224 = 1.6878$   
 $D_o / t = 65.224 / 0.2616 = 249.3220$   
From table G: A = 0.000195  
From table CS-2: B = 2,804.8786 psi

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

$$= 4 * 2,804.88 / (3 * (65.224 / 0.2616))$$

$$= 15 \text{ psi}$$

**Design thickness for external pressure  $P_a = 15 \text{ psi}$**

$$t_a = t + \text{Corrosion} = 0.2616 + 0.125 = 0.3866''$$

**Maximum Allowable External Pressure, (Corroded & at 140 °F) UG-28(c)**

$$L / D_o = 110.0833 / 65.224 = 1.6878$$

$$D_o / t = 65.224 / 2.487 = 26.2260$$

From table G:  $A = 0.005788$

From table  
CS-2:  $B = 17,236.009 \text{ psi}$

$$P_a = 4 * B / (3 * (D_o / t))$$

$$= 4 * 17,236.01 / (3 * (65.224 / 2.487))$$

$$= 876.28 \text{ psi}$$

**% Extreme fiber elongation - UCS-79(d)**

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

$$= (50 * 2.612 / 31.306) * (1 - 31.306 / \infty)$$

$$= 4.1717\%$$

The extreme fiber elongation does not exceed 5%.

**Design thickness = 2.297''**

The governing condition is due to internal pressure.

The cylinder thickness of 2.612'' is adequate.



### Thickness Required Due to Pressure + External Loads

Condition	Pressure P (psi)	Allowable Stress Before UG-23 Stress Increase (psi)		Temperature (°F)	Corrosion C (in)	Load	Req'd Thk Due to Tension (in)	Req'd Thk Due to Compression (in)
		S <sub>t</sub>	S <sub>c</sub>					
<u>Operating, Hot &amp; Corroded</u>	1,378	20,000	<u>17,359</u>	140	0.125	Wind	<u>0.8543</u>	<u>0.8459</u>
						Seismic	<u>0.8726</u>	<u>0.8227</u>
<u>Operating, Hot &amp; New</u>	1,378	20,000	<u>17,371</u>	140	0	Wind	<u>0.8506</u>	<u>0.8421</u>
						Seismic	<u>0.8694</u>	<u>0.8182</u>
<u>Hot Shut Down, Corroded</u>	0	20,000	<u>17,359</u>	140	0.125	Wind	<u>0.0008</u>	<u>0.0105</u>
						Seismic	<u>0.0176</u>	<u>0.0372</u>
<u>Hot Shut Down, New</u>	0	20,000	<u>17,371</u>	140	0	Wind	<u>0.001</u>	<u>0.0108</u>
						Seismic	<u>0.018</u>	<u>0.0383</u>
<u>Empty, Corroded</u>	0	20,000	<u>17,359</u>	70	0.125	Wind	<u>0.0008</u>	<u>0.0105</u>
						Seismic	<u>0.0118</u>	<u>0.0306</u>
<u>Empty, New</u>	0	20,000	<u>17,371</u>	70	0	Wind	<u>0.001</u>	<u>0.0108</u>
						Seismic	<u>0.0122</u>	<u>0.0317</u>
<u>Vacuum</u>	-15	20,000	<u>17,359</u>	140	0.125	Wind	<u>0.0116</u>	<u>0.0214</u>
						Seismic	<u>0.0082</u>	<u>0.048</u>
<u>Hot Shut Down, Corroded, Weight &amp; Eccentric Moments Only</u>	0	20,000	<u>17,359</u>	140	0.125	Weight	<u>0.0016</u>	<u>0.0119</u>

#### Allowable Compressive Stress, Hot and Corroded- S<sub>CHC</sub> (table CS-2)

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (32.612 / 2.487) \\
 &= 0.009533 \\
 B &= 17,359 \text{ psi} \\
 S &= 20,000 / 1.00 = 20,000 \text{ psi} \\
 S_{CHC} &= \min(B, S) = \underline{17,359 \text{ psi}}
 \end{aligned}$$

#### Allowable Compressive Stress, Hot and New- S<sub>CHN</sub> (table CS-2)

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (32.612 / 2.612) \\
 &= 0.010012 \\
 B &= 17,371 \text{ psi} \\
 S &= 20,000 / 1.00 = 20,000 \text{ psi} \\
 S_{CHN} &= \min(B, S) = \underline{17,371 \text{ psi}}
 \end{aligned}$$

#### Allowable Compressive Stress, Cold and New- S<sub>CCN</sub> (table CS-2)

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (32.612 / 2.612) \\
 &= 0.010012 \\
 B &= 17,371 \text{ psi} \\
 S &= 20,000 / 1.00 = 20,000 \text{ psi} \\
 S_{CCN} &= \min(B, S) = \underline{17,371 \text{ psi}}
 \end{aligned}$$

**Allowable Compressive Stress, Cold and Corroded-  $S_{cCC}$ , (table CS-2)**

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (32.612 / 2.487) \\
 &= 0.009533 \\
 B &= 17,359 \text{ psi} \\
 S &= 20,000 / 1.00 = 20,000 \text{ psi} \\
 S_{cCC} &= \min(B, S) = \underline{17,359 \text{ psi}}
 \end{aligned}$$

**Allowable Compressive Stress, Vacuum and Corroded-  $S_{cVC}$ , (table CS-2)**

$$\begin{aligned}
 A &= 0.125 / (R_o / t) \\
 &= 0.125 / (32.612 / 2.487) \\
 &= 0.009533 \\
 B &= 17,359 \text{ psi} \\
 S &= 20,000 / 1.00 = 20,000 \text{ psi} \\
 S_{cVC} &= \min(B, S) = \underline{17,359 \text{ psi}}
 \end{aligned}$$

**Operating, Hot & Corroded, Wind, Bottom Seam**

$$\begin{aligned}
 t_p &= P \cdot R / (2 \cdot S_t \cdot K_s \cdot E_c + 0.40 \cdot |P|) && \text{(Pressure)} \\
 &= 1,378 \cdot 30.125 / (2 \cdot 20,000 \cdot 1.20 \cdot 1.00 + 0.40 \cdot |1,378|) \\
 &= 0.855" \\
 t_m &= M / (\pi \cdot R_m^2 \cdot S_t \cdot K_s \cdot E_c) && \text{(bending)} \\
 &= 312,960 / (\pi \cdot 31.3685^2 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\
 &= 0.0042" \\
 t_w &= W / (2 \cdot \pi \cdot R_m \cdot S_t \cdot K_s \cdot E_c) && \text{(Weight)} \\
 &= 23,199.5 / (2 \cdot \pi \cdot 31.3685 \cdot 20,000 \cdot 1.20 \cdot 1.00) \\
 &= 0.0049" \\
 t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\
 &= 0.855 + 0.0042 - (0.0049) \\
 &= \underline{0.8543"} \\
 t_c &= |t_{mc} + t_{wc} - t_{pc}| && \text{(total, net tensile)} \\
 &= |0.0042 + (0.0049) - (0.855)| \\
 &= \underline{0.8459"}
 \end{aligned}$$

**Maximum allowable working pressure, Longitudinal Stress**

$$\begin{aligned}
 P &= 2 \cdot S_t \cdot K_s \cdot E_c \cdot (t - t_m + t_w) / (R - 0.40 \cdot (t - t_m + t_w)) \\
 &= 2 \cdot 20,000 \cdot 1.20 \cdot 1.00 \cdot (2.487 - 0.0042 + (0.0049)) / (30.125 - 0.40 \cdot (2.487 - 0.0042 + (0.0049))) \\
 &= 4,099.18 \text{ psi}
 \end{aligned}$$

**Operating, Hot & New, Wind, Bottom Seam**

$$\begin{aligned}
 t_p &= P \cdot R / (2 \cdot S_t \cdot K_s \cdot E_c + 0.40 \cdot |P|) && \text{(Pressure)} \\
 &= 1,378 \cdot 30 / (2 \cdot 20,000 \cdot 1.20 \cdot 1.00 + 0.40 \cdot |1,378|) \\
 &= 0.8515"
 \end{aligned}$$

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

$$= 315,781 / (\pi 31.306^2 20,000 * 1.20 * 1.00)$$

$$= 0.0043''$$

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

$$= 24,089.2 / (2 \pi 31.306 * 20,000 * 1.20 * 1.00)$$

$$= 0.0051''$$

$$t_t = t_p + t_m - t_w \quad (\text{total required, tensile})$$

$$= 0.8515 + 0.0043 - (0.0051)$$

$$= \underline{0.8506''}$$

$$t_c = |t_{mc} + t_{wc} - t_{pc}| \quad (\text{total, net tensile})$$

$$= |0.0043 + (0.0051) - (0.8515)|$$

$$= \underline{0.8421''}$$

### Maximum allowable working pressure, Longitudinal Stress

$$P = 2 S_t K_s E_c (t - t_m + t_w) / (R - 0.40(t - t_m + t_w))$$

$$= 2 * 20,000 * 1.20 * 1.00 * (2.612 - 0.0043 + (0.0051)) / (30 - 0.40 * (2.612 - 0.0043 + (0.0051)))$$

$$= 4,331.42 \text{ psi}$$

### Hot Shut Down, Corroded, Wind, Bottom Seam

$$t_p = 0'' \quad (\text{Pressure})$$

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

$$= 312,960 / (\pi 31.3685^2 * 17,359.27 * 1.20)$$

$$= 0.0049''$$

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

$$= 23,199.5 / (2 \pi 31.3685 * 17,359.27 * 1.20)$$

$$= 0.0057''$$

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

$$= |0 + 0.0049 - (0.0057)|$$

$$= \underline{0.0008''}$$

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

$$= 0.0049 + (0.0057) - (0)$$

$$= \underline{0.0105''}$$

### Hot Shut Down, New, Wind, Bottom Seam

$$t_p = 0'' \quad (\text{Pressure})$$

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

$$= 315,781 / (\pi 31.306^2 * 17,371.43 * 1.20)$$

$$= 0.0049''$$

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

$$= 24,089.2 / (2 \pi 31.306 * 17,371.43 * 1.20)$$

$$= 0.0059''$$

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

$$= |0 + 0.0049 - (0.0059)|$$

$$= \underline{0.001''}$$

$$\begin{aligned}
 t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\
 &= 0.0049 + (0.0059) - (0) \\
 &= \underline{0.0108"}
 \end{aligned}$$

**Empty, Corroded, Wind, Bottom Seam**

$$\begin{aligned}
 t_p &= 0" && \text{(Pressure)} \\
 t_m &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\
 &= 312,960 / (\pi * 31.3685^2 * 17,359.27 * 1.20) \\
 &= 0.0049" \\
 t_w &= W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\
 &= 23,199.5 / (2 * \pi * 31.3685 * 17,359.27 * 1.20) \\
 &= 0.0057" \\
 t_t &= |t_p + t_m - t_w| && \text{(total, net compressive)} \\
 &= |0 + 0.0049 - (0.0057)| \\
 &= \underline{0.0008"} \\
 t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\
 &= 0.0049 + (0.0057) - (0) \\
 &= \underline{0.0105"}
 \end{aligned}$$

**Empty, New, Wind, Bottom Seam**

$$\begin{aligned}
 t_p &= 0" && \text{(Pressure)} \\
 t_m &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\
 &= 315,781 / (\pi * 31.306^2 * 17,371.43 * 1.20) \\
 &= 0.0049" \\
 t_w &= W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\
 &= 24,089.2 / (2 * \pi * 31.306 * 17,371.43 * 1.20) \\
 &= 0.0059" \\
 t_t &= |t_p + t_m - t_w| && \text{(total, net compressive)} \\
 &= |0 + 0.0049 - (0.0059)| \\
 &= \underline{0.001"} \\
 t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\
 &= 0.0049 + (0.0059) - (0) \\
 &= \underline{0.0108"}
 \end{aligned}$$

**Vacuum, Wind, Bottom Seam**

$$\begin{aligned}
 t_p &= P * R / (2 * S_c * K_s + 0.40 * |P|) && \text{(Pressure)} \\
 &= -15 * 30.125 / (2 * 17,359.27 * 1.20 + 0.40 * |15|) \\
 &= -0.0108" \\
 t_m &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\
 &= 312,960 / (\pi * 31.3685^2 * 17,359.27 * 1.20) \\
 &= 0.0049" \\
 t_w &= W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\
 &= 23,199.5 / (2 * \pi * 31.3685 * 17,359.27 * 1.20) \\
 &= 0.0057"
 \end{aligned}$$

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

$$= |-0.0108 + 0.0049 - (0.0057)|$$

$$= \underline{0.0116''}$$

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

$$= 0.0049 + (0.0057) - (-0.0108)$$

$$= \underline{0.0214''}$$

### Maximum Allowable External Pressure, Longitudinal Stress

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

$$= 2*17,359.27*1.20*(2.487 - 0.0049 - 0.0057) / (30.125 - 0.40*(2.487 - 0.0049 - 0.0057))$$

$$= 3,541.38 \text{ psi}$$

### Hot Shut Down, Corroded, Weight & Eccentric Moments Only, Bottom Seam

$$t_p = 0'' \quad (\text{Pressure})$$

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

$$= 276,644 / (\pi*31.3685^2*17,359.27*1.00)$$

$$= 0.0052''$$

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

$$= 23,199.5 / (2*\pi*31.3685*17,359.27*1.00)$$

$$= 0.0068''$$

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

$$= |0 + 0.0052 - (0.0068)|$$

$$= \underline{0.0016''}$$

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

$$= 0.0052 + (0.0068) - (0)$$

$$= \underline{0.0119''}$$

### Operating, Hot & Corroded, Seismic, Bottom Seam

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

$$= 1,378*30.125 / (2*20,000*1.20*1.00 + 0.40*|1,378|)$$

$$= 0.855''$$

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

$$= 1,667,950 / (\pi*31.3685^2*20,000*1.20*1.00)$$

$$= 0.0225''$$

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

$$= 23,199.5 / (2*\pi*31.3685*20,000*1.20*1.00)$$

$$= 0.0049''$$

$$t_t = t_p + t_m - t_w \quad (\text{total required, tensile})$$

$$= 0.855 + 0.0225 - (0.0049)$$

$$= \underline{0.8726''}$$

$$t_{wc} = (1 + V\text{Accel})*W / (2*\pi*R_m*S_t*K_s*E_c) \quad (\text{Weight})$$

$$= 2.00*23,199.5 / (2*\pi*31.3685*20,000*1.20*1.00)$$

$$= 0.0098''$$

$$t_c = |t_{mc} + t_{wc} - t_{pc}| \quad (\text{total, net tensile})$$

$$= |0.0225 + (0.0098) - (0.855)|$$

$$= \underline{0.8227"}$$

### Maximum allowable working pressure, Longitudinal Stress

$$P = 2*S_t*K_s*E_c*(t - t_m + t_w) / (R - 0.40*(t - t_m + t_w))$$

$$= 2*20,000*1.20*1.00*(2.487 - 0.0225 + (0.0049)) / (30.125 - 0.40*(2.487 - 0.0225 + (0.0049)))$$

$$= 4,068.07 \text{ psi}$$

### Operating, Hot & New, Seismic, Bottom Seam

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

$$= 1,378*30 / (2*20,000*1.20*1.00 + 0.40*|1,378|)$$

$$= 0.8515"$$

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

$$= 1,705,206 / (\pi*31.306^2*20,000*1.20*1.00)$$

$$= 0.0231"$$

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

$$= 24,089.2 / (2*\pi*31.306*20,000*1.20*1.00)$$

$$= 0.0051"$$

$$t_t = t_p + t_m - t_w \quad (\text{total required, tensile})$$

$$= 0.8515 + 0.0231 - (0.0051)$$

$$= \underline{0.8694"}$$

$$t_{wc} = (1 + V\text{Accel})*W / (2*\pi*R_m*S_t*K_s*E_c) \quad (\text{Weight})$$

$$= 2.00*24,089.2 / (2*\pi*31.306*20,000*1.20*1.00)$$

$$= 0.0102"$$

$$t_c = |t_{mc} + t_{wc} - t_{pc}| \quad (\text{total, net tensile})$$

$$= |0.0231 + (0.0102) - (0.8515)|$$

$$= \underline{0.8182"}$$

### Maximum allowable working pressure, Longitudinal Stress

$$P = 2*S_t*K_s*E_c*(t - t_m + t_w) / (R - 0.40*(t - t_m + t_w))$$

$$= 2*20,000*1.20*1.00*(2.612 - 0.0231 + (0.0051)) / (30 - 0.40*(2.612 - 0.0231 + (0.0051)))$$

$$= 4,299.14 \text{ psi}$$

### Hot Shut Down, Corroded, Seismic, Bottom Seam

$$t_p = 0" \quad (\text{Pressure})$$

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

$$= 1,667,950 / (\pi*31.3685^2*20,000*1.20*1.00)$$

$$= 0.0225"$$

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

$$= 23,199.5 / (2*\pi*31.3685*20,000*1.20*1.00)$$

$$= 0.0049"$$

$$t_t = t_p + t_m - t_w \quad (\text{total required, tensile})$$

$$= 0 + 0.0225 - (0.0049)$$

$$= \underline{0.0176"}$$



$$\begin{aligned}
 t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\
 &= 1,667,950 / (\pi * 31.3685^2 * 17,359.27 * 1.20) \\
 &= 0.0259" \\
 t_{wc} &= (1 + V_{Accel}) * W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\
 &= 2.00 * 23,199.5 / (2 * \pi * 31.3685 * 17,359.27 * 1.20) \\
 &= 0.0113" \\
 t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\
 &= 0.0259 + (0.0113) - (0) \\
 &= \underline{0.0372"}
 \end{aligned}$$

**Hot Shut Down, New, Seismic, Bottom Seam**

$$\begin{aligned}
 t_p &= 0" && \text{(Pressure)} \\
 t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\
 &= 1,705,206 / (\pi * 31.306^2 * 20,000 * 1.20 * 1.00) \\
 &= 0.0231" \\
 t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\
 &= 24,089.2 / (2 * \pi * 31.306 * 20,000 * 1.20 * 1.00) \\
 &= 0.0051" \\
 t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\
 &= 0 + 0.0231 - (0.0051) \\
 &= \underline{0.018"} \\
 t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\
 &= 1,705,206 / (\pi * 31.306^2 * 17,371.43 * 1.20) \\
 &= 0.0266" \\
 t_{wc} &= (1 + V_{Accel}) * W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\
 &= 2.00 * 24,089.2 / (2 * \pi * 31.306 * 17,371.43 * 1.20) \\
 &= 0.0117" \\
 t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\
 &= 0.0266 + (0.0117) - (0) \\
 &= \underline{0.0383"}
 \end{aligned}$$

**Empty, Corroded, Seismic, Bottom Seam**

$$\begin{aligned}
 t_p &= 0" && \text{(Pressure)} \\
 t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\
 &= 1,240,219 / (\pi * 31.3685^2 * 20,000 * 1.20 * 1.00) \\
 &= 0.0167" \\
 t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\
 &= 23,199.5 / (2 * \pi * 31.3685 * 20,000 * 1.20 * 1.00) \\
 &= 0.0049" \\
 t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\
 &= 0 + 0.0167 - (0.0049) \\
 &= \underline{0.0118"} \\
 t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\
 &= 1,240,219 / (\pi * 31.3685^2 * 17,359.27 * 1.20)
 \end{aligned}$$

$$= 0.0193''$$

$$\begin{aligned} t_{wc} &= (1 + V_{Accel}) * W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\ &= 2.00 * 23,199.5 / (2 * \pi * 31.3685 * 17,359.27 * 1.20) \\ &= 0.0113'' \end{aligned}$$

$$\begin{aligned} t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\ &= 0.0193 + (0.0113) - (0) \\ &= \underline{0.0306''} \end{aligned}$$

#### Empty, New, Seismic, Bottom Seam

$$\begin{aligned} t_p &= 0'' && \text{(Pressure)} \\ t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\ &= 1,281,341 / (\pi * 31.306^2 * 20,000 * 1.20 * 1.00) \\ &= 0.0173'' \end{aligned}$$

$$\begin{aligned} t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\ &= 24,089.2 / (2 * \pi * 31.306 * 20,000 * 1.20 * 1.00) \\ &= 0.0051'' \end{aligned}$$

$$\begin{aligned} t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\ &= 0 + 0.0173 - (0.0051) \\ &= \underline{0.0122''} \end{aligned}$$

$$\begin{aligned} t_{mc} &= M / (\pi * R_m^2 * S_c * K_s) && \text{(bending)} \\ &= 1,281,341 / (\pi * 31.306^2 * 17,371.43 * 1.20) \\ &= 0.02'' \end{aligned}$$

$$\begin{aligned} t_{wc} &= (1 + V_{Accel}) * W / (2 * \pi * R_m * S_c * K_s) && \text{(Weight)} \\ &= 2.00 * 24,089.2 / (2 * \pi * 31.306 * 17,371.43 * 1.20) \\ &= 0.0117'' \end{aligned}$$

$$\begin{aligned} t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\ &= 0.02 + (0.0117) - (0) \\ &= \underline{0.0317''} \end{aligned}$$

#### Vacuum, Seismic, Bottom Seam

$$\begin{aligned} t_p &= P * R / (2 * S_t * K_s * E_c + 0.40 * |P|) && \text{(Pressure)} \\ &= -15 * 30.125 / (2 * 20,000 * 1.20 * 1.00 + 0.40 * |15|) \\ &= -0.0094'' \end{aligned}$$

$$\begin{aligned} t_m &= M / (\pi * R_m^2 * S_t * K_s * E_c) && \text{(bending)} \\ &= 1,667,950 / (\pi * 31.3685^2 * 20,000 * 1.20 * 1.00) \\ &= 0.0225'' \end{aligned}$$

$$\begin{aligned} t_w &= W / (2 * \pi * R_m * S_t * K_s * E_c) && \text{(Weight)} \\ &= 23,199.5 / (2 * \pi * 31.3685 * 20,000 * 1.20 * 1.00) \\ &= 0.0049'' \end{aligned}$$

$$\begin{aligned} t_t &= t_p + t_m - t_w && \text{(total required, tensile)} \\ &= -0.0094 + 0.0225 - (0.0049) \\ &= \underline{0.0082''} \end{aligned}$$

$$\begin{aligned} t_{pc} &= P * R / (2 * S_c * K_s + 0.40 * |P|) && \text{(Pressure)} \\ &= -15 * 30.125 / (2 * 17,359.27 * 1.20 + 0.40 * |15|) \end{aligned}$$

$$= -0.0108''$$

$$\begin{aligned} t_{mc} &= M / (\pi R_m^2 S_c K_s) && \text{(bending)} \\ &= 1,667,950 / (\pi 31.3685^2 17,359.27 1.20) \\ &= 0.0259'' \end{aligned}$$

$$\begin{aligned} t_{wc} &= (1 + V_{\text{Accel}}) W / (2 \pi R_m S_c K_s) && \text{(Weight)} \\ &= 2.00 23,199.5 / (2 \pi 31.3685 17,359.27 1.20) \\ &= 0.0113'' \end{aligned}$$

$$\begin{aligned} t_c &= t_{mc} + t_{wc} - t_{pc} && \text{(total required, compressive)} \\ &= 0.0259 + (0.0113) - (-0.0108) \\ &= \underline{0.048''} \end{aligned}$$

#### Maximum Allowable External Pressure, Longitudinal Stress

$$\begin{aligned} P &= 2 S_c K_s (t - t_{mc} - t_{wc}) / (R - 0.40(t - t_{mc} - t_{wc})) \\ &= 2 17,359.27 1.20 (2.487 - 0.0259 - 0.0113) / (30.125 - 0.40(2.487 - 0.0259 - 0.0113)) \\ &= 3,501.93 \text{ psi} \end{aligned}$$

## 60 ID BOTTOM SE HEAD

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

Component: Ellipsoidal Head  
Material Specification: SA-516 70 (II-D p.18, In. 19)  
Straight Flange governs MDMT

Internal design pressure:  $P = 1,378 \text{ psi @ } 140 \text{ }^\circ\text{F}$

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

#### Static liquid head:

$P_s = 4.75 \text{ psi (SG=1.1, } H_s=119.625" \text{ Operating head)}$

$P_{th} = 2.54 \text{ psi (SG=1, } H_s=70.5" \text{ Horizontal test head)}$

Corrosion allowance: Inner C = 0.125" Outer C = 0"

Design MDMT =  $-20 \text{ }^\circ\text{F}$

Rated MDMT =  $-32.7 \text{ }^\circ\text{F}$

Impact test performed

Material is normalized

Material is not produced to fine grain practice

PWHT is 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 = 3,524.5 lb corr = 3,363.9 lb

Capacity\*: new = 146.9 US gal corr = 149.1 US gal

\* includes straight flange

Inner diameter = 60"  
Minimum head thickness = 2.491"  
Head ratio D/2h = 2 (new)  
Head ratio D/2h = 1.9917 (corroded)  
Straight flange length  $L_{sf}$  = 2"  
Nominal straight flange thickness  $t_{sf}$  = 2.612"

#### Results Summary

The governing condition is internal pressure.

Minimum thickness per UG-16 =  $0.0625" + 0.125" = 0.1875"$

Design thickness due to internal pressure (t) = 2.2108"

Design thickness due to external pressure ( $t_e$ ) = 0.2819"

Maximum allowable working pressure (MAWP) = 1,562.35 psi

Maximum allowable external pressure (MAEP) = 750.1 psi

#### K (Corroded)

$$K = (1/6) * [2 + (D / (2 * h))^2] = (1/6) * [2 + (60.25 / (2 * 15.125))^2] = 0.994502$$

#### K (New)

$$K = (1/6) * [2 + (D / (2 * h))^2] = (1/6) * [2 + (60 / (2 * 15))^2] = 1$$

**Design thickness for internal pressure, (Corroded at 140 °F) Appendix 1-4(c)**

$$\begin{aligned}t &= P \cdot D \cdot K / (2 \cdot S \cdot E - 0.2 \cdot P) + \text{Corrosion} \\&= 1,382.75 \cdot 60.25 \cdot 0.994502 / (2 \cdot 20,000 \cdot 1 - 0.2 \cdot 1,382.75) + 0.125 \\&= 2.2107''\end{aligned}$$

The head internal pressure design thickness is 2.2108".

**Maximum allowable working pressure, (Corroded at 140 °F) Appendix 1-4(c)**

$$\begin{aligned}P &= 2 \cdot S \cdot E \cdot t / (K \cdot D + 0.2 \cdot t) - P_s \\&= 2 \cdot 20,000 \cdot 1 \cdot 2.366 / (0.994502 \cdot 60.25 + 0.2 \cdot 2.366) - 4.75 \\&= 1,562.35 \text{ psi}\end{aligned}$$

The maximum allowable working pressure (MAWP) is 1,562.35 psi.

**Design thickness for external pressure, (Corroded at 140 °F) UG-33(d)**

Equivalent outside spherical radius ( $R_o$ )

$$\begin{aligned}R_o &= K_o \cdot D_o \\&= 0.8359 \cdot 64.982 \\&= 54.3193 \text{ in}\end{aligned}$$

$$\begin{aligned}A &= 0.125 / (R_o / t) \\&= 0.125 / (54.3193 / 0.156888) \\&= 0.000361\end{aligned}$$

From Table CS-2:  $B = 5,193.454$  psi

$$\begin{aligned}P_a &= B / (R_o / t) \\&= 5,193.454 / (54.3193 / 0.1569) \\&= 15 \text{ psi}\end{aligned}$$

$$t = 0.1569'' + \text{Corrosion} = 0.1569'' + 0.125'' = 0.2819''$$

Check the external pressure per UG-33(a)(1) Appendix 1-4(c)

$$\begin{aligned}t &= 1.67 \cdot P_e \cdot D \cdot K / (2 \cdot S \cdot E - 0.2 \cdot 1.67 \cdot P_e) + \text{Corrosion} \\&= 1.67 \cdot 15 \cdot 60.25 \cdot 0.994502 / (2 \cdot 20,000 \cdot 1 - 0.2 \cdot 1.67 \cdot 15) + 0.125 \\&= 0.1625''\end{aligned}$$

The head external pressure design thickness ( $t_e$ ) is 0.2819".

**Maximum Allowable External Pressure, (Corroded at 140 °F) UG-33(d)**

Equivalent outside spherical radius ( $R_o$ )

$$\begin{aligned}R_o &= K_o \cdot D_o \\&= 0.8359 \cdot 64.982 \\&= 54.3193 \text{ in}\end{aligned}$$

$$\begin{aligned}A &= 0.125 / (R_o / t) \\&= 0.125 / (54.3193 / 2.366) \\&= 0.005445\end{aligned}$$

From Table CS-2:  $B = 17,220.94$  psi

$$\begin{aligned} P_a &= B / (R_o / t) \\ &= 17,220.94 / (54.3193 / 2.366) \\ &= 750.0974 \text{ psi} \end{aligned}$$

**Check the Maximum External Pressure, UG-33(a)(1) Appendix 1-4(c)**

$$\begin{aligned} P &= 2 * S * E * t / ((K * D + 0.2 * t) * 1.67) - P_{s2} \\ &= 2 * 20,000 * 1 * 2.366 / ((0.994502 * 60.25 + 0.2 * 2.366) * 1.67) - 0 \\ &= 938.38 \text{ psi} \end{aligned}$$

The maximum allowable external pressure (MAEP) is 750.1 psi.

**% Extreme fiber elongation - UCS-79(d)**

$$\begin{aligned} EFE &= (75 * t / R_i) * (1 - R_i / R_o) \\ &= (75 * 2.612 / 11.506) * (1 - 11.506 / \infty) \\ &= 17.0259\% \end{aligned}$$

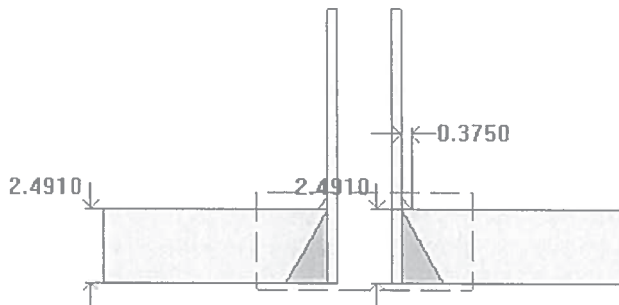


## Bottom Drain (N1)

ASME Section VIII Division 1, 2010 Edition, A11 Addenda

$$t_{w(\text{lower})} = 2.491 \text{ in}$$

$$\text{Leg}_{41} = 0.375 \text{ in}$$



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

### Location and Orientation

Located on:	60 ID BOTTOM SE HEAD
Orientation:	0°
End of nozzle to datum line:	123.7383 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-333 1 Wld & smls pipe (II-D p. 10, In. 1)
Description:	NPS 2 Sch 160
Inside diameter, new:	1.687 in
Nominal wall thickness:	0.344 in
Corrosion allowance:	0.125 in
Projection available outside vessel, L <sub>pr</sub> :	4.009 in
Projection available outside vessel to flange face, L <sub>f</sub> :	8.259 in
Local vessel minimum thickness:	2.491 in
Liquid static head included:	5.0724 psi
Longitudinal joint efficiency:	1

### ASME B16.5-2009 Flange

Description:	NPS 2 Class 900 WN A350 LF2
Bolt Material:	SA-193 B7 Bolt <= 2 1/2 (II-D p. 334, In. 32)
Blind included:	No
Rated MDMT:	-55°F per UCS-66(b)(1)(b)
Liquid static head:	5.1713 psi
MAWP rating:	2,146 psi @ 140°F
MAP rating:	2,220 psi @ 50°F
Hydrotest rating:	3,350 psi @ 50°F

PWHT performed:

Yes

Circumferential joint radiography:

Full UW-11(a) Type 1



**Reinforcement Calculations for Chamber MAWP**

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For P = 1,383.07 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary (in)</b> The nozzle passes UG-45	
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2598	0.301

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

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (in)	Actual weld throat size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	0.1533	0.2625	weld size is adequate

**Calculations for internal pressure 1,383.07 psi @ 140 °F**

Fig UCS-66.2 general note (1) applies.

Nozzle is impact tested to -50 °F with an additional 5 °F reduction per UCS-66(g).

Nozzle UCS-66 governing thk: 0.301 in

Nozzle rated MDMT: -55 °F

**Parallel Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(1.937, 0.9685 + (0.344 - 0.125) + (2.491 - 0.125)) \\
 &= 3.5535 \text{ in}
 \end{aligned}$$

**Outer Normal Limit of reinforcement per UG-40**

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(2.491 - 0.125), 2.5*(0.344 - 0.125) + 0) \\
 &= 0.5475 \text{ in}
 \end{aligned}$$

**Nozzle required thickness per UG-27(c)(1)**

$$\begin{aligned}
 t_{rn} &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 1,383.0724 \cdot 0.9685 / (15,700 \cdot 1 - 0.6 \cdot 1,383.0724) \\
 &= 0.0901 \text{ in}
 \end{aligned}$$

### Required thickness $t_r$ from UG-37(a)(c)

$$\begin{aligned}t_r &= P \cdot K_1 \cdot D / (2 \cdot S \cdot E - 0.2 \cdot P) \\ &= 1,383.0724 \cdot 0.8963 \cdot 60.25 / (2 \cdot 20,000 \cdot 1 - 0.2 \cdot 1,383.0724) \\ &= 1.8802 \text{ in}\end{aligned}$$

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

### UW-16(c) Weld Check

Fillet weld:  $t_{\min}$  = lesser of 0.75 or  $t_n$  or  $t = 0.219$  in

$t_{c(\min)}$  = lesser of 0.25 or  $0.7 \cdot t_{\min} = 0.1533$  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.

$$\begin{aligned}t_{a \text{ UG-27}} &= P \cdot R / (S \cdot E - 0.6 \cdot P) + \text{Corrosion} \\ &= 1,383.1713 \cdot 0.9685 / (15,700 \cdot 1 - 0.6 \cdot 1,383.1713) + 0.125 \\ &= 0.2151 \text{ in}\end{aligned}$$

$$\begin{aligned}t_a &= \max[ t_{a \text{ UG-27}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.2151, 0 ] \\ &= 0.2151 \text{ in}\end{aligned}$$

$$t_{b1} = 2.2112 \text{ in}$$

$$\begin{aligned}t_{b1} &= \max[ t_{b1}, t_{b \text{ UG16}} ] \\ &= \max[ 2.2112, 0.1875 ] \\ &= 2.2112 \text{ in}\end{aligned}$$

$$\begin{aligned}t_b &= \min[ t_{b3}, t_{b1} ] \\ &= \min[ 0.2598, 2.2112 ] \\ &= 0.2598 \text{ in}\end{aligned}$$

$$\begin{aligned}t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.2151, 0.2598 ] \\ &= 0.2598 \text{ in}\end{aligned}$$

Available nozzle wall thickness new,  $t_n = 0.875 \cdot 0.344 = 0.301$  in

The nozzle neck thickness is adequate.

## Reinforcement Calculations for MAEP

<b>UG-37 Area Calculation Summary</b> (in <sup>2</sup> ) For Pe = 750.1 psi @ 140 °F							<b>UG-45 Nozzle Wall Thickness Summary (in)</b> The nozzle passes UG-45	
A required	A available	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>5</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
This nozzle is exempt from area calculations per UG-36(c)(3)(a)							0.2598	0.301

<b>UG-41 Weld Failure Path Analysis Summary</b>
Weld strength calculations are not required for external pressure

<b>UW-16 Weld Sizing Summary</b>			
Weld description	Required weld throat size (In)	Actual weld throat size (In)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	0.1533	0.2625	weld size is adequate

Calculations for external pressure 750.1 psi @ 140 °F

### Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(1.937, 0.9685 + (0.344 - 0.125) + (2.491 - 0.125)) \\
 &= 3.5535 \text{ in}
 \end{aligned}$$

### Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(2.491 - 0.125), 2.5*(0.344 - 0.125) + 0) \\
 &= 0.5475 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28  $t_m = 0.0861 \text{ in}$

From UG-37(d)(1) required thickness  $t_r = 2.366 \text{ in}$

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

### UW-16(c) Weld Check

$$\begin{aligned}
 \text{Fillet weld: } t_{\text{min}} &= \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.219 \text{ in} \\
 t_{\text{c(min)}} &= \text{lesser of } 0.25 \text{ or } 0.7*t_{\text{min}} = 0.1533 \text{ in} \\
 t_{\text{c(actual)}} &= 0.7*\text{Leg} = 0.7*0.375 = 0.2625 \text{ in}
 \end{aligned}$$

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

Interpretation VIII-1-83-66 has been applied.

$$t_{a \text{ UG-28}} = 0.2111 \text{ in}$$

$$\begin{aligned} t_a &= \max[ t_{a \text{ UG-28}}, t_{a \text{ UG-22}} ] \\ &= \max[ 0.2111, 0 ] \\ &= 0.2111 \text{ in} \end{aligned}$$

$$t_{b2} = 1.2529 \text{ in}$$

$$\begin{aligned} t_{b2} &= \max[ t_{b2}, t_{b \text{ UG16}} ] \\ &= \max[ 1.2529, 0.1875 ] \\ &= 1.2529 \text{ in} \end{aligned}$$

$$\begin{aligned} t_b &= \min[ t_{b3}, t_{b2} ] \\ &= \min[ 0.2598, 1.2529 ] \\ &= 0.2598 \text{ in} \end{aligned}$$

$$\begin{aligned} t_{\text{UG-45}} &= \max[ t_a, t_b ] \\ &= \max[ 0.2111, 0.2598 ] \\ &= 0.2598 \text{ in} \end{aligned}$$

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)

$$L / D_o = 8.259 / 2.375 = 3.4775$$

$$D_o / t = 2.375 / 0.0861 = 27.5742$$

From table G: A = 0.002387

From table  
CS-2: B = 15,512.509 psi

$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_o / t)) \\ &= 4 \cdot 15,512.51 / (3 \cdot (2.375 / 0.0861)) \\ &= 750.1 \text{ psi} \end{aligned}$$

### Design thickness for external pressure $P_a = 750.1 \text{ psi}$

$$t_a = t + \text{Corrosion} = 0.0861 + 0.125 = 0.2111''$$



### 63-1/4" OD Skirt

Material:	SA-516 70 (II-D p. 18, In. 19)
Design temperature, operating:	140 °F
Design temperature, vacuum:	0 °F
Inner diameter at top, new:	61.75 in
Inner diameter at bottom, new:	61.75 in
Overall length (includes base ring thickness):	23.25 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:	0.75 in
Skirt is attached to:	60 ID BOTTOM SE HEAD
Skirt attachment offset:	7.4575in down from the top seam

**Skirt design thickness, largest of the following + corrosion = 0.0557 in**

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

The skirt thickness of 0.75 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	21,012.37	-130.1	<u>0.0046</u>
Wind	operating, corroded (-)	bottom	140	21,012.37	419.41	<u>0.015</u>
Wind	operating, new (+)	top	140	21,012.37	-135.09	<u>0.0048</u>
Wind	operating, new (-)	bottom	140	21,012.37	426.85	<u>0.0152</u>
Wind	empty, corroded (+)	top	50	21,012.37	-41.16	<u>0.0015</u>
Wind	empty, corroded (-)	bottom	50	21,012.37	330.47	<u>0.0118</u>
Wind	empty, new (+)	top	50	21,012.37	-46.98	<u>0.0017</u>
Wind	empty, new (-)	bottom	50	21,012.37	338.74	<u>0.0121</u>
Wind	vacuum, corroded (+)	top	0	21,012.37	-130.1	<u>0.0046</u>
Wind	vacuum, corroded (-)	bottom	0	21,012.37	419.41	<u>0.015</u>
Seismic	operating, corroded (+)	top	140	26,000	912.72	<u>0.0263</u>
Seismic	operating, corroded (-)	bottom	140	21,012.37	1,525.18	<u>0.0544</u>
Seismic	operating, new (+)	top	140	26,000	932.63	<u>0.0269</u>
Seismic	operating, new (-)	bottom	140	21,012.37	1,559.42	<u>0.0557</u>
Seismic	empty, corroded (+)	top	50	26,000	709.59	<u>0.0205</u>
Seismic	empty, corroded (-)	bottom	50	21,012.37	1,080.46	<u>0.0386</u>
Seismic	empty, new (+)	top	50	26,000	731.28	<u>0.0211</u>
Seismic	empty, new (-)	bottom	50	21,012.37	1,118.79	<u>0.0399</u>
Seismic	vacuum, corroded (+)	top	0	26,000	912.72	<u>0.0263</u>
Seismic	vacuum, corroded (-)	bottom	0	21,012.37	1,525.18	<u>0.0544</u>

## Loading due to wind, operating & corroded

### Windward side (tensile)

Required thickness, tensile stress at base:

$$\begin{aligned}
 t &= -W / (\pi * D * S_t * E) + 48 * M / (\pi * D^2 * S_t * E) \\
 &= -40,423.69 / (\pi * 62.5 * 21,012 * 1) + 48 * 27,784.9 / (\pi * 62.5^2 * 21,012 * 1) \\
 &= \underline{0.0046} \text{ in}
 \end{aligned}$$

Required thickness, tensile stress at the top:

$$\begin{aligned}
 t &= -W_t / (\pi * D_t * S_t * E) + 48 * M_t / (\pi * D_t^2 * S_t * E) \\
 &= -39,411.11 / (\pi * 62.5 * 21,012 * 1) + 48 * 26,370.5 / (\pi * 62.5^2 * 21,012 * 1) \\
 &= \underline{0.0046} \text{ in}
 \end{aligned}$$

### Leeward side (compressive)

Required thickness, compressive stress at base:

$$\begin{aligned}
 t &= W / (\pi * D * S_c * E_c) + 48 * M / (\pi * D^2 * S_c * E_c) \\
 &= 40,423.69 / (\pi * 62.5 * 21,012 * 1) + 48 * 27,784.9 / (\pi * 62.5^2 * 21,012 * 1) \\
 &= \underline{0.015} \text{ in}
 \end{aligned}$$

**Required thickness, compressive stress at the top:**

$$\begin{aligned}t &= W_t / (\pi * D_t * S_c * E_c) + 48 * M_t / (\pi * D_t^2 * S_c * E_c) \\&= 39,411.11 / (\pi * 62.5 * 21,012 * 1) + 48 * 26,370.5 / (\pi * 62.5^2 * 21,012 * 1) \\&= \underline{0.0145} \text{ in}\end{aligned}$$

## **Loading due to wind, operating & new**

**Windward side (tensile)**

**Required thickness, tensile stress at base:**

$$\begin{aligned}t &= -W / (\pi * D * S_t * E) + 48 * M / (\pi * D^2 * S_t * E) \\&= -41,339.78 / (\pi * 62.5 * 21,012 * 1) + 48 * 28,020 / (\pi * 62.5^2 * 21,012 * 1) \\&= \underline{0.0048} \text{ in}\end{aligned}$$

**Required thickness, tensile stress at the top:**

$$\begin{aligned}t &= -W_t / (\pi * D_t * S_t * E) + 48 * M_t / (\pi * D_t^2 * S_t * E) \\&= -40,327.2 / (\pi * 62.5 * 21,012 * 1) + 48 * 26,605.6 / (\pi * 62.5^2 * 21,012 * 1) \\&= \underline{0.0048} \text{ in}\end{aligned}$$

**Leeward side (compressive)**

**Required thickness, compressive stress at base:**

$$\begin{aligned}t &= W / (\pi * D * S_c * E_c) + 48 * M / (\pi * D^2 * S_c * E_c) \\&= 41,339.78 / (\pi * 62.5 * 21,012 * 1) + 48 * 28,020 / (\pi * 62.5^2 * 21,012 * 1) \\&= \underline{0.0152} \text{ in}\end{aligned}$$

**Required thickness, compressive stress at the top:**

$$\begin{aligned}t &= W_t / (\pi * D_t * S_c * E_c) + 48 * M_t / (\pi * D_t^2 * S_c * E_c) \\&= 40,327.2 / (\pi * 62.5 * 21,012 * 1) + 48 * 26,605.6 / (\pi * 62.5^2 * 21,012 * 1) \\&= \underline{0.0147} \text{ in}\end{aligned}$$

## **Loading due to wind, empty & corroded**

**Windward side (tensile)**

**Required thickness, tensile stress at base:**

$$\begin{aligned}t &= -W / (\pi * D * S_t * E) + 48 * M / (\pi * D^2 * S_t * E) \\&= -27,326.21 / (\pi * 62.5 * 21,012 * 1) + 48 * 27,784.9 / (\pi * 62.5^2 * 21,012 * 1) \\&= \underline{0.0015} \text{ in}\end{aligned}$$

**Required thickness, tensile stress at the top:**

$$\begin{aligned}t &= -W_t / (\pi^*D_t^*S_t^*E) + 48^*M_t / (\pi^*D_t^2^*S_t^*E) \\&= -26,313.63 / (\pi^*62.5^*21,012^*1) + 48^*26,370.5 / (\pi^*62.5^2^*21,012^*1) \\&= \underline{0.0015} \text{ in}\end{aligned}$$

**Leeward side (compressive)**

**Required thickness, compressive stress at base:**

$$\begin{aligned}t &= W / (\pi^*D^*S_c^*E_c) + 48^*M / (\pi^*D^2^*S_c^*E_c) \\&= 27,326.21 / (\pi^*62.5^*21,012^*1) + 48^*27,784.9 / (\pi^*62.5^2^*21,012^*1) \\&= \underline{0.0118} \text{ in}\end{aligned}$$

**Required thickness, compressive stress at the top:**

$$\begin{aligned}t &= W_t / (\pi^*D_t^*S_c^*E_c) + 48^*M_t / (\pi^*D_t^2^*S_c^*E_c) \\&= 26,313.63 / (\pi^*62.5^*21,012^*1) + 48^*26,370.5 / (\pi^*62.5^2^*21,012^*1) \\&= \underline{0.0113} \text{ in}\end{aligned}$$

## Loading due to wind, empty & new

**Windward side (tensile)**

**Required thickness, tensile stress at base:**

$$\begin{aligned}t &= -W / (\pi^*D^*S_t^*E) + 48^*M / (\pi^*D^2^*S_t^*E) \\&= -28,364.53 / (\pi^*62.5^*21,012^*1) + 48^*28,020 / (\pi^*62.5^2^*21,012^*1) \\&= \underline{0.0017} \text{ in}\end{aligned}$$

**Required thickness, tensile stress at the top:**

$$\begin{aligned}t &= -W_t / (\pi^*D_t^*S_t^*E) + 48^*M_t / (\pi^*D_t^2^*S_t^*E) \\&= -27,351.94 / (\pi^*62.5^*21,012^*1) + 48^*26,605.6 / (\pi^*62.5^2^*21,012^*1) \\&= \underline{0.0017} \text{ in}\end{aligned}$$

**Leeward side (compressive)**

**Required thickness, compressive stress at base:**

$$\begin{aligned}t &= W / (\pi^*D^*S_c^*E_c) + 48^*M / (\pi^*D^2^*S_c^*E_c) \\&= 28,364.53 / (\pi^*62.5^*21,012^*1) + 48^*28,020 / (\pi^*62.5^2^*21,012^*1) \\&= \underline{0.0121} \text{ in}\end{aligned}$$

**Required thickness, compressive stress at the top:**

$$\begin{aligned}t &= W_t / (\pi^*D_t^*S_c^*E_c) + 48^*M_t / (\pi^*D_t^2^*S_c^*E_c) \\&= 27,351.94 / (\pi^*62.5^*21,012^*1) + 48^*26,605.6 / (\pi^*62.5^2^*21,012^*1) \\&= \underline{0.0116} \text{ in}\end{aligned}$$

## Loading due to wind, vacuum & corroded

### Windward side (tensile)

Required thickness, tensile stress at base:

$$\begin{aligned}t &= -W / (\pi \cdot D \cdot S_t \cdot E) + 48 \cdot M / (\pi \cdot D^2 \cdot S_t \cdot E) \\&= -40,423.69 / (\pi \cdot 62.5 \cdot 21,012 \cdot 1) + 48 \cdot 27,784.9 / (\pi \cdot 62.5^2 \cdot 21,012 \cdot 1) \\&= \underline{0.0046} \text{ in}\end{aligned}$$

Required thickness, tensile stress at the top:

$$\begin{aligned}t &= -W_t / (\pi \cdot D_t \cdot S_t \cdot E) + 48 \cdot M_t / (\pi \cdot D_t^2 \cdot S_t \cdot E) \\&= -39,411.11 / (\pi \cdot 62.5 \cdot 21,012 \cdot 1) + 48 \cdot 26,370.5 / (\pi \cdot 62.5^2 \cdot 21,012 \cdot 1) \\&= \underline{0.0046} \text{ in}\end{aligned}$$

### Leeward side (compressive)

Required thickness, compressive stress at base:

$$\begin{aligned}t &= W / (\pi \cdot D \cdot S_c \cdot E_c) + 48 \cdot M / (\pi \cdot D^2 \cdot S_c \cdot E_c) \\&= 40,423.69 / (\pi \cdot 62.5 \cdot 21,012 \cdot 1) + 48 \cdot 27,784.9 / (\pi \cdot 62.5^2 \cdot 21,012 \cdot 1) \\&= \underline{0.015} \text{ in}\end{aligned}$$

Required thickness, compressive stress at the top:

$$\begin{aligned}t &= W_t / (\pi \cdot D_t \cdot S_c \cdot E_c) + 48 \cdot M_t / (\pi \cdot D_t^2 \cdot S_c \cdot E_c) \\&= 39,411.11 / (\pi \cdot 62.5 \cdot 21,012 \cdot 1) + 48 \cdot 26,370.5 / (\pi \cdot 62.5^2 \cdot 21,012 \cdot 1) \\&= \underline{0.0145} \text{ in}\end{aligned}$$

## Loading due to earthquake, operating & corroded

### Tensile side

Required thickness, tensile stress at base:

$$\begin{aligned}t &= -W / (\pi \cdot D \cdot S_t \cdot E) + 48 \cdot M / (\pi \cdot D^2 \cdot S_t \cdot E) \\&= -40,423.69 / (\pi \cdot 62.5 \cdot 26,000 \cdot 0.8) + 48 \cdot 187,179.7 / (\pi \cdot 62.5^2 \cdot 26,000 \cdot 0.8) \\&= \underline{0.0253} \text{ in}\end{aligned}$$

Required thickness, tensile stress at the top:

$$\begin{aligned}t &= -W_t / (\pi \cdot D_t \cdot S_t \cdot E) + 48 \cdot M_t / (\pi \cdot D_t^2 \cdot S_t \cdot E) \\&= -39,411.11 / (\pi \cdot 62.5 \cdot 26,000 \cdot 0.55) + 48 \cdot 147,573.4 / (\pi \cdot 62.5^2 \cdot 26,000 \cdot 0.55) \\&= \underline{0.0263} \text{ in}\end{aligned}$$

## Compressive side

Required thickness, compressive stress at base:

$$\begin{aligned}t &= (1 + V_{\text{Accel}}) * W / (\pi * D * S_c * E_c) + 48 * M / (\pi * D^2 * S_c * E_c) \\&= (1 + 1) * 40,423.69 / (\pi * 62.5 * 21,012 * 1) + 48 * 187,179.7 / (\pi * 62.5^2 * 21,012 * 1) \\&= \underline{0.0544} \text{ in}\end{aligned}$$

Required thickness, compressive stress at the top:

$$\begin{aligned}t &= (1 + V_{\text{Accel}}) * W_t / (\pi * D_t * S_c * E_c) + 48 * M_t / (\pi * D_t^2 * S_c * E_c) \\&= (1 + 1) * 39,411.11 / (\pi * 62.5 * 21,012 * 1) + 48 * 147,573.4 / (\pi * 62.5^2 * 21,012 * 1) \\&= \underline{0.0466} \text{ in}\end{aligned}$$

## Loading due to earthquake, operating & new

### Tensile side

Required thickness, tensile stress at base:

$$\begin{aligned}t &= -W / (\pi * D * S_t * E) + 48 * M / (\pi * D^2 * S_t * E) \\&= -41,339.78 / (\pi * 62.5 * 26,000 * 0.8) + 48 * 191,359.8 / (\pi * 62.5^2 * 26,000 * 0.8) \\&= \underline{0.0259} \text{ in}\end{aligned}$$

Required thickness, tensile stress at the top:

$$\begin{aligned}t &= -W_t / (\pi * D_t * S_t * E) + 48 * M_t / (\pi * D_t^2 * S_t * E) \\&= -40,327.2 / (\pi * 62.5 * 26,000 * 0.55) + 48 * 150,865.9 / (\pi * 62.5^2 * 26,000 * 0.55) \\&= \underline{0.0269} \text{ in}\end{aligned}$$

### Compressive side

Required thickness, compressive stress at base:

$$\begin{aligned}t &= (1 + V_{\text{Accel}}) * W / (\pi * D * S_c * E_c) + 48 * M / (\pi * D^2 * S_c * E_c) \\&= (1 + 1) * 41,339.78 / (\pi * 62.5 * 21,012 * 1) + 48 * 191,359.8 / (\pi * 62.5^2 * 21,012 * 1) \\&= \underline{0.0557} \text{ in}\end{aligned}$$

Required thickness, compressive stress at the top:

$$\begin{aligned}t &= (1 + V_{\text{Accel}}) * W_t / (\pi * D_t * S_c * E_c) + 48 * M_t / (\pi * D_t^2 * S_c * E_c) \\&= (1 + 1) * 40,327.2 / (\pi * 62.5 * 21,012 * 1) + 48 * 150,865.9 / (\pi * 62.5^2 * 21,012 * 1) \\&= \underline{0.0476} \text{ in}\end{aligned}$$

## Loading due to earthquake, empty & corroded



## Tensile side

Required thickness, tensile stress at base:

$$\begin{aligned}t &= -W / (\pi * D * S_t * E) + 48 * M / (\pi * D^2 * S_t * E) \\&= -27,326.21 / (\pi * 62.5 * 26,000 * 0.8) + 48 * 136,014.5 / (\pi * 62.5^2 * 26,000 * 0.8) \\&= \underline{0.0189} \text{ in}\end{aligned}$$

Required thickness, tensile stress at the top:

$$\begin{aligned}t &= -W_t / (\pi * D_t * S_t * E) + 48 * M_t / (\pi * D_t^2 * S_t * E) \\&= -26,313.63 / (\pi * 62.5 * 26,000 * 0.55) + 48 * 109,096.9 / (\pi * 62.5^2 * 26,000 * 0.55) \\&= \underline{0.0205} \text{ in}\end{aligned}$$

## Compressive side

Required thickness, compressive stress at base:

$$\begin{aligned}t &= (1 + V_{\text{Accel}}) * W / (\pi * D * S_c * E_c) + 48 * M / (\pi * D^2 * S_c * E_c) \\&= (1 + 1) * 27,326.21 / (\pi * 62.5 * 21,012 * 1) + 48 * 136,014.5 / (\pi * 62.5^2 * 21,012 * 1) \\&= \underline{0.0386} \text{ in}\end{aligned}$$

Required thickness, compressive stress at the top:

$$\begin{aligned}t &= (1 + V_{\text{Accel}}) * W_t / (\pi * D_t * S_c * E_c) + 48 * M_t / (\pi * D_t^2 * S_c * E_c) \\&= (1 + 1) * 26,313.63 / (\pi * 62.5 * 21,012 * 1) + 48 * 109,096.9 / (\pi * 62.5^2 * 21,012 * 1) \\&= \underline{0.0331} \text{ in}\end{aligned}$$

## Loading due to earthquake, empty & new

### Tensile side

Required thickness, tensile stress at base:

$$\begin{aligned}t &= -W / (\pi * D * S_t * E) + 48 * M / (\pi * D^2 * S_t * E) \\&= -28,364.53 / (\pi * 62.5 * 26,000 * 0.8) + 48 * 140,660.2 / (\pi * 62.5^2 * 26,000 * 0.8) \\&= \underline{0.0195} \text{ in}\end{aligned}$$

Required thickness, tensile stress at the top:

$$\begin{aligned}t &= -W_t / (\pi * D_t * S_t * E) + 48 * M_t / (\pi * D_t^2 * S_t * E) \\&= -27,351.94 / (\pi * 62.5 * 26,000 * 0.55) + 48 * 112,736.4 / (\pi * 62.5^2 * 26,000 * 0.55) \\&= \underline{0.0211} \text{ in}\end{aligned}$$

### Compressive side

**Required thickness, compressive stress at base:**

$$\begin{aligned}t &= (1 + V_{\text{Accel}}) * W / (\pi * D * S_c * E_c) + 48 * M / (\pi * D^2 * S_c * E_c) \\&= (1 + 1) * 28,364.53 / (\pi * 62.5 * 21,012 * 1) + 48 * 140,660.2 / (\pi * 62.5^2 * 21,012 * 1) \\&= \underline{0.0399} \text{ in}\end{aligned}$$

**Required thickness, compressive stress at the top:**

$$\begin{aligned}t &= (1 + V_{\text{Accel}}) * W_t / (\pi * D_t * S_c * E_c) + 48 * M_t / (\pi * D_t^2 * S_c * E_c) \\&= (1 + 1) * 27,351.94 / (\pi * 62.5 * 21,012 * 1) + 48 * 112,736.4 / (\pi * 62.5^2 * 21,012 * 1) \\&= \underline{0.0342} \text{ in}\end{aligned}$$

## Loading due to earthquake, vacuum & corroded

### Tensile side

**Required thickness, tensile stress at base:**

$$\begin{aligned}t &= -W / (\pi * D * S_t * E) + 48 * M / (\pi * D^2 * S_t * E) \\&= -40,423.69 / (\pi * 62.5 * 26,000 * 0.8) + 48 * 187,179.7 / (\pi * 62.5^2 * 26,000 * 0.8) \\&= \underline{0.0253} \text{ in}\end{aligned}$$

**Required thickness, tensile stress at the top:**

$$\begin{aligned}t &= -W_t / (\pi * D_t * S_t * E) + 48 * M_t / (\pi * D_t^2 * S_t * E) \\&= -39,411.11 / (\pi * 62.5 * 26,000 * 0.55) + 48 * 147,573.4 / (\pi * 62.5^2 * 26,000 * 0.55) \\&= \underline{0.0263} \text{ in}\end{aligned}$$

### Compressive side

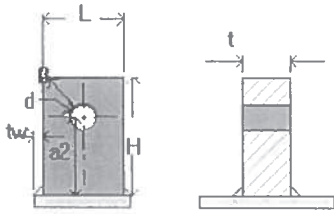
**Required thickness, compressive stress at base:**

$$\begin{aligned}t &= (1 + V_{\text{Accel}}) * W / (\pi * D * S_c * E_c) + 48 * M / (\pi * D^2 * S_c * E_c) \\&= (1 + 1) * 40,423.69 / (\pi * 62.5 * 21,012 * 1) + 48 * 187,179.7 / (\pi * 62.5^2 * 21,012 * 1) \\&= \underline{0.0544} \text{ in}\end{aligned}$$

**Required thickness, compressive stress at the top:**

$$\begin{aligned}t &= (1 + V_{\text{Accel}}) * W_t / (\pi * D_t * S_c * E_c) + 48 * M_t / (\pi * D_t^2 * S_c * E_c) \\&= (1 + 1) * 39,411.11 / (\pi * 62.5 * 21,012 * 1) + 48 * 147,573.4 / (\pi * 62.5^2 * 21,012 * 1) \\&= \underline{0.0466} \text{ in}\end{aligned}$$

## Tail lug



### Geometry Inputs

Attached To	63-1/4" OD Skirt
Material	SA-516 70N
Orientation	Longitudinal
Distance of Lift Point From Datum	123.2075"
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, D <sub>p</sub>	1.5"
Load Eccentricity, a <sub>1</sub>	0"
Distance from Load to Shell or Pad, a <sub>2</sub>	5"
Weld Size, t <sub>w</sub>	0.625"
Load Angle Normal to Vessel, β	42.0000 °
Load Angle from Vertical, φ	-48.0000 °

### Intermediate Values

Load Factor	1.5000
Vessel Weight (new, incl. Load Factor), W	43247 lb
Lug Weight (new), $W_{lug}$	16 lb
Distance from Center of Gravity to Top Lug, $l_1$	67.5931"
Distance from Center of Gravity to Tail Lug, $l_2$	70.6144"
Distance from Vessel Center Line to Tail Lug, $l_3$	36.625"
Allowable Stress, Tensile, $\sigma_t$	19980 psi
Allowable Stress, Shear, $\sigma_s$	13320 psi
Allowable Stress, Bearing, $\sigma_p$	29970 psi
Allowable Stress, Bending, $\sigma_b$	22201 psi
Allowable Stress, Weld Shear, $\tau_{allowable}$	13320 psi
Allowable Stress set to 1/3 Sy per ASME B30.20	No

### Summary Values

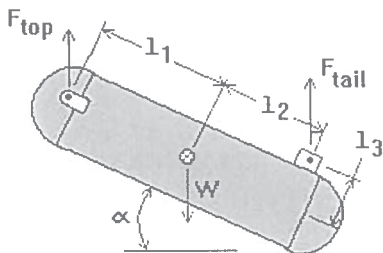
Required Lift Pin Diameter, $d_{reqd}$	1.0054"
Required Lug Thickness, $t_{reqd}$	0.4705"
Lug Stress Ratio, $\sigma_{ratio}$	0.51
Weld Shear Stress Ratio, $\tau_{ratio}$	0.33
Lug Design	Acceptable
Local Stresses	<b>Unacceptable</b>
Base ring loading	Acceptable

### Lift Forces

Lift force on lugs during rotational lift ( $0^\circ \leq \alpha \leq 90^\circ$ ):

$$2 * F_{top} = W * (l_2 * \cos(\alpha) + l_3 * \sin(\alpha)) / (l_1 * \cos(\alpha) + l_2 * \cos(\alpha) + l_3 * \sin(\alpha))$$

$$F_{tail} = W - (2 * F)$$



$\alpha$ [°]	$F_{top}$ [lbf]	$F_{tail}$ [lbf]
0	11,048	21,151
15	11,749	19,749
30	12,451	18,344
45	13,264	16,720
60	14,375	14,497
75	16,307	10,634
90	21,624	0
52 <sup>1</sup>	13,726	15,794
0 <sup>2</sup>	11,048	21,151
<sup>1</sup> Lift angle at maximum lug stress.		
<sup>2</sup> Lift angle at maximum weld stress.		

### Lug Pin Diameter - Shear stress

$$d_{reqd} = (2 \cdot F_r / (\pi \cdot \sigma_s))^{0.5}$$

$$= (2 \cdot 21,151 / (\pi \cdot 13,320))^{0.5} = \underline{1.0054"}$$

$$d_{reqd} / D_p = 1.0054 / 1.5 = 0.67 \quad \text{Acceptable}$$

$$\sigma = F_r / A$$

$$= F_r / (2 \cdot (0.25 \cdot \pi \cdot D_p^2))$$

$$= 21,151 / (2 \cdot (0.25 \cdot \pi \cdot 1.5^2)) = 5,984 \text{ psi}$$

$$\sigma / \sigma_s = 5,984 / 13,320 = 0.45 \quad \text{Acceptable}$$

### Lug Thickness - Tensile stress

$$t_{reqd} = F_r / ((L - d) \cdot \sigma_t)$$

$$= 21,151 / ((5 - 1.5625) \cdot 19,980) = 0.308"$$

$$t_{reqd} / t = 0.308 / 1.5 = 0.21 \quad \text{Acceptable}$$

$$\sigma = F_r / A$$

$$= F_r / ((L - d) \cdot t)$$

$$= 21,151 / ((5 - 1.5625) \cdot 1.5) = 4,102 \text{ psi}$$

$$\sigma / \sigma_t = 4,102 / 19,980 = 0.21 \quad \text{Acceptable}$$

### Lug Thickness - Bearing stress

$$t_{reqd} = F_v / (D_p \cdot \sigma_p)$$

$$= 21,151 / (1.5 \cdot 29,970) = \underline{0.4705"}$$

$$t_{\text{reqd}} / t = 0.4705 / 1.5 = 0.31 \quad \text{Acceptable}$$

$$\begin{aligned} \sigma &= F_v / A_{\text{bearing}} \\ &= F_v / (D_p * t) \\ &= 21,151 / (1.5 * 1.5) = 9,400 \text{ psi} \end{aligned}$$

$$\sigma / \sigma_p = 9,400 / 29,970 = 0.31 \quad \text{Acceptable}$$

### Lug Thickness - Shear stress

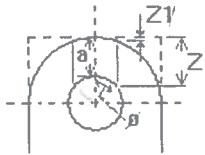
$$\begin{aligned} t_{\text{reqd}} &= [F_v / \sigma_s] / (2 * L_{\text{shear}}) \\ &= (21,151 / 13,320) / (2 * 2.0153) = \underline{0.394"} \end{aligned}$$

$$t_{\text{reqd}} / t = 0.394 / 1.5 = 0.26 \quad \text{Acceptable}$$

$$\begin{aligned} \tau &= F_v / A_{\text{shear}} \\ &= F_v / (2 * t * L_{\text{shear}}) \\ &= 21,151 / (2 * 1.5 * 2.0153) = 3,498 \text{ psi} \end{aligned}$$

$$\tau / \sigma_s = 3,498 / 13,320 = 0.26 \quad \text{Acceptable}$$

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



$$\begin{aligned} \phi &= 55 * D_p / d \\ &= 55 * 1.5 / 1.5625 \\ &= 52.8^\circ \end{aligned}$$

$$\begin{aligned} L_{\text{shear}} &= (H - a_2 - 0.5 * d) + 0.5 * D_p * (1 - \cos(\phi)) \\ &= (7.5 - 5 - 0.5 * 1.5625) + 0.5 * 1.5 * (1 - \cos(52.8)) \\ &= 2.0153" \end{aligned}$$

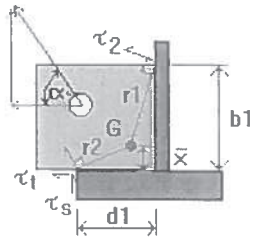
### Lug Plate Stress

Lug stress tensile + bending during lift:

$$\begin{aligned} \sigma_{\text{ratio}} &= [F_{\text{ten}} / (A_{\text{ten}} * \sigma_t)] + [M_{\text{bend}} / (Z_{\text{bend}} * \sigma_b)] \leq 1 \\ &= [(F_{\text{tail}}(\alpha) * \cos(\alpha)) / (t * L * \sigma_t)] + [(6 * \text{abs}(F_{\text{tail}}(\alpha) * \sin(\alpha) * \text{Hght} - F_{\text{tail}}(\alpha) * \cos(\alpha) * a_1)) / (t * L^2 * \sigma_b)] \leq 1 \\ &= (15,794 * \cos(52.0)) / (1.5 * 5 * 19,980) + (6 * \text{abs}(15,794 * \sin(52.0) * 5 - 15,794 * \cos(52.0) * 0)) / (1.5 * 5^2 * 22,201) \\ &= \underline{0.51} \quad \text{Acceptable} \end{aligned}$$



## Weld Stress



Weld stress, tensile, bending and shear during lift:

Direct shear:

Maximum shear stress occurs at lift angle 0.00°; lift force = 21,151 lbf

$$A_{\text{weld}} = 2 * (0.707) * t_w * (b_1 + d_1 + t)$$

$$= 2 * (0.707) * 0.625 * (5 + 4.875 + 1.5) = 10.0527 \text{ in}^2$$

$$\tau_t = F_{\text{tail}} * \cos(\alpha) / A_{\text{weld}}$$

$$= 21,151 * \cos(0.0) / 10.0527 = 2,104 \text{ psi}$$

$$\tau_s = F_{\text{tail}} * \sin(\alpha) / A_{\text{weld}}$$

$$= 21,151 * \sin(0.0) / 10.0527 = 0 \text{ psi}$$

Torsional shear:

Weld areas

$$A_1 = 0.707 * t_w * L_1$$

$$A_1 = 0.707 * 0.625 * 4.875 = 2.1541 \text{ in}^2$$

$$A_2 = 0.707 * 0.625 * 5 = 2.2094 \text{ in}^2$$

$$A_{\text{weld torsion}} = \Sigma A_i = 4.3635 \text{ in}^2$$

Weld centroid locations

$$x_1 = 0"$$

$$y_1 = 2.4375"$$

$$x_2 = 2.5"$$

$$y_2 = 0"$$

$$X_{\text{bar}} = \Sigma (A_i * x_i) / \Sigma A_i$$

$$Y_{\text{bar}} = \Sigma (A_i * y_i) / \Sigma A_i$$

$$X_{\text{bar}} = (2.1541 * 0 + 2.2094 * 2.5) / 4.3635 = 1.2658"$$

$$Y_{\text{bar}} = (2.1541 * 2.4375 + 2.2094 * 0) / 4.3635 = 1.2033"$$

Radius to centroid locations

$$r_i = \text{sqr}((X_{\text{bar}} - x_i)^2 + (Y_{\text{bar}} - y_i)^2)$$

$$r_1 = \text{sqr}((1.2658 - 0)^2 + (1.2033 - 2.4375)^2) = 1.7679"$$

$$r_2 = \text{sqr}((1.2658 - 2.5)^2 + (1.2033 - 0)^2) = 1.7237"$$

Radial distance from centroid to weld:

$$r = \text{sqr}(\Delta X^2 + \Delta Y^2)$$

$$= \text{sqr}(3.7342^2 + 1.2033^2) = 3.9233''$$

$$\theta_r = \text{arctan}(\Delta Y / \Delta X)$$

$$= \text{arctan}(1.2033 / 3.7342) = 17.86^\circ$$

Polar Moment of Area

$$J_1 = 0.707 \cdot t_w \cdot (L_1^3) / 12$$

$$J_1 = 0.707 \cdot 0.625 \cdot (4.875^3) / 12 = 4.2662 \text{ in}^4$$

$$J_2 = 0.707 \cdot 0.625 \cdot (5^3) / 12 = 4.6029 \text{ in}^4$$

$$J = 2 \cdot \Sigma (J_i + A_i \cdot r_i^2) \quad \text{Parallel axis theorem (weld on both sides of lug)}$$

$$J = 2 \cdot [4.2662 + 2.1541 \cdot (1.7679)^2 + 4.6029 + 2.2094 \cdot (1.7237)^2] = 44.33 \text{ in}^4$$

Secondary shear

$$\tau_2 = M \cdot r / J$$

$$= [F(\alpha) \cdot \cos(\alpha) \cdot (X - X_{\text{bar}}) - F(\alpha) \cdot \sin(\alpha) \cdot (Y - Y_{\text{bar}})] \cdot r / J$$

$$= (21,151 \cdot \cos(0.0) \cdot (2.5 - 1.2658) - 21,151 \cdot \sin(0.0) \cdot (5 - 1.2033)) \cdot 3.9233 / 44.3326$$

$$= 2,310 \text{ psi}$$

$$\tau_{\text{ratio}} = \text{sqr}((\tau_1 + \tau_2 \cdot \cos(\theta_r))^2 + (\tau_s + \tau_2 \cdot \sin(\theta_r))^2) / \tau_{\text{allowable}} \leq 1$$

$$= \text{sqr}((2,104 + 2,310 \cdot \cos(17.86))^2 + (0 + 2,310 \cdot \sin(17.86))^2) / 13,320$$

$$= \underline{0.33} \quad \text{Acceptable}$$

## EN 13445 Lift Lug Procedure

### Geometry Inputs - EN13445

Nominal Vessel Thickness, $e_n$	0.75"
Pad Thickness, $e_2$	0"
Length of Lug, $b_1$	5"
Width of Pad, $b_2$	0"
Length of Pad, $b_3$	0"

### Intermediate Values - EN13445

Equivalent Diameter of Vessel at Lug, $ID_{\text{eq}}$	<u>61.75"</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, $F_r$	17.076 lbf
Maximum Allowable Load, $F_{Rmax}$	12.200 lbf
Load Acceptance Ratio, $F_r / F_{Rmax}$	<b>1.3997</b>
Lug Design	<b>Unacceptable</b>

### Equivalent Inner Diameter

$$ID_{eq} = \text{cone inner diameter at center of lug}$$

$$ID_{eq} = D_{cone} / \cos(\alpha)$$

$$ID_{eq} = 61.75 / \cos(0)$$

$$ID_{eq} = 61.75"$$

### Applied Force

$$F_r = \text{force on vessel at lug}$$

$$F_{tail} = W[1 - (l_2 \cdot \cos(\alpha) + l_3 \cdot \sin(\alpha)) / (l_1 \cdot \cos(\alpha) + l_2 \cdot \cos(\alpha) + l_3 \cdot \sin(\alpha))]$$

$$= 43,247 \cdot (1 - (70.6144 \cdot \cos(42.0000) + 36.625 \cdot \sin(42.0000)) / (67.5931 \cdot \cos(42.0000) + 70.6144 \cdot \cos(42.0000) + 36.625 \cdot \sin(42.0000)))$$

$$= \underline{17.076 \text{ lbf}}$$

where ' $l_1$ ' is the distance between the center of gravity and the top lug  
' $l_2$ ' is the distance between this tailing lug and the center of gravity  
' $l_3$ ' is the distance between the vessel centerline and this tailing lug

### Lug factors

$$\lambda = \text{line load factor}$$

$$\lambda = b / \sqrt{ID_{eq} \cdot e_n}$$

$$= 5 / \sqrt{61.75 \cdot 0.75}$$

$$= 0.735$$

$$v_1 = \text{ratio between local membrane stress and local bending stress}$$

$$v_1 = \min(0.08 \cdot \lambda, 0.2)$$

$$= 0.059$$

$$\sigma_m = \text{global membrane stress}$$

$$\sigma_m = P \cdot ID_{eq} / (2 \cdot e_n)$$

$$= 0 \cdot 61.75 / (2 \cdot 0.75)$$

$$= 0.0000 \text{ psi}$$

$$v_2 = \text{ratio between global membrane stress and allowable stress}$$

$$v_2 = \sigma_m / (K_2 \cdot f)$$

$$= 0 / (1.25 \cdot 20,000)$$

$$= 0$$

$$\begin{aligned}
 K_{13} &= 1 / (1.2 * \text{sqr}(1 + 0.06 * \lambda^2)) \\
 &= 1 / (1.2 * \text{sqr}(1 + 0.06 * 0.7347^2)) \\
 &= 0.8202
 \end{aligned}$$

$$\begin{aligned}
 K_{14} &= 1 / (0.6 * \text{sqr}(1 + 0.03 * \lambda^2)) \\
 &= 1 / (0.6 * \text{sqr}(1 + 0.03 * 0.7347^2)) \\
 &= 1.6533
 \end{aligned}$$

### Bending Limit Stress

$$\begin{aligned}
 K_1 &= (1 - \nu_2^2) / ( (1/3 + \nu_1 * \nu_2) + \text{sqr}( (1/3 + \nu_1 * \nu_2)^2 + (1 - \nu_2^2) * \nu_1^2 ) ) \\
 &= (1 - 0^2) / ( (1/3 + 0.0588 * 0) + \text{sqr}( (1/3 + 0.0588 * 0)^2 + (1 - 0^2) * 0.0588^2 ) ) \\
 &= 1.4885
 \end{aligned}$$

$$\begin{aligned}
 \sigma_b &= K_1 * K_2 * f \\
 &= 1.4885 * 1.25 * 20,000 \\
 &= 37,213 \text{ psi}
 \end{aligned}$$

### Maximum Allowable Load

$$\begin{aligned}
 F_{Rmax} &= \sigma_b * e_n^2 / (K_{13} * |\cos(\beta)| + K_{14} * |a_2 * \sin(\beta) - a_1 * \cos(\beta)| / b_1) \\
 &= 37,213 * (0.75)^2 / (0.8202 * |\cos(42.0000)| + 1.6533 * |5 * \sin(42.0000) - 0 * \cos(42.0000)| / 5) \\
 &= 12,200 \text{ lbf}
 \end{aligned}$$

### Base Ring Sectional Properties

$t_1$	0.75"	$L_1$	3.7762"	
$t_2$	1"	$L_{2a}$	4.875"	
		$L_{2b}$	2.625"	
Base Ring Geometry				

Effective skirt length:

$$\begin{aligned}
 R_m &= (D_i + t_1) * 0.5 \\
 &= (61.75 + 0.75) * 0.5 = 31.25" \\
 L_1 &= \text{Min}(0.78 * \text{sqr}(R_m * t_1), 16 * t_1) \\
 &= 0.78 * \text{sqr}(31.25 * 0.75) = 3.7762"
 \end{aligned}$$

Section Area:

$$\begin{aligned}
 A_1 &= t_1 * L_1 = 0.75 * 3.7762 = 2.8321 \text{ in}^2 \\
 A_2 &= t_2 * L_2 = 1 * (4.875 + 2.625) = 7.5 \text{ in}^2 \\
 A_{total} &= A_1 + A_2 = 2.8321 + 7.5 = 10.3321 \text{ in}^2
 \end{aligned}$$

Centroid, C:

$$\begin{aligned}
 h_1 &= L_{2a} + 0.5 * t_1 = 4.875 + 0.5 * 0.75 = 5.25" \\
 h_2 &= 0.5 * (L_{2a} + L_{2b}) = 0.5 * (4.875 + 2.625) = 3.75" \\
 C &= (A_1 * h_1 + A_2 * h_2) / A_{total}
 \end{aligned}$$

$$= ((2.8321*5.25) + (7.5*3.75)) / 10.3321 = 4.1612''$$

Moment of Inertia, I:

$$I_1 = (L_1 * t_1^3) / 12 + A_1 * (h_1 - C)^2$$

$$= (3.7762 * 0.75^3) / 12 + 2.8321 * (5.25 - 4.1612)^2 = 3.5 \text{ in}^4$$

$$I_2 = t_2 * (L_{2a} + L_{2b})^3 / 12 + A_2 * (h_2 - C)^2$$

$$= 1 * (4.875 + 2.625)^3 / 12 + 7.5 * (3.75 - 4.1612)^2 = 36.4 \text{ in}^4$$

$$I_{\text{ring}} = I_1 + I_2$$

$$= 3.4904 + 36.4242 = 39.9 \text{ in}^4$$

Section Modulus, Z:

$$Z = I_{\text{ring}} / C_{\text{max}} = 39.9146 / 4.1612 = 9.592 \text{ in}^3$$

### Base Ring Loads without stiffener beam

Base Ring Load

$$W_r = W = F_{\text{tail}} = 21,151 \text{ lbf}$$

### Base Ring Loading

Reference: Roark's Formulas for Stress & Strain - 6<sup>th</sup> Edition. Table 17, Case 20

For thin ring sections  $k_1 = k_2 = 1$

$$\text{Change in vertical diameter, } D_v = (-W) * R^3 * (\pi * k_1 / 8 - k_2^2 / \pi) / (E * I)$$

$$\text{Internal Moment, } M_A = W * R * (k_2 - 0.5) / (2 * \pi)$$

$$\text{Internal Force, } N_A = 0.75 * W / \pi$$

$$\text{Internal Shear Force, } V_A = 0$$

$$\text{Ring loading, } W_r = 21,151 \text{ lbf}$$

$$D_{v_r} = -21,151 * 32.3388^3 * (\pi * 1 / 8 - 1^2 / \pi) / (29,000,000 * 39.9146) = -0.046''$$

$$M_{A_r} = 21,151 * 32.3388 * (1 - 0.5) / (2 * \pi) = 54430.4090 \text{ lbf-in}$$

$$N_{A_r} = 0.75 * 21,151 / \pi = 5,049 \text{ lbf}$$

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 <sub>M</sub> [in-lbf]	LT <sub>N</sub> [lbf]	LT <sub>V</sub> [lbf]	M [in-lbf]	N [lbf]	V [lbf]
180	0.00	-0.00	0.00	54430.41	5049.38	0.00
150	669.47	-881.28	156.70	33223.01	3491.61	-2367.99
120	10134.98	-3052.86	1152.70	-17080.23	-528.16	-3220.20
90	46723.46	-5287.70	3366.26	-62137.36	-5287.70	-1683.13
60	129130.77	-6105.71	6440.40	-61375.66	-8630.41	2067.50
30	263775.63	-4406.42	9315.27	13500.46	-8779.31	6790.58
0	435443.27	-0.00	10575.41	163291.23	-5049.38	10575.41

(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

$$f_a = N / A = -5,049 / 10.3321 = -489 \text{ psi}$$

$$f_b = M / Z = 163,291 / 9.5922 = 17,023 \text{ psi}$$

$$f_a / F_a + f_b / F_b = 0.74 \quad \text{Acceptable}$$

Maximum shear stress occurs at 0.00 degrees

$$f_s = V / A = 10,575 / 10.3321 = 1,024 \text{ psi}$$

$$f_s / F_s = 0.07 \quad \text{Acceptable}$$



## 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:	68.5 in
Anchor bolt corrosion allowance (applied to root radius):	0 in
Anchor bolt clearance:	0.375 in
Base plate material:	SA-516 70
Base plate allowable stress, $S_p$ :	20,000 psi
Base plate inner diameter, $D_i$ :	58 in
Base plate outer diameter, $D_o$ :	73 in
Base plate thickness, $t_b$ :	1 in
Gusset separation, w:	4 in
Gusset height, h:	4.625 in
Gusset thickness, $t_g$ :	0.375 in
Initial bolt preload:	0 % (0 psi)
Number of bolts, N:	8
Bolt size and type:	1.25 inch series 8 threaded
Bolt root area (corroded), $A_b$ :	0.929 in <sup>2</sup>
Diameter of anchor bolt holes, $d_b$ :	1.625 in

Load	Vessel condition	Base M (lb-ft)	W (lb)	Required bolt area (In <sup>2</sup> )	$t_r$ Base (In)	Foundation bearing stress (psi)
Wind	operating, corroded	27,784.9	40,890.5	<u>0</u>	<u>0.365</u>	<u>41.3</u>
Wind	operating, new	28,020	41,806.6	<u>0</u>	<u>0.3682</u>	<u>42.02</u>
Wind	empty, corroded	27,784.9	27,793	<u>0</u>	<u>0.3249</u>	<u>32.72</u>
Wind	empty, new	28,020	28,831.4	<u>0</u>	<u>0.3288</u>	<u>33.52</u>
Wind	vacuum, corroded	27,784.9	40,890.5	<u>0</u>	<u>0.365</u>	<u>41.3</u>
Seismic	operating, corroded	187,179.7	40,890.5	<u>0.5642</u>	<u>0.9511</u>	<u>280.41</u>
Seismic	operating, new	191,359.8	41,806.6	<u>0.5768</u>	<u>0.9617</u>	<u>286.68</u>
Seismic	empty, corroded	136,014.5	27,793	<u>0.422</u>	<u>0.8056</u>	<u>201.17</u>
Seismic	empty, new	140,660.2	28,831.4	<u>0.4358</u>	<u>0.8195</u>	<u>208.17</u>
Seismic	vacuum, corroded	187,179.7	40,890.5	<u>0.5642</u>	<u>0.9511</u>	<u>280.41</u>

### Anchor bolt load (operating, corroded + Wind)

$$\begin{aligned}
 P &= -W / N + 48 * M / (N*BC) \\
 &= -40,890.52 / 8 + 48 * 27,784.9 / (8*68.5) \\
 &= -2,677.6 \text{ lb}_f
 \end{aligned}$$

The anchor bolts are satisfactory (no net uplift on anchor bolt)

### Foundation bearing stress (operating, corroded + Wind)

$$\begin{aligned}
 A_c &= \pi*(D_o^2 - D_i^2) / 4 - N*\pi*d_b^2 / 4 \\
 &= \pi*(73^2 - 58^2) / 4 - 8*\pi*1.625^2 / 4
 \end{aligned}$$

$$= 1,526.7159 \text{ in}^2$$

$$\begin{aligned} I_c &= \pi(D_o^4 - D_i^4) / 64 \\ &= \pi(73^4 - 58^4) / 64 \\ &= 838,498.2 \text{ in}^4 \end{aligned}$$

$$\begin{aligned} f_c &= N \cdot A_b \cdot \text{Preload} / A_c + W / A_c + 6 \cdot M \cdot D_o / I_c \\ &= 8 \cdot 0.929 \cdot 0 / 1,526.7159 + 40,890.52 / 1,526.7159 + 6 \cdot 27,784.9 \cdot 73 / 838,498.2 \\ &= 41 \text{ psi} \end{aligned}$$

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

#### Base plate required thickness (operating, corroded + Wind)

From Brownell & Young, Table 10.3;  $l / b = 0.2201$

$$M_x = 0.0052 \cdot 41 \cdot 22.1499^2 = 104.3 \text{ lb}_f$$

$$M_y = -0.4525 \cdot 41 \cdot 4.875^2 = -444.1 \text{ lb}_f$$

$$\begin{aligned} t_r &= (6 \cdot M_{\max} / S_p)^{0.5} \\ &= (6 \cdot 444.07 / 20,000)^{0.5} \\ &= 0.365 \text{ in} \end{aligned}$$

The base plate thickness is satisfactory.

#### Base plate bolt load (Jawad & Farr eq. 12.13, operating, corroded + Wind)

$$\text{Bolt load} = A_b \cdot f_s = 0.929 \cdot 0 = 0 \text{ lb}_f$$

$$\begin{aligned} t_r &= (3.91 \cdot F / (S_y \cdot (2 \cdot b / w + w / (2 \cdot l) - d_b \cdot (2 / w + 1 / (2 \cdot l))))))^{0.5} \\ &= (3.91 \cdot 0 / (36,000 \cdot (2 \cdot 4.875 / 4 + 4 / (2 \cdot 2.625) - 1.625 \cdot (2 / 4 + 1 / (2 \cdot 2.625))))))^{0.5} \\ &= 0 \text{ in} \end{aligned}$$

The base plate thickness is satisfactory.

#### Check skirt for gusset reaction (Jawad & Farr eq. 12.14)

$$\begin{aligned} S_r &= 1.5 \cdot F \cdot b / (\text{gussets} \cdot \pi \cdot t_{sk}^2 \cdot h) \\ &= 1.5 \cdot 0 \cdot 4.875 / (2 \cdot \pi \cdot 0.75^2 \cdot 4.625) \\ &= 0 \text{ psi} \end{aligned}$$

As  $S_r \leq 30,000$  psi the skirt thickness is adequate to resist the gusset reaction.

#### Anchor bolt load (operating, new + Wind)

$$\begin{aligned} P &= -W / N + 48 \cdot M / (N \cdot BC) \\ &= -41,806.61 / 8 + 48 \cdot 28,020 / (8 \cdot 68.5) \\ &= -2,771.52 \text{ lb}_f \end{aligned}$$

The anchor bolts are satisfactory (no net uplift on anchor bolt)

#### Foundation bearing stress (operating, new + Wind)

$$\begin{aligned} A_c &= \pi(D_o^2 - D_i^2) / 4 - N \cdot \pi \cdot d_b^2 / 4 \\ &= \pi(73^2 - 58^2) / 4 - 8 \cdot \pi \cdot 1.625^2 / 4 \\ &= 1,526.7159 \text{ in}^2 \end{aligned}$$

$$\begin{aligned}
 I_c &= \pi(D_o^4 - D_i^4) / 64 \\
 &= \pi(73^4 - 58^4) / 64 \\
 &= 838,498.2 \text{ in}^4
 \end{aligned}$$

$$\begin{aligned}
 f_c &= N \cdot A_b \cdot \text{Preload} / A_c + W / A_c + 6 \cdot M \cdot D_o / I_c \\
 &= 8 \cdot 0.929 \cdot 0 / 1,526.7159 + 41,806.61 / 1,526.7159 + 6 \cdot 28,020 \cdot 73 / 838,498.2 \\
 &= \underline{42} \text{ psi}
 \end{aligned}$$

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:  $l / b = 0.2201$

$$M_x = 0.0052 \cdot 42 \cdot 22.1499^2 = 106.2 \text{ lb}_f$$

$$M_y = -0.4525 \cdot 42 \cdot 4.875^2 = -451.8 \text{ lb}_f$$

$$\begin{aligned}
 t_r &= (6 \cdot M_{\max} / S_p)^{0.5} \\
 &= (6 \cdot 451.84 / 20,000)^{0.5} \\
 &= \underline{0.3682} \text{ in}
 \end{aligned}$$

The base plate thickness is satisfactory.

#### Base plate bolt load (Jawad & Farr eq. 12.13, operating, new + Wind)

$$\text{Bolt load} = A_b \cdot f_s = 0.929 \cdot 0 = 0 \text{ lb}_f$$

$$\begin{aligned}
 t_r &= (3.91 \cdot F / (S_y \cdot (2 \cdot b / w + w / (2 \cdot l) - d_b \cdot (2 / w + 1 / (2 \cdot l))))))^{0.5} \\
 &= (3.91 \cdot 0 / (36,000 \cdot (2 \cdot 4.875 / 4 + 4 / (2 \cdot 2.625) - 1.625 \cdot (2 / 4 + 1 / (2 \cdot 2.625))))))^{0.5} \\
 &= 0 \text{ in}
 \end{aligned}$$

The base plate thickness is satisfactory.

#### Check skirt for gusset reaction (Jawad & Farr eq. 12.14)

$$\begin{aligned}
 S_r &= 1.5 \cdot F \cdot b / (\text{gussets} \cdot \pi \cdot t_{sk}^2 \cdot h) \\
 &= 1.5 \cdot 0 \cdot 4.875 / (2 \cdot \pi \cdot 0.75^2 \cdot 4.625) \\
 &= 0 \text{ psi}
 \end{aligned}$$

As  $S_r \leq 30,000$  psi the skirt thickness is adequate to resist the gusset reaction.

#### Anchor bolt load (empty, corroded + Wind)

$$\begin{aligned}
 P &= -W / N + 48 \cdot M / (N \cdot BC) \\
 &= -27,793.03 / 8 + 48 \cdot 27,784.9 / (8 \cdot 68.5) \\
 &= -1,040.42 \text{ lb}_f
 \end{aligned}$$

The anchor bolts are satisfactory (no net uplift on anchor bolt)

#### Foundation bearing stress (empty, corroded + Wind)

$$\begin{aligned}
 A_c &= \pi(D_o^2 - D_i^2) / 4 - N \cdot \pi \cdot d_b^2 / 4 \\
 &= \pi(73^2 - 58^2) / 4 - 8 \cdot \pi \cdot 1.625^2 / 4 \\
 &= 1,526.7159 \text{ in}^2
 \end{aligned}$$

$$I_c = \pi(D_o^4 - D_i^4) / 64$$

$$= \pi(73^4 - 58^4) / 64$$

$$= 838,498.2 \text{ in}^4$$

$$f_c = N \cdot A_b \cdot \text{Preload} / A_c + W / A_c + 6 \cdot M \cdot D_o / I_c$$

$$= 8 \cdot 0.929 \cdot 0 / 1,526.7159 + 27,793.03 / 1,526.7159 + 6 \cdot 27,784.9 \cdot 73 / 838,498.2$$

$$= 33 \text{ psi}$$

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;  $l / b = 0.2201$

$$M_x = 0.0052 \cdot 33 \cdot 22.1499^2 = 82.7 \text{ lb}_f$$

$$M_y = -0.4525 \cdot 33 \cdot 4.875^2 = -351.8 \text{ lb}_f$$

$$t_r = (6 \cdot M_{\max} / S_p)^{0.5}$$

$$= (6 \cdot 351.82 / 20,000)^{0.5}$$

$$= 0.3249 \text{ in}$$

The base plate thickness is satisfactory.

#### Base plate bolt load (Jawad & Farr eq. 12.13, empty, corroded + Wind)

$$\text{Bolt load} = A_b \cdot f_s = 0.929 \cdot 0 = 0 \text{ lb}_f$$

$$t_r = (3.91 \cdot F / (S_y \cdot (2 \cdot b / w + w / (2 \cdot l) - d_b \cdot (2 / w + 1 / (2 \cdot l))))))^{0.5}$$

$$= (3.91 \cdot 0 / (36,000 \cdot (2 \cdot 4.875 / 4 + 4 / (2 \cdot 2.625) - 1.625 \cdot (2 / 4 + 1 / (2 \cdot 2.625))))))^{0.5}$$

$$= 0 \text{ in}$$

The base plate thickness is satisfactory.

#### Check skirt for gusset reaction (Jawad & Farr eq. 12.14)

$$S_r = 1.5 \cdot F \cdot b / (\text{gussets} \cdot \pi \cdot t_{sk}^2 \cdot h)$$

$$= 1.5 \cdot 0 \cdot 4.875 / (2 \cdot \pi \cdot 0.75^2 \cdot 4.625)$$

$$= 0 \text{ psi}$$

As  $S_r \leq 30,000$  psi the skirt thickness is adequate to resist the gusset reaction.

#### Anchor bolt load (empty, new + Wind)

$$P = -W / N + 48 \cdot M / (N \cdot BC)$$

$$= -28,831.35 / 8 + 48 \cdot 28,020 / (8 \cdot 68.5)$$

$$= -1,149.61 \text{ lb}_f$$

The anchor bolts are satisfactory (no net uplift on anchor bolt)

#### Foundation bearing stress (empty, new + Wind)

$$A_c = \pi(D_o^2 - D_i^2) / 4 - N \cdot \pi \cdot d_b^2 / 4$$

$$= \pi(73^2 - 58^2) / 4 - 8 \cdot \pi \cdot 1.625^2 / 4$$

$$= 1,526.7159 \text{ in}^2$$

$$I_c = \pi(D_o^4 - D_i^4) / 64$$

$$= \pi(73^4 - 58^4) / 64$$

$$= 838,498.2 \text{ in}^4$$

$$f_c = N \cdot A_b \cdot \text{Preload} / A_c + W / A_c + 6 \cdot M \cdot D_o / I_c$$

$$= 8 \cdot 0.929 \cdot 0 / 1,526.7159 + 28,831.35 / 1,526.7159 + 6 \cdot 28,020 \cdot 73 / 838,498.2$$

$$= \underline{34} \text{ psi}$$

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:  $l / b = 0.2201$

$$M_x = 0.0052 \cdot 34 \cdot 22.1499^2 = 84.7 \text{ lb}_f$$

$$M_y = -0.4525 \cdot 34 \cdot 4.875^2 = -360.5 \text{ lb}_f$$

$$t_r = (6 \cdot M_{\max} / S_p)^{0.5}$$

$$= (6 \cdot 360.45 / 20,000)^{0.5}$$

$$= \underline{0.3288} \text{ in}$$

The base plate thickness is satisfactory.

#### Base plate bolt load (Jawad & Farr eq. 12.13, empty, new + Wind)

$$\text{Bolt load} = A_b \cdot f_s = 0.929 \cdot 0 = 0 \text{ lb}_f$$

$$t_r = (3.91 \cdot F / (S_y \cdot (2 \cdot b / w + w / (2 \cdot l) - d_b \cdot (2 / w + 1 / (2 \cdot l))))))^{0.5}$$

$$= (3.91 \cdot 0 / (36,000 \cdot (2 \cdot 4.875 / 4 + 4 / (2 \cdot 2.625) - 1.625 \cdot (2 / 4 + 1 / (2 \cdot 2.625))))))^{0.5}$$

$$= 0 \text{ in}$$

The base plate thickness is satisfactory.

#### Check skirt for gusset reaction (Jawad & Farr eq. 12.14)

$$S_r = 1.5 \cdot F \cdot b / (\text{gussets} \cdot \pi \cdot t_{sk}^2 \cdot h)$$

$$= 1.5 \cdot 0 \cdot 4.875 / (2 \cdot \pi \cdot 0.75^2 \cdot 4.625)$$

$$= 0 \text{ psi}$$

As  $S_r \leq 30,000$  psi the skirt thickness is adequate to resist the gusset reaction.

#### Anchor bolt load (vacuum, corroded + Wind)

$$P = -W / N + 48 \cdot M / (N \cdot BC)$$

$$= -40,890.52 / 8 + 48 \cdot 27,784.9 / (8 \cdot 68.5)$$

$$= -2,677.6 \text{ lb}_f$$

The anchor bolts are satisfactory (no net uplift on anchor bolt)

#### Foundation bearing stress (vacuum, corroded + Wind)

$$A_c = \pi(D_o^2 - D_i^2) / 4 - N \cdot \pi \cdot d_b^2 / 4$$

$$= \pi(73^2 - 58^2) / 4 - 8 \cdot \pi \cdot 1.625^2 / 4$$

$$= 1,526.7159 \text{ in}^2$$

$$I_c = \pi(D_o^4 - D_i^4) / 64$$

$$= \pi(73^4 - 58^4) / 64$$

$$= 838,498.2 \text{ in}^4$$

$$f_c = N \cdot A_b \cdot \text{Preload} / A_c + W / A_c + 6 \cdot M \cdot D_o / I_c$$

$$= 8 \cdot 0.929 \cdot 0 / 1,526.7159 + 40,890.52 / 1,526.7159 + 6 \cdot 27,784.9 \cdot 73 / 838,498.2$$

$$= 41 \text{ psi}$$

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:,  $l / b = 0.2201$

$$M_x = 0.0052 \cdot 41 \cdot 22.1499^2 = 104.3 \text{ lb}_f$$

$$M_y = -0.4525 \cdot 41 \cdot 4.875^2 = -444.1 \text{ lb}_f$$

$$t_r = (6 \cdot M_{\max} / S_p)^{0.5}$$

$$= (6 \cdot 444.07 / 20,000)^{0.5}$$

$$= 0.365 \text{ in}$$

The base plate thickness is satisfactory.

#### Base plate bolt load (Jawad & Farr eq. 12.13, vacuum, corroded + Wind)

$$\text{Bolt load} = A_b \cdot f_s = 0.929 \cdot 0 = 0 \text{ lb}_f$$

$$t_r = (3.91 \cdot F / (S_y \cdot (2 \cdot b / w + w / (2 \cdot l) - d_b \cdot (2 / w + 1 / (2 \cdot l))))))^{0.5}$$

$$= (3.91 \cdot 0 / (36,000 \cdot (2 \cdot 4.875 / 4 + 4 / (2 \cdot 2.625) - 1.625 \cdot (2 / 4 + 1 / (2 \cdot 2.625))))))^{0.5}$$

$$= 0 \text{ in}$$

The base plate thickness is satisfactory.

#### Check skirt for gusset reaction (Jawad & Farr eq. 12.14)

$$S_r = 1.5 \cdot F \cdot b / (\text{gussets} \cdot \pi \cdot t_{sk}^2 \cdot h)$$

$$= 1.5 \cdot 0 \cdot 4.875 / (2 \cdot \pi \cdot 0.75^2 \cdot 4.625)$$

$$= 0 \text{ psi}$$

As  $S_r \leq 30,000$  psi the skirt thickness is adequate to resist the gusset reaction.

#### Anchor bolt load (operating, corroded + Seismic)

$$P = -W / N + 48 \cdot M / (N \cdot BC)$$

$$= -40,890.52 / 8 + 48 \cdot 187,179.7 / (8 \cdot 68.5)$$

$$= 11,283.99 \text{ lb}_f$$

$$\text{Required area per bolt} = P / S_b = 0.5642 \text{ in}^2$$

The area provided (0.929 in<sup>2</sup>) by the specified anchor bolt is adequate.

#### Support calculations (Jawad & Farr chapter 12, operating, corroded + Seismic)

Base plate width, $t_c$ :	7.5	in
Average base plate diameter, $d$ :	65.5	in
Base plate elastic modulus, $E_s$ :	29.0E+06	psi
Base plate yield stress, $S_y$ :	36,000	psi



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

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

$$\begin{aligned} t_s &= (N * A_b) / (\pi * d) \\ &= (8 * 0.929) / (\pi * 65.5) \\ &= 0.0361 \text{ in} \end{aligned}$$

**From table 12.4 for k = 0.271492:**

$$\begin{aligned} K_1 &= 2.5042, \quad K_2 = 1.4308 \\ L_1 &= 14.9706, \quad L_2 = 36.9789, \quad L_3 = 14.0992 \end{aligned}$$

#### **Total tensile force on bolting**

$$\begin{aligned} T &= (12 * M - W * (L_1 + L_3)) / (L_2 + L_3) \\ &= (12 * 187,179.7 - 40,890.52 * (14.9706 + 14.0992)) / (36.9789 + 14.0992) \\ &= 20,703.19 \text{ lb}_f \end{aligned}$$

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

$$\begin{aligned} f_s &= T / (t_s * (d / 2) * K_1) \\ &= 20,703.19 / (0.0361 * (65.5 / 2) * 2.5042) \\ &= 6,989 \text{ psi} \end{aligned}$$

#### **Total compressive load on foundation**

$$\begin{aligned} C_c &= T + (1 + V_{\text{Accel}}) * W + \text{Bolt Preload} \\ &= 20,703.19 + (1 + 1) * 40,890.52 + 0 \\ &= 102,484.22 \text{ lb}_f \end{aligned}$$

#### **Foundation bearing stress**

$$\begin{aligned} f_c &= C_c / (((t_c - t_s) + n * t_s) * (d / 2) * K_2) \\ &= 102,484.22 / (((7.5 - 0.0361) + 9.2889 * 0.0361) * (65.5 / 2) * 1.4308) \\ &= \underline{280} \text{ psi} \end{aligned}$$

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

$$\begin{aligned} k &= 1 / (1 + f_s / (n * f_c)) \\ &= 1 / (1 + 6,989 / (9.2889 * 280)) \\ &= 0.271492 \end{aligned}$$

#### **Base plate required thickness (operating, corroded + Seismic)**

From Brownell & Young, Table 10.3;  $l / b = 0.2201$

$$M_x = 0.0052 * 280 * 22.1499^2 = 708.5 \text{ lb}_f$$

$$M_y = -0.4525 * 280 * 4.875^2 = -3,015.3 \text{ lb}_f$$

$$\begin{aligned} t_r &= (6 * M_{\text{max}} / S_p)^{0.5} \\ &= (6 * 3,015.29 / 20,000)^{0.5} \\ &= \underline{0.9511} \text{ in} \end{aligned}$$

The base plate thickness is satisfactory.

### Base plate bolt load (Jawad & Farr eq. 12.13, operating, corroded + Seismic)

$$\text{Bolt load} = A_b \cdot f_s = 0.929 \cdot 6,989 = 6,493.17 \text{ lb}_f$$

$$t_r = (3.91 \cdot F / (S_y \cdot (2 \cdot b / w + w / (2 \cdot l) - d_b \cdot (2 / w + 1 / (2 \cdot l))))))^{0.5}$$
$$= (3.91 \cdot 6,493.17 / (36,000 \cdot (2 \cdot 4.875 / 4 + 4 / (2 \cdot 2.625) - 1.625 \cdot (2 / 4 + 1 / (2 \cdot 2.625))))))^{0.5}$$
$$= 0.5827 \text{ in}$$

The base plate thickness is satisfactory.

### Check skirt for gusset reaction (Jawad & Farr eq. 12.14)

$$S_r = 1.5 \cdot F \cdot b / (\text{gussets} \cdot \pi \cdot t_{sk}^2 \cdot h)$$
$$= 1.5 \cdot 6,493.17 \cdot 4.875 / (2 \cdot \pi \cdot 0.75^2 \cdot 4.625)$$
$$= 2,904.75 \text{ psi}$$

As  $S_r \leq 30,000$  psi the skirt thickness is adequate to resist the gusset reaction.

### Anchor bolt load (operating, new + Seismic)

$$P = -W / N + 48 \cdot M / (N \cdot BC)$$
$$= -41,806.61 / 8 + 48 \cdot 191,359.8 / (8 \cdot 68.5)$$
$$= 11,535.62 \text{ lb}_f$$

$$\text{Required area per bolt} = P / S_b = 0.5768 \text{ in}^2$$

The area provided (0.929 in<sup>2</sup>) by the specified anchor bolt is adequate.

### Support calculations (Jawad & Farr chapter 12, operating, new + Seismic)

Base plate width, $t_c$ :	7.5	in
Average base plate diameter, $d$ :	65.5	in
Base plate elastic modulus, $E_s$ :	29.0E+06	psi
Base plate yield stress, $S_y$ :	36,000	psi

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

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

$$t_s = (N \cdot A_b) / (\pi \cdot d)$$
$$= (8 \cdot 0.929) / (\pi \cdot 65.5)$$
$$= 0.0361 \text{ in}$$

From table 12.4 for  $k = 0.271506$ :

$$K_1 = 2.5042, \quad K_2 = 1.4309$$
$$L_1 = 14.9697, \quad L_2 = 36.9782, \quad L_3 = 14.0999$$

### Total tensile force on bolting

$$T = (12 \cdot M - W \cdot (L_1 + L_3)) / (L_2 + L_3)$$
$$= (12 \cdot 191,359.8 - 41,806.61 \cdot (14.9697 + 14.0999)) / (36.9782 + 14.0999)$$
$$= 21,164.02 \text{ lb}_f$$

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

$$f_s = T / (t_s \cdot (d / 2) \cdot K_1)$$

$$= 21,164.02 / (0.0361 * (65.5 / 2) * 2.5042)$$

$$= 7,145 \text{ psi}$$

### Total compressive load on foundation

$$C_c = T + (1 + V_{\text{Accel}}) * W + \text{Bolt Preload}$$

$$= 21,164.02 + (1 + 1) * 41,806.61 + 0$$

$$= 104,777.23 \text{ lb}_f$$

### Foundation bearing stress

$$f_c = C_c / (((t_c - t_s) + n * t_s) * (d / 2) * K_2)$$

$$= 104,777.23 / (((7.5 - 0.0361) + 9.2889 * 0.0361) * (65.5 / 2) * 1.4309)$$

$$= \underline{287} \text{ psi}$$

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

$$k = 1 / (1 + f_s / (n * f_c))$$

$$= 1 / (1 + 7,145 / (9.2889 * 287))$$

$$= 0.271506$$

### Base plate required thickness (operating, new + Seismic)

From Brownell & Young, Table 10.3.:  $l / b = 0.2201$

$$M_x = 0.0052 * 287 * 22.1499^2 = 724.3 \text{ lb}_f$$

$$M_y = -0.4525 * 287 * 4.875^2 = -3,082.7 \text{ lb}_f$$

$$t_r = (6 * M_{\text{max}} / S_p)^{0.5}$$

$$= (6 * 3,082.67 / 20,000)^{0.5}$$

$$= \underline{0.9617} \text{ in}$$

The base plate thickness is satisfactory.

### Base plate bolt load (Jawad & Farr eq. 12.13, operating, new + Seismic)

$$\text{Bolt load} = A_b * f_s = 0.929 * 7,145 = 6,637.79 \text{ lb}_f$$

$$t_r = (3.91 * F / (S_y * (2 * b / w + w / (2 * l) - d_b * (2 / w + 1 / (2 * l))))^{0.5}$$

$$= (3.91 * 6,637.79 / (36,000 * (2 * 4.875 / 4 + 4 / (2 * 2.625) - 1.625 * (2 / 4 + 1 / (2 * 2.625))))^{0.5}$$

$$= 0.5891 \text{ in}$$

The base plate thickness is satisfactory.

### Check skirt for gusset reaction (Jawad & Farr eq. 12.14)

$$S_r = 1.5 * F * b / (\text{gussets} * \pi * t_{\text{sk}}^2 * h)$$

$$= 1.5 * 6,637.79 * 4.875 / (2 * \pi * 0.75^2 * 4.625)$$

$$= 2,969.44 \text{ psi}$$

As  $S_r \leq 30,000$  psi the skirt thickness is adequate to resist the gusset reaction.

### Anchor bolt load (empty, corroded + Seismic)

$$P = -W / N + 48 * M / (N * BC)$$

$$= -27,793.03 / 8 + 48 * 136,014.5 / (8 * 68.5)$$

$$= 8,439.55 \text{ lb}_f$$

$$\text{Required area per bolt} = P / S_b = \underline{0.422} \text{ in}^2$$

The area provided (0.929 in<sup>2</sup>) by the specified anchor bolt is adequate.

### Support calculations (Jawad & Farr chapter 12, empty, corroded + Seismic)

$$\begin{aligned} \text{Base plate width, } t_c &: 7.5 && \text{in} \\ \text{Average base plate diameter, } d &: 65.5 && \text{in} \\ \text{Base plate elastic modulus, } E_s &: 29.0\text{E}+06 && \text{psi} \\ \text{Base plate yield stress, } S_y &: 36,000 && \text{psi} \end{aligned}$$

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

$$n = E_s / E_c = 29.0\text{E}+06 / 3,122,019 = 9.2889$$

$$\begin{aligned} t_s &= (N * A_b) / (\pi * d) \\ &= (8 * 0.929) / (\pi * 65.5) \\ &= 0.0361 \text{ in} \end{aligned}$$

From table 12.4 for  $k = 0.258551$ :

$$\begin{aligned} K_1 &= 2.5324, \quad K_2 = 1.3942 \\ L_1 &= 15.8189, \quad L_2 = 37.6005, \quad L_3 = 13.4328 \end{aligned}$$

### Total tensile force on bolting

$$\begin{aligned} T &= (12 * M - W * (L_1 + L_3)) / (L_2 + L_3) \\ &= (12 * 136,014.5 - 27,793.03 * (15.8189 + 13.4328)) / (37.6005 + 13.4328) \\ &= 16,051.88 \text{ lb}_f \end{aligned}$$

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

$$\begin{aligned} f_s &= T / (t_s * (d / 2) * K_1) \\ &= 16,051.88 / (0.0361 * (65.5 / 2) * 2.5324) \\ &= 5,359 \text{ psi} \end{aligned}$$

### Total compressive load on foundation

$$\begin{aligned} C_c &= T + (1 + V\text{Accel}) * W + \text{Bolt Preload} \\ &= 16,051.88 + (1 + 1) * 27,793.03 + 0 \\ &= 71,637.95 \text{ lb}_f \end{aligned}$$

### Foundation bearing stress

$$\begin{aligned} f_c &= C_c / (((t_c - t_s) + n * t_s) * (d / 2) * K_2) \\ &= 71,637.95 / (((7.5 - 0.0361) + 9.2889 * 0.0361) * (65.5 / 2) * 1.3941) \\ &= \underline{201} \text{ psi} \end{aligned}$$

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

$$\begin{aligned} k &= 1 / (1 + f_s / (n * f_c)) \\ &= 1 / (1 + 5,359 / (9.2889 * 201)) \\ &= 0.258551 \end{aligned}$$

### Base plate required thickness (empty, corroded + Seismic)

From Brownell & Young, Table 10.3:  $l/b = 0.2201$

$$M_x = 0.0052 \cdot 201 \cdot 22.1499^2 = 508.3 \text{ lb}_f$$

$$M_y = -0.4525 \cdot 201 \cdot 4.875^2 = -2,163.2 \text{ lb}_f$$

$$\begin{aligned} t_r &= (6 \cdot M_{\max} / S_p)^{0.5} \\ &= (6 \cdot 2,163.18 / 20,000)^{0.5} \\ &= \underline{0.8056} \text{ in} \end{aligned}$$

The base plate thickness is satisfactory.

#### Base plate bolt load (Jawad & Farr eq. 12.13, empty, corroded + Seismic)

$$\text{Bolt load} = A_b \cdot f_s = 0.929 \cdot 5,359 = 4,978.26 \text{ lb}_f$$

$$\begin{aligned} t_r &= (3.91 \cdot F / (S_y \cdot (2 \cdot b / w + w / (2 \cdot l) - d_b \cdot (2 / w + 1 / (2 \cdot l))))))^{0.5} \\ &= (3.91 \cdot 4,978.26 / (36,000 \cdot (2 \cdot 4.875 / 4 + 4 / (2 \cdot 2.625) - 1.625 \cdot (2 / 4 + 1 / (2 \cdot 2.625))))))^{0.5} \\ &= 0.5102 \text{ in} \end{aligned}$$

The base plate thickness is satisfactory.

#### Check skirt for gusset reaction (Jawad & Farr eq. 12.14)

$$\begin{aligned} S_r &= 1.5 \cdot F \cdot b / (\text{gussets} \cdot \pi \cdot t_{sk}^2 \cdot h) \\ &= 1.5 \cdot 4,978.26 \cdot 4.875 / (2 \cdot \pi \cdot 0.75^2 \cdot 4.625) \\ &= 2,227.05 \text{ psi} \end{aligned}$$

As  $S_r \leq 30,000$  psi the skirt thickness is adequate to resist the gusset reaction.

#### Anchor bolt load (empty, new + Seismic)

$$\begin{aligned} P &= -W / N + 48 \cdot M / (N \cdot BC) \\ &= -28,831.35 / 8 + 48 \cdot 140,660.2 / (8 \cdot 68.5) \\ &= 8,716.68 \text{ lb}_f \end{aligned}$$

$$\text{Required area per bolt} = P / S_b = \underline{0.4358} \text{ in}^2$$

The area provided (0.929 in<sup>2</sup>) by the specified anchor bolt is adequate.

#### Support calculations (Jawad & Farr chapter 12, empty, new + Seismic)

Base plate width, $t_c$ :	7.5	in
Average base plate diameter, $d$ :	65.5	in
Base plate elastic modulus, $E_s$ :	29.0E+06	psi
Base plate yield stress, $S_y$ :	36,000	psi

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

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

$$\begin{aligned} t_s &= (N \cdot A_b) / (\pi \cdot d) \\ &= (8 \cdot 0.929) / (\pi \cdot 65.5) \\ &= 0.0361 \text{ in} \end{aligned}$$

From table 12.4 for  $k = 0.259119$ :

$$K_1 = 2.5312, \quad K_2 = 1.3958$$

$$L_1 = 15.7817, \quad L_2 = 37.5733, \quad L_3 = 13.462$$

### Total tensile force on bolting

$$T = (12 * M - W * (L_1 + L_3)) / (L_2 + L_3)$$

$$= (12 * 140,660.2 - 28,831.35 * (15.7817 + 13.462)) / (37.5733 + 13.462)$$

$$= 16,552.95 \text{ lb}_f$$

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

$$f_s = T / (t_s * (d / 2) * K_1)$$

$$= 16,552.95 / (0.0361 * (65.5 / 2) * 2.5312)$$

$$= 5,529 \text{ psi}$$

### Total compressive load on foundation

$$C_c = T + (1 + V_{\text{Accel}}) * W + \text{Bolt Preload}$$

$$= 16,552.95 + (1 + 1) * 28,831.35 + 0$$

$$= 74,215.65 \text{ lb}_f$$

### Foundation bearing stress

$$f_c = C_c / (((t_c - t_s) + n * t_s) * (d / 2) * K_2)$$

$$= 74,215.65 / (((7.5 - 0.0361) + 9.2889 * 0.0361) * (65.5 / 2) * 1.3958)$$

$$= \underline{208} \text{ psi}$$

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

$$k = 1 / (1 + f_s / (n * f_c))$$

$$= 1 / (1 + 5,529 / (9.2889 * 208))$$

$$= 0.259119$$

### Base plate required thickness (empty, new + Seismic)

From Brownell & Young, Table 10.3.,  $l / b = 0.2201$

$$M_x = 0.0052 * 208 * 22.1499^2 = 526 \text{ lb}_f$$

$$M_y = -0.4525 * 208 * 4.875^2 = -2,238.4 \text{ lb}_f$$

$$t_r = (6 * M_{\text{max}} / S_p)^{0.5}$$

$$= (6 * 2,238.41 / 20,000)^{0.5}$$

$$= \underline{0.8195} \text{ in}$$

The base plate thickness is satisfactory.

### Base plate bolt load (Jawad & Farr eq. 12.13, empty, new + Seismic)

$$\text{Bolt load} = A_b * f_s = 0.929 * 5,529 = 5,136.17 \text{ lb}_f$$

$$t_r = (3.91 * F / (S_y * (2 * b / w + w / (2 * l) - d_b * (2 / w + 1 / (2 * l))))))^{0.5}$$

$$= (3.91 * 5,136.17 / (36,000 * (2 * 4.875 / 4 + 4 / (2 * 2.625) - 1.625 * (2 / 4 + 1 / (2 * 2.625))))))^{0.5}$$

$$= 0.5182 \text{ in}$$



The base plate thickness is satisfactory.

**Check skirt for gusset reaction (Jawad & Farr eq. 12.14)**

$$\begin{aligned} S_r &= 1.5 * F * b / (\text{gussets} * \pi * t_{sk}^2 * h) \\ &= 1.5 * 5,136.17 * 4.875 / (2 * \pi * 0.75^2 * 4.625) \\ &= 2,297.69 \text{ psi} \end{aligned}$$

As  $S_r \leq 30,000$  psi the skirt thickness is adequate to resist the gusset reaction.

**Anchor bolt load (vacuum, corroded + Seismic)**

$$\begin{aligned} P &= -W / N + 48 * M / (N * BC) \\ &= -40,890.52 / 8 + 48 * 187,179.7 / (8 * 68.5) \\ &= 11,283.99 \text{ lb}_f \end{aligned}$$

$$\text{Required area per bolt} = P / S_b = \underline{0.5642} \text{ in}^2$$

The area provided (0.929 in<sup>2</sup>) by the specified anchor bolt is adequate.

**Support calculations (Jawad & Farr chapter 12, vacuum, corroded + Seismic)**

Base plate width,  $t_c$ : 7.5 in  
Average base plate diameter,  $d$ : 65.5 in  
Base plate elastic modulus,  $E_s$ : 29.0E+06 psi  
Base plate yield stress,  $S_y$ : 36,000 psi

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

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

$$\begin{aligned} t_s &= (N * A_b) / (\pi * d) \\ &= (8 * 0.929) / (\pi * 65.5) \\ &= 0.0361 \text{ in} \end{aligned}$$

From table 12.4 for  $k = 0.271492$ :

$$\begin{aligned} K_1 &= 2.5042, \quad K_2 = 1.4308 \\ L_1 &= 14.9706, \quad L_2 = 36.9789, \quad L_3 = 14.0992 \end{aligned}$$

**Total tensile force on bolting**

$$\begin{aligned} T &= (12 * M - W * (L_1 + L_3)) / (L_2 + L_3) \\ &= (12 * 187,179.7 - 40,890.52 * (14.9706 + 14.0992)) / (36.9789 + 14.0992) \\ &= 20,703.19 \text{ lb}_f \end{aligned}$$

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

$$\begin{aligned} f_s &= T / (t_s * (d / 2) * K_1) \\ &= 20,703.19 / (0.0361 * (65.5 / 2) * 2.5042) \\ &= 6,989 \text{ psi} \end{aligned}$$

**Total compressive load on foundation**

$$\begin{aligned} C_c &= T + (1 + V\text{Accel}) * W + \text{Bolt Preload} \\ &= 20,703.19 + (1 + 1) * 40,890.52 + 0 \\ &= 102,484.22 \text{ lb}_f \end{aligned}$$

## Foundation bearing stress

$$\begin{aligned} f_c &= C_c / (((t_c - t_s) + n \cdot t_s) \cdot (d / 2) \cdot K_2) \\ &= 102,484.22 / (((7.5 - 0.0361) + 9.2889 \cdot 0.0361) \cdot (65.5 / 2) \cdot 1.4308) \\ &= \underline{280} \text{ psi} \end{aligned}$$

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

$$\begin{aligned} k &= 1 / (1 + f_s / (n \cdot f_c)) \\ &= 1 / (1 + 6,989 / (9.2889 \cdot 280)) \\ &= 0.271492 \end{aligned}$$

## Base plate required thickness (vacuum, corroded + Seismic)

From Brownell & Young, Table 10.3:,  $l / b = 0.2201$

$$M_x = 0.0052 \cdot 280 \cdot 22.1499^2 = 708.5 \text{ lb}_f$$

$$M_y = -0.4525 \cdot 280 \cdot 4.875^2 = -3,015.3 \text{ lb}_f$$

$$\begin{aligned} t_r &= (6 \cdot M_{\max} / S_p)^{0.5} \\ &= (6 \cdot 3,015.29 / 20,000)^{0.5} \\ &= \underline{0.9511} \text{ in} \end{aligned}$$

The base plate thickness is satisfactory.

## Base plate bolt load (Jawad & Farr eq. 12.13, vacuum, corroded + Seismic)

$$\text{Bolt load} = A_b \cdot f_s = 0.929 \cdot 6,989 = 6,493.17 \text{ lb}_f$$

$$\begin{aligned} t_r &= (3.91 \cdot F / (S_y \cdot (2 \cdot b / w + w / (2 \cdot l) - d_b \cdot (2 / w + 1 / (2 \cdot l))))))^{0.5} \\ &= (3.91 \cdot 6,493.17 / (36,000 \cdot (2 \cdot 4.875 / 4 + 4 / (2 \cdot 2.625) - 1.625 \cdot (2 / 4 + 1 / (2 \cdot 2.625))))))^{0.5} \\ &= 0.5827 \text{ in} \end{aligned}$$

The base plate thickness is satisfactory.

## Check skirt for gusset reaction (Jawad & Farr eq. 12.14)

$$\begin{aligned} S_r &= 1.5 \cdot F \cdot b / (\text{gussets} \cdot \pi \cdot t_{sk}^2 \cdot h) \\ &= 1.5 \cdot 6,493.17 \cdot 4.875 / (2 \cdot \pi \cdot 0.75^2 \cdot 4.625) \\ &= 2,904.75 \text{ psi} \end{aligned}$$

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 -6.5"

Operating Liquid Specific Gravity 1.1



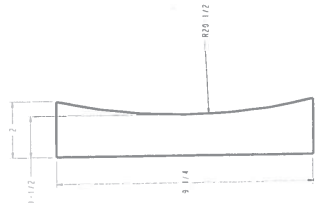
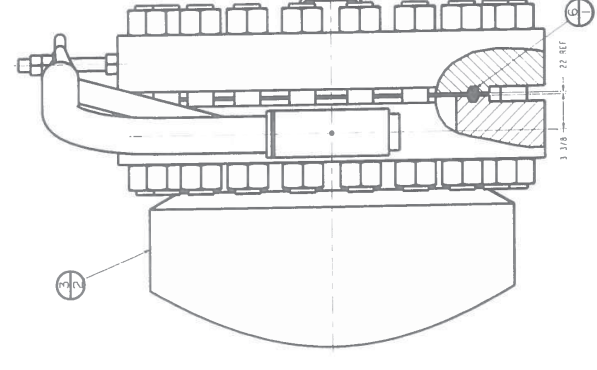
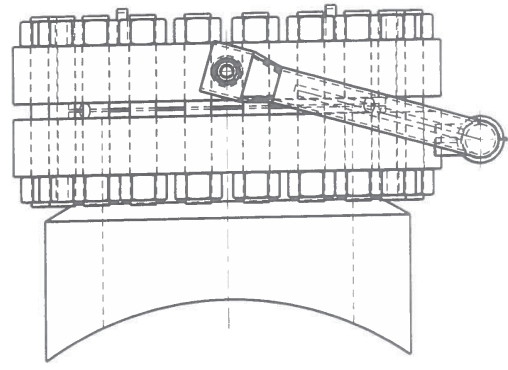
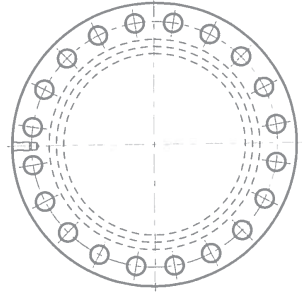
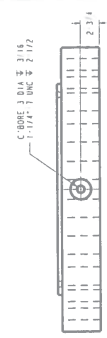




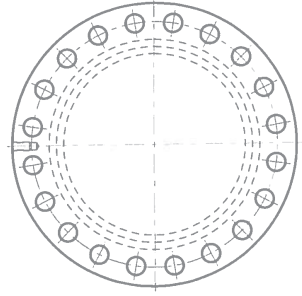




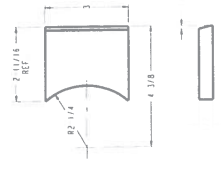
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23 17/4	2" PWR. SEC. 18" x 12" LONG	54 10E8
25 24 2/4	2" PWR. SEC. 18" x 12" LONG	54 10E8
23 3/4	2" PWR. SEC. 18" x 12" LONG	54 10E8
26 4/4	2" PWR. SEC. 18" x 12" LONG	54 514 10A
8 5/4	1" DIA. HPT. 18" x 12" LONG	54 514 10A
21 6/4	2" PWR. SEC. 18" x 12" LONG	54 514 10A
27 7/4	1" DIA. HPT. 18" x 12" LONG	54 514 10A
28 8/4	1" DIA. HPT. 18" x 12" LONG	54 514 10A
29 9/4	3" DIA. HPT. 18" x 12" LONG	54 514 10A
32 10/4	2" PWR. SEC. 18" x 12" LONG	54 514 10A
59 11/4	1" DIA. HPT. 18" x 12" LONG	54 514 10A
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71 13/4	1" DIA. HPT. 18" x 12" LONG	54 514 10A



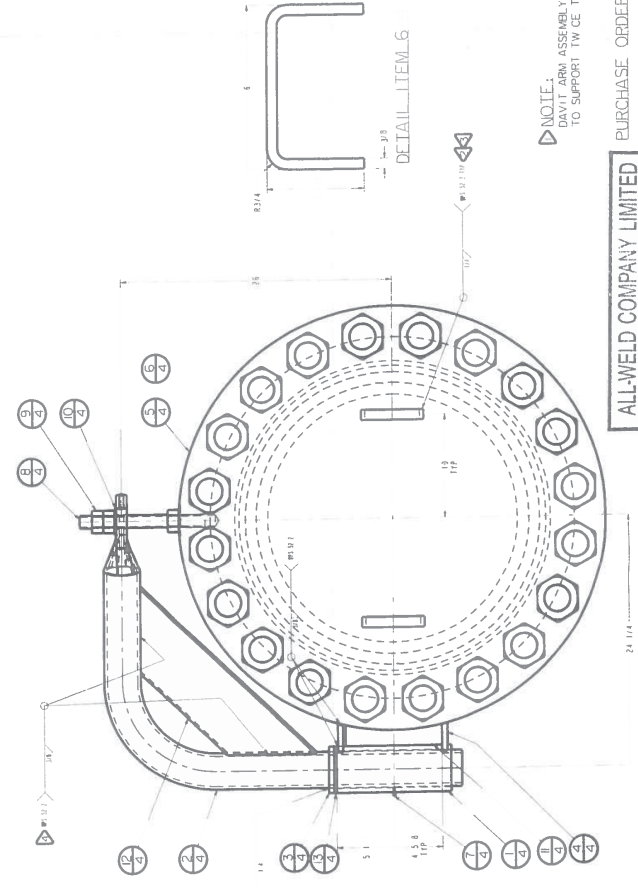
DETAIL ITEM 11/4



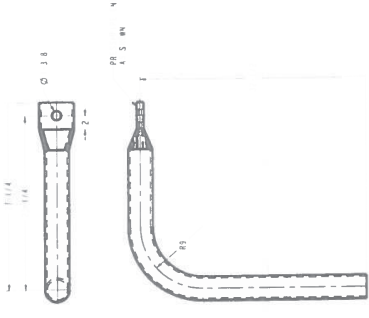
DETAIL ITEM 5/4



DETAIL ITEM 1/4



DETAIL ITEM 6



DETAIL

NOV 13 2013

(2) REQUIRED

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

ALL-WELD COMPANY LIMITED  
**CERTIFIED AS-BUILT**  
 BY GCM DATE NOV 21 2013

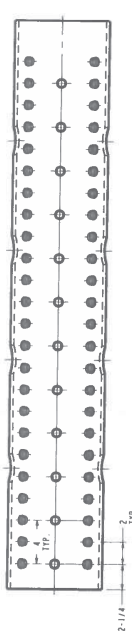
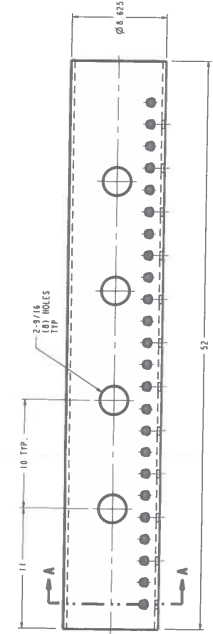
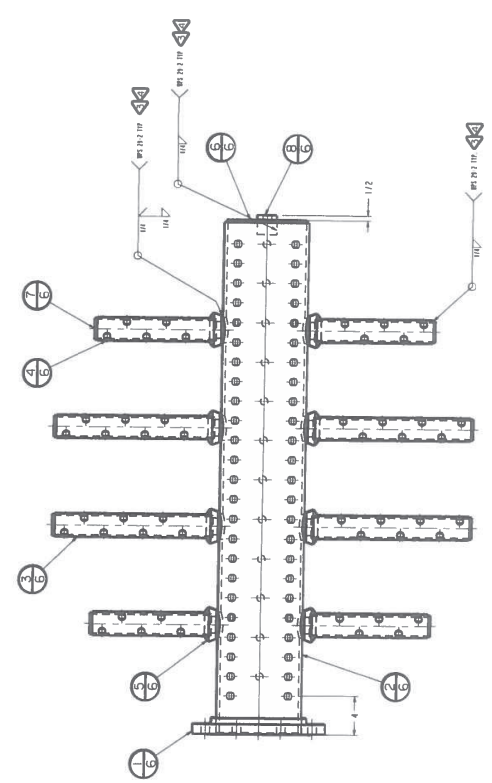
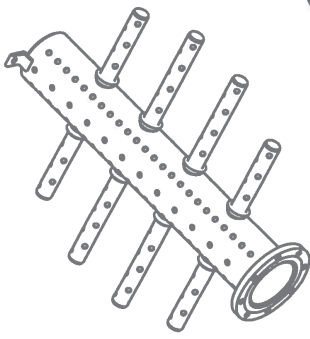
PURCHASE ORDER NUMBER: 1112

**ALL-WELD COMPANY LIMITED**  
 40 PLYMOUTH AVE. WILMINGTON, MAE 01890

REV.	DATE	DESCRIPTION
4	11/15/13	REVISED TO ADD 1/4" DIA. HPT. 18" x 12" LONG
3	11/15/13	REVISED TO ADD 1/4" DIA. HPT. 18" x 12" LONG
2	11/15/13	REVISED TO ADD 1/4" DIA. HPT. 18" x 12" LONG
1	11/15/13	REVISED TO ADD 1/4" DIA. HPT. 18" x 12" LONG

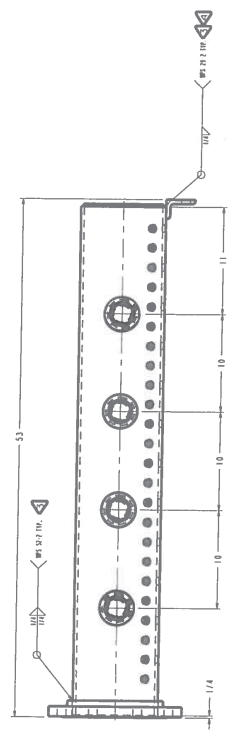
THIS DRAWING IS THE PROPERTY OF ALL-WELD COMPANY LTD. AND MAY BE REPRODUCED OR DISTRIBUTED IN WHATEVER MANNER WITHOUT PERMISSION IN WRITING.

ITEM	QTY	BILL OF MATERIAL DESCRIPTION	SPEC.
39	1/16	1" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7
40	2/16	2" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7
41	3/16	3" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7
42	4/16	4" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7
43	5/16	5" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7
44	6/16	6" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7
45	7/16	7" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7
46	8/16	8" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7
47	9/16	9" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7
48	10/16	10" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7
49	11/16	11" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7
50	12/16	12" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7
51	13/16	13" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7
52	14/16	14" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7
53	15/16	15" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7
54	16/16	16" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7
55	17/16	17" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7
56	18/16	18" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7
57	19/16	19" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7
58	20/16	20" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7
59	21/16	21" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7
60	22/16	22" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7
61	23/16	23" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7
62	24/16	24" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7
63	25/16	25" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7
64	26/16	26" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7
65	27/16	27" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7
66	28/16	28" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7
67	29/16	29" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7
68	30/16	30" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7
69	31/16	31" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7
70	32/16	32" DIA. WELD W/ 1/16" THICKNESS	SA-338 B7



DETAIL ITEM 2/6

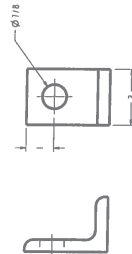
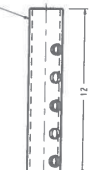
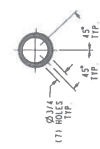
PLAN VIEW  
(TRUE ORIENTATION)



THREAD THIS END

THREAD THIS END

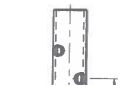
(2) REQUIRED



DETAIL ITEM 8/6



DETAIL ITEM 4/6



NO. PWHT REQUIRED  
PURCHASE ORDER NUMBER:  
1112

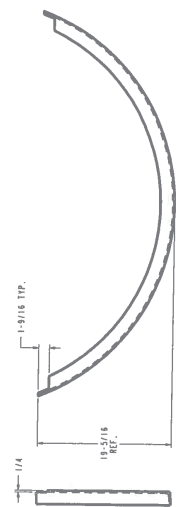
ALL-WELD COMPANY LIMITED  
CERTIFIED AS-BUILT  
BY DGM DATE OCT 07 2016

ALL-WELD COMPANY LIMITED  
ULTRAFAB INDUSTRIES LIMITED

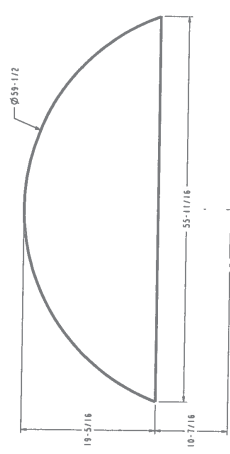
NO.	REVISION	DATE	BY	CHK'D	APP'D
1	ISSUE FOR FABRICATION				
2	ISSUE FOR ASSEMBLY				
3	ISSUE FOR WELDING				
4	ISSUE FOR FINISHING				

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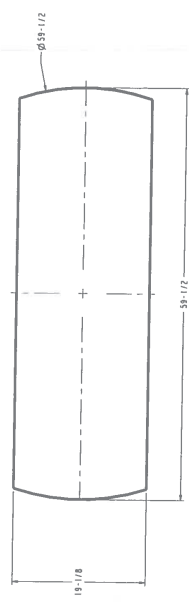
BILL OF MATERIAL		ITEM QTY.	DESCRIPTION	SPEC.
1/7	1	1/4" THK. 30" DIA. 15" X 15" TYP. FORMER W/ 2" X 1/8" R.	C.S.	
2/7	2	1/4" THK. 30" DIA. 15" X 15" TYP. FORMER W/ 2" X 1/8" R.	C.S.	
3/7	4	2" X 1/8" ANGLE X 35 LONG	30-38	
4/7	2	2" X 1/8" ANGLE X 35 LONG	30-38	
5/7	12	3/8" - 16 UNC. WEL. HEAD DIA. X 11 1/2" LONG	30-38	
6/7	6	3/8" - 16 UNC. WEL. HEAD DIA. X 11 1/2" LONG	30-38	
7/7	18	3/8" - 16 UNC. WEL. HEAD DIA. X 11 1/2" LONG	30-38	
8/7	36	3/8" - 16 UNC. WEL. HEAD DIA. X 11 1/2" LONG	30-38	
9/7	2	1/4" THK. 30" DIA. 15" X 15" TYP. FORMER W/ 2" X 1/8" R.	C.S.	
10/7	2	1/4" THK. 30" DIA. 15" X 15" TYP. FORMER W/ 2" X 1/8" R.	C.S.	



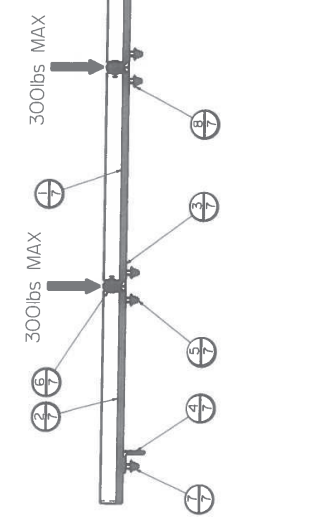
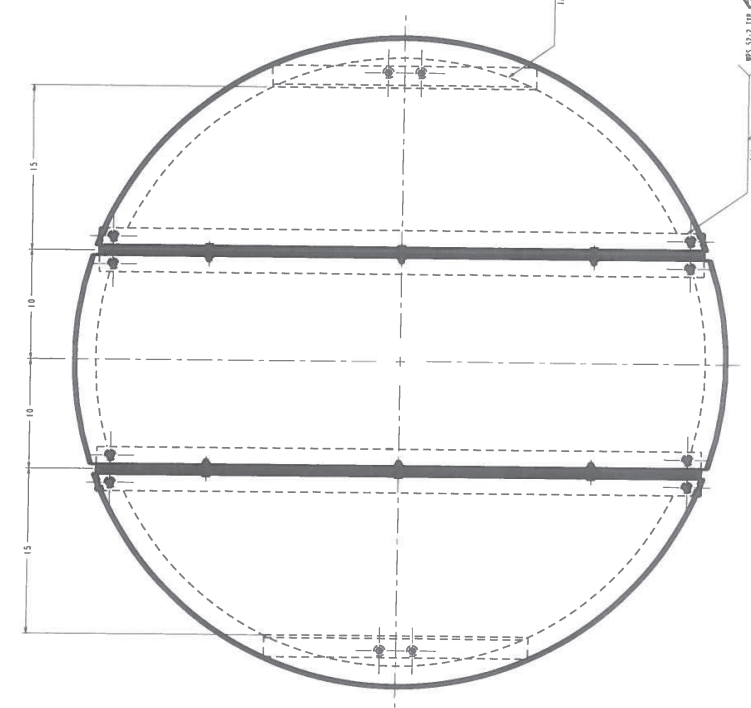
DETAIL ITEM 9/Z



DETAIL ITEM 2/Z



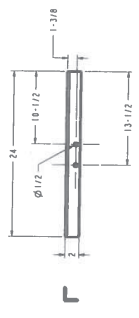
DETAIL ITEM 1/Z



BOLTING DETAIL



DETAIL ITEM 10/Z



DETAIL ITEM 4/Z

ALL-WELD COMPANY LIMITED  
 CERTIFIED AS-BUILT  
 BY QCM DATE OCT 07 2018

PURCHASE ORDER NUMBER: 11112

REQUIRED

PLOTTED:  
**ALL-WELD COMPANY LIMITED**  
 1000 W. 100th St., Suite 100  
 Chicago, IL 60658-1000  
 Phone: 773.437.1112  
 Fax: 773.437.1113

3	3000 U.S. STANDARD AND WEIGHT MEASUREMENTS	INCHES	DATE	3/19/13
2	3000 U.S. STANDARD AND WEIGHT MEASUREMENTS	INCHES	DATE	3/19/13
1	3000 U.S. STANDARD AND WEIGHT MEASUREMENTS	INCHES	DATE	3/19/13

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