

## Timothy Chung

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**From:** Timothy Chung  
**Sent:** Thursday, July 24, 2014 4:38 PM  
**To:** Dale Martin  
**Subject:** Knock Out Drum (Equipment # 66005116)  
**Attachments:** Sylvan Lake KO Drum.pdf

Hi Dale,

The structural integrity of the KO drum at Sylvan Lake gas plant has been evaluated at design conditions of 14.9 psig & 200 F.

The following vessel data are used for evaluation:

- 1) Vessel dimension: 7'-0" ID x 11'-0" long
- 2) Design pressure & temperature: 14.9 psig, 200 F
- 3) Allowable stresses for Head & Shell : SA283-C material in 1995 ASME code used
- 4) Corrosion allowance: 0
- 5) 20" nozzle material: SA106-B, Sch 40 Pipe assumed
- 6) 2" nozzle material: SA106-B, Sch 80 Pipe assumed
- 7) Flanged & dished head assumed

Below are the thickness comparison of each component of the vessel:

Components	Required minimum design thickness	Actual thickness (May 9, 2012)	Nominal thickness
Cylinder	0.3444"	0.748"	0.75
Head	0.2271"	0.64"	0.75
Straight Flange	0.3438"	0.64"	0.75
Nozzle #1 (20")	0.3281"	N/A	0.5198"
Nozzle #2 (2")	0.1348"	N/A	0.1908"
Nozzle #3 (2")	0.1348"	N/A	0.1908"

As you can see, all the components of the vessel (Actual & Nominal) have more thickness than required t-min. Therefore, the vessel is structurally safe to operate at these design conditions.

Attached is COMPRESS calculations for your reference.

Please note that the relocation height for the bottom hole nozzle will be determined by operations during the shutdown in Sept this year.

Thanks,

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M-3  
FLARE STACK  
SIZE: 305mm O.D. x 25908mm HIGH  
MFR: TORNADO TECHNOLOGIES INC  
IGNITOR TYPE: TPWR 120V NO. 6  
TIP LENGTH: 5 FT  
DWG: HUSK-002977a/b  
SERIAL NUMBER: 2977  
HUSKY NUMBER: 245132

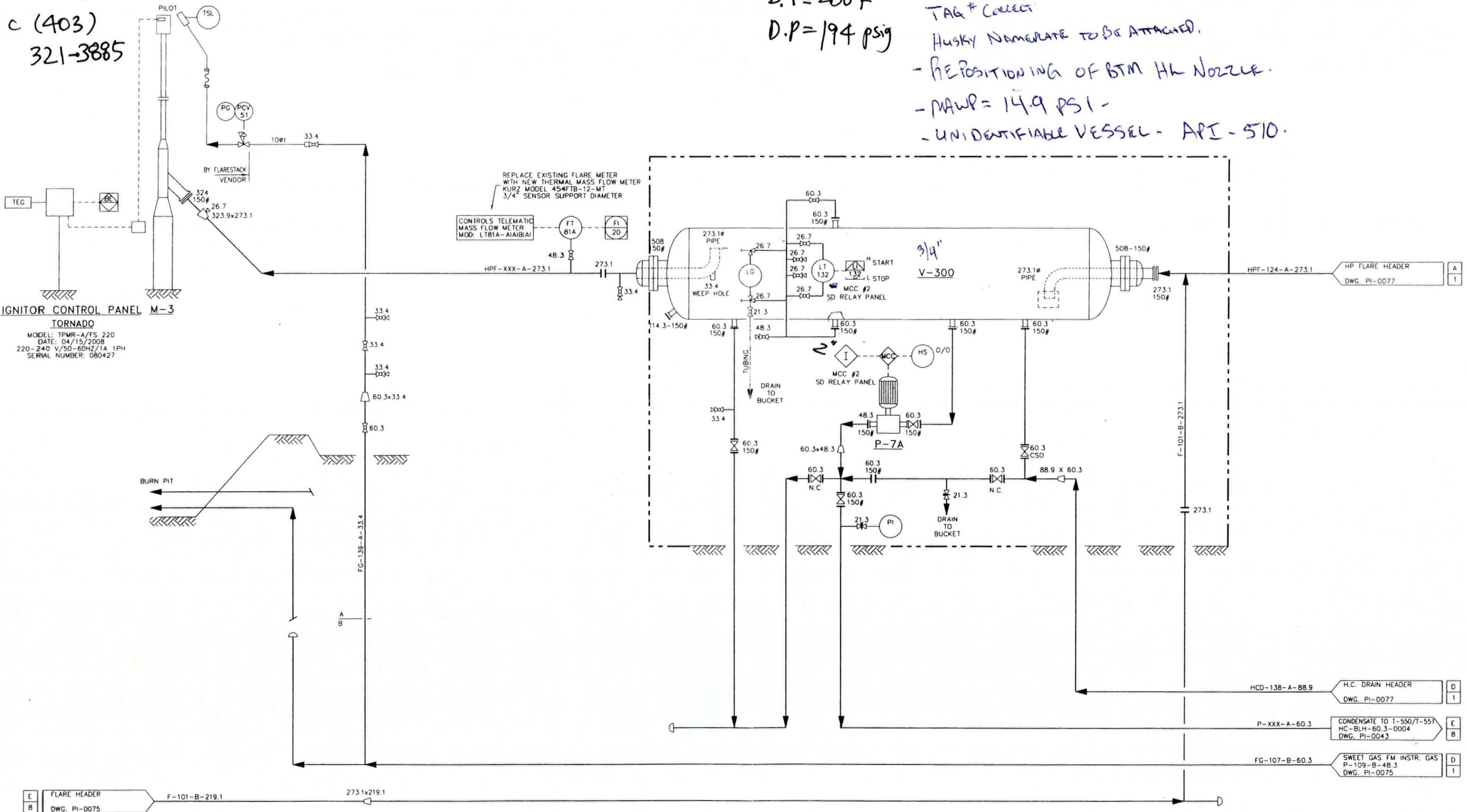
P-7A  
K.O. PUMP  
MAKE: UNION PUMPS  
CAPACITY: 6 1/2 GPM  
DRIVE: 7.5 HP @ 3500RPM  
SERIAL NUMBER: 753560-101  
HUSKY NUMBER: 043507

5'-3"φ x 10'-9"  
V-300  
FLARE K.O. DRUM  
SIZE: 1600 mm O.D. x 3277 mm S/S  
MAWP: 1338 kPa @ 93°C  
MFR: BARBER MACHINERY CO.  
SERIAL NUMBER: 1012-D-2  
CRN: 4317.2  
A' NUMBER: 17726  
HUSKY NUMBER: 43357

DESIGN TEMP 200°F

D.T = 200°F  
D.P = 194 psig

TAG # Collect  
Husky NAMEPLATE TO BE ATTACHED.  
- REPOSITIONING OF BTM HL NOZZLE.  
- MAWP = 14.9 PSI -  
- UNIDENTIFIABLE VESSEL - API - 510.



REF DWG NO	REFERENCE DRAWING DESCRIPTION	NO	REVISION HISTORY	REV AUTHOR	REV DATE	ISSUED FOR	NO	CURRENT REVISION	ISSUED FOR
		A	ISSUED FOR APPROVAL	EPC_MAJESTIC	2006/10/02	APPROVAL	6	AS BUILT FOR PO 8400774466 STANTEC 110616933.1100.2	DOC DATE 2014/05/19
		1	AS BUILT	EPC_CALTECH	2007/02/21	AS BUILT			DOC AUTHOR STANTEC
		2	AS BUILT, CALTECH CS11604	EPC_CALTECH	2007/09/14	AS BUILT			SCALE NTS
		3	ISSUED FOR CONSTRUCTION FOR EWR 11794-001	MILLED	2008/04/29	CONSTRUCTION			ALTERNATE IDENTIFIER D-7563-05
		4	INSTRUMENTATION AS BUILT, CALTECH CS11604	EPC_CALTECH	2008/06/24	AS BUILT			SURFACE LSP
		5	AS BUILT PER FIELD MARK-UPS FOR CC 77024 STANTEC 110616306	STANTEC	2013/02/19	AS BUILT			01-21-038-02W5
		6							DOCUMENT IDENTIFIER PI-0076-01

**Husky Energy**

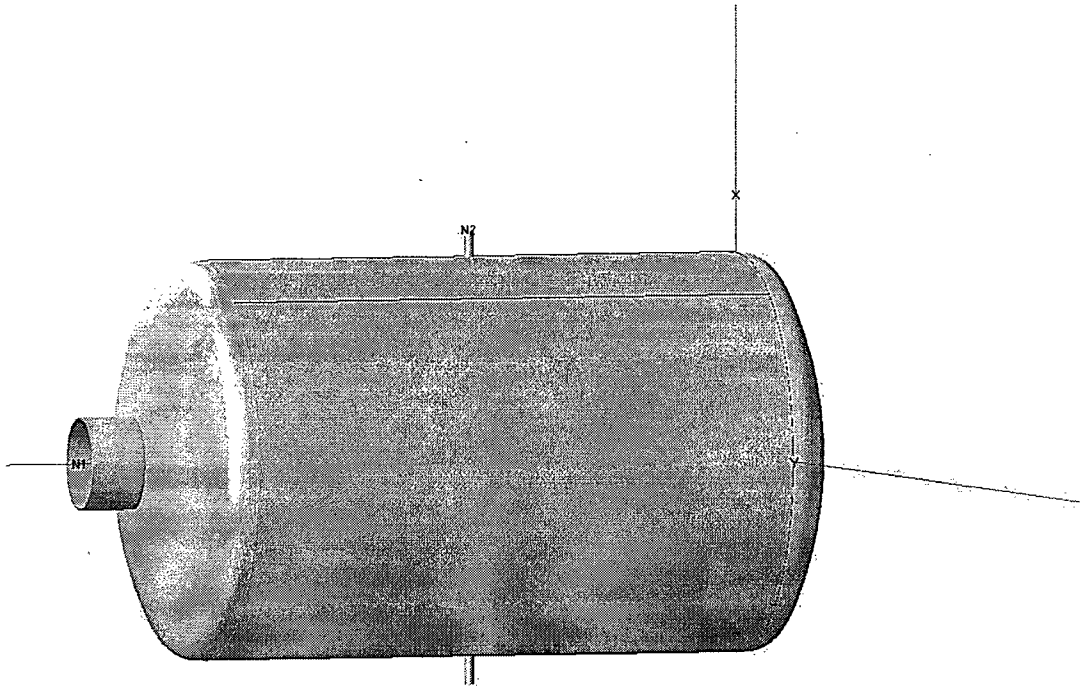
SYLVAN LAKE 01-21-038-02W5 GAS PLANT  
V-300 FLARE KNOCKOUT DRUM & M-3 FLARE STACK  
PIPING & INSTRUMENTATION DIAGRAM

DO NOT CHANGE MANUALLY

Codeware, Inc.

Sarasota, FL, USA

www.codeware.com



### COMPRESS Pressure Vessel Design Calculations

Item: Sylvan Lake Flare Knockout Drum  
Equipment No: 66005116  
Customer: Husky Energy  
Designer: Tim Chung  
Date: July 24, 2014

Design Pressure: 14.9 psig  
Design Temperature: 200 F  
Corrosion Allowance: 0  
1995 Allowable Stress Values of SA-283- C are used for Shell & Head Materials  
For 2" Nozzles, SA-106-B Sch 80 Pipe is assumed  
For 20" Nozzle, SA-106-B Sch 40 Pipe is assumed  
Flanged & Dished Head is assumed

## Cylinder #1

ASME Section VIII Division 1, 1995 Edition

Component: Cylinder  
 Material specification: SA-283 C (II-D p. 6, ln. 10)  
 Material is impact tested per UG-84 to -50 °F  
 UCS-66(i) reduction of 78.2 °F applied (ratio = 0.4488).

Internal design pressure:  $P = 14.9$  psi @ 200 °F  
 External design pressure:  $P_e = 15$  psi @ 200 °F

Static liquid head:

$$P_{th} = 3.28 \text{ psi (SG = 1, } H_s = 90.748", \text{ Horizontal test head)}$$

Corrosion allowance      Inner C = 0"      Outer C = 0"

Design MDMT = -20 °F      Impact test performed  
 Rated MDMT = -128.2 °F      Material is not normalized  
    Material is not produced to Fine Grain Practice  
    PWHT is performed

Radiography:      Longitudinal joint -      Full UW-11(a) Type I  
                          Left circumferential joint -      Full UW-11(a) Type I  
                          Right circumferential joint -      Full UW-11(a) Type I

Estimated weight New = 7,437.6 lb      corr = 7,437.6 lb  
 Capacity      New = 3,166.73 US gal      corr = 3,166.73 US gal

ID = 84"  
 Length  $L_c = 132"$   
 t = 0.748"

Design thickness, (at 200 °F) UG-27(c)(1)

$$\begin{aligned} t &= P \cdot R / (S \cdot E - 0.60 \cdot P) + \text{Corrosion} \\ &= 14.9 \cdot 42 / (12,696 \cdot 1.00 - 0.60 \cdot 14.9) + 0 \\ &= 0.0494" \end{aligned}$$

Maximum allowable working pressure, (at 200 °F) UG-27(c)(1)

$$\begin{aligned} P &= S \cdot E \cdot t / (R + 0.60 \cdot t) - P_s \\ &= 12,696 \cdot 1.00 \cdot 0.748 / (42 + 0.60 \cdot 0.748) - 0 \\ &= 223.72 \text{ psi} \end{aligned}$$

Maximum allowable pressure, (at 70 °F) UG-27(c)(1)

$$\begin{aligned} P &= S \cdot E \cdot t / (R + 0.60 \cdot t) \\ &= 12,696 \cdot 1.00 \cdot 0.748 / (42 + 0.60 \cdot 0.748) \\ &= 223.72 \text{ psi} \end{aligned}$$

External Pressure, (Corroded &amp; at 200 °F) UG-28(c)

$$\begin{aligned} L / D_0 &= 146.0629 / 85.496 = 1.7084 \\ D_0 / t &= 85.496 / 0.3444 = 248.2528 \\ \text{From table G: } A &= 0.000195 \\ \text{From table CS-2: } B &= 2,792.8348 \text{ psi} \end{aligned}$$

$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_0 / t)) \\ &= 4 \cdot 2,792.83 / (3 \cdot (85.496 / 0.3444)) \\ &= 15 \text{ psi} \end{aligned}$$

Design thickness for external pressure  $P_a = 15$  psi

$$t_a = t + \text{Corrosion} = 0.3444 + 0 = 0.3444"$$

Maximum Allowable External Pressure, (Corroded &amp; at 200 °F) UG-28(c)

$$\begin{aligned} L / D_0 &= 146.0629 / 85.496 = 1.7084 \\ D_0 / t &= 85.496 / 0.748 = 114.2995 \\ \text{From table G: } A &= 0.000635 \\ \text{From table CS-2: } B &= 9,149.6499 \text{ psi} \end{aligned}$$

$$\begin{aligned} P_a &= 4 \cdot B / (3 \cdot (D_0 / t)) \\ &= 4 \cdot 9,149.65 / (3 \cdot (85.496 / 0.748)) \\ &= 106.73 \text{ psi} \end{aligned}$$

% Extreme fiber elongation - UCS-79(d)

$$\begin{aligned} EFE &= (50 \cdot t / R_f) \cdot (1 - R_f / R_0) \\ &= (50 \cdot 0.748 / 42.374) \cdot (1 - 42.374 / \infty) \\ &= 0.8826\% \end{aligned}$$

The extreme fiber elongation does not exceed 5%.



## F&amp;D Head #1

ASME Section VIII Division 1, 1995 Edition

Component: F&D Head  
 Material Specification: SA-283 C (II-D p.6, ln. 10)  
Straight Flange governs MDMT

Internal design pressure:  $P = 14.9$  psi @ 200 °F  
 External design pressure:  $P_e = 15$  psi @ 200 °F

Static liquid head:

$P_s = 0$  psi (SG=1,  $H_s=0$ " Operating head)  
 $P_{th} = 3.28$  psi (SG=1,  $H_s=90.748$ " Horizontal test head)

Corrosion allowance:	Inner C = 0"	Outer C = 0"
Design MDMT = -20°F	No impact test performed	
Rated MDMT = -9.9°F	Material is not normalized	
	Material is not produced to fine grain practice	
	PWHT is not performed	
	Do not Optimize MDMT / Find MAWP	
Radiography:	Category A joints - Head to shell seam -	Seamless No RT Full UW-11(a) Type 1
Estimated weight*:	new = 1,320.9 lb	corr = 1,320.9 lb
Capacity*:	new = 265.6 US gal	corr = 265.6 US gal
* includes straight flange		
Inner diameter	= 84"	
Crown radius L	= 78"	
Knuckle radius r	= 5.04"	
Minimum head thickness	= 0.64"	
Straight flange length $L_{sf}$	= 2"	
Nominal straight flange thickness $t_{sf}$	= 0.64"	

## Results Summary

The governing condition is external pressure.  
 Minimum thickness per UG-16 =  $0.0625" + 0" = 0.0625"$   
 Design thickness due to internal pressure ( $t_i$ ) =  $0.0794"$   
 Design thickness due to external pressure ( $t_e$ ) =  $0.2272"$   
 Maximum allowable working pressure (MAWP) =  $120.07$  psi  
 Maximum allowable pressure (MAP) =  $120.07$  psi  
 Maximum allowable external pressure (MAEP) =  $71.9$  psi

## M (Corroded)

$$M = \frac{1}{4} [3 + (L/r)^{1/2}]$$

$$= \frac{1}{4} [3 + (78/5.04)^{1/2}]$$

$$= 1.733495$$

## M (New)

$$M = \frac{1}{4} [3 + (L/r)^{1/2}]$$

$$= \frac{1}{4} [3 + (78/5.04)^{1/2}]$$

$$= 1.733495$$

## Design thickness for internal pressure, (Corroded at 200 °F) Appendix 1-4(d)

$$t = \frac{P \cdot L \cdot M}{2 \cdot S \cdot E - 0.2 \cdot P} + \text{Corrosion}$$

$$= \frac{14.9 \cdot 78 \cdot 1.7335}{2 \cdot 12,696 \cdot 1 - 0.2 \cdot 14.9} + 0$$

$$= 0.0794"$$

The head internal pressure design thickness is 0.0794".

## Maximum allowable working pressure, (Corroded at 200 °F) Appendix 1-4(d)

$$P = \frac{2 \cdot S \cdot E \cdot t}{(L \cdot M + 0.2 \cdot t)} - P_s$$

$$= \frac{2 \cdot 12,696 \cdot 1 \cdot 0.64}{(78 \cdot 1.7335 + 0.2 \cdot 0.64)} - 0$$

$$= 120.07 \text{ psi}$$

The maximum allowable working pressure (MAWP) is 120.07 psi.

## Maximum allowable pressure, (New at 70 °F) Appendix 1-4(d)

$$P = \frac{2 \cdot S \cdot E \cdot t}{(L \cdot M + 0.2 \cdot t)} - P_s$$

$$= \frac{2 \cdot 12,696 \cdot 1 \cdot 0.64}{(78 \cdot 1.7335 + 0.2 \cdot 0.64)} - 0$$

$$= 120.07 \text{ psi}$$

The maximum allowable pressure (MAP) is 120.07 psi.

## Design thickness for external pressure, (Corroded at 200 °F) UG-33(e)

Equivalent outside spherical radius ( $R_0$ )

$$= \text{Outside crown radius}$$

$$= 78.64 \text{ in}$$

$$A = 0.125 / (R_0 / t)$$

$$= 0.125 / (78.64 / 0.227132)$$

$$= 0.000361$$

From Table CS-2:B = 5,193.454 psi

$$P_a = B / (R_0 / t)$$

$$= 5,193.454 / (78.64 / 0.2271)$$

$$= 15 \text{ psi}$$

$$t = 0.2271'' + \text{Corrosion} = 0.2271'' + 0'' = 0.2271''$$

Check the external pressure per UG-33(a)(1) Appendix 1-4(d)

$$t = 1.67 \cdot P_c \cdot L \cdot M / (2 \cdot S \cdot E - 0.2 \cdot 1.67 \cdot P_c) + \text{Corrosion}$$

$$= 1.67 \cdot 15 \cdot 78 \cdot 1.7335 / (2 \cdot 12,696 \cdot 1 - 0.2 \cdot 1.67 \cdot 15) + 0$$

$$= 0.1334''$$

The head external pressure design thickness ( $t_c$ ) is 0.2271''.

Maximum Allowable External Pressure, (Corroded at 200 °F) UG-33(e)

Equivalent outside spherical radius ( $R_0$ )

$$= \text{Outside crown radius}$$

$$= 78.64 \text{ in}$$

$$A = 0.125 / (R_0 / t)$$

$$= 0.125 / (78.64 / 0.64)$$

$$= 0.001017$$

From Table CS-2:B = 12,360.53 psi

$$P_a = B / (R_0 / t)$$

$$= 12,360.53 / (78.64 / 0.64)$$

$$= 100.5943 \text{ psi}$$

Check the Maximum External Pressure, UG-33(a)(1) Appendix 1-4(d)

$$P = 2 \cdot S \cdot E \cdot t / ((L \cdot M + 0.2 \cdot t) \cdot 1.67) - P_{s2}$$

$$= 2 \cdot 12,696 \cdot 1 \cdot 0.64 / ((78 \cdot 1.7335 + 0.2 \cdot 0.64) \cdot 1.67) - 0$$

$$= 71.9 \text{ psi}$$

The maximum allowable external pressure (MAEP) is 71.9 psi.

% Extreme fiber elongation - UCS-79(d)

$$\text{EFE} = (75 \cdot t / R_f) \cdot (1 - R_f / R_0)$$

$$= (75 \cdot 0.64 / 5.36) \cdot (1 - 5.36 / \infty)$$

$$= 8.9552\%$$

The extreme fiber elongation exceeds 5 percent and the thickness exceeds 5/8 inch.; Heat treatment per UCS-56 is required if fabricated by cold forming.

## Straight Flange on F&amp;D Head #1

ASME Section VIII Division 1, 1995 Edition

Component: Straight Flange  
 Material specification: SA-283 C (II-D p. 6, ln. 10)  
 Material impact test exemption temperature from Fig UCS-66 Curve A = 44.2 °F  
 Fig UCS-66.1 MDMT reduction = 54.1 °F, (coincident ratio = 0.5245)  
 UCS-66 governing thickness = 0.64 in

Internal design pressure:  $P = 14.9$  psi @ 200 °FExternal design pressure:  $P_c = 15$  psi @ 200 °F

Static liquid head:

 $P_{th} = 3.28$  psi (SG = 1,  $H_s = 90.748$ ", Horizontal test head)

Corrosion allowance      Inner C = 0"      Outer C = 0"

Design MDMT = -20 °F      No impact test performed  
 Rated MDMT = -9.9 °F      Material is not normalized  
    Material is not produced to Fine Grain Practice  
    PWHT is not performed

Radiography:      Longitudinal joint -      Seamless No RT  
                                  Circumferential joint -      Full UW-11(a) Type I

Estimated weight New = 96.3 lb      corr = 96.3 lb  
 Capacity      New = 47.98 US gal corr = 47.98 US gal

ID = 84"  
 Length  $L_c = 2$ "  
 t = 0.64"

Design thickness, (at 200 °F) UG-27(c)(1)

$$t = \frac{P \cdot R}{S \cdot E - 0.60 \cdot P} + \text{Corrosion}$$

$$= \frac{14.9 \cdot 42}{12,696 \cdot 1.00 - 0.60 \cdot 14.9} + 0$$

$$= 0.0494"$$

Maximum allowable working pressure, (at 200 °F) UG-27(c)(1)

$$P = \frac{S \cdot E \cdot t}{R + 0.60 \cdot t} - P_s$$

$$= \frac{12,696 \cdot 1.00 \cdot 0.64}{42 + 0.60 \cdot 0.64} - 0$$

$$= 191.71 \text{ psi}$$

Maximum allowable pressure, (at 70 °F) UG-27(c)(1)

$$P = \frac{S \cdot E \cdot t}{R + 0.60 \cdot t}$$

$$= \frac{12,696 \cdot 1.00 \cdot 0.64}{42 + 0.60 \cdot 0.64}$$

$$= 191.71 \text{ psi}$$

External Pressure, (Corroded &amp; at 200 °F) UG-28(c)

$$L / D_0 = 146.0629 / 85.28 = 1.7127$$

$$D_0 / t = 85.28 / 0.3438 = 248.0292$$

From table G: A = 0.000194

From table CS-2: B = 2,790.3345 psi

$$P_a = \frac{4 \cdot B}{3 \cdot (D_0 / t)}$$

$$= \frac{4 \cdot 2,790.33}{3 \cdot (85.28 / 0.3438)}$$

$$= 15 \text{ psi}$$

Design thickness for external pressure  $P_a = 15$  psi

$$t_a = t + \text{Corrosion} = 0.3438 + 0 = 0.3438"$$

Maximum Allowable External Pressure, (Corroded &amp; at 200 °F) UG-28(c)

$$L / D_0 = 146.0629 / 85.28 = 1.7127$$

$$D_0 / t = 85.28 / 0.64 = 133.2500$$

From table G: A = 0.000498

From table CS-2: B = 7,172.9603 psi

$$P_a = \frac{4 \cdot B}{3 \cdot (D_0 / t)}$$

$$= \frac{4 \cdot 7,172.96}{3 \cdot (85.28 / 0.64)}$$

$$= 71.77 \text{ psi}$$

% Extreme fiber elongation - UCS-79(d)

$$EFE = (50 \cdot t / R_f) \cdot (1 - R_f / R_0)$$

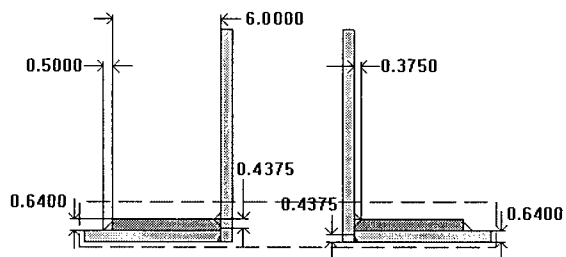
$$= (50 \cdot 0.64 / 42.32) \cdot (1 - 42.32 / \infty)$$

$$= 0.7561\%$$

The extreme fiber elongation does not exceed 5%.

## Nozzle #1 (N1)

ASME Section VIII Division 1, 1995 Edition



$$t_{w(lower)} = 0.4375 \text{ in}$$

$$Leg_{41} = 0.375 \text{ in}$$

$$t_{w(upper)} = 0.4375 \text{ in}$$

$$Leg_{42} = 0.5 \text{ in}$$

$$D_p = 32 \text{ in}$$

$$t_c = 0.64 \text{ in}$$

Note: round inside edges per UG-76(c)

## Location and Orientation

Located on: F&D Head #2  
 Orientation: 0°  
 End of nozzle to datum line: 162 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-106 B Smls pipe (II-D p. 10, ln. 31)  
 Description: NPS 20 Sch 40  
 Inside diameter, new: 18.812 in  
 Nominal wall thickness: 0.594 in  
 Corrosion allowance: 0 in  
 Projection available outside vessel, L<sub>pr</sub>: 12.904 in  
 Local vessel minimum thickness: 0.64 in  
 Liquid static head included: 0 psi  
 Longitudinal joint efficiency: 1

## Reinforcing Pad

Material specification: SA-283 C (II-D p. 6, ln. 10)  
 Diameter: 32 in  
 Is split: No



## Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in <sup>2</sup> ) For P = 14.9 psi @ 200 °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>
0.8612	21.1201	11.1785	1.871	—	7.68	0.3906	0.0794	0.5198

UG-41 Weld Failure Path Analysis Summary (lb <sub>f</sub> ) All failure paths are stronger than the applicable weld loads						
Weld load W	Weld load W <sub>1-1</sub>	Path 1-1 strength	Weld load W <sub>2-2</sub>	Path 2-2 strength	Weld load W <sub>3-3</sub>	Path 3-3 strength
-122,025.32	126,218.55	346,473.47	35,192.3	331,549.55	135,871.58	285,481.61

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg <sub>41</sub> )	0.25	0.2625	weld size is adequate
Pad to shell fillet (Leg <sub>42</sub> )	0.32	0.35	weld size is adequate
Nozzle to pad groove (Upper)	0.4158	0.4375	weld size is adequate
Nozzle to shell groove (Lower)	0.4158	0.4375	weld size is adequate

Calculations for internal pressure 14.9 psi @ 200 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(18.812, 9.406 + (0.594 - 0) + (0.64 - 0)) \\
 &= 18.812 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(0.64 - 0), 2.5*(0.594 - 0) + 0.64) \\
 &= 1.6 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_{rn} &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 14.9 \cdot 9.406 / (15,000 \cdot 1 - 0.6 \cdot 14.9) \\
 &= 0.0093 \text{ in}
 \end{aligned}$$

Required thickness  $t_r$  from UG-37(a)(1)

$$\begin{aligned}
 t_r &= P \cdot L \cdot M / (2 \cdot S \cdot E - 0.2 \cdot P) \\
 &= 14.9 \cdot 78 \cdot 1 / (2 \cdot 12,696 \cdot 1 - 0.2 \cdot 14.9) \\
 &= 0.0458 \text{ in}
 \end{aligned}$$

Required thickness  $t_r$  per Interpretation VIII-1-07-50

$$\begin{aligned}
 t_r &= P \cdot L \cdot M / (2 \cdot S \cdot E - 0.2 \cdot P) \\
 &= 14.9 \cdot 78 \cdot 1.7335 / (2 \cdot 12,696 \cdot 1 - 0.2 \cdot 14.9) \\
 &= 0.0794 \text{ in}
 \end{aligned}$$

Area required per UG-37(c)

Allowable stresses:  $S_n = 15,000$ ,  $S_v = 12,696$ ,  $S_p = 12,696$  psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r3} = \text{lesser of } f_{r2} \text{ or } S_p / S_v = 1$$

$$f_{r4} = \text{lesser of } 1 \text{ or } S_p / S_v = 1$$

$$\begin{aligned}
 A &= d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1}) \\
 &= 18.812 \cdot 0.0458 \cdot 1 + 2 \cdot 0.594 \cdot 0.0458 \cdot 1 \cdot (1 - 1) \\
 &= 0.8612 \text{ in}^2
 \end{aligned}$$

Area available from FIG. UG-37.1

 $A_1 = \text{larger of the following} = 11.1785 \text{ in}^2$ 

$$\begin{aligned}
 &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\
 &= 18.812 \cdot (1 \cdot 0.64 - 1 \cdot 0.0458) - 2 \cdot 0.594 \cdot (1 \cdot 0.64 - 1 \cdot 0.0458) \cdot (1 - 1) \\
 &= 11.1785 \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 &= 2*(t + t_n)*(E_1*t - F*t_r) - 2*t_n*(E_1*t - F*t_r)*(1 - f_{r1}) \\
 &= 2*(0.64 + 0.594)*(1*0.64 - 1*0.0458) - 2*0.594*(1*0.64 - 1*0.0458)*(1 - 1) \\
 &= 1.4665 \text{ in}^2
 \end{aligned}$$

$A_2$  = smaller of the following = 1.871 in<sup>2</sup>

$$\begin{aligned}
 &= 5*(t_n - t_{rn})*f_{r2}*t \\
 &= 5*(0.594 - 0.0093)*1*0.64 \\
 &= 1.871 \text{ in}^2 \\
 &= 2*(t_n - t_{rn})*(2.5*t_n + t_c)*f_{r2} \\
 &= 2*(0.594 - 0.0093)*(2.5*0.594 + 0.64)*1 \\
 &= 2.485 \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 A_{41} &= Leg^2*f_{r3} \\
 &= 0.375^2*1 \\
 &= \underline{0.1406} \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 A_{42} &= Leg^2*f_{r4} \\
 &= 0.5^2*1 \\
 &= \underline{0.25} \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 A_5 &= (D_p - d - 2*t_n)*t_c*f_{r4} \\
 &= (32 - 18.812 - 2*0.594)*0.64*1 \\
 &= \underline{7.68} \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 \text{Area} &= A_1 + A_2 + A_{41} + A_{42} + A_5 \\
 &= 11.1785 + 1.871 + 0.1406 + 0.25 + 7.68 \\
 &= \underline{21.1201} \text{ in}^2
 \end{aligned}$$

As Area >= A the reinforcement is adequate.

#### UW-16(d) Weld Check

$$\begin{aligned}
 \text{Inner fillet: } t_{\min} &= \text{lesser of } 0.75 \text{ or } t_n \text{ or } t_c = 0.594 \text{ in} \\
 t_{c(\min)} &= \text{lesser of } 0.25 \text{ or } 0.7*t_{\min} = \underline{0.25} \text{ in} \\
 t_{c(\text{actual})} &= 0.7*Leg = 0.7*0.375 = 0.2625 \text{ in}
 \end{aligned}$$

$$\begin{aligned}
 \text{Outer fillet: } t_{\min} &= \text{lesser of } 0.75 \text{ or } t_c \text{ or } t = 0.64 \text{ in} \\
 t_{w(\min)} &= 0.5*t_{\min} = \underline{0.32} \text{ in} \\
 t_{w(\text{actual})} &= 0.7*Leg = 0.7*0.5 = 0.35 \text{ in}
 \end{aligned}$$

$$\begin{aligned}
 \text{Upper groove: } t_{\min} &= \text{lesser of } 0.75 \text{ or } t_n \text{ or } t_c = 0.594 \text{ in} \\
 t_{w(\min)} &= 0.7*t_{\min} = \underline{0.4158} \text{ in} \\
 t_{w(\text{actual})} &= 0.4375 \text{ in}
 \end{aligned}$$

$$\begin{aligned}
 \text{Lower groove: } t_{\min} &= \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.594 \text{ in} \\
 t_{w(\min)} &= 0.7*t_{\min} = \underline{0.4158} \text{ in} \\
 t_{w(\text{actual})} &= 0.4375 \text{ in}
 \end{aligned}$$

#### UG-45 Nozzle Neck Thickness Check

Interpretation VIII-1-83-66 has been applied.

$$\text{Wall thickness per UG-45(a): } t_{r1} = 0.0093 \text{ in (E=1)}$$

$$\text{Wall thickness per UG-45(b)(1): } t_{r2} = 0.0794 \text{ in}$$

$$\text{Wall thickness per UG-16(b): } t_{r3} = 0.0625 \text{ in}$$

$$\text{Standard wall pipe per UG-45(b)(4): } t_{r4} = 0.3281 \text{ in}$$

$$\text{The greater of } t_{r2} \text{ or } t_{r3}: t_{r5} = 0.0794 \text{ in}$$

$$\text{The lesser of } t_{r4} \text{ or } t_{r5}: t_{r6} = 0.0794 \text{ in}$$

Required per UG-45 is the larger of  $t_{r1}$  or  $t_{r6} = 0.0794$  in

$$\text{Available nozzle wall thickness new, } t_n = 0.875*0.594 = 0.5198 \text{ in}$$

The nozzle neck thickness is adequate.

#### Allowable stresses in joints UG-45(c) and UW-15(c)

$$\text{Groove weld in tension: } 0.74*12,696 = 9,395 \text{ psi}$$

$$\text{Nozzle wall in shear: } 0.7*15,000 = 10,500 \text{ psi}$$

$$\text{Inner fillet weld in shear: } 0.49*12,696 = 6,221 \text{ psi}$$

$$\text{Outer fillet weld in shear: } 0.49*12,696 = 6,221 \text{ psi}$$

$$\text{Upper groove weld in tension: } 0.74*12,696 = 9,395 \text{ psi}$$

Strength of welded joints:

(1) Inner fillet weld in shear

$$(\pi / 2) * \text{Nozzle OD} * \text{Leg} * S_i = (\pi / 2) * 20 * 0.375 * 6,221 = 73,289.9 \text{ lbf}$$

(2) Outer fillet weld in shear

$$(\pi / 2) * \text{Pad OD} * \text{Leg} * S_o = (\pi / 2) * 32 * 0.5 * 6,221 = 156,351.79 \text{ lbf}$$

(3) Nozzle wall in shear

$$(\pi / 2) * \text{Mean nozzle dia} * t_n * S_n = (\pi / 2) * 19.406 * 0.594 * 10,500 = 190,121.68 \text{ lbf}$$

(4) Groove weld in tension

$$(\pi / 2) * \text{Nozzle OD} * t_w * S_u = (\pi / 2) * 20 * 0.4375 * 9,395 = 129,129.82 \text{ lbf}$$

(6) Upper groove weld in tension

$$(\pi / 2) * \text{Nozzle OD} * t_w * S_u = (\pi / 2) * 20 * 0.4375 * 9,395 = 129,129.82 \text{ lbf}$$

Loading on welds per UG-41(b)(1)

$$\begin{aligned} W &= (A - (d - 2 * t_n) * (E_1 * t - F * t_r)) * S_v \\ &= (0.8612 - (18.812 - 2 * 0.594) * (1 * 0.64 - 1 * 0.0458)) * 12,696 \\ &= -122,025.32 \text{ lbf} \end{aligned}$$

$$\begin{aligned} W_{1-1} &= (A_2 + A_5 + A_{41} + A_{42}) * S_v \\ &= (1.871 + 7.68 + 0.1406 + 0.25) * 12,696 \\ &= 126,218.55 \text{ lbf} \end{aligned}$$

$$\begin{aligned} W_{2-2} &= (A_2 + A_3 + A_{41} + A_{43} + 2 * t_n * t * f_{r1}) * S_v \\ &= (1.871 + 0 + 0.1406 + 0 + 2 * 0.594 * 0.64 * 1) * 12,696 \\ &= 35,192.3 \text{ lbf} \end{aligned}$$

$$\begin{aligned} W_{3-3} &= (A_2 + A_3 + A_5 + A_{41} + A_{42} + A_{43} + 2 * t_n * t * f_{r1}) * S_v \\ &= (1.871 + 0 + 7.68 + 0.1406 + 0.25 + 0 + 2 * 0.594 * 0.64 * 1) * 12,696 \\ &= 135,871.58 \text{ lbf} \end{aligned}$$

Load for path 1-1 lesser of W or  $W_{1-1} = -122,025.32 \text{ lbf}$

Path 1-1 through (2) & (3) =  $156,351.79 + 190,121.68 = 346,473.47 \text{ lbf}$

Path 1-1 is stronger than W so it is acceptable per UG-41(b)(2).

Load for path 2-2 lesser of W or  $W_{2-2} = -122,025.32 \text{ lbf}$

Path 2-2 through (1), (4), (6) =  $73,289.9 + 129,129.82 + 129,129.82 = 331,549.55 \text{ lbf}$

Path 2-2 is stronger than W so it is acceptable per UG-41(b)(2).

Load for path 3-3 lesser of W or  $W_{3-3} = -122,025.32 \text{ lbf}$

Path 3-3 through (2), (4) =  $156,351.79 + 129,129.82 = 285,481.61 \text{ lbf}$

Path 3-3 is stronger than W so it is acceptable per UG-41(b)(2).

## Reinforcement Calculations for MAWP

UG-37 Area Calculation Summary (in <sup>2</sup> ) For P = 100.98 psi @ 200 °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>
5.8402	15.9674	6.1995	1.6973	--	7.68	0.3906	0.3281	0.5198

UG-41 Weld Failure Path Analysis Summary (lb <sub>f</sub> ) All failure paths are stronger than the applicable weld loads						
Weld load W	Weld load W <sub>1,1</sub>	Path 1-1 strength	Weld load W <sub>2,2</sub>	Path 2-2 strength	Weld load W <sub>3,3</sub>	Path 3-3 strength
408.76	124,013.26	346,473.47	32.987	331,549.55	133,666.28	285,481.61

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg <sub>21</sub> )	0.25	0.2625	weld size is adequate
Pad to shell fillet (Leg <sub>22</sub> )	0.32	0.35	weld size is adequate
Nozzle to pad groove (Upper)	0.4158	0.4375	weld size is adequate
Nozzle to shell groove (Lower)	0.4158	0.4375	weld size is adequate

Calculations for internal pressure 100.98 psi @ 200 °F

Fig UCS-66.2 general note (1) applies.

Nozzle is impact test exempt to -150 °F per UCS-66(b)(3) (coincident ratio = 0.1223).

Pad impact test exemption temperature from Fig UCS-66 Curve A = 44.2 °F

Fig UCS-66.1 MDMT reduction = 64.2 °F, (coincident ratio = 0.4851).

Nozzle UCS-66 governing thk: 0.5198 in

Nozzle rated MDMT: -150 °F

Pad UCS-66 governing thickness: 0.64 in

Pad rated MDMT: -20 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(18.812, 9.406 + (0.594 - 0) + (0.64 - 0)) \\
 &= 18.812 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_c) \\
 &= \text{MIN}(2.5*(0.64 - 0), 2.5*(0.594 - 0) + 0.64) \\
 &= 1.6 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_{rn} &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 100.9837 \cdot 9.406 / (15,000 \cdot 1 - 0.6 \cdot 100.9837) \\
 &= 0.0636 \text{ in}
 \end{aligned}$$

Required thickness  $t_r$  from UG-37(a)(1)

$$\begin{aligned}
 t_r &= P \cdot L \cdot M / (2 \cdot S \cdot E - 0.2 \cdot P) \\
 &= 100.9837 \cdot 78 \cdot 1 / (2 \cdot 12,696 \cdot 1 - 0.2 \cdot 100.9837) \\
 &= 0.3105 \text{ in}
 \end{aligned}$$

Required thickness  $t_r$  per Interpretation VIII-1-07-50

$$\begin{aligned}
 t_r &= P \cdot L \cdot M / (2 \cdot S \cdot E - 0.2 \cdot P) \\
 &= 100.98 \cdot 78 \cdot 1.7335 / (2 \cdot 12,696 \cdot 1 - 0.2 \cdot 100.98) \\
 &= 0.5382 \text{ in}
 \end{aligned}$$

Area required per UG-37(c)

Allowable stresses:  $S_n = 15,000$ ,  $S_v = 12,696$ ,  $S_p = 12,696$  psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r3} = \text{lesser of } f_{r2} \text{ or } S_p / S_v = 1$$

$$f_{r4} = \text{lesser of } 1 \text{ or } S_p / S_v = 1$$



$$\begin{aligned}
 A &= d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1}) \\
 &= 18.812 \cdot 0.3105 \cdot 1 + 2 \cdot 0.594 \cdot 0.3105 \cdot 1 \cdot (1 - 1) \\
 &= \underline{5.8402 \text{ in}^2}
 \end{aligned}$$

Area available from FIG. UG-37.1

$A_1$  = larger of the following = 6.1995 in<sup>2</sup>

$$\begin{aligned}
 &= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\
 &= 18.812 \cdot (1 \cdot 0.64 - 1 \cdot 0.3105) - 2 \cdot 0.594 \cdot (1 \cdot 0.64 - 1 \cdot 0.3105) \cdot (1 - 1) \\
 &= 6.1995 \text{ in}^2 \\
 &= 2 \cdot (t + t_n) \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1}) \\
 &= 2 \cdot (0.64 + 0.594) \cdot (1 \cdot 0.64 - 1 \cdot 0.3105) - 2 \cdot 0.594 \cdot (1 \cdot 0.64 - 1 \cdot 0.3105) \cdot (1 - 1) \\
 &= 0.8133 \text{ in}^2
 \end{aligned}$$

$A_2$  = smaller of the following = 1.6973 in<sup>2</sup>

$$\begin{aligned}
 &= 5 \cdot (t_n - t_{rn}) \cdot f_{r2} \cdot t \\
 &= 5 \cdot (0.594 - 0.0636) \cdot 1 \cdot 0.64 \\
 &= 1.6973 \text{ in}^2 \\
 &= 2 \cdot (t_n - t_{rn}) \cdot (2.5 \cdot t_n + t_c) \cdot f_{r2} \\
 &= 2 \cdot (0.594 - 0.0636) \cdot (2.5 \cdot 0.594 + 0.64) \cdot 1 \\
 &= 2.2542 \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 A_{41} &= \text{Leg}^2 \cdot f_{r3} \\
 &= 0.375^2 \cdot 1 \\
 &= \underline{0.1406 \text{ in}^2}
 \end{aligned}$$

$$\begin{aligned}
 A_{42} &= \text{Leg}^2 \cdot f_{r4} \\
 &= 0.5^2 \cdot 1 \\
 &= \underline{0.25 \text{ in}^2}
 \end{aligned}$$

$$\begin{aligned}
 A_5 &= (D_p - d - 2 \cdot t_n) \cdot t_c \cdot f_{r4} \\
 &= (32 - 18.812 - 2 \cdot 0.594) \cdot 0.64 \cdot 1 \\
 &= \underline{7.68 \text{ in}^2}
 \end{aligned}$$

$$\begin{aligned}
 \text{Area} &= A_1 + A_2 + A_{41} + A_{42} + A_5 \\
 &= 6.1995 + 1.6973 + 0.1406 + 0.25 + 7.68 \\
 &= \underline{15.9674 \text{ in}^2}
 \end{aligned}$$

As Area >= A the reinforcement is adequate.

UW-16(d) Weld Check

$$\begin{aligned}
 \text{Inner fillet: } t_{\min} &= \text{lesser of } 0.75 \text{ or } t_n \text{ or } t_c = 0.594 \text{ in} \\
 t_{c(\min)} &= \text{lesser of } 0.25 \text{ or } 0.7 \cdot t_{\min} = \underline{0.25 \text{ in}} \\
 t_{c(\text{actual})} &= 0.7 \cdot \text{Leg} = 0.7 \cdot 0.375 = 0.2625 \text{ in}
 \end{aligned}$$

$$\begin{aligned}
 \text{Outer fillet: } t_{\min} &= \text{lesser of } 0.75 \text{ or } t_c \text{ or } t = 0.64 \text{ in} \\
 t_{w(\min)} &= 0.5 \cdot t_{\min} = \underline{0.32 \text{ in}} \\
 t_{w(\text{actual})} &= 0.7 \cdot \text{Leg} = 0.7 \cdot 0.5 = 0.35 \text{ in}
 \end{aligned}$$

$$\begin{aligned}
 \text{Upper groove: } t_{\min} &= \text{lesser of } 0.75 \text{ or } t_n \text{ or } t_c = 0.594 \text{ in} \\
 t_{w(\min)} &= 0.7 \cdot t_{\min} = \underline{0.4158 \text{ in}} \\
 t_{w(\text{actual})} &= 0.4375 \text{ in}
 \end{aligned}$$

$$\begin{aligned}
 \text{Lower groove: } t_{\min} &= \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.594 \text{ in} \\
 t_{w(\min)} &= 0.7 \cdot t_{\min} = \underline{0.4158 \text{ in}} \\
 t_{w(\text{actual})} &= 0.4375 \text{ in}
 \end{aligned}$$

UG-45 Nozzle Neck Thickness Check

Interpretation VIII-1-83-66 has been applied.

$$\begin{aligned}
 \text{Wall thickness per UG-45(a): } t_{r1} &= 0.0636 \text{ in } (E = 1) \\
 \text{Wall thickness per UG-45(b)(1): } t_{r2} &= 0.5382 \text{ in} \\
 \text{Wall thickness per UG-16(b): } t_{r3} &= 0.0625 \text{ in} \\
 \text{Standard wall pipe per UG-45(b)(4): } t_{r4} &= 0.3281 \text{ in} \\
 \text{The greater of } t_{r2} \text{ or } t_{r3}: t_{r5} &= 0.5382 \text{ in} \\
 \text{The lesser of } t_{r4} \text{ or } t_{r5}: t_{r6} &= 0.3281 \text{ in}
 \end{aligned}$$

Required per UG-45 is the larger of  $t_{r1}$  or  $t_{r6} = \underline{0.3281 \text{ in}}$

Available nozzle wall thickness new,  $t_n = 0.875 \cdot 0.594 = 0.5198 \text{ in}$

The nozzle neck thickness is adequate.

Allowable stresses in joints UG-45(c) and UW-15(c)

Groove weld in tension:  $0.74 * 12,696 = 9,395$  psi  
 Nozzle wall in shear:  $0.7 * 15,000 = 10,500$  psi  
 Inner fillet weld in shear:  $0.49 * 12,696 = 6,221$  psi  
 Outer fillet weld in shear:  $0.49 * 12,696 = 6,221$  psi  
 Upper groove weld in tension:  $0.74 * 12,696 = 9,395$  psi

Strength of welded joints:

(1) Inner fillet weld in shear

$$(\pi / 2) * \text{Nozzle OD} * \text{Leg} * S_i = (\pi / 2) * 20 * 0.375 * 6,221 = 73,289.9 \text{ lbf}$$

(2) Outer fillet weld in shear

$$(\pi / 2) * \text{Pad OD} * \text{Leg} * S_o = (\pi / 2) * 32 * 0.5 * 6,221 = 156,351.79 \text{ lbf}$$

(3) Nozzle wall in shear

$$(\pi / 2) * \text{Mean nozzle dia} * t_n * S_n = (\pi / 2) * 19.406 * 0.594 * 10,500 = 190,121.68 \text{ lbf}$$

(4) Groove weld in tension

$$(\pi / 2) * \text{Nozzle OD} * t_w * S_u = (\pi / 2) * 20 * 0.4375 * 9,395 = 129,129.82 \text{ lbf}$$

(6) Upper groove weld in tension

$$(\pi / 2) * \text{Nozzle OD} * t_w * S_u = (\pi / 2) * 20 * 0.4375 * 9,395 = 129,129.82 \text{ lbf}$$

Loading on welds per UG-41(b)(1)

$$\begin{aligned} W &= (A - (d - 2 * t_n) * (E_1 * t - F * t_f)) * S_v \\ &= (5.8402 - (18.812 - 2 * 0.594) * (1 * 0.64 - 1 * 0.3105)) * 12,696 \\ &= \underline{408.76 \text{ lbf}} \end{aligned}$$

$$\begin{aligned} W_{1-1} &= (A_2 + A_5 + A_{41} + A_{42}) * S_v \\ &= (1.6973 + 7.68 + 0.1406 + 0.25) * 12,696 \\ &= \underline{124,013.26 \text{ lbf}} \end{aligned}$$

$$\begin{aligned} W_{2-2} &= (A_2 + A_3 + A_{41} + A_{43} + 2 * t_n * t * f_{r1}) * S_v \\ &= (1.6973 + 0 + 0.1406 + 0 + 2 * 0.594 * 0.64 * 1) * 12,696 \\ &= \underline{32,987 \text{ lbf}} \end{aligned}$$

$$\begin{aligned} W_{3-3} &= (A_2 + A_3 + A_5 + A_{41} + A_{42} + A_{43} + 2 * t_n * t * f_{r1}) * S_v \\ &= (1.6973 + 0 + 7.68 + 0.1406 + 0.25 + 0 + 2 * 0.594 * 0.64 * 1) * 12,696 \\ &= \underline{133,666.28 \text{ lbf}} \end{aligned}$$

Load for path 1-1 lesser of W or  $W_{1-1} = 408.76 \text{ lbf}$

Path 1-1 through (2) & (3) =  $156,351.79 + 190,121.68 = \underline{346,473.47 \text{ lbf}}$

Path 1-1 is stronger than W so it is acceptable per UG-41(b)(2).

Load for path 2-2 lesser of W or  $W_{2-2} = 408.76 \text{ lbf}$

Path 2-2 through (1), (4), (6) =  $73,289.9 + 129,129.82 + 129,129.82 = \underline{331,549.55 \text{ lbf}}$

Path 2-2 is stronger than W so it is acceptable per UG-41(b)(2).

Load for path 3-3 lesser of W or  $W_{3-3} = 408.76 \text{ lbf}$

Path 3-3 through (2), (4) =  $156,351.79 + 129,129.82 = \underline{285,481.61 \text{ lbf}}$

Path 3-3 is stronger than W so it is acceptable per UG-41(b)(2).

# Reinforcement Calculations for MAP

Available reinforcement per UG-37 governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in <sup>2</sup> ) For P = 186.9 psi @ 70 °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>
10.8161	10.817	1.2235	1.5229	--	7.68	0.3906	0.3281
							0.5198

UG-41 Weld Failure Path Analysis Summary (lbf) All failure paths are stronger than the applicable weld loads						
Weld load W	Weld load W <sub>1-1</sub>	Path 1-1 strength	Weld load W <sub>2-2</sub>	Path 2-2 strength	Weld load W <sub>3-3</sub>	Path 3-3 strength
122,768.83	121,799.08	346,473.47	30,772.82	331,549.55	131,452.1	285,481.61

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg <sub>41</sub> )	0.25	0.2625	weld size is adequate
Pad to shell fillet (Leg <sub>42</sub> )	0.32	0.35	weld size is adequate
Nozzle to pad groove (Upper)	0.4158	0.4375	weld size is adequate
Nozzle to shell groove (Lower)	0.4158	0.4375	weld size is adequate

Calculations for internal pressure 186.9 psi @ 70 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(18.812, 9.406 + (0.594 - 0) + (0.64 - 0)) \\
 &= 18.812 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_c) \\
 &= \text{MIN}(2.5*(0.64 - 0), 2.5*(0.594 - 0) + 0.64) \\
 &= 1.6 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_{rn} &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 186.896 \cdot 9.406 / (15,000 \cdot 1 - 0.6 \cdot 186.896) \\
 &= 0.1181 \text{ in}
 \end{aligned}$$

Required thickness  $t_r$  from UG-37(a)(1)

$$\begin{aligned}
 t_r &= P \cdot L \cdot M / (2 \cdot S \cdot E - 0.2 \cdot P) \\
 &= 186.896 \cdot 78 \cdot 1 / (2 \cdot 12,696 \cdot 1 - 0.2 \cdot 186.896) \\
 &= 0.575 \text{ in}
 \end{aligned}$$

Required thickness  $t_r$  per Interpretation VIII-1-07-50

$$\begin{aligned}
 t_r &= P \cdot L \cdot M / (2 \cdot S \cdot E - 0.2 \cdot P) \\
 &= 186.9 \cdot 78 \cdot 1.7335 / (2 \cdot 12,696 \cdot 1 - 0.2 \cdot 186.9) \\
 &= 0.9967 \text{ in}
 \end{aligned}$$

Area required per UG-37(c)

Allowable stresses:  $S_n = 15,000$ ,  $S_v = 12,696$ ,  $S_p = 12,696$  psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r3} = \text{lesser of } f_{r2} \text{ or } S_p / S_v = 1$$

$$f_{r4} = \text{lesser of } 1 \text{ or } S_p / S_v = 1$$

$$\begin{aligned}
 A &= d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1}) \\
 &= 18.812 \cdot 0.575 \cdot 1 + 2 \cdot 0.594 \cdot 0.575 \cdot 1 \cdot (1 - 1) \\
 &= 10.8161 \text{ in}^2
 \end{aligned}$$

Area available from FIG. UG-37.1

$A_1$  = larger of the following = 1.2235 in<sup>2</sup>

$$= d \cdot (E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n \cdot (E_1 \cdot t - F \cdot t_r) \cdot (1 - f_{r1})$$

$$\begin{aligned}
 &= 18.812(1*0.64 - 1*0.575) - 2*0.594(1*0.64 - 1*0.575)(1 - 1) \\
 &= 1.2235 \text{ in}^2 \\
 &= 2^*(t + t_n)^*(E_1*t - F*t_r) - 2*t_n*(E_1*t - F*t_r)^*(1 - f_{r1}) \\
 &= 2*(0.64 + 0.594)*(1*0.64 - 1*0.575) - 2*0.594*(1*0.64 - 1*0.575)*(1 - 1) \\
 &= 0.1605 \text{ in}^2
 \end{aligned}$$

$A_2 = \text{smaller of the following} = 1.5229 \text{ in}^2$

$$\begin{aligned}
 &= 5*(t_n - t_{rn})^*f_{r2}*t \\
 &= 5*(0.594 - 0.1181)*1*0.64 \\
 &= 1.5229 \text{ in}^2 \\
 &= 2^*(t_n - t_{rn})^*(2.5*t_n + t_c)^*f_{r2} \\
 &= 2*(0.594 - 0.1181)*(2.5*0.594 + 0.64)*1 \\
 &= 2.0226 \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 A_{41} &= \text{Leg}^2*f_{r3} \\
 &= 0.375^2*1 \\
 &= 0.1406 \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 A_{42} &= \text{Leg}^2*f_{r4} \\
 &= 0.5^2*1 \\
 &= 0.25 \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 A_5 &= (D_p - d - 2*t_n)^*t_c*f_{r4} \\
 &= (32 - 18.812 - 2*0.594)*0.64*1 \\
 &= 7.68 \text{ in}^2
 \end{aligned}$$

$$\begin{aligned}
 \text{Area} &= A_1 + A_2 + A_{41} + A_{42} + A_5 \\
 &= 1.2235 + 1.5229 + 0.1406 + 0.25 + 7.68 \\
 &= 10.817 \text{ in}^2
 \end{aligned}$$

As Area >= A the reinforcement is adequate.

#### UW-16(d) Weld Check

Inner fillet:  $t_{\min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t_c = 0.594 \text{ in}$   
 $t_{c(\min)} = \text{lesser of } 0.25 \text{ or } 0.7*t_{\min} = 0.25 \text{ in}$   
 $t_{c(\text{actual})} = 0.7*\text{Leg} = 0.7*0.375 = 0.2625 \text{ in}$

Outer fillet:  $t_{\min} = \text{lesser of } 0.75 \text{ or } t_c \text{ or } t = 0.64 \text{ in}$   
 $t_{w(\min)} = 0.5*t_{\min} = 0.32 \text{ in}$   
 $t_{w(\text{actual})} = 0.7*\text{Leg} = 0.7*0.5 = 0.35 \text{ in}$

Upper groove:  $t_{\min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t_c = 0.594 \text{ in}$   
 $t_{w(\min)} = 0.7*t_{\min} = 0.4158 \text{ in}$   
 $t_{w(\text{actual})} = 0.4375 \text{ in}$

Lower groove:  $t_{\min} = \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.594 \text{ in}$   
 $t_{w(\min)} = 0.7*t_{\min} = 0.4158 \text{ in}$   
 $t_{w(\text{actual})} = 0.4375 \text{ in}$

#### UG-45 Nozzle Neck Thickness Check

Interpretation VIII-1-83-66 has been applied.

Wall thickness per UG-45(a):  $t_{r1} = 0.1181 \text{ in } (E=1)$

Wall thickness per UG-45(b)(1):  $t_{r2} = 0.9967 \text{ in}$

Wall thickness per UG-16(b):  $t_{r3} = 0.0625 \text{ in}$

Standard wall pipe per UG-45(b)(4):  $t_{r4} = 0.3281 \text{ in}$

The greater of  $t_{r2}$  or  $t_{r3}$ :  $t_{r5} = 0.9967 \text{ in}$

The lesser of  $t_{r4}$  or  $t_{r5}$ :  $t_{r6} = 0.3281 \text{ in}$

Required per UG-45 is the larger of  $t_{r1}$  or  $t_{r6} = 0.3281 \text{ in}$

Available nozzle wall thickness new,  $t_n = 0.875*0.594 = 0.5198 \text{ in}$

The nozzle neck thickness is adequate.

Allowable stresses in joints UG-45(c) and UW-15(c)

Groove weld in tension:  $0.74*12,696 = 9,395 \text{ psi}$

Nozzle wall in shear:  $0.7*15,000 = 10,500 \text{ psi}$

Inner fillet weld in shear:  $0.49*12,696 = 6,221 \text{ psi}$

Outer fillet weld in shear:  $0.49*12,696 = 6,221 \text{ psi}$

Upper groove weld in tension:  $0.74*12,696 = 9,395 \text{ psi}$



## Strength of welded joints:

(1) Inner fillet weld in shear

$$(\pi / 2) * \text{Nozzle OD} * \text{Leg} * S_f = (\pi / 2) * 20 * 0.375 * 6,221 = 73,289.9 \text{ lbf}$$

(2) Outer fillet weld in shear

$$(\pi / 2) * \text{Pad OD} * \text{Leg} * S_o = (\pi / 2) * 32 * 0.5 * 6,221 = 156,351.79 \text{ lbf}$$

(3) Nozzle wall in shear

$$(\pi / 2) * \text{Mean nozzle dia} * t_n * S_n = (\pi / 2) * 19.406 * 0.594 * 10,500 = 190,121.68 \text{ lbf}$$

(4) Groove weld in tension

$$(\pi / 2) * \text{Nozzle OD} * t_w * S_u = (\pi / 2) * 20 * 0.4375 * 9,395 = 129,129.82 \text{ lbf}$$

(6) Upper groove weld in tension

$$(\pi / 2) * \text{Nozzle OD} * t_w * S_u = (\pi / 2) * 20 * 0.4375 * 9,395 = 129,129.82 \text{ lbf}$$

## Loading on welds per UG-41(b)(1)

$$\begin{aligned} W &= (A - (d - 2 * t_n) * (E_1 * t_1 - F * t_f)) * S_v \\ &= (10,8161 - (18,812 - 2 * 0.594) * (1 * 0.64 - 1 * 0.575)) * 12,696 \\ &= \underline{122,768.83 \text{ lbf}} \end{aligned}$$

$$\begin{aligned} W_{1-1} &= (A_2 + A_5 + A_{41} + A_{42}) * S_v \\ &= (1.5229 + 7.68 + 0.1406 + 0.25) * 12,696 \\ &= \underline{121,799.08 \text{ lbf}} \end{aligned}$$

$$\begin{aligned} W_{2-2} &= (A_2 + A_3 + A_{41} + A_{43} + 2 * t_n * t * f_{r1}) * S_v \\ &= (1.5229 + 0 + 0.1406 + 0 + 2 * 0.594 * 0.64 * 1) * 12,696 \\ &= \underline{30,772.82 \text{ lbf}} \end{aligned}$$

$$\begin{aligned} W_{3-3} &= (A_2 + A_3 + A_5 + A_{41} + A_{42} + A_{43} + 2 * t_n * t * f_{r1}) * S_v \\ &= (1.5229 + 0 + 7.68 + 0.1406 + 0.25 + 0 + 2 * 0.594 * 0.64 * 1) * 12,696 \\ &= \underline{131,452.1 \text{ lbf}} \end{aligned}$$

Load for path 1-1 lesser of W or  $W_{1-1} = 121,799.08 \text{ lbf}$ Path 1-1 through (2) & (3) =  $156,351.79 + 190,121.68 = \underline{346,473.47 \text{ lbf}}$ Path 1-1 is stronger than  $W_{1-1}$  so it is acceptable per UG-41(b)(1).Load for path 2-2 lesser of W or  $W_{2-2} = 30,772.82 \text{ lbf}$ Path 2-2 through (1), (4), (6) =  $73,289.9 + 129,129.82 + 129,129.82 = \underline{331,549.55 \text{ lbf}}$ Path 2-2 is stronger than  $W_{2-2}$  so it is acceptable per UG-41(b)(1).Load for path 3-3 lesser of W or  $W_{3-3} = 122,768.83 \text{ lbf}$ Path 3-3 through (2), (4) =  $156,351.79 + 129,129.82 = \underline{285,481.61 \text{ lbf}}$ 

Path 3-3 is stronger than W so it is acceptable per UG-41(b)(2).

## Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in <sup>2</sup> ) For $P_e = 15$ psi @ 200 °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>
2.1365	17.5677	7.7667	1.7304	--	7.68	0.3906	0.0799	0.5198

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 size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg <sub>41</sub> )	0.25	0.2625	weld size is adequate
Pad to shell fillet (Leg <sub>42</sub> )	0.32	0.35	weld size is adequate
Nozzle to pad groove (Upper)	0.4158	0.4375	weld size is adequate
Nozzle to shell groove (Lower)	0.4158	0.4375	weld size is adequate

Calculations for external pressure 15 psi @ 200 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(18.812, 9.406 + (0.594 - 0) + (0.64 - 0)) \\
 &= 18.812 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5(t - C), 2.5(t_n - C_n) + t_c) \\
 &= \text{MIN}(2.5(0.64 - 0), 2.5(0.594 - 0) + 0.64) \\
 &= 1.6 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28  $t_{rn} = 0.0532$  inFrom UG-37(d)(1) required thickness  $t_r = 0.2271$  in

Area required per UG-37(d)(1)

Allowable stresses:  $S_n = 15,000$ ,  $S_v = 12,696$ ,  $S_p = 12,696$  psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r3} = \text{lesser of } f_{r2} \text{ or } S_p / S_v = 1$$

$$f_{r4} = \text{lesser of } 1 \text{ or } S_p / S_v = 1$$

$$\begin{aligned}
 A &= 0.5(d \cdot t_r \cdot F + 2 \cdot t_n \cdot t_r \cdot F \cdot (1 - f_{r1})) \\
 &= 0.5(18.812 \cdot 0.2271 \cdot 1 + 2 \cdot 0.594 \cdot 0.2271 \cdot 1 \cdot (1 - 1)) \\
 &= 2.1365 \text{ in}^2
 \end{aligned}$$

Area available from FIG. UG-37.1

 $A_1 = \text{larger of the following} = 7.7667 \text{ in}^2$ 

$$\begin{aligned}
 &= d(E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n(E_1 \cdot t - F \cdot t_r)(1 - f_{r1}) \\
 &= 18.812(1 \cdot 0.64 - 1 \cdot 0.2271) - 2 \cdot 0.594(1 \cdot 0.64 - 1 \cdot 0.2271)(1 - 1) \\
 &= 7.7667 \text{ in}^2 \\
 &= 2 \cdot (t + t_n)(E_1 \cdot t - F \cdot t_r) - 2 \cdot t_n(E_1 \cdot t - F \cdot t_r)(1 - f_{r1}) \\
 &= 2 \cdot (0.64 + 0.594)(1 \cdot 0.64 - 1 \cdot 0.2271) - 2 \cdot 0.594(1 \cdot 0.64 - 1 \cdot 0.2271)(1 - 1) \\
 &= 1.0189 \text{ in}^2
 \end{aligned}$$

 $A_2 = \text{smaller of the following} = 1.7304 \text{ in}^2$ 

$$\begin{aligned}
 &= 5(t_n - t_{rn}) \cdot f_{r2} \cdot t \\
 &= 5(0.594 - 0.0532) \cdot 1 \cdot 0.64 \\
 &= 1.7304 \text{ in}^2 \\
 &= 2 \cdot (t_n - t_{rn}) \cdot (2.5 \cdot t_n + t_c) \cdot f_{r2} \\
 &= 2 \cdot (0.594 - 0.0532) \cdot (2.5 \cdot 0.594 + 0.64) \cdot 1 \\
 &= 2.2982 \text{ in}^2
 \end{aligned}$$

$$A_{41} = \text{Leg}^2 \cdot f_{r3}$$

$$\begin{aligned}
 &= 0.375^2 \times 1 \\
 &= 0.1406 \text{ in}^2 \\
 A_{42} &= \text{Leg}^2 \times f_{r4} \\
 &= 0.5^2 \times 1 \\
 &= 0.25 \text{ in}^2 \\
 A_5 &= (D_p - d - 2 \times t_n) \times t_c \times f_{r4} \\
 &= (32 - 18.812 - 2 \times 0.594) \times 0.64 \times 1 \\
 &= 7.68 \text{ in}^2 \\
 \text{Area} &= A_1 + A_2 + A_{41} + A_{42} + A_5 \\
 &= 7.7667 + 1.7304 + 0.1406 + 0.25 + 7.68 \\
 &= 17.5677 \text{ in}^2
 \end{aligned}$$

As Area  $\geq$  A the reinforcement is adequate.

#### UW-16(d) Weld Check

Inner fillet:  $t_{\min}$  = lesser of 0.75 or  $t_n$  or  $t_c = 0.594$  in  
 $t_{c(\min)}$  = lesser of 0.25 or  $0.7 \times t_{\min} = 0.25$  in  
 $t_{c(\text{actual})} = 0.7 \times \text{Leg} = 0.7 \times 0.375 = 0.2625$  in

Outer fillet:  $t_{\min}$  = lesser of 0.75 or  $t_c$  or  $t = 0.64$  in  
 $t_{w(\min)} = 0.5 \times t_{\min} = 0.32$  in  
 $t_{w(\text{actual})} = 0.7 \times \text{Leg} = 0.7 \times 0.5 = 0.35$  in

Upper groove:  $t_{\min}$  = lesser of 0.75 or  $t_n$  or  $t_c = 0.594$  in  
 $t_{w(\min)} = 0.7 \times t_{\min} = 0.4158$  in  
 $t_{w(\text{actual})} = 0.4375$  in

Lower groove:  $t_{\min}$  = lesser of 0.75 or  $t_n$  or  $t = 0.594$  in  
 $t_{w(\min)} = 0.7 \times t_{\min} = 0.4158$  in  
 $t_{w(\text{actual})} = 0.4375$  in

#### UG-45 Nozzle Neck Thickness Check

Interpretation VIII-1-83-66 has been applied.

Wall thickness per UG-45(a):  $t_{r1} = 0.0532$  in  
 Wall thickness per UG-45(b)(2):  $t_{r2} = 0.0799$  in  
 Wall thickness per UG-16(b):  $t_{r3} = 0.0625$  in  
 Standard wall pipe per UG-45(b)(4):  $t_{r4} = 0.3281$  in  
 The greater of  $t_{r2}$  or  $t_{r3}$ :  $t_{r5} = 0.0799$  in  
 The lesser of  $t_{r4}$  or  $t_{r5}$ :  $t_{r6} = 0.0799$  in

Required per UG-45 is the larger of  $t_{r1}$  or  $t_{r6} = 0.0799$  in

Available nozzle wall thickness new,  $t_n = 0.875 \times 0.594 = 0.5198$  in

The nozzle neck thickness is adequate.

## Reinforcement Calculations for MAEP

UG-37 Area Calculation Summary (in <sup>2</sup> ) For $P_c = 71.77$ psi @ 200 °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>4</sub>	A welds	t <sub>req</sub>	t <sub>min</sub>
4.6794	12.332	2.6809	1.5805	--	7.68	0.3906	0.3281	0.5198

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 size (in)	Actual weld size (in)	Status
Nozzle to pad fillet (Leg <sub>41</sub> )	0.25	0.2625	weld size is adequate
Pad to shell fillet (Leg <sub>42</sub> )	0.32	0.35	weld size is adequate
Nozzle to pad groove (Upper)	0.4158	0.4375	weld size is adequate
Nozzle to shell groove (Lower)	0.4158	0.4375	weld size is adequate

Calculations for external pressure 71.77 psi @ 200 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(18.812, 9.406 + (0.594 - 0) + (0.64 - 0)) \\
 &= 18.812 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5^*(t - C), 2.5^*(t_n - C_n) + t_c) \\
 &= \text{MIN}(2.5^*(0.64 - 0), 2.5^*(0.594 - 0) + 0.64) \\
 &= 1.6 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28  $t_{rn} = 0.1001$  inFrom UG-37(d)(1) required thickness  $t_r = 0.4975$  in

Area required per UG-37(d)(1)

Allowable stresses:  $S_n = 15,000$ ,  $S_v = 12,696$ ,  $S_p = 12,696$  psi

$$f_{r1} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r2} = \text{lesser of } 1 \text{ or } S_n / S_v = 1$$

$$f_{r3} = \text{lesser of } f_{r2} \text{ or } S_p / S_v = 1$$

$$f_{r4} = \text{lesser of } 1 \text{ or } S_p / S_v = 1$$

$$\begin{aligned}
 A &= 0.5^*(d^*t_r^*F + 2^*t_n^*t_r^*F^*(1 - f_{r1})) \\
 &= 0.5^*(18.812^*0.4975^*1 + 2^*0.594^*0.4975^*1^*(1 - 1)) \\
 &= 4.6794 \text{ in}^2
 \end{aligned}$$

Area available from FIG. UG-37.1

 $A_1 = \text{larger of the following} = 2.6809 \text{ in}^2$ 

$$\begin{aligned}
 &= d^*(E_1^*t - F^*t_r) - 2^*t_n^*(E_1^*t - F^*t_r)^*(1 - f_{r1}) \\
 &= 18.812^*(1^*0.64 - 1^*0.4975) - 2^*0.594^*(1^*0.64 - 1^*0.4975)^*(1 - 1) \\
 &= 2.6809 \text{ in}^2 \\
 &= 2^*(t + t_n)^*(E_1^*t - F^*t_r) - 2^*t_n^*(E_1^*t - F^*t_r)^*(1 - f_{r1}) \\
 &= 2^*(0.64 + 0.594)^*(1^*0.64 - 1^*0.4975) - 2^*0.594^*(1^*0.64 - 1^*0.4975)^*(1 - 1) \\
 &= 0.3517 \text{ in}^2
 \end{aligned}$$

 $A_2 = \text{smaller of the following} = 1.5805 \text{ in}^2$ 

$$\begin{aligned}
 &= 5^*(t_n - t_{rn})^*f_{r2}^*t \\
 &= 5^*(0.594 - 0.1001)^*1^*0.64 \\
 &= 1.5805 \text{ in}^2 \\
 &= 2^*(t_n - t_{rn})^*(2.5^*t_n + t_c)^*f_{r2} \\
 &= 2^*(0.594 - 0.1001)^*(2.5^*0.594 + 0.64)^*1 \\
 &= 2.0991 \text{ in}^2
 \end{aligned}$$

$$A_{41} = \text{Leg}^2^*f_{r3}$$



$$\begin{aligned}
 &= 0.375^2 \times 1 \\
 &= 0.1406 \text{ in}^2 \\
 A_{42} &= \text{Leg}^2 \times f_{r4} \\
 &= 0.5^2 \times 1 \\
 &= 0.25 \text{ in}^2 \\
 A_5 &= (D_p - d - 2 \times t_n) \times t_c \times f_{r4} \\
 &= (32 - 18.812 - 2 \times 0.594) \times 0.64 \times 1 \\
 &= 7.68 \text{ in}^2 \\
 \text{Area} &= A_1 + A_2 + A_{41} + A_{42} + A_5 \\
 &= 2.6809 + 1.5805 + 0.1406 + 0.25 + 7.68 \\
 &= 12.332 \text{ in}^2
 \end{aligned}$$

As Area  $\geq$  A the reinforcement is adequate.

#### UW-16(d) Weld Check

$$\begin{aligned}
 \text{Inner fillet: } t_{\min} &= \text{lesser of } 0.75 \text{ or } t_n \text{ or } t_c = 0.594 \text{ in} \\
 t_{c(\min)} &= \text{lesser of } 0.25 \text{ or } 0.7 \times t_{\min} = 0.25 \text{ in} \\
 t_{c(\text{actual})} &= 0.7 \times \text{Leg} = 0.7 \times 0.375 = 0.2625 \text{ in} \\
 \text{Outer fillet: } t_{\min} &= \text{lesser of } 0.75 \text{ or } t_c \text{ or } t = 0.64 \text{ in} \\
 t_{w(\min)} &= 0.5 \times t_{\min} = 0.32 \text{ in} \\
 t_{w(\text{actual})} &= 0.7 \times \text{Leg} = 0.7 \times 0.5 = 0.35 \text{ in} \\
 \text{Upper groove: } t_{\min} &= \text{lesser of } 0.75 \text{ or } t_n \text{ or } t_c = 0.594 \text{ in} \\
 t_{w(\min)} &= 0.7 \times t_{\min} = 0.4158 \text{ in} \\
 t_{w(\text{actual})} &= 0.4375 \text{ in} \\
 \text{Lower groove: } t_{\min} &= \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.594 \text{ in} \\
 t_{w(\min)} &= 0.7 \times t_{\min} = 0.4158 \text{ in} \\
 t_{w(\text{actual})} &= 0.4375 \text{ in}
 \end{aligned}$$

#### UG-45 Nozzle Neck Thickness Check

Interpretation VIII-1-83-66 has been applied.

$$\begin{aligned}
 \text{Wall thickness per UG-45(a): } t_{r1} &= 0.1001 \text{ in} \\
 \text{Wall thickness per UG-45(b)(2): } t_{r2} &= 0.3824 \text{ in} \\
 \text{Wall thickness per UG-16(b): } t_{r3} &= 0.0625 \text{ in} \\
 \text{Standard wall pipe per UG-45(b)(4): } t_{r4} &= 0.3281 \text{ in} \\
 \text{The greater of } t_{r2} \text{ or } t_{r3}: t_{r5} &= 0.3824 \text{ in} \\
 \text{The lesser of } t_{r4} \text{ or } t_{r5}: t_{r6} &= 0.3281 \text{ in}
 \end{aligned}$$

Required per UG-45 is the larger of  $t_{r1}$  or  $t_{r6} = 0.3281 \text{ in}$

Available nozzle wall thickness new,  $t_n = 0.875 \times 0.594 = 0.5198 \text{ in}$

The nozzle neck thickness is adequate.

#### External Pressure, (Corroded & at 200 °F) UG-28(c)

$$\begin{aligned}
 L / D_o &= 12.904 / 20 = 0.6452 \\
 D_o / t &= 20 / 0.1001 = 199.8333 \\
 \text{From table G: } A &= 0.000746 \\
 \text{From table CS-2: } B &= 10,757.1652 \text{ psi}
 \end{aligned}$$

$$\begin{aligned}
 P_a &= 4 \times B / (3 \times (D_o / t)) \\
 &= 4 \times 10,757.17 / (3 \times (20 / 0.1001)) \\
 &= 71.77 \text{ psi}
 \end{aligned}$$

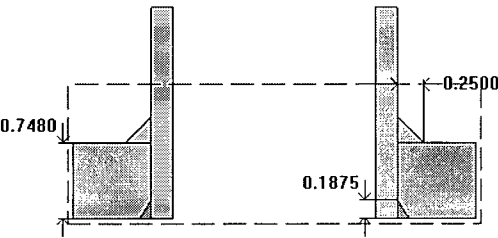
Design thickness for external pressure  $P_a = 71.77 \text{ psi}$

$$t_a = t + \text{Corrosion} = 0.1001 + 0 = 0.1001''$$

Nozzle #2 (N2)

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$t_{w(lower)} = 0.1875 \text{ in}$   
 $Leg_{41} = 0.25 \text{ in}$



Note: round inside edges per UG-76(c)

Location and Orientation

Located on:	Cylinder #1
Orientation:	0°
Nozzle center line offset to datum line:	66 in
End of nozzle to shell center:	48.748 in
Passes through a Category A joint:	No

Nozzle

Access opening:	No
Material specification:	SA-106 B Smls pipe (II-D p. 10, ln. 31)
Description:	NPS 2 Sch 80 (XS)
Inside diameter, new:	1.939 in
Nominal wall thickness:	0.218 in
Corrosion allowance:	0 in
Projection available outside vessel, Lpr:	6 in
Local vessel minimum thickness:	0.748 in
Liquid static head included:	0 psi
Longitudinal joint efficiency:	1

## Reinforcement Calculations for Internal Pressure

UG-37 Area Calculation Summary (in <sup>2</sup> ) For P = 14.9 psi @ 200 °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)							0.0625	0.1908

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 size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (L <sub>eg41</sub> )	0.1526	0.175	weld size is adequate
Nozzle to shell groove (Lower)	0.1526	0.1875	weld size is adequate

Calculations for internal pressure 14.9 psi @ 200 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(1.939, 0.9695 + (0.218 - 0) + (0.748 - 0)) \\
 &= 1.939 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_c) \\
 &= \text{MIN}(2.5*(0.748 - 0), 2.5*(0.218 - 0) + 0) \\
 &= 0.545 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_{rn} &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 14.9 \cdot 0.9695 / (15,000 \cdot 1 - 0.6 \cdot 14.9) \\
 &= 0.001 \text{ in}
 \end{aligned}$$

Required thickness  $t_r$  from UG-37(a)

$$\begin{aligned}
 t_r &= P \cdot R / (S \cdot E - 0.6 \cdot P) \\
 &= 14.9 \cdot 42 / (12,696 \cdot 1 - 0.6 \cdot 14.9) \\
 &= 0.0493 \text{ in}
 \end{aligned}$$

Required thickness  $t_r$  per Interpretation VIII-1-07-50

$$\begin{aligned}
 t_r &= P \cdot R / (S \cdot E - 0.6 \cdot P) \\
 &= 14.9 \cdot 42 / (12,696 \cdot 1 - 0.6 \cdot 14.9) \\
 &= 0.0493 \text{ in}
 \end{aligned}$$

This opening does not require reinforcement per UG-36(c)(3)(a)

UW-16(d) Weld Check

$$\begin{aligned}
 t_{\min} &= \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.218 \text{ in} \\
 t_1(\min) \text{ or } t_2(\min) &= \text{lesser of } 0.25 \text{ or } 0.7 \cdot t_{\min} = 0.1526 \text{ in} \\
 t_1(\text{actual}) &= 0.7 \cdot L_{eg} = 0.7 \cdot 0.25 = 0.175 \text{ in} \\
 \text{The weld size } t_1 &\text{ is satisfactory.} \\
 t_2(\text{actual}) &= 0.1875 \text{ in} \\
 \text{The weld size } t_2 &\text{ is satisfactory.} \\
 t_1 + t_2 &= 0.3625 \geq 1.25 \cdot t_{\min}
 \end{aligned}$$

The combined weld sizes for  $t_1$  and  $t_2$  are satisfactory.

UG-45 Nozzle Neck Thickness Check

$$\begin{aligned}
 \text{Wall thickness per UG-45(a):} & \quad t_{r1} = 0.001 \text{ in (E=1)} \\
 \text{Wall thickness per UG-45(b)(1):} & \quad t_{r2} = 0.0493 \text{ in} \\
 \text{Wall thickness per UG-16(b):} & \quad t_{r3} = 0.0625 \text{ in} \\
 \text{Standard wall pipe per UG-45(b)(4):} & \quad t_{r4} = 0.1348 \text{ in} \\
 \text{The greater of } t_{r2} \text{ or } t_{r3}: & \quad t_{r5} = 0.0625 \text{ in} \\
 \text{The lesser of } t_{r4} \text{ or } t_{r5}: & \quad t_{r6} = 0.0625 \text{ in}
 \end{aligned}$$

Required per UG-45 is the larger of  $t_{r1}$  or  $t_{r6} = 0.0625$  inAvailable nozzle wall thickness new,  $t_n = 0.875 \cdot 0.218 = 0.1908$  in

The nozzle neck thickness is adequate.

# Reinforcement Calculations for MAWP

The vessel wall thickness governs the MAWP of this nozzle.

UG-37 Area Calculation Summary (in <sup>2</sup> ) For P = 223.72 psi @ 200 °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)							0.1348	0.1908

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 size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg <sub>fil</sub> )	0.1526	0.175	weld size is adequate
Nozzle to shell groove (Lower)	0.1526	0.1875	weld size is adequate

Calculations for internal pressure 223.72 psi @ 200 °F

Fig UCS-66.2 general note (1) applies.

Nozzle is impact test exempt to -150 °F per UCS-66(b)(3) (coincident ratio = 0.0344).

Nozzle UCS-66 governing thk: 0.1908 in

Nozzle rated MDMT: -150 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(1.939, 0.9695 + (0.218 - 0) + (0.748 - 0)) \\
 &= 1.939 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_c) \\
 &= \text{MIN}(2.5*(0.748 - 0), 2.5*(0.218 - 0) + 0) \\
 &= 0.545 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_{rn} &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 223.7196 \cdot 0.9695 / (15,000 \cdot 1 - 0.6 \cdot 223.7196) \\
 &= 0.0146 \text{ in}
 \end{aligned}$$

Required thickness  $t_r$  from UG-37(a)

$$\begin{aligned}
 t_r &= P \cdot R / (S \cdot E - 0.6 \cdot P) \\
 &= 223.7196 \cdot 42 / (12,696 \cdot 1 - 0.6 \cdot 223.7196) \\
 &= 0.748 \text{ in}
 \end{aligned}$$

Required thickness  $t_r$  per Interpretation VIII-1-07-50

$$\begin{aligned}
 t_r &= P \cdot R / (S \cdot E - 0.6 \cdot P) \\
 &= 223.7196 \cdot 42 / (12,696 \cdot 1 - 0.6 \cdot 223.7196) \\
 &= 0.748 \text{ in}
 \end{aligned}$$

This opening does not require reinforcement per UG-36(c)(3)(a)

UW-16(d) Weld Check

$$\begin{aligned}
 t_{\min} &= \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.218 \text{ in} \\
 t_{1(\min)} \text{ or } t_{2(\min)} &= \text{lesser of } 0.25 \text{ or } 0.7 \cdot t_{\min} = 0.1526 \text{ in} \\
 t_{1(\text{actual})} &= 0.7 \cdot \text{Leg} = 0.7 \cdot 0.25 = 0.175 \text{ in} \\
 \text{The weld size } t_1 &\text{ is satisfactory.} \\
 t_{2(\text{actual})} &= 0.1875 \text{ in} \\
 \text{The weld size } t_2 &\text{ is satisfactory.}
 \end{aligned}$$

$$t_1 + t_2 = 0.3625 \geq 1.25 \cdot t_{\min}$$

The combined weld sizes for  $t_1$  and  $t_2$  are satisfactory.

UG-45 Nozzle Neck Thickness Check

$$\text{Wall thickness per UG-45(a): } t_{r1} = 0.0146 \text{ in (E=1)}$$

$$\text{Wall thickness per UG-45(b)(1): } t_{r2} = 0.748 \text{ in}$$



Wall thickness per UG-16(b):  $t_{r3} = 0.0625$  in

Standard wall pipe per UG-45(b)(4):  $t_{r4} = 0.1348$  in

The greater of  $t_{r2}$  or  $t_{r3}$ :  $t_{r5} = 0.748$  in

The lesser of  $t_{r4}$  or  $t_{r5}$ :  $t_{r6} = 0.1348$  in

Required per UG-45 is the larger of  $t_{r1}$  or  $t_{r6} = 0.1348$  in

Available nozzle wall thickness new,  $t_n = 0.875 \times 0.218 = 0.1908$  in

The nozzle neck thickness is adequate.

# Reinforcement Calculations for MAP

The vessel wall thickness governs the MAP of this nozzle.

UG-37 Area Calculation Summary (in <sup>2</sup> ) For P = 223.72 psi @ 70 °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)							0.1348	0.1908

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 size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (L <sub>EG41</sub> )	0.1526	0.175	weld size is adequate
Nozzle to shell groove (Lower)	0.1526	0.1875	weld size is adequate

Calculations for internal pressure 223.72 psi @ 70 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(1.939, 0.9695 + (0.218 - 0) + (0.748 - 0)) \\
 &= 1.939 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_c) \\
 &= \text{MIN}(2.5*(0.748 - 0), 2.5*(0.218 - 0) + 0) \\
 &= 0.545 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-27(c)(1)

$$\begin{aligned}
 t_{rn} &= P \cdot R_n / (S_n \cdot E - 0.6 \cdot P) \\
 &= 223.7196 \cdot 0.9695 / (15,000 \cdot 1 - 0.6 \cdot 223.7196) \\
 &= 0.0146 \text{ in}
 \end{aligned}$$

Required thickness  $t_r$  from UG-37(a)

$$\begin{aligned}
 t_r &= P \cdot R / (S \cdot E - 0.6 \cdot P) \\
 &= 223.7196 \cdot 42 / (12,696 \cdot 1 - 0.6 \cdot 223.7196) \\
 &= 0.748 \text{ in}
 \end{aligned}$$

Required thickness  $t_r$  per Interpretation VIII-1-07-50

$$\begin{aligned}
 t_r &= P \cdot R / (S \cdot E - 0.6 \cdot P) \\
 &= 223.7196 \cdot 42 / (12,696 \cdot 1 - 0.6 \cdot 223.7196) \\
 &= 0.748 \text{ in}
 \end{aligned}$$

This opening does not require reinforcement per UG-36(c)(3)(a)

UW-16(d) Weld Check

$$\begin{aligned}
 t_{\min} &= \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.218 \text{ in} \\
 t_1(\min) \text{ or } t_2(\min) &= \text{lesser of } 0.25 \text{ or } 0.7 \cdot t_{\min} = 0.1526 \text{ in} \\
 t_1(\text{actual}) &= 0.7 \cdot \text{Leg} = 0.7 \cdot 0.25 = 0.175 \text{ in} \\
 \text{The weld size } t_1 &\text{ is satisfactory.} \\
 t_2(\text{actual}) &= 0.1875 \text{ in} \\
 \text{The weld size } t_2 &\text{ is satisfactory.}
 \end{aligned}$$

$$t_1 + t_2 = 0.3625 \geq 1.25 \cdot t_{\min}$$

The combined weld sizes for  $t_1$  and  $t_2$  are satisfactory.

UG-45 Nozzle Neck Thickness Check

$$\begin{aligned}
 \text{Wall thickness per UG-45(a):} & \quad t_{r1} = 0.0146 \text{ in (E=1)} \\
 \text{Wall thickness per UG-45(b)(1):} & \quad t_{r2} = 0.748 \text{ in} \\
 \text{Wall thickness per UG-16(b):} & \quad t_{r3} = 0.0625 \text{ in} \\
 \text{Standard wall pipe per UG-45(b)(4):} & \quad t_{r4} = 0.1348 \text{ in} \\
 \text{The greater of } t_{r2} \text{ or } t_{r3}: & \quad t_{r5} = 0.748 \text{ in} \\
 \text{The lesser of } t_{r4} \text{ or } t_{r5}: & \quad t_{r6} = 0.1348 \text{ in}
 \end{aligned}$$

Required per UG-45 is the larger of  $t_{r1}$  or  $t_{r6} = 0.1348 \text{ in}$

Available nozzle wall thickness new,  $t_n = 0.875 \times 0.218 = 0.1908$  in

The nozzle neck thickness is adequate.

## Reinforcement Calculations for External Pressure

UG-37 Area Calculation Summary (in <sup>2</sup> ) For $P_e = 15 \text{ psi @ } 200^\circ\text{F}$							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)							0.0625	0.1908

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 size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (L <sub>g41</sub> )	0.1526	0.175	weld size is adequate
Nozzle to shell groove (Lower)	0.1526	0.1875	weld size is adequate

Calculations for external pressure 15 psi @ 200 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(1.939, 0.9695 + (0.218 - 0) + (0.748 - 0)) \\
 &= 1.939 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5(t - C), 2.5(t_n - C_n) + t_c) \\
 &= \text{MIN}(2.5(0.748 - 0), 2.5(0.218 - 0) + 0) \\
 &= 0.545 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28  $t_{rn} = 0.0112 \text{ in}$ From UG-37(d)(1) required thickness  $t_r = 0.3444 \text{ in}$ 

This opening does not require reinforcement per UG-36(c)(3)(a)

UW-16(d) Weld Check

$$\begin{aligned}
 t_{\min} &= \text{lesser of } 0.75 \text{ or } t_n \text{ or } t = 0.218 \text{ in} \\
 t_1(\min) \text{ or } t_2(\min) &= \text{lesser of } 0.25 \text{ or } 0.7 \cdot t_{\min} = 0.1526 \text{ in} \\
 t_1(\text{actual}) &= 0.7 \cdot L_{eg} = 0.7 \cdot 0.25 = 0.175 \text{ in} \\
 \text{The weld size } t_1 &\text{ is satisfactory.} \\
 t_2(\text{actual}) &= 0.1875 \text{ in} \\
 \text{The weld size } t_2 &\text{ is satisfactory.} \\
 t_1 + t_2 &= 0.3625 \geq 1.25 \cdot t_{\min}
 \end{aligned}$$

The combined weld sizes for  $t_1$  and  $t_2$  are satisfactory.

UG-45 Nozzle Neck Thickness Check

$$\begin{aligned}
 \text{Wall thickness per UG-45(a):} & \quad t_{r1} = 0.0112 \text{ in} \\
 \text{Wall thickness per UG-45(b)(2):} & \quad t_{r2} = 0.0497 \text{ in} \\
 \text{Wall thickness per UG-16(b):} & \quad t_{r3} = 0.0625 \text{ in} \\
 \text{Standard wall pipe per UG-45(b)(4):} & \quad t_{r4} = 0.1348 \text{ in} \\
 \text{The greater of } t_{r2} \text{ or } t_{r3}: & \quad t_{r5} = 0.0625 \text{ in} \\
 \text{The lesser of } t_{r4} \text{ or } t_{r5}: & \quad t_{r6} = 0.0625 \text{ in}
 \end{aligned}$$

Required per UG-45 is the larger of  $t_{r1}$  or  $t_{r6} = 0.0625 \text{ in}$ Available nozzle wall thickness new,  $t_n = 0.875 \cdot 0.218 = 0.1908 \text{ in}$ 

The nozzle neck thickness is adequate.

## Reinforcement Calculations for MAEP

UG-37 Area Calculation Summary (in <sup>2</sup> ) For $P_c = 106.73$ psi @ 200 °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)							0.1348	0.1908

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 size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg <sub>41</sub> )	0.1526	0.175	weld size is adequate
Nozzle to shell groove (Lower)	0.1526	0.1875	weld size is adequate

Calculations for external pressure 106.73 psi @ 200 °F

Parallel Limit of reinforcement per UG-40

$$\begin{aligned}
 L_R &= \text{MAX}(d, R_n + (t_n - C_n) + (t - C)) \\
 &= \text{MAX}(1.939, 0.9695 + (0.218 - 0) + (0.748 - 0)) \\
 &= 1.939 \text{ in}
 \end{aligned}$$

Outer Normal Limit of reinforcement per UG-40

$$\begin{aligned}
 L_H &= \text{MIN}(2.5*(t - C), 2.5*(t_n - C_n) + t_e) \\
 &= \text{MIN}(2.5*(0.748 - 0), 2.5*(0.218 - 0) + 0) \\
 &= 0.545 \text{ in}
 \end{aligned}$$

Nozzle required thickness per UG-28  $t_{rn} = 0.0247$  in

From UG-37(d)(1) required thickness  $t_r = 0.748$  in

This opening does not require reinforcement per UG-36(c)(3)(a)

UW-16(d) Weld Check

$t_{min}$  = lesser of 0.75 or  $t_n$  or  $t = 0.218$  in  
 $t_1(min)$  or  $t_2(min)$  = lesser of 0.25 or  $0.7*t_{min} = 0.1526$  in  
 $t_1(actual) = 0.7*Leg = 0.7*0.25 = 0.175$  in  
 The weld size  $t_1$  is satisfactory.  
 $t_2(actual) = 0.1875$  in  
 The weld size  $t_2$  is satisfactory.

$$t_1 + t_2 = 0.3625 \geq 1.25*t_{min}$$

The combined weld sizes for  $t_1$  and  $t_2$  are satisfactory.

UG-45 Nozzle Neck Thickness Check

Wall thickness per UG-45(a):  $t_{r1} = 0.0247$  in  
 Wall thickness per UG-45(b)(2):  $t_{r2} = 0.3549$  in  
 Wall thickness per UG-16(b):  $t_{r3} = 0.0625$  in  
 Standard wall pipe per UG-45(b)(4):  $t_{r4} = 0.1348$  in  
 The greater of  $t_{r2}$  or  $t_{r3}$ :  $t_{r5} = 0.3549$  in  
 The lesser of  $t_{r4}$  or  $t_{r5}$ :  $t_{r6} = 0.1348$  in

Required per UG-45 is the larger of  $t_{r1}$  or  $t_{r6} = 0.1348$  in

Available nozzle wall thickness new,  $t_n = 0.875*0.218 = 0.1908$  in

The nozzle neck thickness is adequate.

External Pressure, (Corroded & at 200 °F) UG-28(c)

$$\begin{aligned}
 L/D_o &= 6.0165 / 2.375 = 2.5333 \\
 D_o/t &= 2.375 / 0.0247 = 96.2255 \\
 \text{From table G: } A &= 0.000535 \\
 \text{From table CS-2: } B &= 7,702.8735 \text{ psi}
 \end{aligned}$$

$$\begin{aligned}
 P_a &= 4*B / (3*(D_o/t)) \\
 &= 4*7,702.87 / (3*(2.375 / 0.0247)) \\
 &= 106.73 \text{ psi}
 \end{aligned}$$

Design thickness for external pressure  $P_a = 106.73$  psi

$$t_a = t + \text{Corrosion} = 0.0247 + 0 = 0.0247''$$



Atmospheric Pressure 1,600 mm Hg  
3.277 Lpm



ISO 9001:2008

# NDE CONTINUATION REPORT

REPORT: U MB120509

ACUREN

CLIENT: Husky Oil May 2012 Plant Shut Down

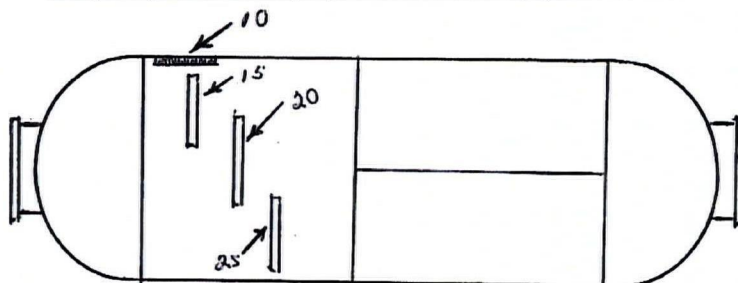
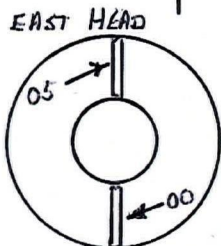
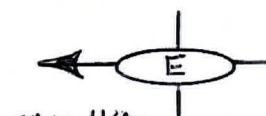
DATE: 9-May-12

PAGE: 14 OF 14

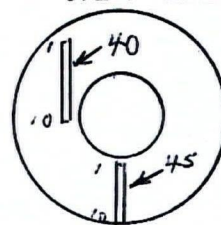
## RESULTS:

A# 17726

FLARE KNOCK OUT DRUM



WEST HEAD



00-1	0.687"	10-1	0.785"	20-1	0.772"	40-1	0.644"
-2	0.687"	-2	0.787"	-2	0.768"	-2	0.647"
-3	0.685"	-3	0.788"	-3	0.768"	-3	0.642"
-4	0.696"	-4	0.792"	-4	0.778"	-4	0.640"
-5	0.700"	-5	0.791"	-5	0.773"	-5	0.642"
-6	0.638"	-6	0.788"	-6	0.770"	-6	0.643"
-7	0.673"	-7	0.790"	-7	0.790"	-7	0.645"
-8	0.729"	-8	0.793"	-8	0.769"	-8	0.648"
-9	0.764"	-9	0.786"	-9	0.763"	-9	0.647"
-10	0.869"	-10	0.779"	-10	0.774"	-10	0.663"
05-1	0.765"	15-1	0.786"	25-1	0.758"	45-1	0.662"
-2	0.763"	-2	0.790"	-2	0.762"	-2	0.673"
-3	0.714"	-3	0.788"	-3	0.754"	-3	0.663"
-4	0.723"	-4	0.791"	-4	0.755"	-4	0.662"
-5	0.718"	-5	0.795"	-5	0.762"	-5	0.664"
-6	0.725"	-6	0.796"	-6	0.751"	-6	0.670"
-7	0.721"	-7	0.790"	-7	0.755"	-7	0.665"
-8	0.707"	-8	0.787"	-8	0.752"	-8	0.687"
-9	0.705"	-9	0.792"	-9	0.760"	-9	0.662"
-10	0.701"	-10	0.792"	-10	0.748"	-10	0.663"

## SIGNATURES:

TECHNICIAN (SIGN):

PRINT NAME

Marcel Bertrand

1<sup>ST</sup> TECHNICIAN

2<sup>ND</sup> TECHNICIAN / ASSISTANT



VESSEL (A): 0017726

Equip 66005116



## Replacement

# Certificate of Inspection Permit

Based on Last Inspection performed by an ABSA Safety Codes Officer

### HUSKY OIL OPERATIONS LTD

BOX 6525 STN D  
CALGARY/WESTERN CDA UPSTREAM  
ATTN DALE MARTIN  
CALGARY AB  
T2P 3G7

Issue Date: 2013 May 14

Year Built: 1953

CRN: 4317.2

Serial #: 1012-D-2

Volume: 15.01 m<sup>3</sup>

Heating Surface:

Surface Area:

COMPANY CODE: 66005116

DESCRIPTION: FLARE KNOCK OUT DRUM

LOCATION: LSD SYLVAN LAKE GAS PLANT 01-21-038-02W5

MANUFACTURER: BARBER MACHINERY CO. LTD.

### Pressure Relief Valves

PART	MAX. ALLOWABLE PRESSURE	Temperature			VALVE ID	SETTING		CAPACITY		LOCATION
		Max	Min							
VESSEL	1,337 KPA	93	0	C	SV1	1	KPA	0	MM	OPEN TO ATMOSPHERE

### Terms and Conditions:

Owner must ensure this vessel/boiler is designed, constructed, installed, operated, maintained and decommissioned in accordance with the Safety Codes Act and Regulations.

Owner must ensure an integrity assessment of this vessel/boiler is conducted after it is installed but prior to its operation. The integrity assessment shall be conducted by a person holding qualifications acceptable to the Administrator. Refer to ABSA publications AB-506, AB-512 and AB-515 for details about qualifications acceptable to the Administrator.

Owner must ensure this vessel/boiler has overpressure protection that is a relief valve that meets the requirements of the ASME Code, or other means accepted by the Administrator expressly for this item.

Owner must establish and maintain an integrity assessment program for this vessel/boiler. Refer to ABSA publication AB-506 for integrity assessment program requirements.

Owner must ensure this vessel/boiler, its overpressure protection devices, pressure gauges and regulating or controlling devices are maintained in good working order and operated safely.

**Replacement Permit to take the place of the permit previously issued for this boiler/vessel. Owner must ensure this vessel/boiler is in safe operating condition.**

### NOTE: REQUIREMENTS OF THE SAFETY CODES ACT AND THE REGULATIONS ISSUED THEREUNDER:

An owner or vendor must notify the Administrator in writing when the pressure equipment identified on this certificate is sold or otherwise disposed of.

The owner or person in charge shall report all accidents involving Pressure Equipment to the district Safety Codes Officer immediately and shall send a full report in writing to the Administrator as required by the Act. No repairs or alterations may be made unless authorized by a Safety Codes Officer.





# AFFIDAVIT OF MANUFACTURER

## Covering Boiler or Pressure Vessel

As Approved by the Boiler & Pressure Vessel Committee of the C.S.A.

Upon shipment of Boiler or Pressure Vessel this form fully and correctly filled in and attested to must be mailed to the office of the Chief Inspector in the province of installation in accordance with the regulations under The Act governing the construction and installation of boilers and pressure vessels, otherwise the use of same may be prohibited or the working pressure severely penalized.

- Manufactured by Barber Machinery Ltd. - Calgary, Alberta.  
(Name and Address of Manufacturer)  
Manufactured for Canadian Western Natural Gas Company Ltd.  
(Name and Address of Purchaser or Consignee)  
Ultimate owner Canadian Western Natural Gas Company Ltd.  
(Name and Address)  
Location of installation Brooks' Gas Plant, Brooks, Alberta.  
(This address is essential)
- Type of boiler or pressure vessel Gas Purifier Mfg. Serial No. 1012-D-2.  
Provincial Registration No. 4317.2 Drwg. No. B-1012-D  
To be used for: (Air, CO<sub>2</sub>, Propan., Ammonia, Steam, Hot Water, etc.) Natural Gas
- Dia 7" - 0" I.D. Overall length 20" - 4" Cu. ft. capacity 530 Heating surface - sq. ft.
- Were test reports checked on all plates used in the fabrication of this vessel? Yes  
Does all material meet A.S.M.E. Code requirements? Yes  
A.S.M.E., A.S.T.M. or other material specification No. A-285-C Tensile strength 55,000 (Min)
- If welded or brazed, what paragraph of Code: (P101 to P114 or U68, U69 or U70; U-200 or U-201; etc?) U  
Was vessel stress relieved? No Was vessel X-rayed? No  
Are the following records on mfg's files? X-ray films No Stress relieving procedure No  
Spot Examinations  
Were ~~these examinations~~ and found to meet Code requirements? OK U - 52e.
- Welders employed upon vessel.

Name of welders and Province or State in which qualified	Identifying Symbol	Date of last weld test	Qualified for welding under Code Para.	Name of Inspector supervising tests	National Board No.
<u>C. Schott</u>	<u>203</u>	<u>Jan. 4/51</u>	<u>U-69</u>	<u>H.N. Inkes.</u>	
<u>W. Wusyk</u>	<u>W-8</u>	<u>" " "</u>	<u>U-69</u>	<u>H.N. Inkes.</u>	

Does all welding on this vessel and the testing of coupons where required meet A.S.M.E. Code requirements? Yes

- Hydrostatic tests and Working Pressures.

NAME OF PART	Hammer tested at psi.	Final test psi.	Maximum working pressure psi	Maximum operating temperature degrees F.
<u>Entire Vessel</u>	<u>292</u>	<u>388</u>	<u>194.</u>	<u>200</u>

Did the hydrostatic tests fully conform to Code requirements? Yes

- SAFETY VALVES:-

No. of valves	Maker's Name, Trade Mark or Type No.	Provincial Registration No.	Inlet Diameter	Seat Diameter	Set to relieve at psi.	Free discharge area	Capacity lbs. per hour
	<u>Not Supplied.</u>						

Does safety valve stamping, blow-down adjustment, etc., meet A.S.M.E. requirements?

8. Actual minimum stamping of the vessel shall conform to the following and shall be reproduced here:

**FOR POWER & HEATING BOILERS** (on attached plate for cast iron)

Canadian Interprovincial Registration number \_\_\_\_\_ C.I.S. \_\_\_\_\_  
National Board number (if manufactured in U.S.A.) \_\_\_\_\_ Nat. Bd. \_\_\_\_\_  
Manufacturer and manufacturers' serial number \_\_\_\_\_ Sr. No. \_\_\_\_\_  
Plate mfg's initials, spec. No. and tensile strength (Stelco. SA 285 etc.) \_\_\_\_\_ T.S. \_\_\_\_\_  
Maximum working pressure \_\_\_\_\_ (for S and W if both) Max. W.P. \_\_\_\_\_ Lbs. \_\_\_\_\_  
Heating surface and year built (1949 etc.) \_\_\_\_\_ H.S. \_\_\_\_\_ Ft. \_\_\_\_\_  
Initials of authorized provincial shop inspector \_\_\_\_\_

**UNFIRED PRESSURE VESSEL—**

Canadian Interprovincial Registration number \_\_\_\_\_ C.I.S. 4317.2  
National Board number (if manufactured in U.S.A.) \_\_\_\_\_ Nat. Bd. \_\_\_\_\_  
Manufacturer and manufacturers' serial number Barber Machinery Ltd. Sr. No. 1012-D-2  
Plate mfg's initials, spec. No. and tensile strength (Stelco. SA 285 etc.) SA-285-C T.S. 55,000  
Maximum working pressure and temperature \_\_\_\_\_ Max. W.P. 194 Temp. 200  
Thickness of shell and heads \_\_\_\_\_ T. Shell 3/4 T. Heads 5/8  
Code paragraph number and year built (1949 etc.) \_\_\_\_\_ U. W 1953

10. I HEREBY DECLARE that the foregoing statements, having reference to Vessel bearing manufacturers' Serial No. 1012-D-2, built by Barber Machinery Ltd. of Calgary, Alberta.

and completed on the 5th day of August 19 53, are in all respects correct and true, and that the said Vessel has been built in accordance with Provincial registered design No. 4317.2 and that it complies fully with the A.S.M.E. Code and regulations of the Province of Installation under The Act governing the construction of boilers and pressure vessels.

Sworn before me at Calgary  
in the Province (or State) of Alberta,  
this 5 day of August 19 53.  
P. E. Easton  
A Commissioner of Oaths, J.P. or N.P.

Signed [Signature] Shop Foreman.  
For Barber Machinery  
Calgary, Alberta.  
Firm Name and Address.

My commission expires December 31, 1954.

11.

**CERTIFICATE OF SHOP INSPECTION**

I, the undersigned, a duly authorized Inspector of Boilers and Pressure Vessels employed by Dept. of Labour Boiler Inspection Dept. of Alberta Government.

do hereby certify that the foregoing statements are correct and that the material, construction and workmanship are in accordance with the A.S.M.E. Code.

Date August, 1953 Signed [Signature] No. \_\_\_\_\_  
Provincial or National Board Inspector.

**TO BE FILLED IN BY ALBERTA INSPECTOR**

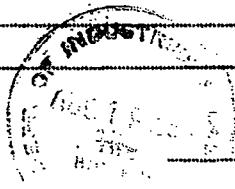
12 Received August 5, 19 53. Inspector's Pressure Vessel No. (A) 17726

Checked August 10, 19 53.

I have allowed a working pressure of 194 lbs. per square inch, based on a F.S. of 4  
and have issued Certificate No. 36682 B therefor.

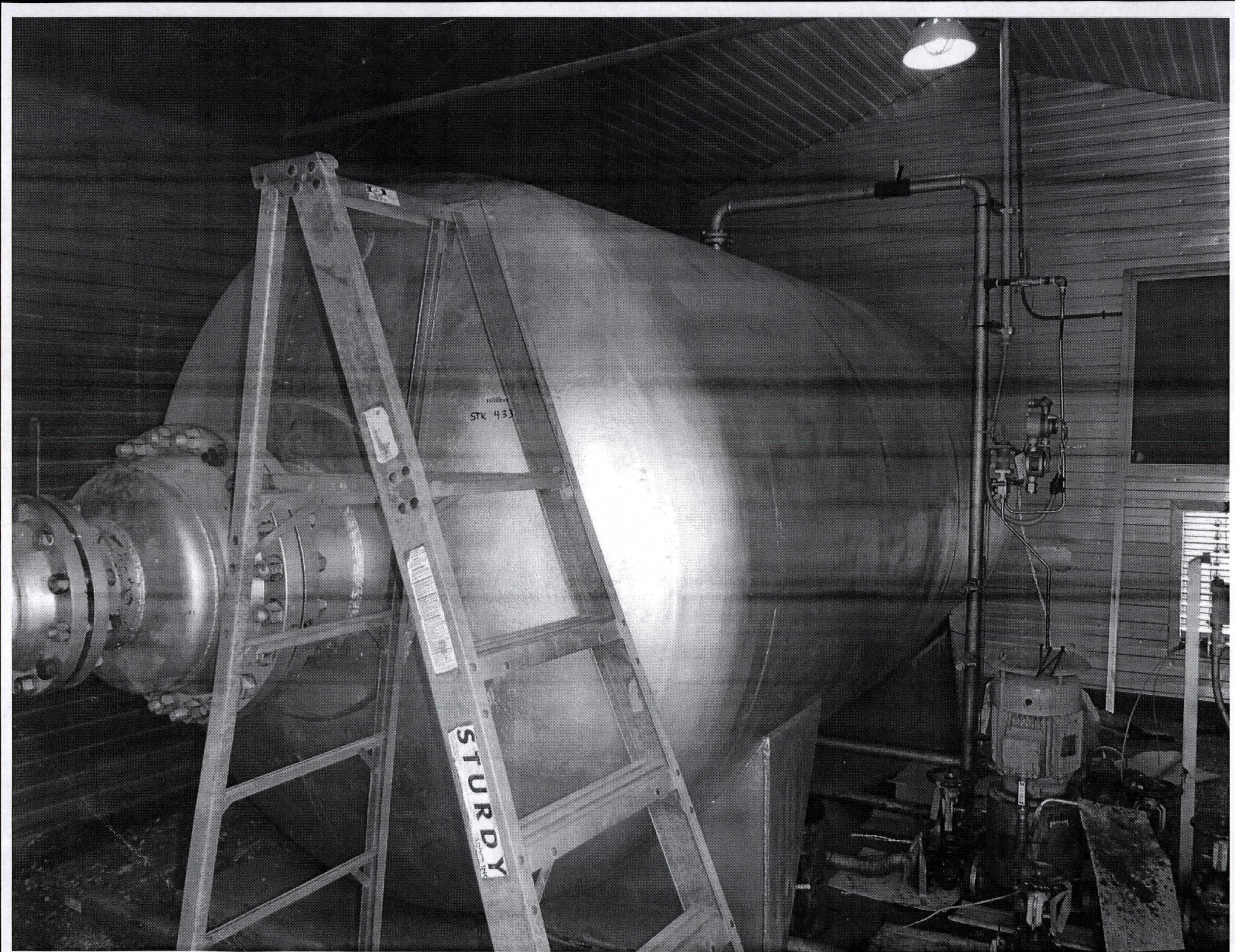
Vessel owned by Barber Machinery Ltd. of Calgary, Alberta.

Remarks: For Sale to Canadian Western Natural Gas Company Ltd.



[Signature]  
(Signature of Alberta Inspector.)

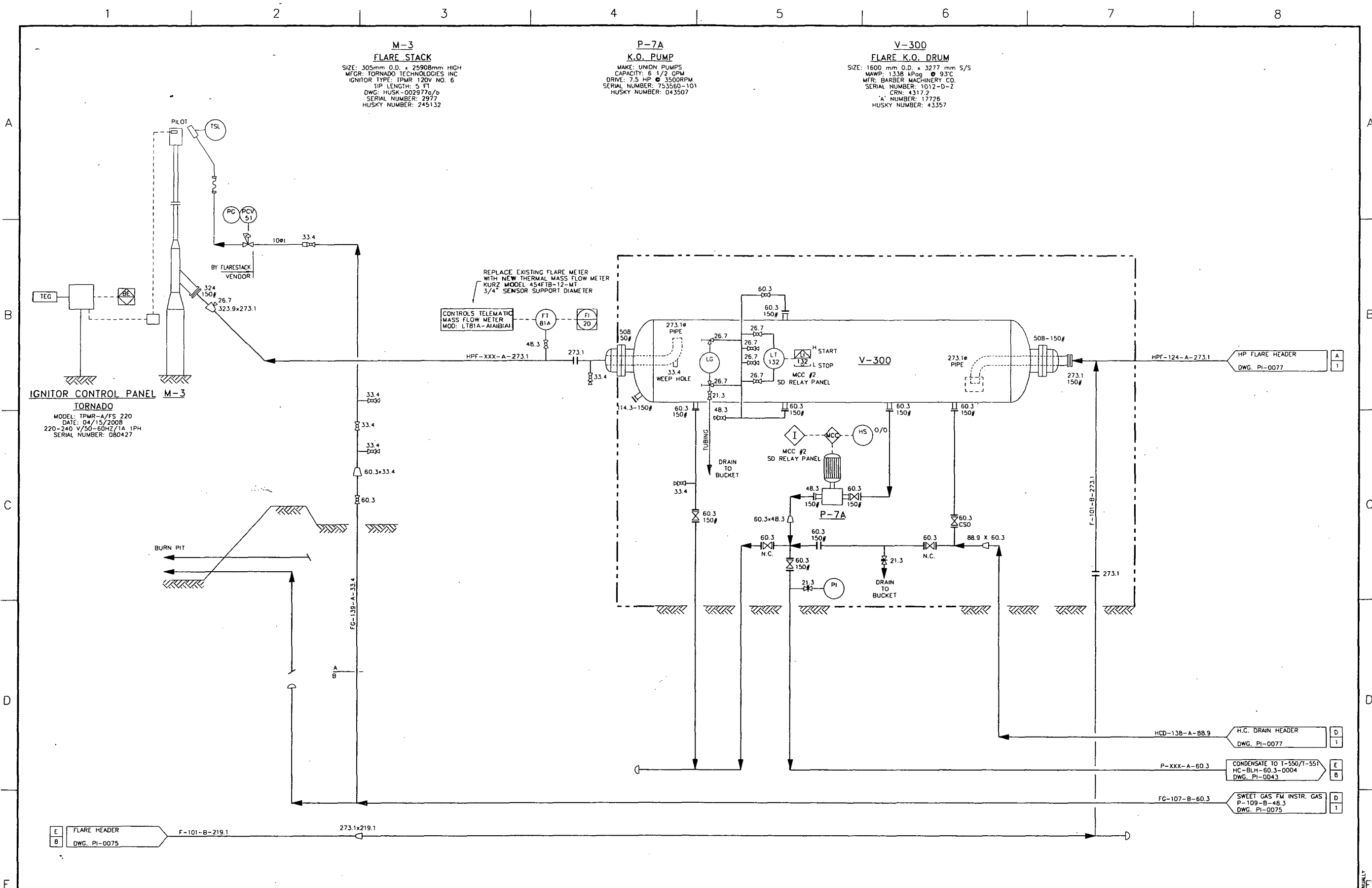












REF DWG NO	REFERENCE DRAWING DESCRIPTION	NO	REVISION HISTORY	REV AUTHOR	REV DATE	ISSUED FOR	NO	CURRENT REVISION	ISSUED FOR AS BUILT
		A	ISSUED FOR APPROVAL	EPC_MAJESTIC	2006/10/02	APPROVAL	6	AS BUILT FOR PO 8400774466 STANTEC 110616933.1100.2	DOC DATE 2014/05/19
		1	AS BUILT	EPC_CALTECH	2007/02/21	AS BUILT			DOC AUTHOR STANTEC
		2	AS BUILT, CALTECH CS11604	EPC_CALTECH	2007/09/14	AS BUILT			SCALE NTS
		3	ISSUED FOR CONSTRUCTION FOR EWR 11794-001	MILLED	2008/04/29	CONSTRUCTION			ALTERNATE IDENTIFIER D-7563-05
		4	INSTRUMENTATION AS BUILT, CALTECH CS11604	EPC_CALTECH	2008/06/24	AS BUILT			SURFACE LSO D1-21-038-02W5
		5	AS BUILT PER FIELD MARK-UPS FOR CC 77024 STANTEC 110616306	STANTEC	2013/02/19	AS BUILT			DOCUMENT IDENTIFIER PI-0076-01
		6							

**Husky Energy**

SYLVAN LAKE 01-21-038-02W5 GAS PLANT

V-300 FLARE KNOCKOUT DRUM & M-3 FLARE STACK  
 PIPING & INSTRUMENTATION DIAGRAM

DO NOT CHANGE MANUALLY

Table 7-1—Values of Spherical Radius Factor  $K_1$ 

$D/2h$	$K_1$
3.0	1.36
2.8	1.27
2.6	1.18
2.4	1.08
2.2	0.99
2.0	0.90
1.8	0.81
1.6	0.73
1.4	0.65
1.2	0.57
1.0	0.50

Note: The equivalent spherical radius equals  $K_1 D$ ; the axis ratio equals  $D/2h$ . Interpolation is permitted for intermediate values.

such as those documented in API 579, may be used for this evaluation and must be applicable to the specific damage observed. The following techniques may be used as an alternative to the evaluation techniques in 7.4.

- To evaluate metal loss in excess of the corrosion allowance, a fitness-for-service assessment may be performed in accordance with API 579, Parts 4 or 5, as applicable. This assessment requires the use of a future corrosion allowance, which shall be established based on Section 6 of this inspection code.
- To evaluate blisters and laminations, a fitness-for-service assessment should be performed in accordance with API 579, Part 7. In some cases, this evaluation will require the use of a future corrosion allowance, which shall be established based on Section 6 of this inspection code.
- To evaluate weld misalignment and shell distortions, a fitness-for-service assessment should be performed in accordance with API 579, Part 8.
- To evaluate crack-like flaws, a fitness-for-service assessment should be performed in accordance with API 579, Part 9. When manual shear wave ultrasonic techniques are employed to size flaws, an industry-qualified UT shear wave examiner shall be used.
- To evaluate the effects of fire damage, a fitness-for-service assessment should be performed in accordance with API 579, Part 11.

## 7.6 Required Thickness Determination

The required thickness shall be based on pressure, mechanical, and structural considerations using the appropriate design formulae and code allowable stress. For services with high potential consequences if failure were to occur, the engineer should consider increasing the required thickness above the calculated minimum thickness to provide for unanticipated or unknown loadings, undiscovered metal loss, or resistance to normal abuse.

## 7.7 Evaluation Of Existing Equipment With Minimal Documentation

For pressure vessels that have no nameplate and minimal or no design and construction documentation, the following steps may be used to verify operating integrity:

- Perform inspection to determine condition of the vessel.
- Define design parameters and prepare drawings.
- Perform design calculations based on applicable codes and standards. Do not use allowable stress values of the current ASME Code (based on design factor of 3.5) for vessels designed to an edition or addendum of the ASME Code earlier than the 1999 Addenda and was not designed to Code Case 2290 or 2278.

See ASME Code Section VIII, Division I, Paragraph UG-10(c) for guidance on evaluation of unidentified materials. If UG-10(c) is not followed, then for carbon steels, use allowable stresses for SA-283 Grade C; and for alloy and nonferrous materials, use x-ray fluorescence analysis to determine material type on which to base allowable stress values.

When extent of radiography originally performed is not known, use joint factor of 0.7 for butt welds, or consider performing radiography if a higher joint factor is required. (Recognize that performing radiography on welds in a vessel with minimal or no design and construction documentation may result in the need for a fitness-for-service evaluation and significant repairs.)

4. Attach a nameplate or stamping showing the maximum allowable working pressure and temperature, minimum allowable temperature, and date.
5. Perform pressure test as soon as practical, as required by code of construction used for design calculations.

## 7.8 Reports And Records

**7.8.1** Pressure vessel owners and users shall maintain permanent and progressive records of their pressure vessels and pressure-relieving devices. Permanent records will be maintained throughout the service life of each equipment item; progressive records will be regularly updated to include new information pertinent to the operation, inspection, and maintenance history of the equipment.

**7.8.2** Pressure vessel and pressure-relieving device records shall contain four types of information pertinent to mechanical integrity as follows:

- a. Construction and design information. For example, equipment serial number or other identifier, manufacturer's data reports (MDRs), design specification data, vessel design calculations, pressure-relieving device sizing calculations and construction drawings.
- b. Inspection history. For example, inspection reports, and data for each type of inspection conducted (for example, internal, external, thickness measurements), and inspection recommendations for repair. Inspection reports shall document the date of each inspection and/or examination, the date of the next scheduled inspection, the name of the person who performed the inspection and/or examination, the serial number or other identifier of the equipment inspected, a description of the inspection and/or examination performed, and the results of the inspection and/or examination. Pressure vessel RBI records should be in accordance with API 580, Section 16.
- c. Repair, alteration, and rerating information. For example, (1) repair and alteration forms like that shown in Appendix D; (2) reports indicating that equipment still in-service with either identified deficiencies, temporary repairs or recommendations for repair, are suitable for continued service until repairs can be completed; and (3) rerating documentation (including rerating calculations, new design conditions, and evidence of stamping).
- d. Fitness-for-service assessment documentation requirements are described in API 579, Part 2.8. Specific documentation requirements for the type of flaw being assessed are provided in the appropriate part of API 579.

**7.8.3** Site operating and maintenance records, such as operating conditions, including process upsets that may affect mechanical integrity, mechanical damage from maintenance should also be available to the inspector.



# AFFIDAVIT OF MANUFACTURER

## Covering Boiler or Pressure Vessel

As Approved by the Boiler & Pressure Vessel Committee of the C.S.A.

Upon shipment of Boiler or Pressure Vessel this form fully and correctly filled in and attested to must be mailed to the office of the Chief Inspector in the province of installation in accordance with the regulations under The Act governing the construction and installation of boilers and pressure vessels, otherwise the use of same may be prohibited or the working pressure severely penalized.

- Manufactured by Barber Machinery Ltd. - Calgary, Alberta.  
(Name and Address of Manufacturer)  
Manufactured for Canadian Western Natural Gas Company Ltd.  
(Name and Address of Purchaser or Consignee)  
Ultimate owner Canadian Western Natural Gas Company Ltd.  
(Name and Address)  
Location of installation Brooks' Gas Plant, Brooks, Alberta.  
(This address is essential)
- Type of boiler or pressure vessel Gas Purifier Mfg. Serial No. 1012-D-2.  
Provincial Registration No. 4317.2 Drwg. No. B-1012-D  
To be used for: (Air, CO<sub>2</sub>, Propane, Ammonia, Steam, Hot Water, etc.) Natural Gas
- Dia. 7" - 0" I.D. Overall length 20' - 4" Cu. ft. capacity 530 Heating surface - sq. ft.
- Were test reports checked on all plates used in the fabrication of this vessel? Yes  
Does all material meet A.S.M.E. Code requirements? Yes  
A.S.M.E., A.S.T.M. or other material specification No. A-285-C Tensile strength 55,000 (Min)
- If welded or brazed, what paragraph of Code: (P101 to P114 or U68, U69 or U70; U-200 or U-201; etc?) U  
Was vessel stress relieved? No Was vessel X-rayed? No  
Are the following records on mfg's files? X-ray films No Stress relieving procedure No  
Spot Examinations  
Were ~~hydrostatic tests~~ and found to meet Code requirements? OK U - 52e.
- Welders employed upon vessel.

Name of welders and Province or State in which qualified	Identifying Symbol	Date of last weld test	Qualified for welding under Code Para.	Name of Inspector supervising tests	National Board No.
<u>G. Schott</u>	<u>203</u>	<u>Jan. 4/51</u>	<u>U-69</u>	<u>H.N. Inkes,</u>	
<u>W. Wusyk</u>	<u>W-8</u>	<u>" " "</u>	<u>U-69</u>	<u>H.N. Inkes,</u>	

Does all welding on this vessel and the testing of coupons where required meet A.S.M.E. Code requirements? Yes

- Hydrostatic tests  
and  
Working Pressures.

NAME OF PART	Hammer tested at psi.	Final test psi.	Maximum working pressure psi.	Maximum operating temperature degrees F.
<u>Entire Vessel</u>	<u>292</u>	<u>388</u>	<u>194.</u>	<u>200</u>

Did the hydrostatic tests fully conform to Code requirements? Yes

- SAFETY VALVES:—

No. of valves	Maker's Name, Trade Mark or Type No.	Provincial Registration No.	Inlet Diameter	Seat Diameter	Set to relieve at psi.	Free discharge area	Capacity lbs. per hour
	<u>Not Supplied.</u>						

Does safety valve stamping, blow-down adjustment, etc., meet A.S.M.E. requirements? \_\_\_\_\_



9. Actual minimum stamping of the vessel shall conform to the following and shall be reproduced here:

**FOR POWER & HEATING BOILERS (on attached plate for cast iron)**

Canadian Interprovincial Registration number \_\_\_\_\_ C.I.S. \_\_\_\_\_  
National Board number (if manufactured in U.S.A.) \_\_\_\_\_ Nat. Bd. \_\_\_\_\_  
Manufacturer and manufacturers' serial number \_\_\_\_\_ Sr. No. \_\_\_\_\_  
Plate mfg's initials, spec. No. and tensile strength (Stelco. SA 285 etc.) \_\_\_\_\_ T.S. \_\_\_\_\_  
Maximum working pressure \_\_\_\_\_ (for S and W if both) Max. W.P. \_\_\_\_\_ Lbs. \_\_\_\_\_  
Heating surface and year built (1949 etc.) \_\_\_\_\_ H.S. \_\_\_\_\_ Ft. \_\_\_\_\_  
Initials of authorized provincial shop inspector \_\_\_\_\_

**UNFIRED PRESSURE VESSEL—**

Canadian Interprovincial Registration number \_\_\_\_\_ C.I.S. 4317.2  
National Board number (if manufactured in U.S.A.) \_\_\_\_\_ Nat. Bd. \_\_\_\_\_  
Manufacturer and manufacturers' serial number Barber Machinery Ltd. Sr. No. 1012-D-2  
Plate mfg's initials, spec. No. and tensile strength (Stelco. SA 285 etc.) SA-285-C T.S. 55,000  
Maximum working pressure and temperature \_\_\_\_\_ Max. W.P. 19 1/4 Temp. 200  
Thickness of shell and heads \_\_\_\_\_ T. Shell 3/4 T. Heads 5/8  
Code paragraph number and year built (1949 etc.) \_\_\_\_\_ U. W 1953

10. I HEREBY DECLARE that the foregoing statements, having reference to Vessel bearing manufacturers' Serial No. 1012-D-2, built by Barber Machinery Ltd. of Calgary, Alberta.

and completed on the 5th day of August 19 53 are in all respects correct and true, and that the said Vessel has been built in accordance with Provincial registered design No. 4317.2 and that it complies fully with the A.S.M.E. Code and regulations of the Province of Installation under The Act governing the construction of boilers and pressure vessels.

Sworn before me at Calgary  
in the Province (or State) of Alberta.  
this 5 day of August 19 53.  
P. E. Easton  
A Commissioner of Oaths, J.P. or N.P.

Signed

E. Kutnyk  
Shop Foreman.

For Barber Machinery

Calgary, Alberta.

Firm Name and Address.

My commission expires December 31, 1954.

11.

**CERTIFICATE OF SHOP INSPECTION**

I, the undersigned, a duly authorized Inspector of Boilers and Pressure Vessels employed by Dept. of Labour Boiler Inspection Dept. of Alberta Government.

do hereby certify that the foregoing statements are correct and that the material, construction and workmanship are in accordance with the A.S.M.E. Code.

Date August, 1953.

Signed

P. E. Easton  
Provincial or National Board Inspector.

**TO BE FILLED IN BY ALBERTA INSPECTOR**

12 Received August 5, 19 53.

Inspector's Pressure Vessel No. (A) 17726

Checked August 10, 19 53.

I have allowed a working pressure of 19 1/4 lbs. per square inch, based on a F.S. of 4.

and have issued Certificate No. 36682 B therefor.

Vessel owned by Barber Machinery Ltd. of Calgary, Alberta.

Remarks: For Sale to Canadian Western Natural Gas Company Ltd.

P. E. Easton  
(Signature of Alberta Inspector.)

# Pressure Vessel External Visual Inspection Report



Organization: Husky

Inspection Date: 16/10/2008 12:00:00AM

Plant: East Central

Equipment ID: 66005116

Asset No: 66005116

System: 00001 Sylvan Lake Gas Plant 01-21-038-02W5

Operating Unit: EC-SO-015 Sylvan Lake

## Background

Description:	Knock-Out, Flare
Asset Type:	

## Inspection

Inspector:	MANCELITA, E	Company:	N/A	Insulated:	
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## External Location Categories

Barrier Penetrations:		Damaged Insulation:		Vessel Supports:		Insulation Rings:	
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## Inspection Comments

ID	Description	Condition	Location	NCR	Comments
MANCELITA,		N/A			<ul style="list-style-type: none"><li>- The vessel is painted and is in good condition with no notable corrosion being found.</li><li>- The nameplate and registration number could not be located, visual inspection of the vessel external surface failed to locate the nameplate, not even the nameplate bracket, no stamping on the shell was evident. The piping and external attachments are in good condition. No sign of leaks</li><li>- The vessel has no PSV, does not require a PSV as it is directly connected to the flare stack and vented to atmosphere.</li><li>- The gauges are clear and in good condition.</li><li>- The vessel is level but appears not secured to its foundation.</li><li>- The overall condition of the vessel is good.</li></ul>

## ***Pressure Vessel External Visual Inspection Report***

### **Inspection Summary**

- The vessel is painted and is in good condition with no notable corrosion being found. - The nameplate and registration number could not be located, visual inspection of the vessel external surface failed to locate the nameplate, not even the nameplate bracket, no stamping on the shell was evident. The piping and external attachments are in good condition. No sign of leaks
- The vessel has no PSV, does not require a PSV as it is directly connected to the flare stack and vented to atmosphere. - The gauges are clear and in good condition.
- The vessel is level but appears not secured to its foundation. - The overall condition of the vessel is good.



Login Home Quality Assurance Help

EQ #	Exit	NO #
Copied	Scanned	Entered
		HDMS Linked

## KNOCK\_OUT INSPECTION REPORT

Print Back Cancel

### Inspection Report

Notification Number 6069867 Work Order 6072757  
Notification Desc Tank FLARE KNOCK-OUT Maintenance Plan QNATANK0064  
Tasklist Operation ( 5Y Inspection Interval ) 5Y Code Inspection Process KO Drum - Sw

### Equipment Static Data

Equipment Number	66005116	Equipment Description	KNOCK-OUT, FLARE
Class	KNOCK_OUT	Tag Number	01-21-038-02W5
Serial Number	1012-D-2	Year Built	
Manufacturer	BARBER MACHINERY CO. LTD.		
Location	EC-SO-015-00001	Location Description	SYLVAN LAKE GAS PLANT 01-21-038-02W5
Provincial Number	0017726	PM Activity	Code
Status Codes	NOPR ORAS	Equipment Status	In Service - Fully Utilized

CRN Number	4317.2	Code Stamp		Fluid Description	GAS/EMULSION
Fluid Service	SWEET	Internal Coating Exists	N	Length	11.00 FOOT
MDMT - Min. Design Metal Temp		Shell MAWP	194 PSI	Stress Relief	NONE
Vessel Diameter	84.0 IN	Volume	(1337142)	Ray	

### PRD Static Data

Equip ID	Location	Size		Set Pressure	Capacity	Manufacturer	Serial Number	Model Number	Next Service Date
		Inlet	Outlet						

### Process Data

Product Description Fluid Service ☐ Sweet ☐ Sour PPM  
Operating Pressure KPA Operating Temperature °C

### Pressure Test

Test Completed ☐ Yes ☐ No Test Acceptable ☐ Yes ☐ No Test Report #

### PSV Data

Tag/Serial No.	Location	Size		Set Pressure	Capacity	Model / Type	Service Date
		Inlet	Outlet				
NONE							

### Inspection History

Inspected By MANCELITA, E Inspection Date 2008.10.16

### Inspection Summary

An external and UT inspection was performed to verify the vessels integrity. Vessel was not secured, vessel has no nameplate, static data could not be confirmed, however the vessel is considered acceptable for continued service.

### Recommendations

- 1) Secure the vessel to its foundation.
- 2) Locate vessel nameplate or shell stamping to confirm vessel static datas.

### Repairs Completed

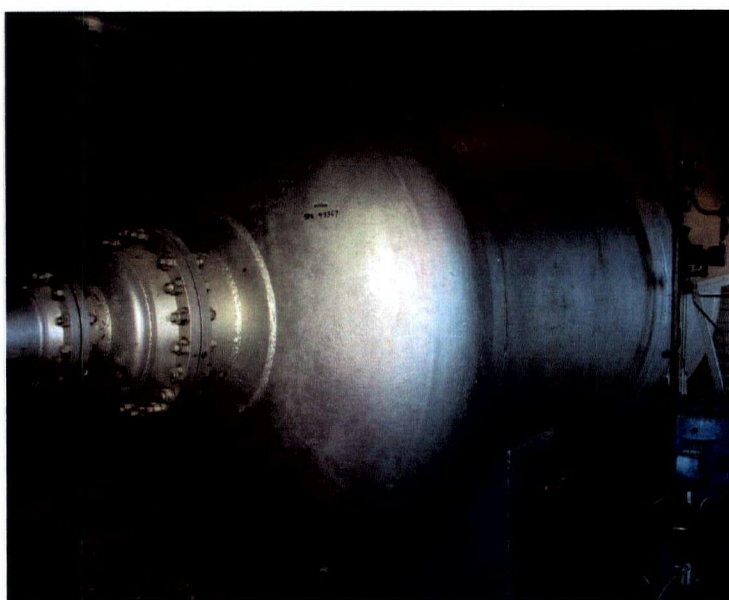
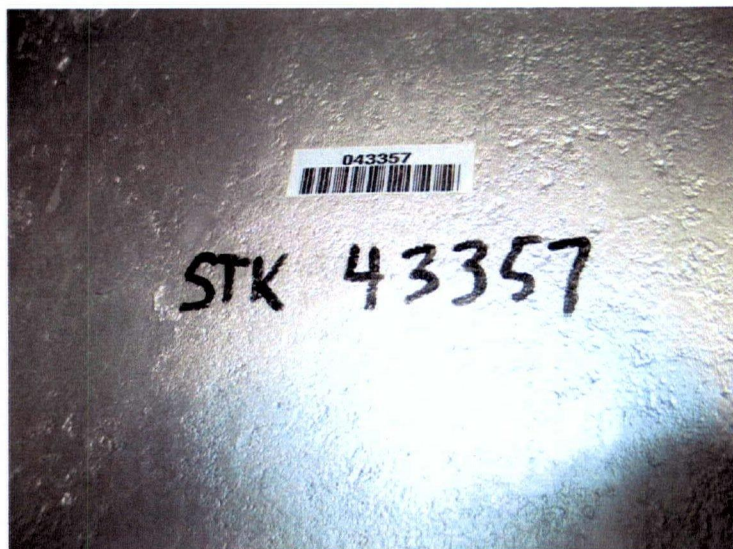
### Equipment Status

Integrity Status ☒ Suitable for Continued Service ☐ Immediate Repairs Required ☐ Replace  
☐ Future Repairs Required  
Inventory Status ☒ In Service - Fully Utilized ☐ Idle ☐ Surplus ☐ Scrap

### QA Activities

<input type="checkbox"/> Leave As-Is	<input type="checkbox"/> Weld Overlayed	<input type="checkbox"/> Part / Component Replaced
<input type="checkbox"/> Equipment Replaced	<input type="checkbox"/> Grind Dressed	<input type="checkbox"/> Patch Installed
<input type="checkbox"/> MAWP Derated	<input type="checkbox"/> Coating - Cleaned & Patched	<input type="checkbox"/> Coating - Removed & Replaced
<input type="checkbox"/> Defect Removed & Rewelded	<input type="checkbox"/> Part Cleaned	<input type="checkbox"/> Lapped & Dressed
<input type="checkbox"/> Epoxy Patched		

Oct, 16, 2008  
Insp Report Attachment 1-2  
Flare KO drum: "A" 17726 (Notif 6069867 )  
Sylvan Lake GP 01-21-038-02W5





Oct, 16, 2008  
Insp Report Attachment 1-2  
Flare KO drum: "A" 17726 (Notif 6069867 )  
Sylvan Lake GP 01-21-038-02W5



Vessel was not secured.

# Inspection History Report



Organization: Husky

System: 00001 SYLVAN LAKE GAS PLANT 01-21-0

Plant: East Central North

Equipment ID: 66005116

Operating Unit: EC-SO-015 SYLVAN LAKE

## Inspection List

Date	Inspection Type	Method	Inspector	Company	Summary
14/05/2003	OtherGeneral	UT Thickness	YUEN, MANLEY	N/A	External NDE Exam
14/05/2003	OtherGeneral	UT Thickness	YUEN, MANLEY	N/A	Ext. NDE is required
14/05/2003	VIInt		YUEN, MANLEY	N/A	Area inspector to confirm if internal inspection is required
14/05/2003	VIExt		YUEN, MANLEY	N/A	Vessel has good appearance. Paint is intact. No visible corrosion or damage. Piping is in good condition. Saddles and concrete base are in good condition. No nameplate or identification is found on the knockout drum. Identification is through plant records only. The vessel has obviously been altered from its original design. Shell is only 11' long as opposed to 20'04" as listed on manufacturer's data sheet. Shell diameter corresponds with dimension listed on data sheet.
16/10/2008	VIInt		MANCELITA, E	N/A	Area inspector to confirm if internal inspection is required
16/10/2008	OtherGeneral	UT Thickness	MANCELITA, E	N/A	External NDE Exam
16/10/2008	OtherGeneral	UT Thickness	MANCELITA, E	N/A	UT inspection was performed by Elmer Mancelita. All UT values were found to be acceptable. Shell $\phi$ 0.773 - 0.774 in. Head $\phi$ 0.827 - 0.828 in.
16/10/2008	VIExt		MANCELITA, E	N/A	<ul style="list-style-type: none"> <li>- The vessel is painted and is in good condition with no notable corrosion being found.</li> <li>- The nameplate and registration number could not be located, visual inspection of the vessel external surface failed to locate the nameplate, not even the nameplate bracket, no stamping on the shell was evident. The piping and external attachments are in good condition. No sign of leaks</li> <li>- The vessel has no PSV, does not require a PSV as it is directly connected to the flare stack and vented to atmosphere.</li> <li>- The gauges are clear and in good condition.</li> <li>- The vessel is level but appears not secured to its foundation.</li> <li>- The overall condition of the vessel is good.</li> </ul>
09/05/2012	NDE	UT	Acuren - Marcel Bertrand		A UT survey was carried out by Acuren Technician Marcel Bertrand. For details of this survey, refer to Report U MB120509 (page 14 of 14).
09/05/2012	VIExt		Timothy Britton	Husky Energy Inc.	A visual external inspection was carried out with no significant findings to report.
09/05/2012	VIInt		Timothy Britton	Husky Energy Inc.	<p>A visual internal inspection was carried out. There were no significant findings reported.</p> <p>Photo's are located at; R:\Technical Services\Asset Integrity\Reports - Inspn &amp; Corr Monitoring\PEPTI\Insp Reports 2012\Timothy Britton, Henry H\Evidence of Tim's Completed Inspections in 2012\EC-SO\SYLVAN LAKE GAS PLANT SHUTDOWN 2012</p>

## ***Inspection History Report***

### **Inspection Planning**

Date of Inspection: \_\_\_\_\_ Date of last Inspection: \_\_\_\_\_ Date of Next Inspection: \_\_\_\_\_

The signature below certify that the above is a true report of the inspection / test of the equipment specified and consider fit for service until the date of next inspection.

Competent Inspector: \_\_\_\_\_ Report Generation Date: \_\_\_\_\_

**Reviewed and Accepted by:**

Next Inspection Date: \_\_\_\_\_

**Approved by:**

Signature: \_\_\_\_\_ Date: \_\_\_\_\_

Signature: \_\_\_\_\_ Date: \_\_\_\_\_





Renaissance Energy Ltd.

## VESSEL / TANK INSPECTION REPORT - Exhibit #300, Page 1 of 2

Facility SYLVAN LAKE G.P.  
LSD 1-21-38-2 WS  
Inspector MANLEY YUEN

AFE # \_\_\_\_\_  
Date NOV. 21, 2000

Date of Last Inspection 1996 (INTERNAL INSPECTION)

## Equipment Details

☐ Vessel ☐ Tank HORIZONTAL  $\approx 8'-0" \phi \times 12'-0"$   
Type FLARE KNOCK OUT VESSEL Service SWEET A# 0017726 \*  
Manufacturer BARBER MACHINERY CO. LTD. \* MAWP ? at Design Temp ?  
Year Built 1953 \* Serial # 1012-D-2 \* Corr. Allowance \_\_\_\_\_

## Coating Integrity

Coating Type \_\_\_\_\_

Blistering: ☐ Yes ☐ No  
Holidays: ☐ Yes ☐ No  
Mech. Dam: ☐ Yes ☐ No  
Coupons: ☐ Yes ☐ No

Average Thickness \_\_\_\_\_

Location(s) \_\_\_\_\_

Location(s) \_\_\_\_\_

Location(s) \_\_\_\_\_

Comments \_\_\_\_\_

Date Coated \_\_\_\_\_

Comments \_\_\_\_\_

## Internal Equipment Assessment

Head/Shell ☐ Visual ☐ UT ☐ MPI ☐ Dye Pen  
Firetubes ☐ Visual ☐ UT ☐ MPI ☐ Dye Pen  
Pitting ☐ Yes ☐ No Pit Depth \_\_\_\_\_  
Anodes: Material \_\_\_\_\_ Date Installed \_\_\_\_\_ % Consumed \_\_\_\_\_

Comments \_\_\_\_\_

## External Equipment Assessment

Ladders / Stairs / Platforms ☐ Inspection Performed Comments N/A  
Foundations / Skirts ☒ Inspection Performed Comments OK  
Elect./ Instrum./ Grounding ☐ Inspection Performed Comments N/A  
Pressure / Temp Gauges ☐ Inspection Performed Comments N/A  
External Insulation ☐ Inspection Performed Comments N/A

A # 0017726

**PSV Data**

N/A - ATMOSPHERIC PRESSURE ONLY AS PER DAUF RUSSELL

Serial # \_\_\_\_\_

PSV Tag # \_\_\_\_\_

CRN # \_\_\_\_\_

Manufacturer \_\_\_\_\_

Set Pressure \_\_\_\_\_

Capacity \_\_\_\_\_

Last Service Date \_\_\_\_\_

Service Comp. \_\_\_\_\_

**Picture ID**

Picture 1 \_\_\_\_\_

Picture 2 \_\_\_\_\_

Picture 3 \_\_\_\_\_

Picture 4 \_\_\_\_\_

Picture 5 \_\_\_\_\_

Picture 6 \_\_\_\_\_

Picture 7 \_\_\_\_\_

Picture 8 \_\_\_\_\_

**General Comments and Recommendations**

Vessel is in good condition

Some scale visible in weep hole of re-pad

**Equipment Status**

Suitable for Further Service

☒ Yes☐ No

Repairs Required

☐ Yes☒ No

Repairs Completed

☐ Yes☐ No

Repairs Completed By: \_\_\_\_\_

Repair Company AQP# \_\_\_\_\_

Repair Date \_\_\_\_\_

Facility Inspector

Mauley J. J.

Date

Nov. 21, 2000

QA Coordinator

\_\_\_\_\_

Date

\_\_\_\_\_



# CHEVRON VESSEL INSPECTION REPORT

Brazeau

*Sylvan*  
~~BRAZEAU 16-35-48-12 W5~~

Battery

A number :

Vessel :

Description

Service :

Solution Gas

~~N/A~~

Flare KO

Flare KO Drum

Insp. Date:

Result :

Rec. Next Insp:

5/6/96

FFS

Inspectors :

A Greenfield

Inspection Method :

Visual Int. under Mask

Relief Valves Protecting Vessel:

Inspection Results:

Corrosion :

1. Vessel was constructed using backing rings.
2. Appears the vessel was originally coated with a rubber like coating which has since failed and is blistered and disbonded throughout.
3. Internal surfaces have a modelled appearance. There is approx. a 30 to 40 mil difference between the highs and lows.
4. Inlet nozzle was rotated so the diverter elbow faces horizontally rather than vertically downwards.

Process : *Diverter added to inlet to deflect fluids horizontally rather*

Recommendations :

Inspector's Signature: 

Foreman's Signature: 