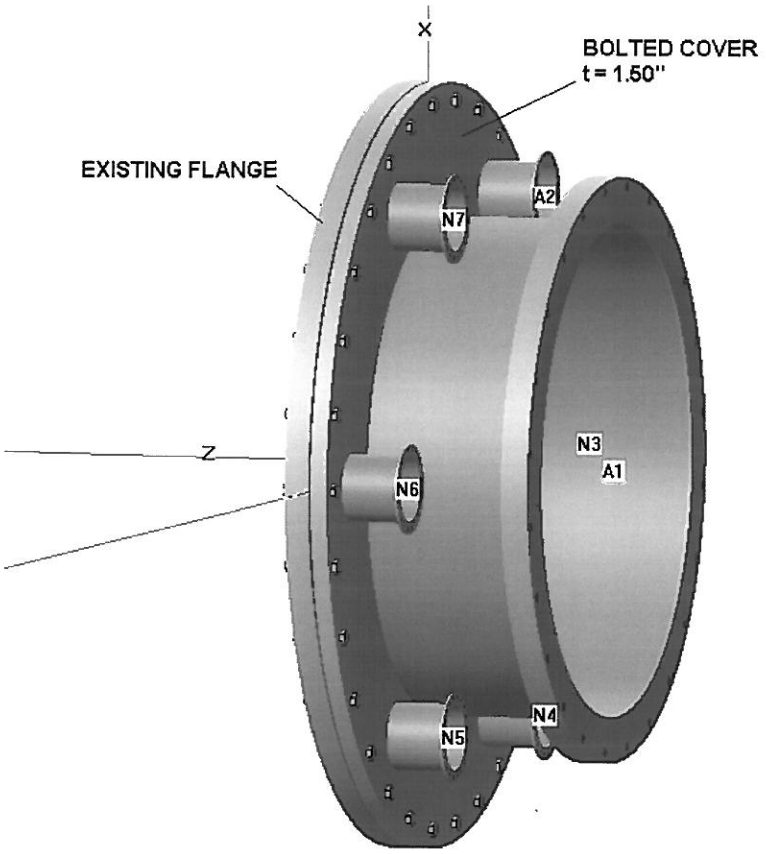
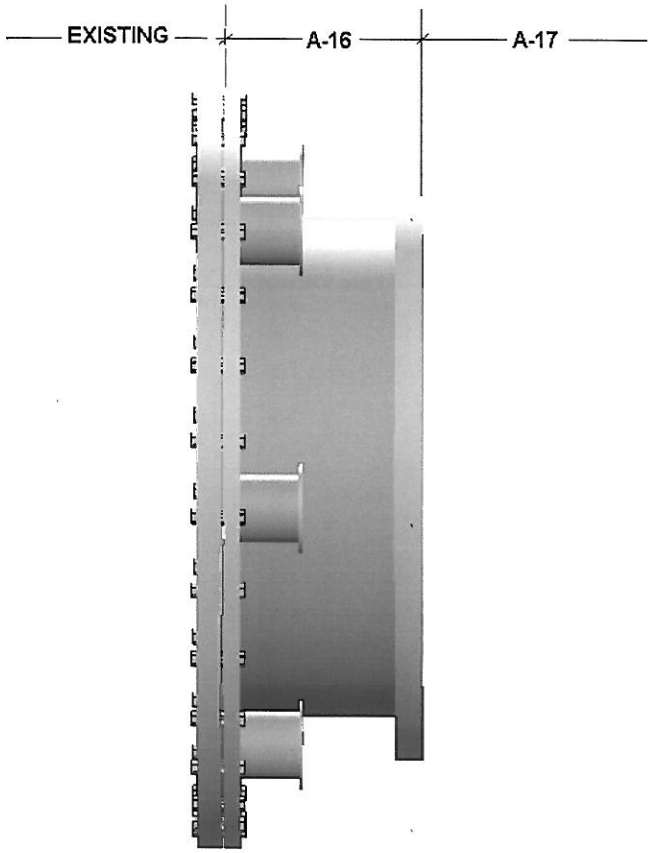

X
BOLTED COVER
t = 1.50"
EXISTING FLANGE
N7
A2
Z
N3
A1
N6
N4
N5


EXISTING
A-16
A-17

ADAPTER A-16

Thickness Summary

Component Identifier	Material	Diameter (in)	Length (in)	Nominal t (in)	Design t (in)	Total Corrosion (in)	Joint E	Load
Cylinder #1	SA-240 304	60 ID	2	0.25	0.0774	0	0.70	External
Bolted Cover #1	SA-240 304	68.25 OD	1.5	1.5*	0.9798	0	1.00	External

Nominal t: Vessel wall nominal thickness

Design t: Required vessel thickness due to governing loading + corrosion

Joint E: Longitudinal seam joint efficiency

* Head minimum thickness after forming

Load

internal: Circumferential stress due to internal pressure governs

external: External pressure governs

Wind: Combined longitudinal stress of pressure + weight + wind governs

Seismic: Combined longitudinal stress of pressure + weight + seismic governs

Bolted Cover #1

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Component:	Bolted Cover
Material specification:	SA-240 304 (II-D p. 90, ln. 4)

Impact test exempt per UHA-51(g)(coincident ratio = 0.02978)

Internal design pressure: P = 1 psi @ 302 °F
External design pressure: P_e = 15 psi @ 302 °F

Static liquid head:

P_{lh} =2.17 psi (SG=1.0000, H_s=60", Horizontal test head)

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

Design MDMT = -20 °F
Rated MDMT = -320 °F

No impact test performed
Material is not normalized
Material is not produced to Fine Grain Practice
PWHT is not performed

Radiography: Category A joints - Seamless No RT

Estimated weight: New = 840.6 lb corr = 840.6 lb

Head diameter, d = 63.5" (ASSUMED "O-RING" GASKET DIAM.)
Cover thickness, t = 1.5"
Gasket groove depth = 0"

Design thickness, (at 302 °F) UG-34 (c)(2), flange operating

$t = d*Sqr(C*P / (S*E) + 1.9*W*h_G / (S*E*d^3)) + Corrosion$
$= 63.5*Sqr(0.3*1 / (18,900*1) + 1.9*3,165.32*1.375 / (18,900*1*63.5^3)) + 0$
= 0.2663 in

Design thickness, (at 70 °F) UG-34 (c)(2), gasket seating

$t = d*Sqr(1.9*W*h_G / (S*E*d^3)) + Corrosion$
$= 63.5*Sqr(1.9*120,141.6*1.375 / (20,000*1*63.5^3)) + 0$
= 0.4971 in

Maximum allowable working pressure, (at 302 °F)

$P = (S*E / C)*((t / d)^2 - (1.9*W*h_G / (S*E*d^3))) - P_s$
$= (18,900*1 / 0.3)*((1.5 / 63.5)^2 - (1.9*100,458.9*1.375 / (18,900*1*63.5^3))) - 0$
= 31.74 psi

Design thickness for external pressure, (at 302 °F) U-2(g)

$t = d*Sqr(C*P_a / (S*E)) + Corrosion$
$= 63.5*Sqr(0.3*15 / (18,900*1)) + 0$
= 0.9798 in

Maximum allowable external pressure, (At 302 °F) U-2(g)

$P_a = (S*E / C)*(t / d)^2$
$= (18,900*1 / 0.3)*(1.5 / 63.5)^2$

Nozzle #1 (A1)

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

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

Located on:	Bolted Cover #1
Liquid static head included:	0 psi
Nozzle material specification:	SA-240 304 (II-D p. 90, ln. 4)
Nozzle longitudinal joint efficiency:	1
Nozzle orientation:	0°
Local vessel minimum thickness:	1.5 in
Nozzle inside diameter, new:	44 in
Nozzle nominal wall thickness:	0.25 in
Nozzle corrosion allowance:	0 in
Projection available outside vessel, Lpr:	13.81 in
Projection available outside vessel to flange face, Lf:	16.31 in
Distance to head center, R:	0 in

Reinforcement Calculations for External Pressure

UG-39 Area Calculation Summary (in^2) For Pe = 15 psi @ 302 °F The opening is adequately reinforced							UG-45 Nozzle Wall Thickness Summary (in) The nozzle passes UG-45	
A required	A available	A_1	A_2	A_3	A_5	A welds	t_{req}	t_{min}
21.5563	23.1412	22.8875	0.1912	--	--	0.0625	0.097	0.25

UG-41 Weld Failure Path Analysis Summary (lb_f) All failure paths are stronger than the applicable weld loads				
Weld load W	Weld load W_{1-1}	Path 1-1 strength	Weld load W_{2-2}	Path 2-2 strength
-20,244.82	4,794.93	391,733.81	18,969.93	345,142.13

UW-16 Weld Sizing Summary			
Weld description	Required weld size (in)	Actual weld size (in)	Status
Nozzle to shell fillet (Leg_{41})	0.175	0.175	weld size is adequate
Nozzle to shell groove (Lower)	0.175	0.1875	weld size is adequate

Calculations for external pressure 15 psi @ 302 °F

Parallel Limits of reinforcement per UG-40

L_R = $MAX(d, R_n + (t_n - C_n) + (t - C))$
= $MAX(44, 22 + (0.25 - 0) + (1.5 - 0))$
= 44 in

Outer Normal Limits of reinforcement per UG-40

L_H = $MIN(2.5*(t - C), 2.5*(t_n - C_n) + t_e)$
= $MIN(2.5*(1.5 - 0), 2.5*(0.25 - 0) + 0)$
= 0.625 in

Nozzle required thickness per UG-28 t_{rn} = 0.097 in

From UG-34 required thickness t_r = 0.9798 in

Area required per UG-39

Allowable stresses: S_n = 18,900, S_v = 18,900 psi

f_{r1} = lesser of 1 or S_n/S_v = 1
f_{r2} = lesser of 1 or S_n/S_v = 1

A = $0.5*(d*t_r*F + 2*t_n*t_r*F*(1 - f_{r1}))$
= $0.5*(44*0.9798*1 + 2*0.25*0.9798*1*(1 - 1))$
= 21.5563 in^2

Area available from FIG. UG-37.1

A_1 = larger of the following= 22.8875 in^2

= $d*(E_1*t - F*t_r) - 2*t_n*(E_1*t - F*t_r)*(1 - f_{r1})$
= $44*(1*1.5 - 1*0.9798) - 2*0.25*(1*1.5 - 1*0.9798)*(1 - 1)$
= 22.8875 in^2

= $2*(t + t_n)*(E_1*t - F*t_r) - 2*t_n*(E_1*t - F*t_r)*(1 - f_{r1})$
= $2*(1.5 + 0.25)*(1*1.5 - 1*0.9798) - 2*0.25*(1*1.5 - 1*0.9798)*(1 - 1)$
= 1.8206 in^2

A_2 = smaller of the following= 0.1912 in^2

= $5*(t_n - t_{rn})*f_{r2}*t$
= $5*(0.25 - 0.097)*1*1.5$
= 1.1472 in^2

= $5*(t_n - t_{rn})*f_{r2}*t_n$
= $5*(0.25 - 0.097)*1*0.25$
= 0.1912 in^2

A_{41} = Leg^2*f_{r2}
= 0.25^2*1
= 0.0625 in^2

Area = $A_1 + A_2 + A_{41}$
= 22.8875 + 0.1912 + 0.0625
= 23.1412 in^2

As Area >= A the reinforcement is adequate.

UW-16(d) Weld Check

t_{min} = lesser of 0.75 or t_n or t = 0.25 in
$t_{1(min)}$ or $t_{2(min)}$ = lesser of 0.25 or $0.7*t_{min}$ = 0.175 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.

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

The combined weld sizes for t_1 and t_2 are satisfactory.

UG-45 Nozzle Neck Thickness Check (Access Opening)

Wall thickness req'd per UG-45(a): $t_{r1} = \underline{0.097}$ in
Wall thickness per UG-16(b): $t_{r3} = 0.0625$ in

Available nozzle wall thickness new, $t_n = 0.25$ in

The nozzle neck thickness is adequate.

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

Groove weld in tension:	0.74*18,900 =	13,986 psi
Nozzle wall in shear:	0.7*18,900 =	13,230 psi
Inner fillet weld in shear:	0.49*18,900 =	9,261 psi

Strength of welded joints:

(1) Inner fillet weld in shear
$(\pi/2)$*Nozzle OD*Leg*$S_i = (\pi/2)*44.5*0.25*9{,}261 = 161{,}836.98$ lb$_f$

(3) Nozzle wall in shear
$(\pi/2)$*Mean nozzle dia*t_n*$S_n = (\pi/2)*44.25*0.25*13{,}230 = 229{,}896.84$ lb$_f$

(4) Groove weld in tension
$(\pi/2)$*Nozzle OD*t_w*$S_g = (\pi/2)*44.5*0.1875*13{,}986 = 183{,}305.16$ lb$_f$

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

$W = (A - A_1 + 2*t_n*f_{r1}*(E_1*t - F*t_r))*S_v$
$= (21.5563 - 22.8875 + 2*0.25*1*(1*1.5 - 1*0.9798))*18{,}900$
$= \underline{-20{,}244.82}$ lb$_f$

$W_{1\text{-}1} = (A_2 + A_5 + A_{41} + A_{42})*S_v$
$= (0.1912 + 0 + 0.0625 + 0)*18{,}900$
$= \underline{4{,}794.93}$ lb$_f$

$W_{2\text{-}2} = (A_2 + A_3 + A_{41} + A_{43} + 2*t_n*t*f_{r1})*S_v$
$= (0.1912 + 0 + 0.0625 + 0 + 2*0.25*1.5*1)*18{,}900$
$= \underline{18{,}969.93}$ lb$_f$

Load for path 1-1 lesser of W or $W_{1\text{-}1} = -20244.82$ lb$_f$
Path 1-1 through (1) & (3) = 161,837 + 229,896.8 = $\underline{391{,}733.81}$ lb$_f$
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 $W_{2\text{-}2} = -20244.82$ lb$_f$
Path 2-2 through (1), (4) = 161,837 + 183,305.2 = $\underline{345{,}142.13}$ lb$_f$

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

External Pressure, (Corroded & at 302 °F) UG-28(c)

L / D_o = 16.31 / 44.5 = 0.3665

D_o / t = 44.5 / 0.097 = 458.5623

From table G: A = 0.000392

From table HA-1: B = 5,159 psi

P_a = 4*B / (3*(D_o / t))
= 4*5158.8174 / (3*(44.5 / 0.097))
= 15 psi

Design thickness for external pressure P_a = 15 psi

t_a = t + Corrosion = 0.097 + 0 = 0.097"

Weight Summary

Component	Weight (lb) Contributed by Vessel Elements							Surface Area ft²
	Metal New*	Metal Corroded*	Insulation & Supports	Lining	Piping + Liquid	Operating Liquid	Test Liquid	
Cylinder #1	27.4	27.4	0	0	0	0	247.5	3
Bolted Cover #1	840.6	840.6	0	0	0	0	926.4	16
TOTAL:	**868**	**868**	**0**	**0**	**0**	**0**	**1,173.9**	**18**

* Shells with attached nozzles have weight reduced by material cut out for opening.

Component	Weight (lb) Contributed by Attachments								Surface Area ft²
	Body Flanges		Nozzles & Flanges		Packed Beds	Trays & Supports	Rings & Clips	Vertical Loads	
	New	Corroded	New	Corroded					
Cylinder #1	542.2	542.2	0	0	0	0	0	0	19
Bolted Cover #1	0	0	667.2	667.2	0	0	0	0	23
TOTAL:	**542.2**	**542.2**	**667.2**	**667.2**	**0**	**0**	**0**	**0**	**23**

Vessel operating weight, Corroded: 2,077 lb
Vessel operating weight, New: 2,077 lb
Vessel empty weight, Corroded: 2,077 lb
Vessel empty weight, New: 2,077 lb
Vessel test weight, New: 3,251 lb
Vessel surface area: 42 ft²

Vessel center of gravity location - from datum - lift condition

Vessel Lift Weight, New: 2,077 lb
Center of Gravity: -4.1752"

Vessel Capacity

Vessel Capacity** (New): 24 US gal
Vessel Capacity** (Corroded): 24 US gal
**The vessel capacity does not include volume of nozzle, piping or other attachments.