Sample Vessel 8

PVE-Sample 8

Pressure Vessel Calculations

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PVE-Sample 8 Rev 0

XYZ Vessel Inc.	Customer
Sample Vessel 8	Vessel
PVE-Sample 8	Part Number
PVE-Sample 8	Drawing
PVE-Sample 8 Rev 0	Job

42	Outside Diameter [inch]
72	straight Shell (not including straight flange on heads)
66	Volume [cuft]
Kerosene	Fluid (value from Material Properties)
9000	Weight Empty [lbs.]
12300	Weight Full
12300	Weight Under Test

Maximum Internal pressure, psi **350**	Maximum External Pressure, psi **7.5**	At Temperature, ºF **650**	Maximum Allowed Working Pressure
Maximum Temperature, ºF **650**	Minimum Temperature, ºF **-20**	At Pressure, psi **350**	Maximum Design Metal Temperature
Test Pressure, psi **455**	At a Minimum Temperature of: ºF **55°F**	For a Minimum Duration of: **1/2 hr**	Hydrostatic Test

SA-240 304	Primary Material of Construction
16,200	Allowable Stress
0.0625	Minimum allowed thickness per UG-16(b)
No	Material Normalized
No	Material Impact Tested (not required per UHA-51(d))
No	Radiography required
0	Corrosion Allowance

ASME VIII-1			Code
2004			Edition
none			Addenda
IID			Materials
none			Code Cases Required

UG-22 Loadings Considered

Yes	(a) Internal pressure
Yes	(a) External pressure
Yes	(b) Vessel weight full, empty and at hydro test
Yes	(c) Weight of attached equipment and piping
	(d)(1) Attachment of internals
Yes	(d)(2) Attachment of vessel supports
	(d) Cyclic or dynamic reactions
	(f) Wind
	(f) Snow
Yes	(f) Seismic
	(g) Fluid impact shock reactions
	(h) Temperature gradients
	(h) Differential thermal expansion
	(i) Abnormal pressures like deflagration

Material Properties

ASME VIII, IID 2004 Edition no Addenda

Sample Vessel 8 <- Vessel

Design Pressure UG-22(a)

350.0 <- P, internal operating pressure at top of vessel (psig)
7.5 <- mPa, external operation pressure
Kerosene <- Operating Fluid Source - Machinery's handbook - 26th edition
11.25 <- h, fluid height (ft)
0.800 <- rho, fluid density (1.0 for water)

Design Pressure = P + 0.4331*rho*h = 350 + 0.4331 * 0.8 * 11.25 **mDp = 353.9**

Hydro Test (UG-99(b))

pressure measured at top of vessel, rounded up

Test Press = P * 1.3 * MR = 350 * 1.3 * 1 **mTp = *455***

Material Properties (ASME IID)

650 <- mTemp, design temp ºF Test at ambient temp

Material	Where Used	Ambient Strength	Design Strength	Strength Ratio	Max ºF	Ext Graph
SA-240 304 Plate	Shell & Heads	**20000**	**16200**	**1.235**	**1500**	**HA-1**
SA-312 TP304 Sms. and Wld. Pipe	Pipe	**20000**	**16200**	**1.235**	**1500**	**HA-1**
SA/CSA-G40.21 44W	Legs	**17100**	**17100**	**1.000**	**650**	**CS-2**
SA-182 F304 Forging	Flanges	**20000**	**16200**	**1.235**	**1500**	**HA-1**

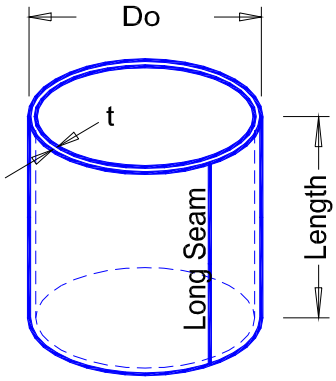
Min Ratio (MR) = ***1.000***

Pipe and Shell ver 2.39

ASME Code VIII Div I 2004 Edition No Addenda www.pveng.com

Sample Vessel 8 <- Vessel

42" OD Rolled Plate <- Description



Dimensions:

42.000	<- Do - Outside Diameter (inch)
0.750	<- t - Nominal Wall Thickness (inch)
0.063	<- tminUG16(b) - Minimum Wall Thickness Per UG-16(b)
79.000	<- Le - Effective Length (inch)
72.000	<- Length for volume and weight (inch)
0.000	<- Corr, Corrosion Allowance (inch)
N/A	<- n, Number of Threads

Material and Conditions:

SA-240 304	<- Material		
16,200	<- S, Allowable Stress Level (psi)		
0.7	<- El - Longitudinal Efficiency (circ. stress)		
0.7	<- Ec - Circ. Connecting Efficiency (longitudinal stress)		
0.0%	<- UTP, Undertolerance allowance (%)	**53.68**	<- Volume (cubic ft)
0.000	<- UTI, Undertolerance allowance (inch)	**1,984.7**	<- Material Weight (lbs cs)
353.9	<- P, Interior Pressure		
7.5	<- Pa, Exterior Pressure		
7,915	<- Ba, From exterior pressure curve	***0.001780***	<- Aa (use to lookup Ba)
1,759	<- Bb, From exterior pressure curve	***0.000136***	<- Ab (use to lookup Bb)

Variables:

UT =	t*UTP+UTI	= 0.75*0+0	undertollerance	UT =	***0.000***
Td =	0.8/n	= NA	Thread depth	Td =	***0.000***
nt =	t-Corr-UT-Td	= 0.75-0-0-0	nominal thick	nt =	***0.750***
Ri =	Do/2-nt	= 42/2-0.75	effective inside radius	Ri =	***20.250***
LDo =	Le/Do	= 79/42		LDo =	***1.881***

Interior Pressure UG-27 (c) (1,2)

ta =	P*Ri/(S*El-0.6*P)	= 353.898*20.25/(16200*0.7-0.6*353.898)		ta =	***0.644***
tb =	P*Ri/(2*S*Ec+0.4*P)	= 353.898*20.25/(2*16200*0.7+0.4*353.89		tb =	***0.314***
tmin =	Max(ta,tb,tminUG16b)	<= nt	**Acceptable**	tmin =	***0.644***
PMaxA =	(S*El*nt)/(Ri+0.6*nt)	= (16200*0.7*0.75)/(20.25+0.6*0.75)		PMaxA =	***410.9***
PMaxB =	(2*S*Ec*nt)/(Ri-0.4*nt)	= (2*16200*0.7*0.75)/(20.25-0.4*0.75)		PMaxB =	***852.6***
PMax =	Min(PMaxA,PMaxB)		**Acceptable**	PMax =	***410.9***
tr1 =	P*Ri/(S*1-0.6*P)	= 353.898*20.25/(16200*1-0.6*353.898)		tr1 =	***0.448***

Exterior Pressure UG-28 (c)

DoT =	Do/nt	= 42/0.75		DoT =	***56.000***
Aa =	Interpolated from IID Part D Table G			Aa =	***0.001780***
PaMax =	4*Ba/(3*DoT)	= 4*7914.982/(3*56)	**Acceptable**	PaMax =	***188.5***
DoTe =	Do/tre	= 42/0.134		DoTe =	***312.669***
Ab =	Interpolated from IID Part D Table G			Ab =	***0.000136***
tre =	(3*Do*Pa)/(4*Bb)	= (3*42*7.5)/(4*1758.76)		tre =	***0.134***
treCorr =	tre+corr+ut+td	= 0.134+0+0+0	**Acceptable**	treCorr =	***0.134***

Shell stress relief -UCS-79(d), UNF-79(d), UHA-44(d)

Rf =	(do-t)/2	= (42-0.75)/2			***20.625***
% elong =	(50*t/Rf)*(1-0)	= (50*0.75/20.625)*(1-0)		% elongation =	***1.8***

20.0%	<- Max Elongation			
Yes	<- Cold formed	***1.8%*** <- Elongation	Required	***no***
no	<- Vessel carries lethal substances (Yes/no)		***no***	***no***
no	<- Impact testing is required (Yes/no)		***no***	***no***
no	<- Greater than 10% reduction in thickness		***no***	***no***
no	<- Formed between 250 and 900 Degrees F		***no***	***no***
YES	<- Shell is greater than 5/8" thick before forming		***Yes ?***	***no***
			Stress Relieve ?	***no***

ASME Code VIII Div I 2004 Edition No Addenda **NO Appendix 1-4(f)**

Sample Vessel 8 <- Vessel

ASME SE Head <- Desc

Dimensions:

42.000 <- Do, outside diameter

10.151 <- h ***10.85*** <- ho

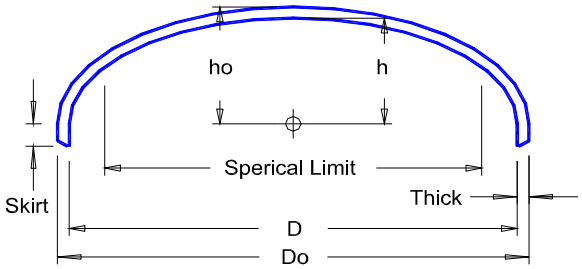
0.750 <- tb, thickness before forming

0.698 <- tf, thickness after forming

0.063 <- tminUG16(b) - Min.t. Per UG-16(b)

0.000 <- Corr, corrosion allowance

1.500 <- Skirt, straight skirt length



Material and Conditions:

SA-240 304 <- material

16,200 <- S, allowable stress level (psi)

0.85 <- E, efficiency

353.9 <- P, interior pressure

7.5 <- Pa, exterior pressure

8,578 <- Ba, from exterior pressure curve ***0.002383*** <- Aa value to lookup Ba

3,484 <- Bb, from exterior pressure curve ***0.000269*** <- Ab value to lookup Bb

Calculated Properties:

52.168 <- Approximate blank diameter ***6.20*** <- Volume (cuft, includes skirt)

454.7 <- Approximate weight for steel, (lbs) ***32.48*** <- Spherical Limit (0.8 * D)

Variables:

D =	Do-2*t		= 42-2*0.698			D = ***40.61***
ho =	h+t		= 10.151+0.698			ho = ***10.85***
D/2h =	D/(2*h)	*UG-37 & Ap 1-4(c)*	= 40.605/(2*10.151)			D/2h = ***2.000***
Do/2ho =	Do/(2*ho)	*UG-37 & Ap 1-4(c)*	= 42/(2*10.849)			Do/2ho = ***1.936***
K =	Interpolated value from table 1-4.1		D/2h	interior		K = ***1.000***
Kone =	Interpolated value from table UG-37		D/2h	spherical		Kone = ***0.900***
Kzero =	Interpolated value from table UG-33.1		Do/2ho	exterior		Kzero = ***0.871***
t =	tf-corr		= 0.698-0			t = ***0.6975***
Ro =	Ko*Do	*UG-33(d)*	= 0.871*42			Ro = ***36.585***

Interior Pressure App 1-4(a), App 1-4(c), UG-37(a)(1):

App. 1-4(a) check: 0.0005 <= tf/(Kone*D) < 0.002 tf/(Kone*D) = ***0.0191***

= 0.0005<=0.698/(0.9*40.605)<0.002 **App. 1-4(f) calculation not needed**

TMinI = (P*D*K)/(2*S*E-0.2*P) <= t TMinI (min thickness) = ***0.523***

= (353.898*40.605*1)/(2*16200*0.85-0.2*353.898) <= 0.698

TMin = Max(TminI,tminUG16(b))<=tf-corr **Acceptable** TMin = ***0.523***

PMax = (2*S*E*t)/(K*D+0.2*t) >= P **Acceptable** PMax = ***471.5***

= (2*16200*0.85*0.698)/(1*40.605+0.2*0.698) >= 354

Interior Pressure for Nozzles App 1-4(a), App 1-4(c), UG-37(a)(1):

TMinE1 = (P*D*K)/(2*S*1-0.2*P) <= t (Nozzle in Knuckle) TMinE1 = ***0.444***

= (353.898*40.605*1)/(2*16200*1-0.2*353.898) <= 0.698

TSpI = (P*D*Kone)/(2*S*E-0.2*P) (Nozzle in Crown) TSpI = ***0.400***

= (353.898*40.605*0.9)/(2*16200*1-0.2*353.898)

Exterior Pressure UG-33(d), UG-28(d):

Aa = 0.125/(Ro/t) = 0.125/(36.585/0.698) Aa = ***0.002383***

PaMax = Ba/(Ro/t) >= Pa = 8577.591/(36.585/0.698) >= 7.5 **Acceptable** PaMax = ***163.5***

Ab = 0.125/(Ro/tMinE) = 0.125/(36.585/0.079) Ab = ***0.000269***

TMinE = (Ro*Pa)/Bb = (36.585*7.5)/3484.34 TMinE = ***0.079***

TMinEC = TMinE + corr = 0.079 + 0 **Acceptable** TMinEC = ***0.079***

Head stress relief UCS-79(d), UNF-79(d), UHA-44(d)

% elong = ((75*t)/h)*(1-0) = ((75*0.698)/10.151)*(1-0) % elong = ***5.5***

20.0% <- Max Elongation

Yes <- Cold Formed ***5.5%*** <- Elongation Required ***no***

no <- Vessel carries lethal substances(Yes/no) ***no*** ***no***

no <- Impact testing is required (Yes/no) ***no*** ***no***

no <- Formed between 250 and 900 Degrees F ***no*** ***no***

no <- Greater than 10% reduction in thickness ***no*** ***no***

Yes <- Head is greater than 5/8" thick before forming ***Yes ?*** ***no***

Stress Relieve ? ***no***

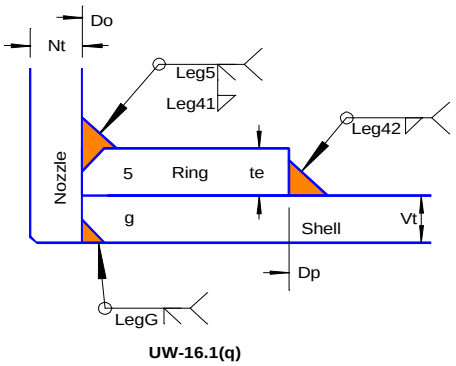
Sample Vessel 8	<- Vessel
Nozzles A - 24" SCH 40 Pipe	<- Description

Shell:

SA-240 304	<- Shell Material
16,200	<- Sv, shell allowable stress level, PSI
1.00	<- Eone, efficiency of shell at nozzle
40.50	<- Ds, Shell ID
0.750	<- Vt, shell wall thick, uncorroded, UT removed
0.448	<- tr, required shell wall thickness int. press.(E=1)
0.134	<- trE, required shell wall thickness ext. press.(E=1)
0.000	<- sca, shell corrosion allowance
0.063	<- tmin16b, Min allowed wall per UG-16(b)

Nozzle:

SA-312 TP304	<- Nozzle Material
16,200	<- Sn, allowable stress level (Sn)
4,071	<- B, from A = ***0.00031***
0.85	<- E, nozzle efficiency
353.9	<- P, internal design pressure
7.5	<- Pa, external design pressure
24.000	<- Do, outside diameter
0.688	<- Nt, wall thick, uncorroded
12.5%	<- UTp, undertolerance (%)
0.000	<- nca, nozzle corrosion allowance
6.000	<- L, exterior Projection



UW-16.1(q)

Note: Nozzle load calculations see "Nozzle A FEA Report".

At least one telltale hole (max. size NPS 1/4 tap) in repad required

Reinforcing:

SA-240 304	<- Reinforcing plate material
16,200	<- Sp, allowable stress level
30.000	<- Dp, outside diameter
0.750	<- te, reinforcement thick
0.563	<- Leg41, size of weld fillet
0.688	<- Leg42, size of weld fillet
0.500	<- LegG, depth of groove
0.500	<- Leg5, depth of groove

Variables:

UT =	Nt*UTp	= 0.688 * 0.125	*Undertolerance*	UT =	***0.086***
Rn =	Do/2 - (Nt-nca) + UT	= 24/2 - (0.688-0) + 0.086	*Effective Radius*	Rn =	***11.398***
Dp =	Min(2*d,DpEntered)	= Min(2*22.624,30)	*Effective Reinforcing*	Dp =	***30.000***
t =	Vt-sca	= 0.75 - 0	*Effective Shell Thickness*	t =	***0.750***
ti =	Nt-2*nca	= 0.688 - 2 * 0	*Nom Thick of Int. Proj.*	ti =	***0.688***
te =	teEntered		*Effective Reinf. Thick.*	te =	***0.750***
tn =	Nt-nca	= 0.688-0	*Avail. Nozzle Thick. No UT*	tn =	***0.688***
d =	Do-2*tn	= 24 - 2*0.688	*Opening Dia.*	d =	***22.624***
fr1 =	MIN(Sn/Sv,1)	= MIN(16200/16200, 1)		fr1 =	***1.000***
fr2 =	MIN(Sn/Sv,1)	= MIN(16200/16200, 1)		fr2 =	***1.000***
fr3 =	MIN(Sn/Sv,Sp/Sv,1)	= MIN(16200/16200, 16200/16200,1)		fr3 =	***1.000***
fr4 =	MIN(Sp/Sv,1)	= MIN(16200/16200,1)		fr4 =	***1.000***
Ro =	Do/2	= 24/2		Ro =	***12.000***
tcLeg41 =	Min(0.25,0.7*Min(0.75,Nt,te))	= Min(0.25,0.7*Min(0.75,0.688,0.75))		tc41 =	***0.250***
F =	1.000			F =	***1.000***

Pipe Required Wall Thickness - trn from internal, trnE from external pressure

trn =	(P*Rn)/(Sn*E - 0.6*P) <= tn-UT	= (353.9*11.398)/(16200*0.85 - 0.6*353.9)		trn =	***0.298***	**Acceptable**
trnR =	(P*Rn)/(Sn*1 - 0.6*P)	= (353.9*11.398)/(16200*1 - 0.6*353.9)	*E=1*	trnR =	***0.252***	
trnE =	(3*Do*Pa)/(4*B) <= tn-ut	= (3*24*7.5)/(4*4071)		trnE =	***0.033***	**Acceptable**

Geometry Constraints:

0.7*Leg41 >=	tc41	0.7*0.563 >=	0.25	***0.394***	>=	***0.250***	**Acceptable**
0.7*Leg42 >=	0.5*Min(0.75,te,Vt)	0.7*0.688 >=	0.5*Min(0.75,0.75,0.75)	***0.481***	>=	***0.375***	**Acceptable**
Leg5 >=	0.7*Min(0.75,te,Nt)	0.5 >=	0.7*Min(0.75,0.75,0.688)	***0.500***	>=	***0.482***	**Acceptable**
LegG >=	0.7*Min(0.75,Vt,Nt)	0.5 >=	0.7*Min(0.75,0.75,0.688)	***0.500***	>=	***0.482***	**Acceptable**

Appendix 1-7 Necessary Check

when Ds>60,if(2*Rn<=Ds/3,if(2*Rn<=40, "App. 1-7 calculations not required","App. 1-7 calculations required"),"App. 1-7 calculations required")
when Ds<=60,if(2*Rn<Ds/2,if(2*Rn<20,"App. 1-7 calculations not required","App. 1-7 calculations required"),"App. 1-7 calculations required")

App. 1-7 calculations required

Area Replacement: Fig UG-37.1

				Pressure From:	Internal	External
A =	1.0*d*tr*F + 2*tn*tr*F*(1-frone)		A Required (internal) =		***10.141***	
=	1.0*22.624*0.448*1 + 2*0.688*0.448*1*(1-1)					
Ae =	0.5*(d*trE*1 + 2*tn*trE*1*(1-frone)) = 0.5*(22.624*0.134*1 + 2*0.688*0.134*1*(1-1))		A Required (external) =			***1.520***
A1 =	max(d, 2*(t+tn)) * (E1*t-F*tr)-2*tn*(E1*t-F*tr)*(1-fr1)		A1 =		***6.827***	
=	max(22.624, 2*(0.75+0.688)) * (1*0.75-1*0.448)-2*0.688*(1*0.75-1*0.448)*(1-1)					
A1e =	max(d, 2*(t+tn)) * (Eone*t-F*trE)-2*tn*(Eone*t-F*trE)*(1-frone)		A1e =			***13.929***
=	max(22.624, 2*(0.75+0.688)) * (1*0.75-1*0.134)-2*0.688*(1*0.75-1*0.134)*(1-1)					
A2 =	min((tn-trn)*fr2*min(5*t,2*L) , (tn-trnR)*(Min(2.5*tn+te,L)*fr1*2)		A2 =		***1.634***	
=	min((0.688-0.252)*1*min(5*0.75,2*6) , (0.688-0.252)*(Min(2.5*0.688+0.75,2*6)*1*2)					
A2e =	min((tn-trnE)*frtwo*Min(5*t,2*L) , 2*(tn-trnE)*Min(2.5*tn+te,L)*frone)		A2e =			***2.456***
=	min((0.688-0.033)*1*Min(5*0.75,2*6) , 2*(0.688-0.033)*Min(2.5*0.688+0.75,6)*1)					
A5 =	(Dp - d - 2tn)te*fr4	=(30 - 22.624 - 2*0.688)*0.75*1	A5 =		***4.500***	***4.500***
A41 =	Leg41^2*frThree	A41 = 0.5625^2*1	A41 =		***0.316***	***0.316***
A42 =	Leg42^2*frfour	A42 = 0.6875^2*1	A42 =		***0.473***	***0.473***
			Actual Area =		***13.750***	***21.674***
			Actual-Required =	**Acceptable**	***3.609***	***20.154***

Internal Weld Load: (UG-41)

WmaxI =	(A - A1 + 2*Tn*Fr1*(E1*t-F*tr))*Sv, min0	= (10.141 - 6.827 + 2*0.688*1*(1*0.75-1*0.448))*16200	WmaxI =	***60,418***
W_{1-1} =	MIN((A2 + A5 + A41 + A42)*Sv,WmaxI)	= MIN((1.634 + 4.5 + 0.316 + 0.473)*16200,60418)	W_{1-1} =	***60,418***
W_{2-2} =	Min((A2 + A3 + A41 + A43 + 2*Tn*t*frone)*Sv,WmaxI)	= Min((1.634 + 0 + 0.316 + 0 + 2*0.688*0.7	W_{2-2} =	***48,313***
W_{3-3} =	Min((A2 + A3 + A5 + A41 + A42 + A43 + 2*Tn*t*fr1)*Sv,WmaxI)	Weld load	W_{3-3} =	***60,418***
=	Min((1.634 + 0 + 4.5 + 0.316 + 0.473 + 0 + 2*0.688*0.75*1)*16200,60418)			

External Weld Load: (UG-41)

WmaxE =	(Ae - A1e + 2*Tn*Fr1*(E1*t-F*tr))*Sv, min0	= (1.52 - 13.929 + 2*0.688*1*(1*0.75-1*0.448))*16200	WmaxE =	***0***
W1-1 =	MIN((A2e + A5 + A41 + A42)*Sv,WmaxE)	*Weld load*	W_{1-1e} =	***0***
=	MIN((2.456 + 4.5 + 0.316 + 0.473)*16200,0)			
W_{2-2} =	Min((A2e + A3 + A41 + A43 + 2*Tn*t*frone)*Sv,WmaxE)	= Min((2.456 + 0 + 0.316 + 0 + 2*0.688*0.7	W_{2-2e} =	***0***
W_{3-3} =	Min((A2e + A3 + A5 + A41 + A42 + A43 + 2*Tn*t*fr1)*Sv,WmaxE)	Weld load	W_{3-3e} =	***0***
=	Min((2.456 + 0 + 4.5 + 0.316 + 0.473 + 0 + 2*0.688*0.75*1)*16200,0)			

Component Strength (UG-45(c), UW-15(c))

A2 shear =	PI()/2*(Do-tn)*tn*Sn*0.7	= PI()/2*(24-0.688)*0.688*16200*0.7	A2s = ***285,694***
g tension =	PI()/2*Do*LegG*Min(Sv,Sn)*0.74	= PI()/2*24*0.5*Min(16200,16200)*0.74	gt = ***225,968***
A41 shear =	PI()/2*Do*Leg41*Min(Sn,Sp)*0.49	= PI()/2*24*0.563*Min(16200,16200)*0.49	A41s = ***168,331***
A42 shear =	PI()/2*DP*Leg42*Min(Sv,Sp)*0.49	= PI()/2*30*0.688*Min(16200,16200)*0.49	A42s = ***257,173***
Leg 5 tens =	PI()/2*Do*Leg5*Min(Sn,Sp)*0.74	= PI()/2*24*0.5*Min(16200,16200)*0.74	Leg5t = ***225,968***

Failure mode along strength path (Greater than Weld Load, see App L-7)

S_{1-1} =	A42s + A2s >= W1-1	**Acceptable**	S_{1-1} = ***542,867***
=	257173 + 285694 >= 60418		
S_{2-2} =	A41s + gt + Leg5t + A43s >= W2-2	**Acceptable**	S_{2-2} = ***620,268***
=	168331 + 225968 + 225968 + 0 >= 48313		
S_{3-3} =	gt + A42s + A43s >= W3-3	**Acceptable**	S_{3-3} = ***483,141***
=	225968 + 257173 + 0 >= 60418		

Tstd =	Standard pipe wall thickness from chart			Tstd =	***0.375***
Swre =	tr * Pa / P	= 0.448 * 7.5 / 353.898	*Req. Exterior pressure*	Swre =	***0.009***
Nact =	Nt * (1-UTp)	= 0.688 * (1-0.125)	*Actual Wall Thick.*	Nact =	***0.602***
Tt =	0.8/Nth	= 0.8/0	*Ug-31(c)(2) threads*	Tt =	***0.000***

UG-45 **Acceptable**

UG45 =	Max(UG45a, UG45b) <= Nact	= Max(0.298, 0.328) <= 0.602	UG45 =	***0.328***
UG45a =	Max(trn,trnE) + Nca + Tt	= Max(0.298,0.033) + 0 + 0	UG45a =	***0.298***
UG45b =	Min(UG45b3,UG45b4)	= Min(0.448, 0.328)	UG45b =	***0.328***
UG45b1 =	Max(tr + Sca, tmin16b + Sca)	= Max(0.448 + 0, 0.063 + 0)	UG45b1 =	***0.448***
UG45b2 =	Max(Swre + Sca,tmin16b + Sca)	= Max(0.009 + 0,0.063 + 0)	UG45b2 =	***0.063***
UG45b3 =	Max(UG45b1,UG45b2)	= Max(0.448,0.063)	UG45b3 =	***0.448***
UG45b4 =	Tstd*0.875 + Nca	= 0.375*0.875 + 0	UG45b4 =	***0.328***

Nozzle Reinforcement ver 3.84

UW16(q) <- SavedDesign 27-Apr-07

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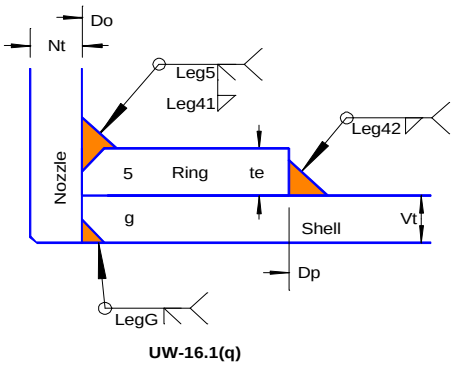
Automatic dh - not hillside
Manually enter Limit Diameter
Curved Shell or Head Section

Sample Vessel 8 <- Vessel
Nozzles A - 24" SCH 40 Pipe - For App. 1-7 <- Description

Shell:

SA-240 304 <- Shell Material
16,200 <- Sv, shell allowable stress level, PSI
1.00 <- Eone, efficiency of shell at nozzle
40.50 <- Ds, Shell ID
0.750 <- Vt, shell wall thick, uncorroded, UT removed
0.448 <- tr, required shell wall thickness int. press.(E=1)
0.134 <- trE, required shell wall thickness ext. press.(E=1)
0.000 <- sca, shell corrosion allowance
0.063 <- tmin16b, Min allowed wall per UG-16(b)



UW-16.1(q)

Nozzle:

SA-312 TP304 <- Nozzle Material
16,200 <- Sn, allowable stress level (Sn)
4,071 <- B, from A = ***0.00031***
0.85 <- E, nozzle efficiency
353.9 <- P, internal design pressure
7.5 <- Pa, external design pressure
24.000 <- Do, outside diameter
16.968 <- dLr, Limit radius <= d
0.688 <- Nt, wall thick, uncorroded
12.5% <- UTp, undertolerance (%)
0.000 <- nca, nozzle corrosion allowance
6.000 <- L, exterior Projection

Reinforcing:

SA-240 304 <- Reinforcing plate material
At least one telltale hole (max. size NPS 1/4 tap) in repad required
16,200 <- Sp, allowable stress level
30.000 <- Dp, outside diameter
0.750 <- te, reinforcement thick
0.563 <- Leg41, size of weld fillet
0.688 <- Leg42, size of weld fillet
0.500 <- LegG, depth of groove
0.500 <- Leg5, depth of groove

Variables:

UT =	Nt*UTp	= 0.688 * 0.125	*Undertolerance*	UT = ***0.086***
Rn =	Do/2 - (Nt-nca) + UT	= 24/2 - (0.688-0) + 0.086	*Effective Radius*	Rn = ***11.398***
Dp =	Min(2*d,DpEntered)	= Min(2*22.624,30)	*Effective Reinforcing*	Dp = ***30.000***
t =	Vt-sca	= 0.75 - 0	*Effective Shell Thickness*	t = ***0.750***
ti =	Nt-2*nca	= 0.688 - 2 * 0	*Nom Thick of Int. Proj.*	ti = ***0.688***
te =	teEntered		*Effective Reinf. Thick.*	te = ***0.750***
tn =	Nt-nca	= 0.688-0	*Avail. Nozzle Thick. No UT*	tn = ***0.688***
d =	Do-2*tn	= 24 - 2*0.688	*Opening Dia.*	d = ***22.624***
fr1 =	MIN(Sn/Sv,1)	= MIN(16200/16200, 1)		fr1 = ***1.000***
fr2 =	MIN(Sn/Sv,1)	= MIN(16200/16200, 1)		fr2 = ***1.000***
fr3 =	MIN(Sn/Sv,Sp/Sv,1)	= MIN(16200/16200, 16200/16200,1)		fr3 = ***1.000***
fr4 =	MIN(Sp/Sv,1)	= MIN(16200/16200,1)		fr4 = ***1.000***
Ro =	Do/2	= 24/2		Ro = ***12.000***
tcLeg41 =	Min(0.25,0.7*Min(0.75,Nt,te))	= Min(0.25,0.7*Min(0.75,0.688,0.75))		tc41 = ***0.250***
F =	1.000			F = ***1.000***

Pipe Required Wall Thickness - trn from internal, trnE from external pressure

trn =	(P*Rn)/(Sn*E - 0.6*P) <= tn-UT	= (353.9*11.398)/(16200*0.85 - 0.6*353.9)		trn = ***0.298***	**Acceptable**
trnR =	(P*Rn)/(Sn*1 - 0.6*P)	= (353.9*11.398)/(16200*1 - 0.6*353.9)	*E=1*	trnR = ***0.252***	
trnE =	(3*Do*Pa)/(4*B) <= tn-ut	= (3*24*7.5)/(4*4071)		trnE = ***0.033***	**Acceptable**

Appendix 1-7 Necessary Check

when Ds>60,if(2*Rn<=Ds/3,if(2*Rn<=40, "App. 1-7 calculations not required","App. 1-7 calculations required"),"App. 1-7 calculations required")
when Ds<=60,if(2*Rn<Ds/2,if(2*Rn<20,"App. 1-7 calculations not required","App. 1-7 calculations required"),"App. 1-7 calculations required")

App. 1-7 calculations required

Area Replacement: Fig UG-37.1

			Pressure From:	**Internal**	**External**
A =	1.0*d*tr*F + 2*tn*tr*F*(1-frone)	A Required (internal) =		***10.141***	
=	1.0*22.624*0.448*1 + 2*0.688*0.448*1*(1-1)				
Ae =	0.5*(d*trE*1 + 2*tn*trE*1*(1-frone)) = 0.5*(22.624*0.134*1 + 2*0.688*0.134*1*(1-1))	A Required (external) =			***1.520***
A1 =	max(2*dLr-d, 2*(t+tn)) * (E1*t-F*tr)-2*tn*(E1*t-F*tr)*(1-fr1)	A1 =		***3.413***	
=	max(11.312, 2*(0.75+0.688)) * (1*0.75-1*0.448)-2*0.688*(1*0.75-1*0.448)*(1-1)				
A1e =	max(2*dLr-d, 2*(t+tn)) * (Eone*t-F*trE)-2*tn*(Eone*t-F*trE)*(1-frone)	A1e =			***6.964***
=	max(11.312, 2*(0.75+0.688)) * (1*0.75-1*0.134)-2*0.688*(1*0.75-1*0.134)*(1-1)				
A2 =	min((tn-trn)*fr2*min(5*t,2*L) , (tn-trnR)*(Min(2.5*tn+te,L)*fr1*2)	A2 =		***1.634***	
=	min((0.688-0.252)*1*min(5*0.75,2*6) , (0.688-0.252)*(Min(2.5*0.688+0.75,2*6)*1*2)				
A2e =	min((tn-trnE)*frtwo*Min(5*t,2*L) , 2*(tn-trnE)*Min(2.5*tn+te,L)*frone)	A2e =			***2.456***
=	min((0.688-0.033)*1*Min(5*0.75,2*6) , 2*(0.688-0.033)*Min(2.5*0.688+0.75,6)*1)				
A5 =	(Dp - d - 2tn)te*fr4 =(30 - 22.624 - 2*0.688)*0.75*1	A5 =		***4.500***	***4.500***
A41 =	Leg41^2*frThree A41 = 0.5625^2*1	A41 =		***0.316***	***0.316***
A42 =	Leg42^2*frfour A42 = 0.6875^2*1	A42 =		***0.473***	***0.473***
		Actual Area =		***10.336***	***14.709***

App 1-7 Nozzle Ver 1.05

Fig 1-7-2 Case A 27-Apr-07

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Sample Vessel 8 <- Vessel

Nozzle A - App. 1-7 <- Description

Dimensions:

42.000	<- Dv, vessel outside diameter
0.750	<- t, vessel wall
24.000	<- Dn, nozzle outside diameter
0.688	<- tn, nozzle wall
3.000	<- Pw, plate width
0.750	<- te, plate thickness
6.000	<- Fw, flange width
2.750	<- tf, flange thickness
10.620	<- Hf, flange standoff
353.9	<- P, pressure
16,200	<- Ss, stress limit for shell
16,200	<- Sn, stress limit for nozzle

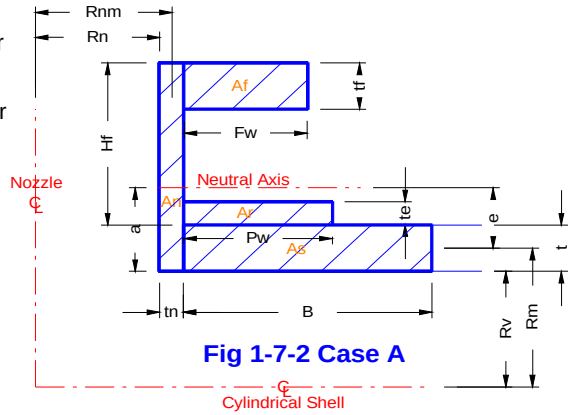


Fig 1-7-2 Case A

10.336	<- Aactual, actual area from limit radius by app. 1-7(a)
10.141	<- Arequired, required area

Geometry

Rv =	Dv/2-t	= 42/2-0.75	Rv =	***20.250***
Rn =	Dn/2-tn	= 24/2-0.688	Rn =	***11.312***
Rm =	Rv + t/2	= 20.25 + 0.75/2	Rm =	***20.625***
Rnm =	Rn + tn/2	= 11.312 + 0.688/2	Rnm =	***11.656***
B =	Sqrt(Rm*t)	= Sqrt(20.625*0.75)	B =	***3.933***
H =	Hf	= 10.62	H =	***10.620***
Hfmax =	Max(Sqrt(Rnm*tn)+te,16*tn) >= Hf	**Okay**	Hmax =	***11.008***
=	Max(Sqrt(11.656*0.688)+0.75,16*0.688) >= 10.62			

App. 1-7(a)

Limit radius =	Max(0.75*2*Rn, Rn+t+tn)	dLr =	**16.968**
=	Max(0.75*2*11.312, 11.312+0.75+0.688)		
Aactual >=	(2/3)*Arequired 10.336 >= 10.141*2/3	**Acceptable**	

App. 1-7(b) necessary check

	App. 1-7(b) required
If(Rn/Rv>0.7,"U-2(g) needed","U-2(g) not needed")	***U-2(g) not needed***
If(2*Rv>60,"Required","not required)	***Not required***
If(2*Rn>40,"Required","not required")	***Not required***
if(2*Rn>3.4*Sqrt(Rv*t),"Required","Not required")	***Required***

Moment of Inertia about Neutral Axis a

Width	Depth	Y	Area	A*Y	A*Y^2	Io Depth	
3.933	0.750	0.375	2.950	1.106	0.415	0.138	Shell - As
3.000	0.750	1.125	2.250	2.531	2.848	0.105	Plate - Ar
6.000	2.750	9.995	16.500	164.918	1648.350	10.398	Flange - Af
0.688	11.370	5.685	7.823	44.471	252.819	84.273	Nozzle - An
		Area = As	**29.522**	**213.026**	**1904.432**	**94.915**	Total

a =	AY/As	= 213.026/29.522	a =	***7.216***
I =	AYtwo+IoD - Cxx*Ay	= 1904.432+94.915 - 7.216*213	I =	***462.201***

Stress Limts

SmMax =	Min(Ss,Sn)	= Min(16200,16200)	SmMax =	***16,200***
SbMax =	1.5*SmMax	= 1.5*16200	SbMax =	***24,300***

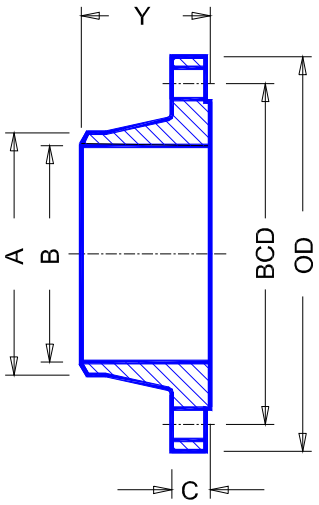
Membrane Stress

Sm =	P*(Rv*(Rn+tn+B) + Rn*(t+te+H))/As <= SmMax	Sm =	***5,511***
=	353.898*(20.25*(11.312+0.688+3.933) + 11.312*(0.75+0.75+10.62))/29.522 <= 16200	**Acceptable**	

Bending Stress

e =	a-t/2	= 7.216-0.75/2	e =	***6.841***
M =	P*(Rn^3/6 + Rv*Rn*e)		M =	***639,936***
=	353.898*(11.312^3/6 + 20.25*11.312*6.841)			
Sb =	M*a/I	= 639936*7.216/462.201	Sb =	***9,991***
Limit =	Sb + Sm <= SbMax	= 9991 + 5511 <= 24300	Limit =	***15,502***
				Acceptable

ASME B16.5 & B16.47-1996 ASME VIII 2004 Edition No Addenda



Sample Vessel 8 <- Vessel
Flange A <- Description

Select Flange

SA <- Category
Forged <- Material Type
SA 182 Gr. F304 <- Material
300 <- Pressure Class
24.00 <- Nominal Size

Nominal - ***18Cr-8Ni***
Table - ***2-2.1***
Max Temp ºF - ***1500***
Pod, pipe OD - ***24.000***

Operating Conditions

650 <- T, temperature ºF
353.9 <- P, pressure, psig
0.000 <- Corr, corrosion allowance

Acceptable

Max press @100ºF [p1] ***720***
Max press @650ºF [p2] ***430***

Flange Welds: VIII UW-15 (c)

16200 <- Sp, allowable stress, pipe
16200 <- Sf, allowable stress, flange
22.624 <- B, flange bore
0.70 <- E, weld efficiency

Weld Strength:

Min Sa =	MIN(Sp,Sf)	= MIN(16200,16200)	Min Sa = ***16,200***
Max Weld Stress =	Sa * E	= 16200 * 0.7	Max Weld Stress = ***11,340***
Weld Load =	POD^2*pi*P/4	= 24^2*pi*353.898/4	Load = ***160,100***
Weld Area =	Pi*(A^2-(B+2*Corr)^2)/4	= Pi*(24^2-(22.624+2*0)^2)/4	Area = ***50.387***
Weld Stress =	Load/Area	= 160099.638/50.387	Stress = ***3,177***

Acceptable

Sample Vessel 8 <- Vessel

Nozzles B - 12" SCH 40 Pipe <- Description

Shell:

SA-240 304 <- Shell Material

16,200 <- Sv, shell allowable stress level, PSI

1.00 <- Eone, efficiency of shell at nozzle

0.698 <- Vt, shell wall thick, uncorroded, UT removed

0.400 <- tr, required shell wall thickness int. press.(E=1)

0.079 <- trE, required shell wall thickness ext. press.(E=1)

0.000 <- sca, shell corrosion allowance

0.063 <- tmin16b, Min allowed wall per UG-16(b)

Nozzle:

SA-312 TP304 <- Nozzle Material

16,200 <- Sn, allowable stress level (Sn)

3,699 <- B, from A = ***0.00029***

0.85 <- E, nozzle efficiency

353.9 <- P, internal design pressure

7.5 <- Pa, external design pressure

12.750 <- Do, outside diameter

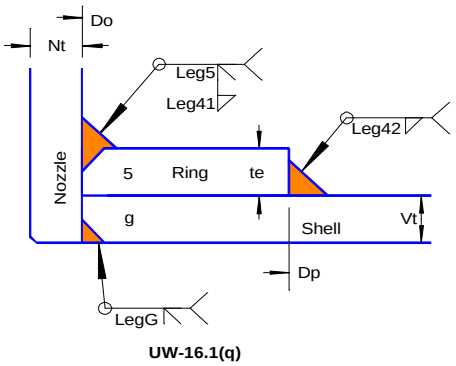
10.000 <- dLr, Limit radius <= d

0.406 <- Nt, wall thick, uncorroded

12.5% <- UTp, undertolerance (%)

0.000 <- nca, nozzle corrosion allowance

4.000 <- L, exterior Projection



UW-16.1(q)

Reinforcing:

SA-240 304 <- Reinforcing plate material

At least one telltale hole (max. size NPS 1/4 tap) in repad required

16,200 <- Sp, allowable stress level

16.000 <- Dp, outside diameter

0.500 <- te, reinforcement thick

0.375 <- Leg41, size of weld fillet

0.438 <- Leg42, size of weld fillet

0.698 <- LegG, depth of groove

0.500 <- Leg5, depth of groove

Variables:

UT =	Nt*UTp	= 0.406 * 0.125	*Undertolerance*	UT =	***0.051***
Rn =	Do/2 - (Nt-nca) + UT	= 12.75/2 - (0.406-0) + 0.051	*Effective Radius*	Rn =	***6.020***
Dp =	Min(2*d,DpEntered)	= Min(2*11.938,16)	*Effective Reinforcing*	Dp =	***16.000***
t =	Vt-sca	= 0.6975 - 0	*Effective Shell Thickness*	t =	***0.698***
ti =	Nt-2*nca	= 0.406 - 2 * 0	*Nom Thick of Int. Proj.*	ti =	***0.406***
te =	teEntered		*Effective Reinf. Thick.*	te =	***0.500***
tn =	Nt-nca	= 0.406-0	*Avail. Nozzle Thick. No UT*	tn =	***0.406***
d =	Do-2*tn	= 12.75 - 2*0.406	*Opening Dia.*	d =	***11.938***
fr1 =	MIN(Sn/Sv,1)	= MIN(16200/16200, 1)		fr1 =	***1.000***
fr2 =	MIN(Sn/Sv,1)	= MIN(16200/16200, 1)		fr2 =	***1.000***
fr3 =	MIN(Sn/Sv,Sp/Sv,1)	= MIN(16200/16200, 16200/16200,1)		fr3 =	***1.000***
fr4 =	MIN(Sp/Sv,1)	= MIN(16200/16200,1)		fr4 =	***1.000***
Ro =	Do/2	= 12.75/2		Ro =	***6.375***
tcLeg41 =	Min(0.25,0.7*Min(0.75,Nt,te))	= Min(0.25,0.7*Min(0.75,0.406,0.5))		tc41 =	***0.250***
F =	1.000			F =	***1.000***

Pipe Required Wall Thickness - trn from internal, trnE from external pressure

trn =	(P*Rn)/(Sn*E - 0.6*P) <= tn-UT	= (353.9*6.02)/(16200*0.85 - 0.6*353.9)		trn =	***0.157***	**Acceptable**
trnR =	(P*Rn)/(Sn*1 - 0.6*P)	= (353.9*6.02)/(16200*1 - 0.6*353.9)	*E=1*	trnR =	***0.133***	
trnE =	(3*Do*Pa)/(4*B) <= tn-ut	= (3*12.75*7.5)/(4*3699)		trnE =	***0.019***	**Acceptable**

Geometry Constraints:

0.7*Leg41 >=	tc41	0.7*0.375 >=	0.25	***0.263***	>=	***0.250***	**Acceptable**
0.7*Leg42 >=	0.5*Min(0.75,te,Vt)	0.7*0.438 >=	0.5*Min(0.75,0.5,0.698)	***0.306***	>=	***0.250***	**Acceptable**
Leg5 >=	0.7*Min(0.75,te,Nt)	0.5 >=	0.7*Min(0.75,0.5,0.406)	***0.500***	>=	***0.284***	**Acceptable**
LegG >=	0.7*Min(0.75,Vt,Nt)	0.698 >=	0.7*Min(0.75,0.698,0.406)	***0.698***	>=	***0.284***	**Acceptable**

Area Replacement: Fig UG-37.1

			Pressure From:	Internal	External
A =	1.0*d*tr*F + 2*tn*tr*F*(1-frone)		A Required (internal) =	***4.776***	
=	1.0*11.938*0.4*1 + 2*0.406*0.4*1*(1-1)				
Ae =	0.5*(d*trE*1 + 2*tn*trE*1*(1-frone)) = 0.5*(11.938*0.079*1 + 2*0.406*0.079*1*(1-1))		A Required (external) =		***0.470***
A1 =	max(2*dLr-d, 2*(t+tn)) * (E1*t-F*tr)-2*tn*(E1*t-F*tr)*(1-fr1)		A1 =	***2.398***	
=	max(8.062, 2*(0.698+0.406)) * (1*0.698-1*0.4)-2*0.406*(1*0.698-1*0.4)*(1-1)				
A1e =	max(2*dLr-d, 2*(t+tn)) * (Eone*t-F*trE)-2*tn*(Eone*t-F*trE)*(1-frone)		A1e =		***4.988***
=	max(8.062, 2*(0.698+0.406)) * (1*0.698-1*0.079)-2*0.406*(1*0.698-1*0.079)*(1-1)				
A2 =	min((tn-trn)*fr2*min(5*t,2*L) , (tn-trnR)*(Min(2.5*tn+te,L)*fr1*2)		A2 =	***0.826***	
=	min((0.406-0.133)*1*min(5*0.698,2*4) , (0.406-0.133)*(Min(2.5*0.406+0.5,2*4)*1*2)				
A2e =	min((tn-trnE)*frtwo*Min(5*t,2*L) , 2*(tn-trnE)*Min(2.5*tn+te,L)*frone)		A2e =		***1.171***
=	min((0.406-0.019)*1*Min(5*0.698,2*4) , 2*(0.406-0.019)*Min(2.5*0.406+0.5,4)*1)				
A5 =	(Dp - d - 2tn)te*fr4 =(16 - 11.938 - 2*0.406)*0.5*1		A5 =	***1.625***	***1.625***
A41 =	Leg41^2*frThree A41 = 0.375^2*1		A41 =	***0.141***	***0.141***
A42 =	Leg42^2*frfour A42 = 0.4375^2*1		A42 =	***0.191***	***0.191***
			Actual Area =	***5.182***	***8.117***
		Acceptable	Actual-Required =	***0.406***	***7.647***

Internal Weld Load: (UG-41)

WmaxI =	(A - A1 + 2*Tn*Fr1*(E1*t-F*tr))*Sv, min0	= (4.776 - 2.398 + 2*0.406*1*(1*0.698-1*0.4))*16200	WmaxI =	***42,430***
W_{1-1} =	MIN((A2 + A5 + A41 + A42)*Sv,WmaxI)	= MIN((0.826 + 1.625 + 0.141 + 0.191)*16200,42430)	W_{1-1} =	***42,430***
W_{2-2} =	Min((A2 + A3 + A41 + A43 + 2*Tn*t*frone)*Sv,WmaxI)	= Min((0.826 + 0 + 0.141 + 0 + 2*0.406*0.6	W_{2-2} =	***24,841***
W_{3-3} =	Min((A2 + A3 + A5 + A41 + A42 + A43 + 2*Tn*t*fr1)*Sv,WmaxI)	Weld load	W_{3-3} =	***42,430***
=	Min((0.826 + 0 + 1.625 + 0.141 + 0.191 + 0 + 2*0.406*0.698*1)*16200,42430)			

External Weld Load: (UG-41)

WmaxE =	(Ae - A1e + 2*Tn*Fr1*(E1*t-F*tr))*Sv, min0	= (0.47 - 4.988 + 2*0.406*1*(1*0.698-1*0.4))*16200	WmaxE =	***0***
W1-1 =	MIN((A2e + A5 + A41 + A42)*Sv,WmaxE)	*Weld load*	W_{1-1e} =	***0***
=	MIN((1.171 + 1.625 + 0.141 + 0.191)*16200,0)			
W_{2-2} =	Min((A2e + A3 + A41 + A43 + 2*Tn*t*frone)*Sv,WmaxE)	= Min((1.171 + 0 + 0.141 + 0 + 2*0.406*0.6	W_{2-2e} =	***0***
W_{3-3} =	Min((A2e + A3 + A5 + A41 + A42 + A43 + 2*Tn*t*fr1)*Sv,WmaxE)	Weld load	W_{3-3e} =	***0***
=	Min((1.171 + 0 + 1.625 + 0.141 + 0.191 + 0 + 2*0.406*0.698*1)*16200,0)			

Component Strength (UG-45(c), UW-15(c))

A2 shear =	PI()/2*(Do-tn)*tn*Sn*0.7	= PI()/2*(12.75-0.406)*0.406*16200*0.7	A2s =	***89,272***
g tension =	PI()/2*Do*LegG*Min(Sv,Sn)*0.74	= PI()/2*12.75*0.698*Min(16200,16200)*0.74	gt =	***167,464***
A41 shear =	PI()/2*Do*Leg41*Min(Sn,Sp)*0.49	= PI()/2*12.75*0.375*Min(16200,16200)*0.49	A41s =	***59,617***
A42 shear =	PI()/2*DP*Leg42*Min(Sv,Sp)*0.49	= PI()/2*16*0.438*Min(16200,16200)*0.49	A42s =	***87,283***
Leg 5 tens =	PI()/2*Do*Leg5*Min(Sn,Sp)*0.74	= PI()/2*12.75*0.5*Min(16200,16200)*0.74	Leg5t =	***120,046***

Failure mode along strength path (Greater than Weld Load, see App L-7)

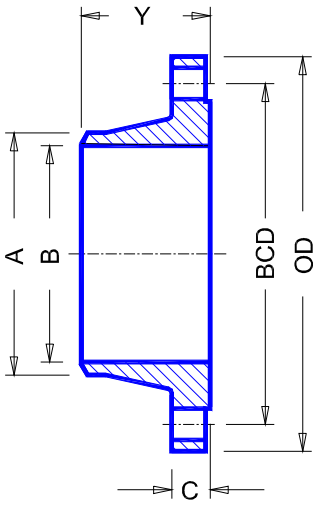
S_{1-1} =	A42s + A2s >= W1-1	**Acceptable**	S_{1-1} =	***176,555***
=	87283 + 89272 >= 42430			
S_{2-2} =	A41s + gt + Leg5t + A43s >= W2-2	**Acceptable**	S_{2-2} =	***347,127***
=	59617 + 167464 + 120046 + 0 >= 24841			
S_{3-3} =	gt + A42s + A43s >= W3-3	**Acceptable**	S_{3-3} =	***254,747***
=	167464 + 87283 + 0 >= 42430			

Tstd =	Standard pipe wall thickness from chart			Tstd =	***0.375***
Swre =	tr * Pa / P	= 0.4 * 7.5 / 353.898	*Req. Exterior pressure*	Swre =	***0.008***
Nact =	Nt * (1-UTp)	= 0.406 * (1-0.125)	*Actual Wall Thick.*	Nact =	***0.355***
Tt =	0.8/Nth	= 0.8/0	*Ug-31(c)(2) threads*	Tt =	***0.000***

UG-45 **Acceptable**

UG45 =	Max(UG45a, UG45b) <= Nact	= Max(0.157, 0.328) <= 0.355	UG45 =	***0.328***
UG45a =	Max(trn,trnE) + Nca + Tt	= Max(0.157,0.019) + 0 + 0	UG45a =	***0.157***
UG45b =	Min(UG45b3,UG45b4)	= Min(0.4, 0.328)	UG45b =	***0.328***
UG45b1 =	Max(tr + Sca, tmin16b + Sca)	= Max(0.4 + 0, 0.063 + 0)	UG45b1 =	***0.400***
UG45b2 =	Max(Swre + Sca,tmin16b + Sca)	= Max(0.008 + 0,0.063 + 0)	UG45b2 =	***0.063***
UG45b3 =	Max(UG45b1,UG45b2)	= Max(0.4,0.063)	UG45b3 =	***0.400***
UG45b4 =	Tstd*0.875 + Nca	= 0.375*0.875 + 0	UG45b4 =	***0.328***

ASME B16.5 & B16.47-1996 ASME VIII 2004 Edition No Addenda



Sample Vessel 8 <- Vessel
Flange B <- Description

Select Flange

SA <- Category
Forged <- Material Type
SA 182 Gr. F304 <- Material
300 <- Pressure Class
12.00 <- Nominal Size

Nominal - ***18Cr-8Ni***
Table - ***2-2.1***
Max Temp ºF - ***1500***
Pod, pipe OD - ***12.750***

Operating Conditions

650 <- T, temperature ºF
353.9 <- P, pressure, psig
0.000 <- Corr, corrosion allowance

Acceptable

Max press @100ºF [p1] ***720***
Max press @650ºF [p2] ***430***

Flange Welds: VIII UW-15 (c)

16200 <- Sp, allowable stress, pipe
16200 <- Sf, allowable stress, flange
12.040 <- B, flange bore
0.70 <- E, weld efficiency

Weld Strength:

Min Sa =	MIN(Sp,Sf)	= MIN(16200,16200)	Min Sa = ***16,200***
Max Weld Stress =	Sa * E	= 16200 * 0.7	Max Weld Stress = ***11,340***
Weld Load =	POD^2*pi*P/4	= 12.75^2*pi*353.898/4	Load = ***45,184***
Weld Area =	Pi*(A^2-(B+2*Corr)^2)/4	= Pi*(12.75^2-(12.04+2*0)^2)/4	Area = ***13.833***
Weld Stress =	Load/Area	= 45184.371/13.833	Stress = ***3,266***

Acceptable

Sample Vessel 8 <- Vessel

Nozzles C& D - 2" SCH 160 Pipe <- Description

Shell:

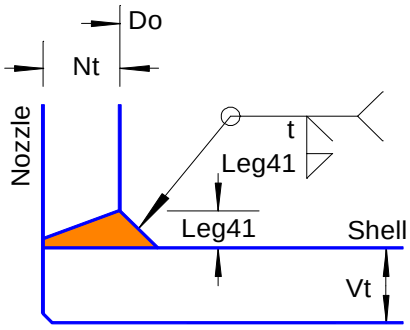
SA-240 304 <- Shell Material
16,200 <- Sv, shell allowable stress level, PSI
1.00 <- Eone, efficiency of shell at nozzle
0.698 <- Vt, shell wall thick, uncorroded, UT removed
0.400 <- tr, required shell wall thickness int. press.(E=1)
0.079 <- trE, required shell wall thickness ext. press.(E=1)
0.000 <- sca, shell corrosion allowance
0.063 <- tmin16b, Min allowed wall per UG-16(b)

Nozzle:

SA-312 TP304 <- Nozzle Material
16,200 <- Sn, allowable stress level (Sn)
1,853 <- B, from A = ***0.00014***
0.85 <- E, nozzle efficiency
353.9 <- P, internal design pressure
7.5 <- Pa, external design pressure
2.375 <- Do, outside diameter
2.225 <- dh, id of hillside nozzle
0.344 <- Nt, wall thick, uncorroded
12.5% <- UTp, undertolerance (%)
0.000 <- nca, nozzle corrosion allowance
4.000 <- L, exterior Projection

Reinforcing:

0.375 <- Leg41, size of weld fillet
1.000 <- F



UW-16.1 (a)

Note: Hillside nozzle C is calculated. Calculation covers nozzle D.

Variables:

UT =	Nt*UTp	= 0.344 * 0.125	*Undertolerance*	UT =	***0.043***
Rn =	Do/2 - (Nt-nca) + UT	= 2.375/2 - (0.344-0) + 0.043	*Effective Radius*	Rn =	***0.887***
t =	Vt-sca	= 0.6975 - 0	*Effective Shell Thickness*	t =	***0.698***
tn =	Nt-nca	= 0.344-0	*Avail. Nozzle Thick. No UT*	tn =	***0.344***
d =	dh	= 2.225	*Finished Opening Dia.*	d =	***2.225***
fr1 =	1.000			fr1 =	***1.000***
fr2 =	MIN(Sn/Sv,1)	= MIN(16200/16200, 1)		fr2 =	***1.000***
tcLeg41 =	Min(0.25,0.7*Min(0.75,Nt,Vt))	= Min(0.25,0.7*Min(0.75,0.344,0.698))		tc41 =	***0.241***
F =	Min(Fenterered, 1)			F =	***1.000***

Pipe Required Wall Thickness - trn from internal, trnE from external pressure

trn =	(P*Rn)/(Sn*E - 0.6*P) <= tn-UT	= (353.9*0.887)/(16200*0.85 - 0.6*353.9)		trn =	***0.023***	**Acceptable**
trnR =	(P*Rn)/(Sn*1 - 0.6*P)	= (353.9*0.887)/(16200*1 - 0.6*353.9)	*E=1*	trnR =	***0.020***	
trnE =	(3*Do*Pa)/(4*B) <= tn-ut	= (3*2.375*7.5)/(4*1853)		trnE =	***0.007***	**Acceptable**

Geometry Constraints:

0.7*Leg41 >=	tc41	0.7*0.375 >= 0.241	***0.263***	>=	***0.241***	**Acceptable**

Area reinforcement calculation exemptions: UG-36(c)(3)(a)

d =	2.225	*net opening diameter*	***Not Required***	d =	***2.225***

IF(Max(tr,trE)>0.375", if(d>2.375", "reinforcement calculations required", "not required"), if(d>3.5", "required", "not required"))

Tstd =	Standard pipe wall thickness from chart			Tstd =	***0.154***
Swre =	tr * Pa / P	= 0.4 * 7.5 / 353.898	*Req. Exterior pressure*	Swre =	***0.008***
Nact =	Nt * (1-UTp)	= 0.344 * (1-0.125)	*Actual Wall Thick.*	Nact =	***0.301***
Tt =	0.8/Nth	= 0.8/0	*Ug-31(c)(2) threads*	Tt =	***0.000***

UG-45 **Acceptable**

UG45 =	Max(UG45a, UG45b) <= Nact	= Max(0.023, 0.135) <= 0.301	UG45 =	***0.135***
UG45a =	Max(trn,trnE) + Nca + Tt	= Max(0.023,0.007) + 0 + 0	UG45a =	***0.023***
UG45b =	Min(UG45b3,UG45b4)	= Min(0.4, 0.135)	UG45b =	***0.135***
UG45b1 =	Max(tr + Sca, tmin16b + Sca)	= Max(0.4 + 0, 0.063 + 0)	UG45b1 =	***0.400***
UG45b2 =	Max(Swre + Sca,tmin16b + Sca)	= Max(0.008 + 0,0.063 + 0)	UG45b2 =	***0.063***
UG45b3 =	Max(UG45b1,UG45b2)	= Max(0.4,0.063)	UG45b3 =	***0.400***
UG45b4 =	Tstd*0.875 + Nca	= 0.154*0.875 + 0	UG45b4 =	***0.135***

Sample Vessel 8 <- Vessel

Nozzles E - 2" SCH 160 Pipe <- Description

Shell:

SA-240 304 <- Shell Material

16,200 <- Sv, shell allowable stress level, PSI

1.00 <- Eone, efficiency of shell at nozzle

40.50 <- Ds, Shell ID

0.750 <- Vt, shell wall thick, uncorroded, UT removed

0.448 <- tr, required shell wall thickness int. press.(E=1)

0.134 <- trE, required shell wall thickness ext. press.(E=1)

0.000 <- sca, shell corrosion allowance

0.063 <- tmin16b, Min allowed wall per UG-16(b)

Nozzle:

SA-312 TP304 <- Nozzle Material

16,200 <- Sn, allowable stress level (Sn)

1,853 <- B, from A = ***0.00014***

0.85 <- E, nozzle efficiency

353.9 <- P, internal design pressure

7.5 <- Pa, external design pressure

2.375 <- Do, outside diameter

0.344 <- Nt, wall thick, uncorroded

12.5% <- UTp, undertolerance (%)

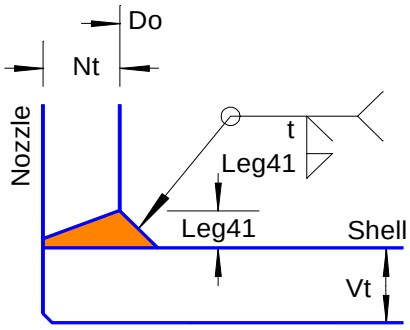
0.000 <- nca, nozzle corrosion allowance

4.000 <- L, exterior Projection

Reinforcing:

0.375 <- Leg41, size of weld fillet

1.000 <- F



UW-16.1 (a)

Variables:

UT =	Nt*UTp	= 0.344 * 0.125	*Undertolerance*	UT =	***0.043***
Rn =	Do/2 - (Nt-nca) + UT	= 2.375/2 - (0.344-0) + 0.043	*Effective Radius*	Rn =	***0.887***
t =	Vt-sca	= 0.75 - 0	*Effective Shell Thickness*	t =	***0.750***
tn =	Nt-nca	= 0.344-0	*Avail. Nozzle Thick. No UT*	tn =	***0.344***
d =	Do-2*tn	= 2.375 - 2*0.344	*Opening Dia.*	d =	***1.687***
fr1 =	1.000			fr1 =	***1.000***
fr2 =	MIN(Sn/Sv,1)	= MIN(16200/16200, 1)		fr2 =	***1.000***
tcLeg41 =	Min(0.25,0.7*Min(0.75,Nt,Vt))	= Min(0.25,0.7*Min(0.75,0.344,0.75))		tc41 =	***0.241***
F =	Min(Fenterered, 1)			F =	***1.000***

Pipe Required Wall Thickness - trn from internal, trnE from external pressure

trn =	(P*Rn)/(Sn*E - 0.6*P) <= tn-UT	= (353.9*0.887)/(16200*0.85 - 0.6*353.9)		trn =	***0.023***	**Acceptable**
trnR =	(P*Rn)/(Sn*1 - 0.6*P)	= (353.9*0.887)/(16200*1 - 0.6*353.9)	*E=1*	trnR =	***0.020***	
trnE =	(3*Do*Pa)/(4*B) <= tn-ut	= (3*2.375*7.5)/(4*1853)		trnE =	***0.007***	**Acceptable**

Geometry Constraints:

0.7*Leg41 >=	tc41	0.7*0.375 >=	0.241	***0.263***	>=	***0.241***	**Acceptable**

Area reinforcement calculation exemptions: UG-36(c)(3)(a)

d =	1.687	*net opening diameter*	***Not Required***	d =	***1.687***

IF(Max(tr,trE)>0.375", if(d>2.375", "reinforcement calculations required", "not required"), if(d>3.5", "required", "not required"))

Appendix 1-7 Necessary Check

when Ds>60,if(2*Rn<=Ds/3,if(2*Rn<=40, "App. 1-7 calculations not required","App. 1-7 calculations required"),"App. 1-7 calculations required")

when Ds<=60,if(2*Rn<Ds/2,if(2*Rn<20,"App. 1-7 calculations not required","App. 1-7 calculations required"),"App. 1-7 calculations required")

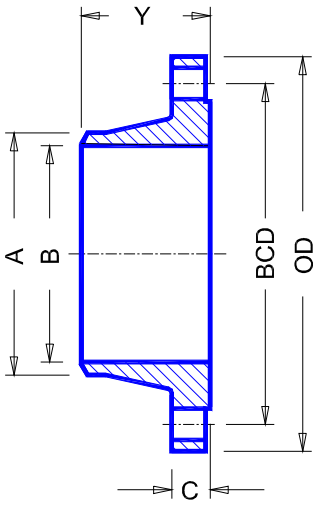
App. 1-7 calculations not required

Tstd =	Standard pipe wall thickness from chart			Tstd =	***0.154***
Swre =	tr * Pa / P	= 0.448 * 7.5 / 353.898	*Req. Exterior pressure*	Swre =	***0.009***
Nact =	Nt * (1-UTp)	= 0.344 * (1-0.125)	*Actual Wall Thick.*	Nact =	***0.301***
Tt =	0.8/Nth	= 0.8/0	*Ug-31(c)(2) threads*	Tt =	***0.000***

UG-45 **Acceptable**

UG45 =	Max(UG45a, UG45b) <= Nact	= Max(0.023, 0.135) <= 0.301	UG45 =	***0.135***
UG45a =	Max(trn,trnE) + Nca + Tt	= Max(0.023,0.007) + 0 + 0	UG45a =	***0.023***
UG45b =	Min(UG45b3,UG45b4)	= Min(0.448, 0.135)	UG45b =	***0.135***
UG45b1 =	Max(tr + Sca, tmin16b + Sca)	= Max(0.448 + 0, 0.063 + 0)	UG45b1 =	***0.448***
UG45b2 =	Max(Swre + Sca,tmin16b + Sca)	= Max(0.009 + 0,0.063 + 0)	UG45b2 =	***0.063***
UG45b3 =	Max(UG45b1,UG45b2)	= Max(0.448,0.063)	UG45b3 =	***0.448***
UG45b4 =	Tstd*0.875 + Nca	= 0.154*0.875 + 0	UG45b4 =	***0.135***

ASME B16.5 & B16.47-1996 ASME VIII 2004 Edition No Addenda



Sample Vessel 8 <- Vessel
Flange C, D & E <- Description

Select Flange

SA <- Category
Forged <- Material Type
SA 182 Gr. F304 <- Material
300 <- Pressure Class
2.00 <- Nominal Size

Nominal - ***18Cr-8Ni***
Table - ***2-2.1***
Max Temp ºF - ***1500***
Pod, pipe OD - ***2.375***

Operating Conditions

650 <- T, temperature ºF
353.9 <- P, pressure, psig
0.000 <- Corr, corrosion allowance

Acceptable

Max press @100ºF [p1] ***720***
Max press @650ºF [p2] ***430***

Flange Welds: VIII UW-15 (c)

16200 <- Sp, allowable stress, pipe
16200 <- Sf, allowable stress, flange
1.687 <- B, flange bore
0.70 <- E, weld efficiency

Weld Strength:

Min Sa =	MIN(Sp,Sf)	= MIN(16200,16200)	Min Sa = ***16,200***
Max Weld Stress =	Sa * E	= 16200 * 0.7	Max Weld Stress = ***11,340***
Weld Load =	POD^2*pi*P/4	= 2.375^2*pi*353.898/4	Load = ***1,568***
Weld Area =	Pi*(A^2-(B+2*Corr)^2)/4	= Pi*(2.375^2-(1.687+2*0)^2)/4	Area = ***2.195***
Weld Stress =	Load/Area	= 1567.816/2.195	Stress = ***714***

Acceptable

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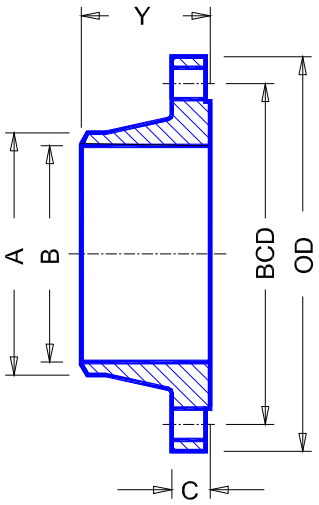
Sample Vessel 8 <- Vessel
Flange 42" <- Description



Select Flange

SA <- Category
Forged <- Material Type
SA 182 Gr. F304 <- Material
300 <- Pressure Class
42.00 <- Nominal Size

Nominal - ***18Cr-8Ni***
Table - ***2-2.1***
Max Temp ºF - ***1500***
Pod, pipe OD - ***42.000***

Operating Conditions

650 <- T, temperature ºF
353.9 <- P, pressure, psig
0.000 <- Corr, corrosion allowance

Acceptable

Max press @100ºF [p1] ***720***
Max press @650ºF [p2] ***430***

Flange Welds: VIII UW-15 (c)

16200 <- Sp, allowable stress, pipe
16200 <- Sf, allowable stress, flange
40.500 <- B, flange bore
0.70 <- E, weld efficiency

Weld Strength:

Min Sa =	MIN(Sp,Sf)	= MIN(16200,16200)	Min Sa = ***16,200***
Max Weld Stress =	Sa * E	= 16200 * 0.7	Max Weld Stress = ***11,340***
Weld Load =	POD^2*pi*P/4	= 42^2*pi*353.898/4	Load = ***490,305***
Weld Area =	Pi*(A^2-(B+2*Corr)^2)/4	= Pi*(42^2-(40.5+2*0)^2)/4	Area = ***97.193***
Weld Stress =	Load/Area	= 490305.142/97.193	Stress = ***5,045***

Acceptable

Sample Vessel 8 <- Vessel

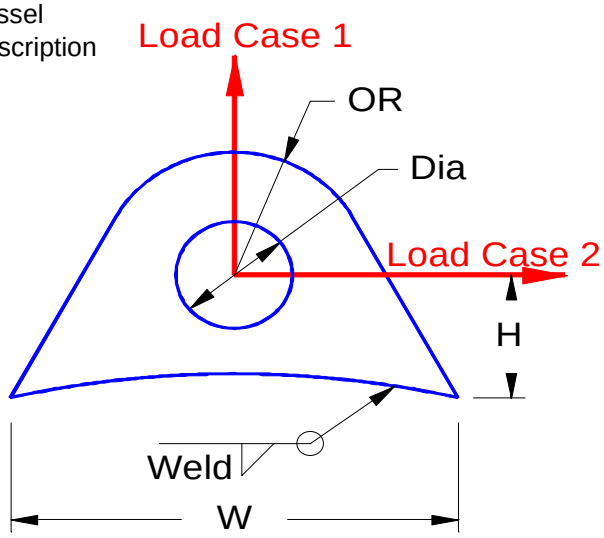
Volume:

0.80	<- Fluid Specific Gravity			
6.23	<- Head each (cuft)	12.46	2 heads	
53.68	<- Shell (cuft)	53.68		
		======		
		66.14	<- cuft	
		411.97	<- Imp Gallons	
		494.74	<- US Gallons	
		3,300	<- fluid wt	***3,300***

Construction:

479	<- Head (ea, lbs)	958.3	2 heads	
1985	<- Shell	1984.7		
6057	<- Misc	6057.038455		
		=======		
		9,000	<- lbs	***9,000***
				======
			Total	***12,300*** lbs

Sample Vessel 8 <- Vessel
Lifting Lugs <- Description



Dimensions (all units inch and lb):

9,000	<- Load, vessel weight empty
5.000	<- W, width
1.000	<- Thick, lug thickness
4.000	<- H, hole height
1.500	<- Dia, hole diameter
2.250	<- OR, outside radius
0.500	<- Weld, leg size
SA-240 304	<- Material
16,200	<- SA, allowed stress in tension

All of load assumed carried by one lug
All load cases analyzed independently
Never load lug perpendicular to face
Contour lug to fit vessel
Do not move or support vessel with this lug when full or pressurized

SB =	SA * 1.5	= 16200 * 1.5		UG-34(b) Max bending stress SB =	***24,300***
SS =	SA * 0.8	= 16200 * 0.8		IID Tbl 1A(d) Max Shear Stress SS =	***12,960***
SSw =	SA * 0.49	= 16200 * 0.49		UW-15© UW-15 Max Weld Shear SSw =	***7,938***

Tensile Stress (case 1)

A1 =	Thick*(OR-Dia/2)	= 1*(2.25-1.5/2)		A1 =	***1.500***
A =	A1 * 2	= 1.5 * 2		A =	***3.000***
Stress =	Load / A <= SA	= 9000 / 3 <= 16200	***Acceptable***	Stress =	***3,000***

Pin Bearing Stress (case 1 and 2)

Area =	Dia * Thick	= 1.5 * 1		Area =	***1.500***
Stress =	Load / Area <= 1.6*SA	= 9000 / 1.5 <= 25920	***Acceptable***	Stress =	***6,000***

Bending Stress (case 2)

Moment =	Load * H	= 9000 * 4		Moment =	***36,000***
I =	Thick * W^3 / 12	= 1 * 5^3 / 12		I =	***10.417***
c =	W/2	= 5/2		c =	***2.500***
Stress =	M*c/I <= SB	= 36000*2.5/10.417 <= 24300	***Acceptable***	Stress =	***8,640***

Shear Stress (case 2)

Area =	W*Thick	= 5*1		Area =	***5.000***
Stress =	Load/Area <= SS	= 9000/5 <= 12960	***Acceptable***	Stress =	***1,800***

Weld Stress (case 1)

Circ =	W*2+Thick*2+Weld*4	= 5*2+1*2+0.5*4		Circ =	***14***
Area =	Circ * Weld	= 14 * 0.5		Area =	***7.000***
Stress =	Load / Area <= SSw	= 9000 / 1.5 <= 7938	***Acceptable***	Stress =	***1,286***

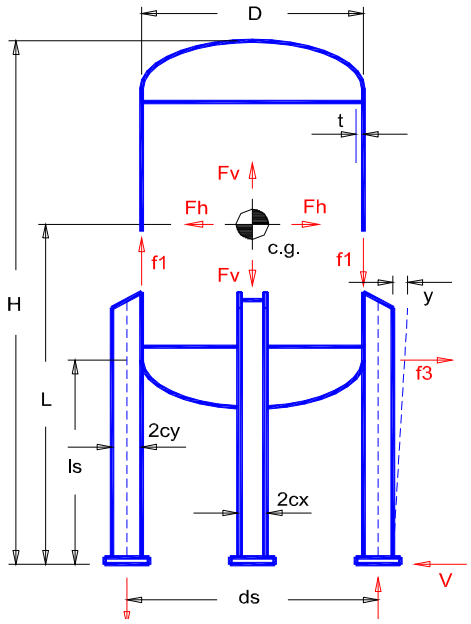
Weld Stress (case 2)

Moment =	Load * H	= 9000 * 4		Moment =	***36,000***
I =	(Thick +2*weld)* (W+2*Weld)^3 / 12 - I2			I =	***25.583***
=	(1 +2*0.5)* (5+2*0.5)^3 / 12 - 10.417				
c =	W/2 + Weld	= 5/2 + 0.5		c =	***3.000***
Stress =	M*c/I <= SSw	= 36000*3/25.583 <= 7938	***Acceptable***	Stress =	***4,221***

Sample Vessel 8 <- Vessel www.pveng.com ***NBC-95***

Vessel Dimensions (Inch and Lbs):

130.000	<- H, height
80.000	<- L, center of gravity
26.500	<- ls, leg free length
42.000	<- Do, shell outside diameter
44.500	<- ds, leg pitch diameter
0.750	<- t, shell corroded thickness
0.250	<- ws - leg weld size
13.500	<- lw - length of leg to shell weld
16.000	<- lwf - length of weld on foot
12,300	<- W, Weight lbs
353.9	<- Pr, Pressure

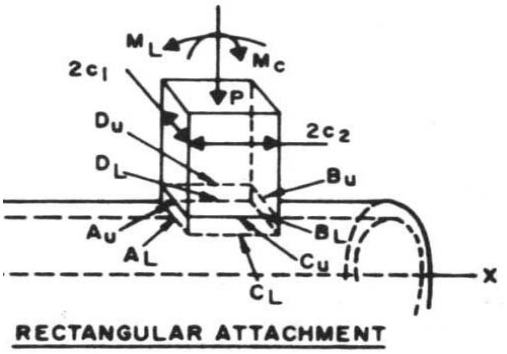


Site Specific Seismic Information per NBC-95:

1.000	<- I, occupation importance factor
0.400	<- v, zonal velocity ratio
6.000	<- Za, acceleration-related seismic zone
5.000	<- Zv, velocity-related seismic zone
1.300	<- Foundation Factor (F)

Leg Supports:

Angles 4" x 5/8"	<- Structural Description
4	<- n, number of legs
6.660	<- Ix, for one leg
6.660	<- Iy, for one leg
1.200	<- fFactor, Least radius of Gyration
4.610	<- A, Leg Cross Sectional Area
4.000	<- 2cx, Beam Depth
4.000	<- 2cy, Beam Width
0.800	<- K1, Leg Anchor Factor



RECTANGULAR ATTACHMENT

Material Properties:

17,100	<- maximum leg bending stress (Sb)
16,200	<- maximum shell stress (Sa)

Attachment Dimensions:

5.657	<- 2C1, Width of rectangular loading
13.500	<- 2C2, Length of rectangular loading

Static Deflection

E = 30,000,000

bc = 12.0 leg boundary condition based on fixed or loose leg

y = (2*W*ls^3)/(bc*n*E*(Ix + Iy)) y = ***0.024***

= (2*12300*26.5^3)/(12*4*30000000*(6.66 + 6.66))

Period of Vibration

g = 386

T = 2*pi*sqrt(y/g) =2 * 3.14 * sqrt(0.02/386) T = ***0.049***

Base Shear

U = 0.6

R = 4

4.200 <- Seismic Response Factor (S)

Ve = v*S*I*F*W = 0.4*4.2*1*1.3*12300 Ve = 26863

V = (Ve/R)*U = (26863.2/4)*0.6 V = **4029**

Horizontal Seismic Force at Top of Vessel

Ftmax =	0.25*V	= 0.25 * 4029		Ftmax = ***1007***
Ftp =	0.07 * T * V	= 0.07 * 0.049 * 4029		Ftp = ***13.94***
Ft =	if (T < 0.7, 0, min(0.07*T*V, Ftmax))			Ft = ***0***

Horizontal Seismic Force at cg

Fh =	V - Ft	= 4029 - 0		Fh = ***4,029***

Vertical force at cg

Fv =	W			Fv = ***12,300***

Overturning Moment at Base

Mb =	L*Fh + H*Ft	= 80 * 4029 + 130 * 0		Mb = ***322,358***

Overturning Moment at Bottom Tangent Line

Mt =	(L-ls)*Fh + (H-ls)*Ft	= (80 - 26.5) * 4029 + (130 - 26.5) * 0		Mt = ***215,577***

Maximum eccentric load

f1 =	Fv/n + 4*Mto/(n*Do)	= 12300/4 + 4*215577/(4 * 42)		f1 = ***8,208***

Axial Load

f2 =	Fv/n + 4*Mb/(n*ds)	= 12300/4 + 4*322358/(4 * 44.5)		f2 = ***10,319***

Leg Loads

f3x =	0.5*V*Ix/(Ix+Iy)	=0.5* 4029*6.66 /(6.66+6.66)		f3x = ***1,007***
f3y =	0.5*V*Iy/(Ix+Iy)	=0.5* 4029*6.66 /(6.66+6.66)		f3y = ***1,007***

Leg Bending Moments

e =	(ds-Do)/2	=(44.5-42)/2		e = ***1.25***
Mx =	f1*e + f3x*ls	=8208*1.25 + 1007*26.5		Mx = ***36,955***
My =	f1*e + f3y*ls	=8208*1.25 + 1007*26.5		My = ***36,955***

Leg Bending Stress

Sbmax =	Sb * 1.25	=17100 * 1.25		Sbmax = ***21,375***
fx =	Mx*cx/Ix	=36955 * 2 / 6.66	**Acceptable**	fx = ***11,098***
fy =	My*cy/Iy	=36955 * 2 / 6.66	**Acceptable**	fy = ***11,098***

Leg axial stress

K1*ls/r =		=0.8 * 26.5 / 1.2		K1*ls/r = ***17.667***
Fa max =	AISC code lookup based on K1*ls/r			Fa max = ***25,675***
fa =	f2/A	=10319 / 4.61	**Acceptable**	fa = ***2,238***

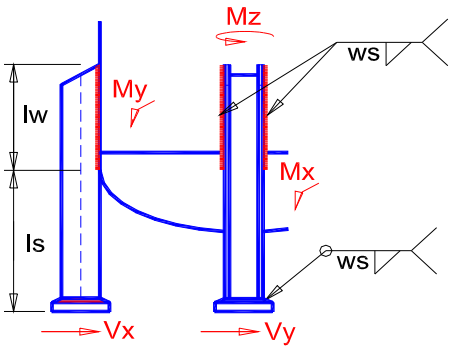
Maximum Euler Stress

Fe =	12*pi^2*E/(23*(K1*L/r)^2)			
=	12*pi^2*30000000/(23*17.667^2)			Fe = ***494,954***

Combined Stress

Fc1 =	fa/Famax + 0.85*fx/((1-fa/Fe)*Sbmax)		**Acceptable**	
=	2238/25675 + 0.85*11098/((1-2238/494954)*21375)			Fc1 = ***0.53***
Fc2 =	fa/Famax + 0.85*fy/((1-fa/Fe)*Sbmax)		**Acceptable**	
=	2238/25675 + 0.85*11098/((1-2238/494954)*21375)			Fc2 = ***0.53***

Beam to Shell Attachment Stresses



Beam Dimensions

cx =	2cx/2	cx =	***2.000***
cy =	2cy/2	cy =	***2.000***

C dimensions for weld stress

weld area =	ws*lw	wa =	***3.375***
wcx =	lw/2	wcx =	***6.750***
wcz =	cy + ws	wcz =	***2.250***
wcy =	sqrt(wcx^2 + wcy^2)	= sqrt(6.75^2 + 7.115^2)	wcy = ***7.115***

Shear Force Distribution

Vx =	(V*lx)/((n/2)*(lx+ly))	= (4029.48*6.66)/((4/2)*(6	Vx = ***1,007***
Vy =	(V*ly)/((n/2)*(lx+ly))	= (4029.48*6.66)/((4/2)*(6	Vy = ***1,007***
Vg =	W/n	gravity = 12300/4	Vg = ***3,075***

Weld Moments of Inertias

Iwx =	(ws*lw^3/12)*2	= (0.25*13.5^3/12)*2	Iwx = ***102.5***
Iwz =	(lw*ws^3/12 + wa*(cy+ws/2)^2)*2		Iwz = ***30.5***
=	(13.5*0.25^3/12 + 3.375*(2+0.25/2)^2)*2		
Iwy =	Iwx + Iwz	= 103 + 31	Iwy = ***133.0***

Weld Moments

Mx =	Vx*(ls+lw/2) + Vg*(ds-Do)/2		Mx = ***37,339***
=	1007*(26.5+13.5/2) + 3075*(44.5-42)/2		
My1 =	Vy*(ls+lw/2)	= 1007*(26.5+13.5/2)	My1 = ***33,495***
Mz =	Vy*(ds-Do)/2	= 1007*(44.5-42)/2	Mz = ***1,259***

Weld Stresses

Sx =	Mx*wcx/Iwx	Bending	= 36955*6.75/102.5	Sx = ***2,433***
Sy =	My1*wcy/Iwy	Twisting	= 33495*7.115/133	Sy = ***1,791***
Sz =	Mz*wcz/Iwz	Torision	= 1259*2.25/30.5	Sz = ***93***
Sg =	Vg/(wa*2)	Gravity	= 3075/(3.375*2)	Sg = ***456***

Stress Limits and Ratios

Slim =	min(Sb,Sa)*0.49	= min(17100,16200)*0.49	Slim = ***7,938***
SxR =	Sx/Slim	= 2433/7938	SxR = ***0.307***
SyR =	Sy/Slim	= 1791/7938	SyR = ***0.226***
SzR =	Sz/Slim	= 93/7938	SzR = ***0.012***
SgR =	Sg/Slim	= 456/7938	SgR = ***0.057***
		Acceptable	**total (<1)** ***0.601***

Foot Plate Attachment Stresses

waf =	ws*lwf	weld area in foot	= 0.25*16	waf = ***4.000***
Vv =	V/n		= 4029/4	Vv = ***1,007***
Sv =	Vv/waf		= 1007/4	Sv = ***252***
Sgf =	Vg/waf		= 3075/4	Sgf = ***769***
SvRf =	Sv/Slim		= 252/7938	SvRf = ***0.032***
SgRf =	Sgf/Slim		= 768.75/7938	SgRf = ***0.097***
			Acceptable	**total (<1)** ***0.129***

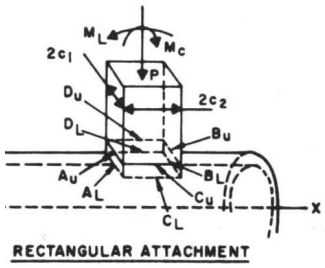
WRC 107 - shell local stress at support

Loads (psi and lb)

1,007.4	<- P, Axial Load (=vx)
10,319.0	<- VL, Longitudinal load(=f2)
0.0	<- Vc, Circumferential load
36,955.0	<- ML, Moment (=My)
0.0	<- Mc, Moment
0.0	<- MT, Torisional

Parameters

MaxSPm =	Sa	for Pm stresses	Pm - primary membrance stress	MaxSPm =	***16,200***
MaxSPmb =	1.5*Sa	for Pm + Pb stresses	Pb - primary bending stress	MaxSPmb =	***24,300***
MaxSPmbQ =	3*Sa	for Pm + Pb + Q stresses	Q - secondary stress	MaxSPmbQ =	***48,600***
Ri =	(Do-2*T)/2			Ri =	***20.25***
Rm =	(Do-T)/2			Rm =	***20.625***
r =	Rm/T		= 20.625/0.75	r =	***27.50***
Beta1 =	2C1/2/Rm		= 5.657/2/20.625	Beta1 =	***0.137***
Beta2 =	2C2/2/Rm		= 13.5/2/20.625	Beta2 =	***0.327***
SL =	(Ri-0.4*T)*Pr/(2*T)		= (20.25-0.4*0.75)*353.898/(2*0.75)	SL =	***4,707***
Sc =	(Ri+0.6*T)*Pr/T		= (20.25+0.6*0.75)*353.898/0.75	Sc =	***9,768***
Stress concentration factors			Kb = ***1***	Kn =	***1***



RECTANGULAR ATTACHMENT

Shell Combined Stresses:

Lookup A	Curve	A Value	A Value	Equation	Cat	Au	AL	Bu	BL	Cu	CL	Du	DL
Pressure Stress	VIII-1 Code	4C	3C	SC	Pm	9768	9768	9768	9768	9768	9768	9768	9768
No/(P/Rm)	3C or 4C	3.74796	1.88561	Kn*A*P/(Rm*T)	Pm	-244	-244	-244	-244	-123	-123	-123	-123
Mo/P	1C or 2C-1	0.08088	0.04871	Kb*A*6*P/T^2	Pb	-523	523	-523	523	-869	869	-869	869
No/(Mc/(Rm^2*beta))	3A		1.05302	Kn*A*Mc/(Rm^2*beta*T)	Pm					0	0	0	0
Mo/(Mc/(Rm*beta))	1A		0.08268	Kb*A*6*Mc/(Rm*beta*T^2)	Q					0	0	0	0
No/(ML/(Rm^2*beta))	3B		2.75635	Kn*A*ML/(Rm^2*beta*T)	Pm	-1304	-1304	1304	1304				
Mo/(ML/(Rm*beta))	1B or 1B-1		0.01754	Kb*A*6*ML/(Rm*beta*T^2)	Q	-1086	1086	1086	-1086				
				Pm	**So**	**8220**	**8220**	**10827**	**10827**	**9645**	**9645**	**9645**	**9645**
				Pm+Pb	**So**	**7696**	**8743**	**10304**	**11351**	**8776**	**10514**	**8776**	**10514**
				Pm+Pb+Q	**So**	**6610**	**9829**	**11390**	**10265**	**8776**	**10514**	**8776**	**10514**
Pressure Stress	VIII-1 Code			SL	Pm	4707	4707	4707	4707	4707	4707	4707	4707
Nx/(P/Rm)	3C or 4C	3.74796	1.88561	Kn*A*P/(Rm*T)	Pm	-123	-123	-123	-123	-244	-244	-244	-244
Mx/P	1C-1 or 2C	0.03139	0.05870	Kb*A*6*P/T^2	Pb	-631	631	-631	631	-337	337	-337	337
Nx/(Mc/(Rm^2*beta))	4A		1.71344	Kn*A*Mc/(Rm^2*beta*T)	Pm					0	0	0	0
Mx/(Mc/(Rm*beta))	2A		0.03430	Kb*A*6*Mc/(Rm*beta*T^2)	Q					0	0	0	0
Nx/(ML/(Rm^2*beta))	4B		1.12882	Kn*A*ML/(Rm^2*beta*T)	Pm	-534	-534	534	534				
Mx/(ML/(Rm*beta))	2B or 2B-1		0.03569	Kb*A*6*ML/(Rm*beta*T^2)	Q	-2556	2556	2556	-2556				
				Pm	**Sx**	**4050**	**4050**	**5118**	**5118**	**4463**	**4463**	**4463**	**4463**
				Pm+Pb	**Sx**	**3419**	**4681**	**4487**	**5749**	**4125**	**4800**	**4125**	**4800**
				Pm+Pb+Q	**Sx**	**864**	**7236**	**7043**	**3193**	**4125**	**4800**	**4125**	**4800**
Shear VL				VL/(Pi*sqrt(c1*c2)*T)						-1002	-1002	1002	1002
Shear VC				VC/(Pi*sqrt(c1*c2)*T)		0	0	0	0				
Total Shear				Sum of shears	**Txo**	**0**	**0**	**0**	**0**	**-1002**	**-1002**	**1002**	**1002**
S1m	((Sx+So)/2)+SQRT(((Sx-So)/2)^2+Txo^2)					8,220	8,220	10,827	10,827	9,832	9,832	9,832	9,832
S2m	((Sx+So)/2)-SQRT(((Sx-So)/2)^2+Txo^2)					4,050	4,050	5,118	5,118	4,276	4,276	4,276	4,276
S12	abs(S1m - S2m)					4,170	4,170	5,709	5,709	5,556	5,556	5,556	5,556
S23	abs(S2m-0)					4,050	4,050	5,118	5,118	4,276	4,276	4,276	4,276
S31	abs(0-S1m)					8,220	8,220	10,827	10,827	9,832	9,832	9,832	9,832
Sm<= MaxSPmb	max(S12,S23,S31)				**Acceptable**	**8,220**	**8,220**	**10,827**	**10,827**	**9,832**	**9,832**	**9,832**	**9,832**
S1m+b	((Sx+So)/2)+SQRT(((Sx-So)/2)^2+Txo^2)					7,696	8,743	10,304	11,351	8,983	10,685	8,983	10,685
S2m+b	((Sx+So)/2)-SQRT(((Sx-So)/2)^2+Txo^2)					3,419	4,681	4,487	5,749	3,919	4,629	3,919	4,629
S12	abs(S1m - S2m)					4,277	4,062	5,817	5,602	5,064	6,055	5,064	6,055
S23	abs(S2m-0)					3,419	4,681	4,487	5,749	3,919	4,629	3,919	4,629
S31	abs(0-S1m)					7,696	8,743	10,304	11,351	8,983	10,685	8,983	10,685
Smb<= MaxSPmb	max(S12,S23,S31)				**Acceptable**	**7,696**	**8,743**	**10,304**	**11,351**	**8,983**	**10,685**	**8,983**	**10,685**
S1m+b+Q	((Sx+So)/2)+SQRT(((Sx-So)/2)^2+Txo^2)					6,610	9,829	11,390	10,265	8,983	10,685	8,983	10,685
S2m+b+Q	((Sx+So)/2)-SQRT(((Sx-So)/2)^2+Txo^2)					864	7,236	7,043	3,193	3,919	4,629	3,919	4,629
S12	abs(S1m - S2m)					5,746	2,593	4,347	7,071	5,064	6,055	5,064	6,055
S23	abs(S2m-0)					864	7,236	7,043	3,193	3,919	4,629	3,919	4,629
S31	abs(0-S1m)					6,610	9,829	11,390	10,265	8,983	10,685	8,983	10,685
Smb<= MaxSPmbQ	max(S12,S23,S31)				**Acceptable**	**6,610**	**9,829**	**11,390**	**10,265**	**8,983**	**10,685**	**8,983**	**10,685**