Vessel with Large Opening

Sample 5

Pressure Vessel Calculations

November 20, 2008

PVE Samples

120 Randall Drive

Waterloo, Ontario

N2V 1C6

PVE Sample Vessels

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PVE-Sample 5

Revision(s)			
Rev	Description	Date	By
0	Initial Release	5/25/05	LB
1	Revised Calculations	11/20/08	BV
2			

PVE Samples	Customer
Vessel with Large Opening	Vessel
Vessel with Large Opening	Part Number
Sample 5	Drawing
PVE-Sample 5	Job

12.75	Outside Diameter [inch]
20	straight Shell (not including straight flange on heads)
2	Volume [cuft]
Water	Fluid (value from Material Properties)
160	Weight Empty [lbs.]
275	Weight Full
275	Weight Under Test

Maximum Internal pressure, psi **200**	Maximum External Pressure, psi **0**	At Temperature, ºF **350**	Maximum Allowed Working Pressure
Maximum Temperature, ºF **350**	Minimum Temperature, ºF **-20**	At Pressure, psi **200**	Maximum Design Metal Temperature
Test Pressure, psi **260**	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
18,600	Allowable Stress
0.0625	Minimum allowed thickness per UG-16(b)
No	Material Normalized
No	Material Impact Tested (not required per UHA-51)
None	Radiography required
0	Corrosion Allowance

ASME VIII-1	Code		
2007	Edition		
-	Addenda		
IID	Materials		
			Code Cases Required

UG-22 Loadings Considered

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

Material Properties ver 2.01

Vessel with Large Opening <- Vessel

Design Pressure UG-22(a)

200.0 <- P, internal operating pressure at top of vessel (psig)
0.0 <- mPa, external operation pressure
Water <- Operating Fluid
2.200 <- h, fluid height (ft)
1.000 <- rho, fluid density (1.0 for water)
Design Pressure = P + 0.4331*rho*h = 200 + 0.4331 * 1 * 2.2 **mDp = 201.0**

Hydro Test (UG-99(b))

pressure measured at top of vessel, rounded up
Test Press = P * 1.3 * MR = 200 * 1.3 * 1 **mTp = *260***

Material Properties (ASME IID)

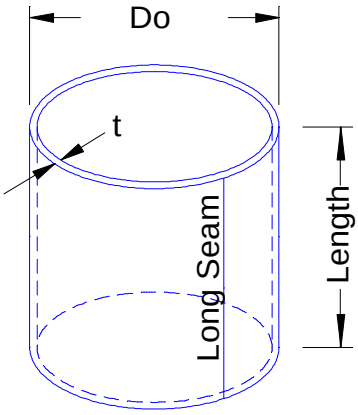
350 <- mTemp, design temp ºF

Test at ambient temp

Material	Where Used	Ambient Strength	Design Strength	Strength Ratio	Max ºF	Ext Graph
SA-240 304 Plate	shell, cone, cover	**20000**	**18600**	**1.075**	**1500**	**HA-1**
SA-312 TP304 Sms. and Wld. Pipe	nozzle, bottom, ferrule	**20000**	**18600**	**1.075**	**1500**	**HA-1**
SA-479 304 Bar	side ferrule	**20000**	**18600**	**1.075**	**1500**	**HA-1**
SA-182 F304 Forging	flange, coupling	**20000**	**17400**	**1.149**	**1500**	**HA-1**
SA-193 B7 Bolts <= 2.5"	bolts	**25000**	**25000**	**1.000**	**1000**	
		Min Ratio (MR) =		***1.000***		

Pipe and Shell ver 4.08

Shell **Description**



Options:

Interior	**ip?** - Calculate interior pressure
No Exterior	**ep?** - Calculate exterior pressure
Rolled Plate	**pr?** - Pipe or rolled plate
Non-Threaded	**pt?** - Type of pipe
No	**relief?** - Stress Relief Calculations Required

Dimensions:

12.750	**Do** [in] - outside diameter
0.1880	**t** [in] - nominal wall thickness
0.063	**tminUG16b** [in] - minimum wall per UG-16(b)
15.500	**L** [in] - length for volume and weight
0.000	**Corr** [in] - corrosion allowance

Material and Conditions:

SA-240 304 **Material**

18,600	**S** [psi] - allowable stress level
0.70	**El** - longitudinal efficiency (circ. stress)
0.70	**Ec** - circ. connecting efficiency (longitudinal stress)
0.000%	**UTP** [%] - undertolerance allowance
0.000	**UTI** [in] - undertolerance allowance
200.95	**P** [psi] - interior pressure

Stress Classification:

NOTE: Both validity checks need to be "Acceptable" in order to use this sheet
If not, refer to sheet "Thick Cylindrical Shell"

ckValidity1 =	tmin < 0.5*(Do/2)	0.096 < 0.5*(12.75/2) =	**Acceptable**
ckValidity2 =	P< 0.385*S*El	200.95< 0.385*18600*0.7 =	**Acceptable**

Variables:

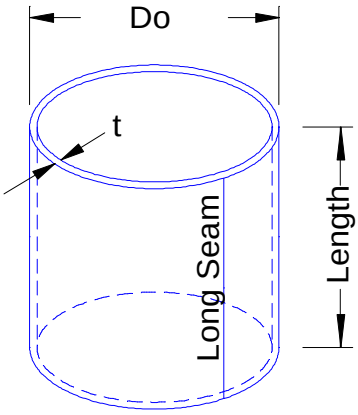
Td =	0.000	0 =	**0.000**
UT [in] =	t*UTP+UTI	0.188*0+0 =	**0.000**
nt [in] =	t-Corr-UT-Td	0.188-0-0-0 =	**0.188**
Ri [in] =	Do/2-nt	12.75/2-0.188 =	**6.187**
Volume [cuft] =	((Do/2-t)^2)*π*L/1728	((12.75/2-0.188)^2)*3.1416*15.5/1728 =	**1.079**
Weight [lb] =	(Do-t)*π*L*t*40.84/144	(12.75-0.188)*3.1416*15.5*0.188*40.84/144 =	**32.62**

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

ta [in] =	P*Ri/(S*El-0.6*P)	200.95*6.187/(18600*0.7-0.6*200.95) =	**0.096**
tb [in] =	P*Ri/(2*S*Ec+0.4*P)	200.95*6.187/(2*18600*0.7+0.4*200.95) =	**0.048**
tmin [in] =	MAX(ta,tb,tminUG16b)	MAX(0.096,0.048,0.063) =	**0.096**
tr1 [in] =	P*Ri/(S*1-0.6*P)	200.95*6.187/(18600*1-0.6*200.95) =	**0.067**
Checkt =	tmin <= nt	0.096 <= 0.188 =	**Acceptable**
PMaxA [psi] =	(S*El*nt)/(Ri+0.6*nt)	(18600*0.7*0.188)/(6.187+0.6*0.188) =	**389**
PMaxB [psi] =	(2*S*Ec*nt)/(Ri-0.4*nt)	(2*18600*0.7*0.188)/(6.187-0.4*0.188) =	**801**
PMax [psi] =	Min(PMaxA,PMaxB)	MIN(389,801) =	**389**
CheckP =	PMax >= P	389 >= 200.95 =	**Acceptable**

Pipe and Shell ver 4.08

Bottom Ferrule - Machined From 8" SCH 80 Pipe **Description**



Options:

Interior	**ip?** - Calculate interior pressure
No Exterior	**ep?** - Calculate exterior pressure
Rolled Plate	**pr?** - Pipe or rolled plate
Non-Threaded	**pt?** - Type of pipe
No	**relief?** - Stress Relief Calculations Required

Dimensions:

8.030	**Do** [in] - outside diameter
0.0780	**t** [in] - nominal wall thickness
0.063	**tminUG16b** [in] - minimum wall per UG-16(b)
1.102	**L** [in] - length for volume and weight
0.000	**Corr** [in] - corrosion allowance

Material and Conditions:

SA-312 TP304 **Material**

18,600	**S** [psi] - allowable stress level
0.85	**El** - longitudinal efficiency (circ. stress)
0.70	**Ec** - circ. connecting efficiency (longitudinal stress)
12.500%	**UTP** [%] - undertolerance allowance
0.000	**UTI** [in] - undertolerance allowance
200.95	**P** [psi] - interior pressure

Stress Classification:

NOTE: Both validity checks need to be "Acceptable" in order to use this sheet
If not, refer to sheet "Thick Cylindrical Shell"

ckValidity1 =	tmin < 0.5*(Do/2)	0.063 < 0.5*(8.03/2) =	**Acceptable**
ckValidity2 =	P< 0.385*S*El	200.95< 0.385*18600*0.85 =	**Acceptable**

Variables:

Td =	0.000	0 =	**0.000**
UT [in] =	t*UTP+UTI	0.078*0.125+0 =	**0.010**
nt [in] =	t-Corr-UT-Td	0.078-0-0.01-0 =	**0.068**
Ri [in] =	Do/2-nt	8.03/2-0.068 =	**3.947**
Volume [cuft] =	((Do/2-t)^2)*π*L/1728	((8.03/2-0.078)^2)*3.1416*1.102/1728 =	**0.031**
Weight [lb] =	(Do-t)*π*L*t*40.84/144	(8.03-0.078)*3.1416*1.102*0.078*40.84/144 =	**0.61**

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

ta [in] =	P*Ri/(S*El-0.6*P)	200.95*3.947/(18600*0.85-0.6*200.95) =	**0.051**
tb [in] =	P*Ri/(2*S*Ec+0.4*P)	200.95*3.947/(2*18600*0.7+0.4*200.95) =	**0.030**
tmin [in] =	MAX(ta,tb,tminUG16b)	MAX(0.051,0.03,0.063) =	**0.063**
tr1 [in] =	P*Ri/(S*1-0.6*P)	200.95*3.947/(18600*1-0.6*200.95) =	**0.043**
Checkt =	tmin <= nt	0.063 <= 0.068 =	**Acceptable**
PMaxA [psi] =	(S*El*nt)/(Ri+0.6*nt)	(18600*0.85*0.068)/(3.947+0.6*0.068) =	**271**
PMaxB [psi] =	(2*S*Ec*nt)/(Ri-0.4*nt)	(2*18600*0.7*0.068)/(3.947-0.4*0.068) =	**453**
PMax [psi] =	Min(PMaxA,PMaxB)	MIN(271,453) =	**271**
CheckP =	PMax >= P	271 >= 200.95 =	**Acceptable**

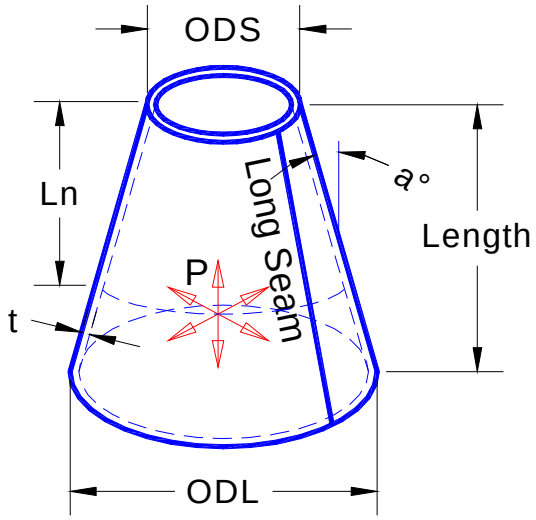
Cone ver 2.61

www.pveng.com

Vessel with Large Opening <- Vessel
Cone <- Description

Dimensions (inch)

12.750 <- ODL, outside diameter large end
8.030 <- ODS, outside diameter small end
0.188 <- t, thickness
5.000 <- L, length
2.500 <- Ln, length from small end to nozzle
0.000 <- ca, Corrosion allowance



Material Properties

SA-240 304 <- Material
18,600 <- S, allowable stress Level (psi)
0.70 <- E, long seam weld efficiency

201.0 <- P, design pressure (psig)
0.0 <- Pa, Exterior Pressure

Calculated Properties:

0.2 <- Volume (cubic ft)
9 <- Material Weight (lbs cs)
25.3 <- a° **0.441** <- a, rad

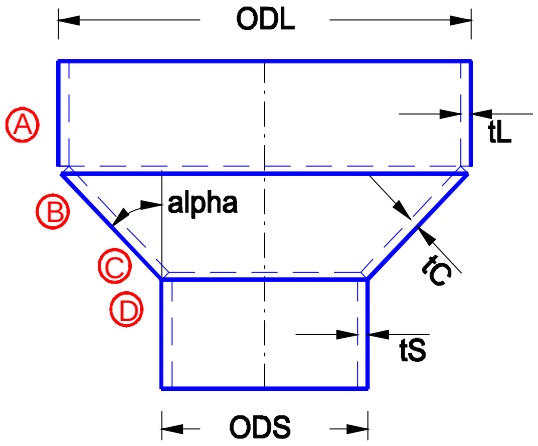
Interior Pressure 1-4(e)

nt = t-ca = 0.188-0 nt = **0.188**
treq = P*ODL/(2*COS(a)*(S*E+0.4*P)) tl = **0.108**
= 200.953*12.75/(2*Cos(0.441)*(18600*0.7+0.4*200.953) **Acceptable**
Outside diameter at nozzle location: ODN = ***10.39***
= ODS+2*((ODL-ODS)/2/L)*Ln
= 8.03+2*((12.75-8.03)/2/5)*2.5
treq at nozzle = P*ODN/(2*COS(a)*(S*E+0.4*P)) tln = **0.088**
= = 200.953*10.39/(2*COS(0.441)*(18600*0.7+0.4*200.953))
Pmax = 2*S*E*nt*cos(a)/(ODL-0.8*nt*cos(a)) Pmax = **351.0**
= 2*18600*0.7*0.188*cos(0.441)/(12.75-0.8*0.188*cos(0.441)) **Acceptable**

Cone Discontinuity Stress ver 4.03

Pressure Vessel Design Handbook - Second Edition - Henry H Bednar. Pages 231 to 240 & ASME VIII-1 5(g)

Cone Discontinuity **Description**



Large Cylinder - Zone A:

SA-240 304	**Material**
18,600	**Sl** [psi] - allowed stress
0.70	**El** - longitudinal efficiency
12.750	**ODL** [in] - outside diameter
0.188	**tLn** [in] - thickness

Cone - Zones B and C:

SA-240 304	**Material**
18,600	**Sc** [psi] - allowed stress
0.70	**Ec** - longitudinal efficiency
25.3	**AlphaDeg** - Angle in degrees
0.188	**tCn** [in] - thickness

Small Cylinder - Zone D:

SA-312 TP304	**Material**
18,600	**Ss** [psi] - allowed stress
0.85	**Es** - longitudinal efficiency
8.030	**ODS** [in] - outside diameter
0.078	**tSn** [in] - thickness

Operating Conditions:

201.0	**P** [psi] - design internal pressure
0.000	**Ca** [in] - corrosion allowance
0.0	**W** [lb] - External load
0.0	**M** [in-lb] - External moment

Geometry:

tL [in] =	tLn - Ca		0.188 - 0 = **0.188**
tC [in] =	tCn - Ca		0.188 - 0 = **0.188**
tS [in] =	tSn - Ca		0.078 - 0 = **0.078**
RL [in] =	(ODL-tL)/2	*Large End*	(12.75-0.188)/2 = **6.281**
Rs [in] =	(ODS-tS)/2	*Small End*	(8.03-0.078)/2 = **3.976**
Alpha [rad] =	AlphaDeg/180*π		25.3/180*3.142 = **0.441**

Constants - Large End:

nL =	tC / tL	0.188 / 0.188 = **1.000**
kL =	sqrt(cos(Alpha)/nL)	SQRT(COS(0.441)/1) = **0.951**
V1L =	kL*(1+nL^2*(1+2*kL*nL))/(kL*nL^4+2*kL^2*nL^3+2*kL*nL^2+2*nL+kL)	
	0.951*(1+1^2*(1+2*0.951*1))/(0.951*1^4+2*0.951^2*1^3+2*0.951*1^2+2*1+0.951) = **0.487**	
V2L =	kL*nL*(1+V1L*(nL^2-1))/(4*(kL*nL^3+1))	
	0.951*1*(1+0.487*(1^2-1))/(4*(0.951*1^3+1)) = **0.122**	

Constants - Small End:

nS =	tC / tS	0.188 / 0.078 = **2.410**
kS =	sqrt(cos(Alpha)/nS)	SQRT(COS(0.441)/2.41) = **0.613**
V1S =	kS*(1+nS^2*(1+2*kS*nS))/(kS*nS^4+2*kS^2*nS^3+2*kS*nS^2+2*nS+kS)	
	0.613*(1+2.41^2*(1+2*0.613*2.41))/(0.613*2.41^4+2*0.613^2*2.41^3+2*0.613*2.41^2+2*2.41+0.613) = **0.336**	
V2S =	kS*nS*(1+V1S*(nS^2-1))/(4*(kS*nS^3+1))	
	0.613*2.41*(1+0.336*(2.41^2-1))/(4*(0.613*2.41^3+1)) = **0.101**	

Discontinuity Influence Coefficients - Large End:

XL =	4.669*V2L*TAN(Alpha)	4.669*0.122*TAN(0.441) = **0.269**
YL =	1.285*(V1L - 2*V2L)*tan(Alpha)	1.285*(0.487 - 2*0.122)*TAN(0.441) = **0.148**
UL =	XL/nL^2	0.269/1^2 = **0.269**

Discontinuity Influence Coefficients - Small End:

XS =	4.669*V2S*TAN(Alpha)	4.669*0.101*TAN(0.441) =	**0.222**
YS =	1.285*(V1S - 2*V2S)*TAN(Alpha)	1.285*(0.336 - 2*0.101)*TAN(0.441) =	**0.081**
US =	XL/nL^2	0.269/1^2 =	**0.269**

Equivalent Loads from W and M:

lL [lb/in] =	(4*M/(π*4*RL^2) + (W / (π*2*RL)))		
		(4*0/(3.142*4*6.281^2) + (0 / (3.142*2*6.281))) =	**0.000**
PeL [psi] =	P+(2*lL/RL)	201+(2*0/6.281) =	**200.953**
lS [lb/in] =	(4*M/(π*4*Rs^2)+(W/(π*2*Rs)))		
		(4*0/(3.142*4*3.976^2)+(0/(3.142*2*3.976))) =	**0.000**
PeS [psi] =	P+(2*lS/Rs)	201+(2*0/3.976) =	**200.953**

Maximum Allowed Stresses: ASME 1-5(g) & UG-23(e)

LLmax [psi] =	3*Sl*El	3*18600*0.7 =	**39,060**
MLmax [psi] =	1.5*Sl*El	1.5*18600*0.7 =	**19,530**
LCmax [psi] =	3*Sc*Min(El,Es)	3*18600*MIN(0.7,0.85) =	**39,060**
MCmax [psi] =	1.5*Sc*Min(El,Es)	1.5*18600*MIN(0.7,0.85) =	**19,530**
LSmax [psi] =	3*Ss*Es	3*18600*0.85 =	**47,430**
MSmax [psi] =	1.5*Ss*Es	1.5*18600*0.85 =	**23,715**

Combined Stresses - Large Cylinder - Zone A:

Long1 [psi] =	(PeL*RL/tL)*(0.5 + XL*SQRT(RL/tL))		
		(200.953*6.281/0.188)*(0.5 + 0.269*SQRT(6.281/0.188)) =	**13,778**
CkLong1 =	ABS(Long1) <= LLmax	ABS(13778) <= 39060 =	**Acceptable**
Long2 [psi] =	(PeL*RL/tL)*(0.5 - XL*SQRT(RL/tL))		
		(200.953*6.281/0.188)*(0.5 - 0.269*SQRT(6.281/0.188)) =	**-7,064**
CkLong1 =	ABS(Long2) <= LLmax	ABS(-7064) <= 39060 =	**Acceptable**
MemTan1 [psi] =	(P*RL/tL)*(1-(PeL/P)*YL*SQRT(RL/tL))		
		(201*6.281/0.188)*(1-(200.953/201)*0.148*SQRT(6.281/0.188)) =	**977**
CkMemTan1 =	ABS(MemTan1) <= MLmax	ABS(977) <= 19530 =	**Acceptable**

Combined Stresses - Large End of Cone - Zone B:

Long3 [psi] =	(PeL*RL/tL)*(0.5/(nL*cos(Alpha)) + UL*SQRT(RL/tL))		
		(200.953*6.281/0.188)*(0.5/(1*COS(0.441)) + 0.269*SQRT(6.281/0.188)) =	**14,133**
CkLong3 =	ABS(Long3) <= LCmax	ABS(14133) <= 39060 =	**Acceptable**
Long4 [psi] =	(PeL*RL/tL)*(0.5/(nL*cos(Alpha)) - UL*SQRT(RL/tL))		
		(200.953*6.281/0.188)*(0.5/(1*COS(0.441)) - 0.269*SQRT(6.281/0.188)) =	**-6,709**
CkLong4 =	ABS(Long4) <= LCmax	ABS(-6709) <= 39060 =	**Acceptable**
MemTan2 [psi] =	(P*RL/tL)*(1/(nL*cos(Alpha))-(PeL/P)*YL*SQRT(RL/tL))		
		(201*6.281/0.188)*(1/(1*COS(0.441))-(200.953/201)*0.148*SQRT(6.281/0.188)) =	**1,688**
CkMemTan2 =	ABS(MemTan2) <= MCmax	ABS(1688) <= 19530 =	**Acceptable**

Combined Stresses - Small End of Cone - Zone C:

Long5 [psi] =	(PeS*Rs/tS)*(0.5/(nS*cos(Alpha)) + US*SQRT(Rs/tS))		
		(200.953*3.976/0.078)*(0.5/(2.41*COS(0.441)) + 0.269*SQRT(3.976/0.078)) =	**21,990**
CkLong5 =	ABS(Long5) <= LCmax	ABS(21990) <= 39060 =	**Acceptable**
Long6 [psi] =	(PeS*Rs/tS)*(0.5/(nS*cos(Alpha)) - US*SQRT(Rs/tS))		
		(200.953*3.976/0.078)*(0.5/(2.41*COS(0.441)) - 0.269*SQRT(3.976/0.078)) =	**-17,290**
CkLong6 =	ABS(Long6) <= LCmax	ABS(-17290) <= 39060 =	**Acceptable**
MemTan3 [psi] =	(P*Rs/tS)*(1/(nS*cos(Alpha))+(PeS/P)*YS*SQRT(Rs/tS))		
		(201*3.976/0.078)*(1/(2.41*COS(0.441))+(200.953/201)*0.081*SQRT(3.976/0.078)) =	**10,650**
CkMemTan3 =	ABS(MemTan3) <= MCmax	ABS(10650) <= 19530 =	**Acceptable**

Combined Stresses - Small Cylinder - Zone D:

Long7 [psi] =	(PeS*Rs/tS)*(0.5 + XS*SQRT(Rs/tS))		
		(200.953*3.976/0.078)*(0.5 + 0.222*SQRT(3.976/0.078)) =	**21,361**

1	**CkLong7** =	ABS(Long7) <= LSmax	ABS(21361) <= 47430 =	**Acceptable**
2	**Long8** [psi] =	(PeS*Rs/tS)*(0.5 - XS*SQRT(Rs/tS))		
3		(200.953*3.976/0.078)*(0.5 - 0.222*SQRT(3.976/0.078)) =		**-11,117**
4	**CkLong8** =	ABS(Long8) <= LSmax	ABS(-11117) <= 47430 =	**Acceptable**
5	**MemTan4** [psi] =	(P*Rs/tS)*(1+(PeS/P)*YS*SQRT(Rs/tS))		
6		(201*3.976/0.078)*(1+(200.953/201)*0.081*SQRT(3.976/0.078)) =		**16,194**
7	**CkMemTan4** =	ABS(MemTan4) <= MSmax	ABS(16194) <= 23715 =	**Acceptable**

Nozzle Reinforcement ver 3.90

www.pveng.com

Manual dh for hillside nozzles
Automatic Limit Diameter
Curved Shell or Head Section

Vessel with Large Opening <- Vessel
2" Ferrule - Nozzel A <- Description

Shell:

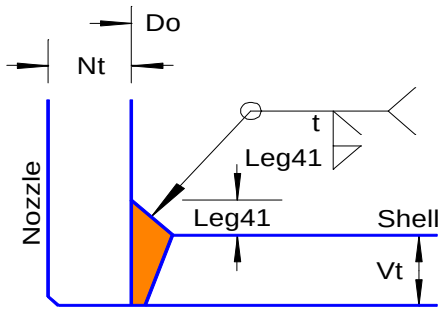
SA-240 304 <- Shell Material
18,600 <- Sv, shell allowable stress level, PSI
1.00 <- E1, efficiency of shell at nozzle
12.37 <- Ds, Shell ID
0.188 <- Vt, shell wall thick, uncorroded, UT removed
0.088 <- tr, required shell wall thickness int. press.(E=1)
0.000 <- trE, required shell wall thickness ext. press.(E=1)
0.063 <- tmin16b, Min allowed wall per UG-16(b)

Nozzle:

SA-312 TP304 <- Nozzle Material
18,600 <- Sn, allowable stress level (Sn)
1,400 <- B, from A = ***0.09590***
1.00 <- E, nozzle efficiency
200.95 <- P, internal design pressure
0.0 <- Pa, external design pressure
2.375 <- Do, outside diameter
2.333 <- dh, id of hillside nozzle
0.154 <- Nt, wall thick, uncorroded
12.5% <- UTp, undertolerance (%)
3.000 <- L, exterior Projection

Reinforcing:

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



UW-16.1 (c)

Variables:

UT =	Nt*UTp	= 0.154 * 0.125	*Undertolerance*	UT =	***0.019***
Rn =	Do/2 - (Nt-nca) + UT	= 2.375/2 - (0.154-0) + 0.019	*Effective Radius*	Rn =	***1.053***
t =	Vt-sca	= 0.188 - 0	*Effective Shell Thickness*	t =	***0.188***
tn =	Nt-nca	= 0.154-0	*Avail. Nozzle Thick. No UT*	tn =	***0.154***
d =	dh	= 2.333	*Finished Opening Dia.*	d =	***2.333***
fr1 =	MIN(Sn/Sv,1)	= MIN(18600/18600, 1)		fr1 =	***1.000***
fr2 =	MIN(Sn/Sv,1)	= MIN(18600/18600, 1)		fr2 =	***1.000***
tcLeg41 =	Min(0.25,0.7*Min(0.75,tn,t))	= Min(0.25,0.7*Min(0.75,0.154,0.188))		tc41 =	***0.108***
F =	Min(Fenterered, 1)			F =	***1.000***

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

LDo =	L/Do LDo = ***1.263***		Dot =	Do/trnE	Dot = ***0.000***	
trn =	(P*Rn)/(Sn*E - 0.6*P) <= tn-UT	= (201*1.053)/(18600*1 - 0.6*201)			trn = ***0.011***	Acceptable
trnR =	(P*Rn)/(Sn*1 - 0.6*P)	= (201*1.053)/(18600*1 - 0.6*201)		*E=1*	trnR = ***0.011***	
trnE =	(3*Do*Pa)/(4*B) <= tn-ut	= (3*2.375*0)/(4*1400)			trnE = ***0.000***	Acceptable

Geometry Constraints:

0.7*Leg41 >= tc41 0.7*0.188 >= 0.108 ***0.132*** >= ***0.108*** 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 not required

Area Replacement: Fig UG-37.1

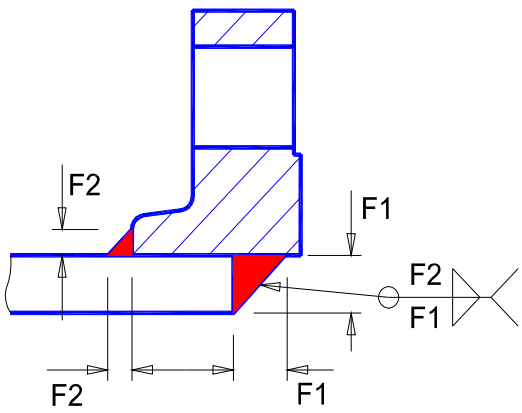
				Pressure From:	**Internal**	**External**
A =	1.0*d*tr*F + 2*tn*tr*F*(1-fr1)			A Required (internal) =	***0.206***	
=	1.0*2.333*0.088*1 + 2*0.154*0.088*1*(1-1)					
Ae =	0.5*(d*trE*1 + 2*tn*trE*1*(1-fr1))	= 0.5*(2.333*0*1 + 2*0.154*0*1*(1-1))		A Required (external) =		***0.000***
A1 =	max(d, 2*(t+tn)) * (E1*t-F*tr)-2*tn*(E1*t-F*tr)*(1-fr1)			A1 =	***0.233***	
=	max(2.333,2*(0.188+0.154))* (1*0.188-1*0.088)-2*0.154*(1*0.188-1*0.088)*(1-1)					
A1e =	max(d, 2*(t+tn)) * (E1*t-F*trE)-2*tn*(E1*t-F*trE)*(1-fr1)			A1e =		***0.439***
=	max(2.333,2*(0.188+0.154))* (1*0.188-1*0)-2*0.154*(1*0.188-1*0)*(1-1)					
A2 =	min((tn-trnR)*fr2*Min(5*t,2*L) , (tn-trnR)*fr2*Min(5*tn,2*L))			A2 =	***0.110***	
=	min((0.154-0.011)*1*Min(5*0.188,2*3) , (0.154-0.011)*1*Min(5*0.154,2*3))					
A2e =	min((tn-trnE)*fr2*Min(5*t,2*L) , (tn-trnE)*fr2*Min(5*tn,2*L))			A2e =		***0.119***
=	min((0.154-0)*1*Min(5*0.188,2*3) , (0.154-0)*1*Min(5*0.154,2*3))					
A41 =	Leg41^2*fr2	= 0.188^2*1		A41 =	***0.035***	***0.035***
				Actual Area =	***0.378***	***0.593***
			Acceptable	Actual-Required =	***0.173***	***0.593***

Tstd =	Standard pipe wall thickness from chart			Tstd =	***0.154***
Swre =	tr * Pa / P	= 0.088 * 0 / 200.953	*Req. Exterior pressure*	Swre =	***0.000***
Nact =	Nt * (1-UTp)	= 0.154 * (1-0.125)	*Actual Wall Thick.*	Nact =	***0.135***
Tt =	0.8/Nth	= 0.8/0	*Ug-31(c)(2) threads*	Tt =	***0.000***

UG-45 Acceptable

UG45 =	Max(UG45a, UG45b) <= Nact	= Max(0.011, 0.088) <= 0.135	UG45 =	***0.088***
UG45a =	Max(trn,trnE) + Nca + Tt	= Max(0.011,0) + 0 + 0	UG45a =	***0.011***
UG45b =	Min(UG45b3,UG45b4)	= Min(0.088, 0.135)	UG45b =	***0.088***
UG45b1 =	Max(tr + Sca, tmin16b + Sca)	= Max(0.088 + 0, 0.063 + 0)	UG45b1 =	***0.088***
UG45b2 =	Max(Swre + Sca,tmin16b + Sca)	= Max(0 + 0,0.063 + 0)	UG45b2 =	
UG45b3 =	Max(UG45b1,UG45b2)	= Max(0.088,)	UG45b3 =	***0.088***
UG45b4 =	Tstd*0.875 + Nca	= 0.154*0.875 + 0	UG45b4 =	***0.135***

Sample Vessel 5 <- Vessel
2" 300# RFSO Flange <- 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***

Nozzle

0.154 <- tn, Nozzle Wall Thickness (inch)
0.011 <- tnr, Required Nozzle Wall Thickness (inch)

Operating Conditions **Acceptable**

350 <- T, temperature ºF
201.0 <- P, pressure, psig
0.000 <- Corr, corrosion allowance

Max press @100ºF [p1] ***720***
Max press @350ºF [p2] ***518***

Flange Welds:

0.154 <- F1, pipe fillet size
0.154 <- F2, flange fillet size F2
18600 <- Sp, allowable stress, pipe
17400 <- Sf, allowable stress, flange

Geometry constraint: VIII UW-21 (b)

wtmin =	0.7*tn	= 0.7*0.154	*Req. weld throat*	wtmin = ***0.108***
wt =	0.7*MIN(F1,F2)		*Actual weld throat*	wt = ***0.108***
=	0.7*MIN(0.154,0.154)			**Acceptable**

Weld Strength:

Min Sa =	MIN(Sp,Sf)	= MIN(18600,17400)	Min Sa = ***17,400***
Max Weld Stress =	Sa * 0.49	= 17400 * 0.49	Max S = ***8,526***
Weld Load =	POD^2*pi*P/4	= 2.375^2*pi*200.953/4	Load = ***890***
Weld Area =	Pod*pi*(F1-corr + F2)		Area = ***2.298***
=	2.375*pi*(0.154-0 + 0.154)		
Weld Stress =	Load/Area	= 890.248/2.298	Stress = ***387***

Acceptable

Vessel with Large Opening <- Vessel
2" Heavy Ferrule - Nozzle B <- Description

Shell:

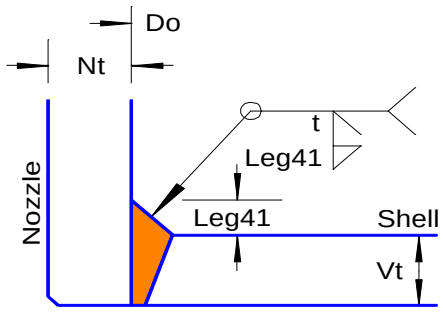
SA-240 304 <- Shell Material
18,600 <- Sv, shell allowable stress level, PSI
1.00 <- E1, efficiency of shell at nozzle
200.95 <- Ds, Shell ID
0.188 <- Vt, shell wall thick, uncorroded, UT removed
0.067 <- tr, required shell wall thickness int. press.(E=1)
0.000 <- trE, required shell wall thickness ext. press.(E=1)
0.063 <- tmin16b, Min allowed wall per UG-16(b)

Nozzle:

SA-479 304 <- Nozzle Material
18,600 <- Sn, allowable stress level (Sn)
1,400 <- B, from A = ***0.09590***
1.00 <- E, nozzle efficiency
200.95 <- P, internal design pressure
0.0 <- Pa, external design pressure
2.192 <- Do, outside diameter
0.161 <- Nt, wall thick, uncorroded
0.0% <- UTp, undertolerance (%)
1.500 <- L, exterior Projection

Reinforcing:

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



UW-16.1 (c)

Variables:

UT =	Nt*UTp	= 0.161 * 0	*Undertolerance*	UT =	***0.000***
Rn =	Do/2 - (Nt-nca) + UT	= 2.192/2 - (0.161-0) + 0	*Effective Radius*	Rn =	***0.935***
t =	Vt-sca	= 0.188 - 0	*Effective Shell Thickness*	t =	***0.188***
tn =	Nt-nca	= 0.161-0	*Avail. Nozzle Thick. No UT*	tn =	***0.161***
d =	Do-2*tn	= 2.192 - 2*0.161	*Opening Dia.*	d =	***1.870***
fr1 =	MIN(Sn/Sv,1)	= MIN(18600/18600, 1)		fr1 =	***1.000***
fr2 =	MIN(Sn/Sv,1)	= MIN(18600/18600, 1)		fr2 =	***1.000***
tcLeg41 =	Min(0.25,0.7*Min(0.75,tn,t))	= Min(0.25,0.7*Min(0.75,0.161,0.188))		tc41 =	***0.113***
F =	Min(Fenterered, 1)			F =	***1.000***

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

LDo =	L/Do	LDo = ***0.684***	Dot =	Do/trnE	Dot =	***0.000***	
trn =	(P*Rn)/(Sn*E - 0.6*P) <= tn-UT	= (201*0.935)/(18600*1 - 0.6*201)			trn =	***0.010***	**Acceptable**
trnR =	(P*Rn)/(Sn*1 - 0.6*P)	= (201*0.935)/(18600*1 - 0.6*201)		*E=1*	trnR =	***0.010***	
trnE =	(3*Do*Pa)/(4*B) <= tn-ut	= (3*2.192*0)/(4*1400)			trnE =	***0.000***	**Acceptable**

Geometry Constraints:

0.7*Leg41 >=	tc41	0.7*0.188 >=	0.113	***0.132***	>=	***0.113***	**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 not required

Area Replacement: Fig UG-37.1

				Pressure From:	**Internal**	**External**
A =	1.0*d*tr*F + 2*tn*tr*F*(1-fr1)			A Required (internal) =	***0.126***	
=	1.0*1.87*0.067*1 + 2*0.161*0.067*1*(1-1)					
Ae =	0.5*(d*trE*1 + 2*tn*trE*1*(1-fr1))	= 0.5*(1.87*0*1 + 2*0.161*0*1*(1-1))		A Required (external) =		***0.000***
A1 =	max(d, 2*(t+tn)) * (E1*t-F*tr)-2*tn*(E1*t-F*tr)*(1-fr1)			A1 =	***0.226***	
=	max(1.87,2*(0.188+0.161))* (1*0.188-1*0.067)-2*0.161*(1*0.188-1*0.067)*(1-1)					
A1e =	max(d, 2*(t+tn)) * (E1*t-F*trE)-2*tn*(E1*t-F*trE)*(1-fr1)			A1e =		***0.352***
=	max(1.87,2*(0.188+0.161))* (1*0.188-1*0)-2*0.161*(1*0.188-1*0)*(1-1)					
A2 =	min((tn-trnR)*fr2*Min(5*t,2*L) , (tn-trnR)*fr2*Min(5*tn,2*L))			A2 =	***0.121***	
=	min((0.161-0.01)*1*Min(5*0.188,2*1.5) , (0.161-0.01)*1*Min(5*0.161,2*1.5))					
A2e =	min((tn-trnE)*fr2*Min(5*t,2*L) , (tn-trnE)*fr2*Min(5*tn,2*L))			A2e =		***0.130***
=	min((0.161-0)*1*Min(5*0.188,2*1.5) , (0.161-0)*1*Min(5*0.161,2*1.5))					
A41 =	Leg41^2*fr2	= 0.188^2*1		A41 =	***0.035***	***0.035***
				Actual Area =	***0.383***	***0.517***
			Acceptable	Actual-Required =	***0.257***	***0.517***

Tstd =	Standard pipe wall thickness from chart			Tstd =	***0.145***
Swre =	tr * Pa / P	= 0.067 * 0 / 200.953	*Req. Exterior pressure*	Swre =	***0.000***
Nact =	Nt * (1-UTp)	= 0.161 * (1-0)	*Actual Wall Thick.*	Nact =	***0.161***
Tt =	0.8/Nth	= 0.8/0	*Ug-31(c)(2) threads*	Tt =	***0.000***

UG-45 **Acceptable**

UG45 =	Max(UG45a, UG45b) <= Nact	= Max(0.01, 0.067) <= 0.161	UG45 =	***0.067***
UG45a =	Max(trn,trnE) + Nca + Tt	= Max(0.01,0) + 0 + 0	UG45a =	***0.010***
UG45b =	Min(UG45b3,UG45b4)	= Min(0.067, 0.127)	UG45b =	***0.067***
UG45b1 =	Max(tr + Sca, tmin16b + Sca)	= Max(0.067 + 0, 0.063 + 0)	UG45b1 =	***0.067***
UG45b2 =	Max(Swre + Sca,tmin16b + Sca)	= Max(0 + 0,0.063 + 0)	UG45b2 =	
UG45b3 =	Max(UG45b1,UG45b2)	= Max(0.067,)	UG45b3 =	***0.067***
UG45b4 =	Tstd*0.875 + Nca	= 0.145*0.875 + 0	UG45b4 =	***0.127***

Nozzle Reinforcement ver 3.90

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

Vessel with Large Opening <- Vessel
10" Nozzle With Limit Radius - Nozzle C <- Description

Shell:

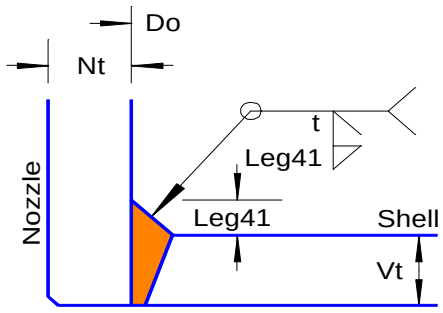
SA-240 304 <- Shell Material
18,600 <- Sv, shell allowable stress level, PSI
1.00 <- E1, efficiency of shell at nozzle
12.37 <- Ds, Shell ID
0.188 <- Vt, shell wall thick, uncorroded, UT removed
0.067 <- tr, required shell wall thickness int. press.(E=1)
0.000 <- trE, required shell wall thickness ext. press.(E=1)
0.063 <- tmin16b, Min allowed wall per UG-16(b)

Nozzle:

SA-312 TP304 <- Nozzle Material
18,600 <- Sn, allowable stress level (Sn)
1,400 <- B, from A = ***0.09590***
1.00 <- E, nozzle efficiency
200.95 <- P, internal design pressure
0.0 <- Pa, external design pressure
10.750 <- Do, outside diameter
7.515 <- dLr, Limit radius <= d
0.365 <- Nt, wall thick, uncorroded
12.5% <- UTp, undertolerance (%)
4.000 <- L, exterior Projection

Reinforcing:

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



UW-16.1 (c)

Variables:

UT =	Nt*UTp	= 0.365 * 0.125	*Undertolerance*	UT =	***0.046***
Rn =	Do/2 - (Nt-nca) + UT	= 10.75/2 - (0.365-0) + 0.046	*Effective Radius*	Rn =	***5.056***
t =	Vt-sca	= 0.188 - 0	*Effective Shell Thickness*	t =	***0.188***
tn =	Nt-nca	= 0.365-0	*Avail. Nozzle Thick. No UT*	tn =	***0.365***
d =	Do-2*tn	= 10.75 - 2*0.365	*Opening Dia.*	d =	***10.020***
fr1 =	MIN(Sn/Sv,1)	= MIN(18600/18600, 1)		fr1 =	***1.000***
fr2 =	MIN(Sn/Sv,1)	= MIN(18600/18600, 1)		fr2 =	***1.000***
tcLeg41 =	Min(0.25,0.7*Min(0.75,tn,t))	= Min(0.25,0.7*Min(0.75,0.365,0.188))		tc41 =	***0.132***
F =	Min(Fenterered, 1)			F =	***1.000***

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

LDo =	L/Do LDo = ***0.372***		Dot =	Do/trnE	Dot = ***0.000***	
trn =	(P*Rn)/(Sn*E - 0.6*P) <= tn-UT	= (201*5.056)/(18600*1 - 0.6*201)			trn = ***0.055***	Acceptable
trnR =	(P*Rn)/(Sn*1 - 0.6*P)	= (201*5.056)/(18600*1 - 0.6*201)		*E=1*	trnR = ***0.055***	
trnE =	(3*Do*Pa)/(4*B) <= tn-ut	= (3*10.75*0)/(4*1400)			trnE = ***0.000***	Acceptable

Geometry Constraints:

0.7*Leg41 >= tc41 0.7*0.25 >= 0.132 ***0.175*** >= ***0.132*** 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-fr1)			A Required (internal) =	***0.674***	
=	1.0*10.02*0.067*1 + 2*0.365*0.067*1*(1-1)					
Ae =	0.5*(d*trE*1 + 2*tn*trE*1*(1-fr1))	= 0.5*(10.02*0*1 + 2*0.365*0*1*(1-1))		A Required (external) =		***0.000***
A1 =	(2*dLr-d) * (E1*t-F*tr)-2*tn*(E1*t-F*tr)*(1-fr1)			A1 =	***0.605***	
=	5.01* (1*0.188-1*0.067)-2*0.365*(1*0.188-1*0.067)*(1-1)					
A1e =	(2*dLr-d) * (E1*t-F*trE)-2*tn*(E1*t-F*trE)*(1-fr1)			A1e =		***0.942***
=	5.01* (1*0.188-1*0)-2*0.365*(1*0.188-1*0)*(1-1)					
A2 =	min((tn-trnR)*fr2*Min(5*t,2*L) , (tn-trnR)*fr2*Min(5*tn,2*L))			A2 =	***0.291***	
=	min((0.365-0.055)*1*Min(5*0.188,2*4) , (0.365-0.055)*1*Min(5*0.365,2*4))					
A2e =	min((tn-trnE)*fr2*Min(5*t,2*L) , (tn-trnE)*fr2*Min(5*tn,2*L))			A2e =		***0.343***
=	min((0.365-0)*1*Min(5*0.188,2*4) , (0.365-0)*1*Min(5*0.365,2*4))					
A41 =	Leg41^2*fr2	= 0.25^2*1		A41 =	***0.063***	***0.063***
				Actual Area =	***0.959***	***1.347***
			Acceptable	Actual-Required =	***0.285***	***1.347***

Tstd =	Standard pipe wall thickness from chart			Tstd =	***0.365***
Swre =	tr * Pa / P	= 0.067 * 0 / 200.953	*Req. Exterior pressure*	Swre =	***0.000***
Nact =	Nt * (1-UTp)	= 0.365 * (1-0.125)	*Actual Wall Thick.*	Nact =	***0.319***
Tt =	0.8/Nth	= 0.8/0	*Ug-31(c)(2) threads*	Tt =	***0.000***

UG-45 Acceptable

UG45 =	Max(UG45a, UG45b) <= Nact	= Max(0.055, 0.067) <= 0.319	UG45 =	***0.067***
UG45a =	Max(trn,trnE) + Nca + Tt	= Max(0.055,0) + 0 + 0	UG45a =	***0.055***
UG45b =	Min(UG45b3,UG45b4)	= Min(0.067, 0.319)	UG45b =	***0.067***
UG45b1 =	Max(tr + Sca, tmin16b + Sca)	= Max(0.067 + 0, 0.063 + 0)	UG45b1 =	***0.067***
UG45b2 =	Max(Swre + Sca,tmin16b + Sca)	= Max(0 + 0,0.063 + 0)	UG45b2 =	
UG45b3 =	Max(UG45b1,UG45b2)	= Max(0.067,)	UG45b3 =	***0.067***
UG45b4 =	Tstd*0.875 + Nca	= 0.365*0.875 + 0	UG45b4 =	***0.319***

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Vessel with Large Opening <- Vessel

10" Nozzle App. 1-7 <- Description

Dimensions:

12.750 <- Dv, vessel outside diameter

0.188 <- t, vessel wall

10.750 <- Dn, nozzle outside diameter

0.365 <- tn, nozzle wall

2.000 <- Fw, flange width

1.000 <- tf, flange thickness

5.000 <- Hf, flange standoff

201.0 <- P, pressure

18,600 <- Ss, stress limit for shell

18,600 <- Sn, stress limit for nozzle

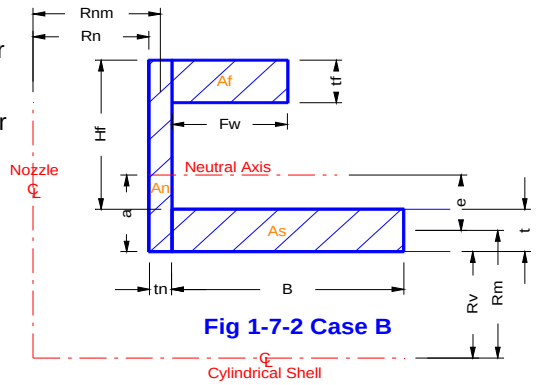


Fig 1-7-2 Case B

0.959 <- Aactual, actual area from limit radius by app. 1-7(a)

0.674 <- Arequired, required area

Geometry

Rv =	Dv/2-t	= 12.75/2-0.188		Rv = ***6.187***
Rn =	Dn/2-tn	= 10.75/2-0.365		Rn = ***5.010***
Rm =	Rv + t/2	= 6.187 + 0.188/2		Rm = ***6.281***
Rnm =	Rn + tn/2	= 5.01 + 0.365/2		Rnm = ***5.193***
B =	Sqrt(Rm*t)	= Sqrt(6.281*0.188)		B = ***1.087***
H =	Hf	= 5		H = ***5.000***
Hfmax =	Max(Sqrt(Rnm*tn),16*tn) >= Hf		**Acceptable**	Hmax = ***5.840***
=	Max(Sqrt(5.193*0.365),16*0.365) >= 5			

App. 1-7(a)

Limit radius =	Max(0.75*2*Rn, Rn+t+tn)			dLr = **7.515**
=	Max(0.75*2*5.01, 5.01+0.188+0.365)			
Aactual >=	(2/3)*Arequired	0.959 >= 0.674*2/3	**Acceptable**	

App. 1-7(b) necessary check

App. 1-7(b) not requir

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

Moment of Inertia about Neutral Axis a

Width	Depth	Y	Area	A*Y	A*Y^2	Io Depth	
1.087	0.188	0.094	0.204	0.019	0.002	0.001	Shell - As
2.000	1.000	4.688	2.000	9.376	43.955	0.167	Flange - Af
0.365	5.188	2.594	1.894	4.912	12.742	4.247	Nozzle - An
		Area = As	**4.098**	**14.307**	**56.698**	**4.415**	Total

a =	AY/As	= 14.307/4.098	a = ***3.491***
I =	AYtwo+IoD - Cxx*Ay	= 56.698+4.415 - 3.491*14.307	I = ***11.161***

Stress Limts

SmMax =	Min(Ss,Sn)	= Min(18600,18600)	SmMax = ***18,600***
SbMax =	1.5*SmMax	= 1.5*18600	SbMax = ***27,900***

Membrane Stress

Sm =	P*(Rv*(Rn+tn+B) + Rn*(t+te+H))/As <= SmMax		Sm = ***3,235***
=	200.953*(6.187*(5.01+0.365+1.087) + 5.01*(0.188+0+5))/4.098 <= 18600		**Acceptable**

Bending Stress

e =	a-t/2	= 3.491-0.188/2	e = ***3.397***
M =	P*(Rn^3/6 + Rv*Rn*e)		M = ***25,373***
=	200.953*(5.01^3/6 + 6.187*5.01*3.397)		
Sb =	M*a/I	= 25373*3.491/11.161	Sb = ***7,937***
Limit =	Sb + Sm <= SbMax	= 7937 + 3235 <= 27900	Limit = ***11,172***
			Acceptable

Flange ver 4.27

ASME VIII Div I Appendix 2

10" Custom Flange **Description**

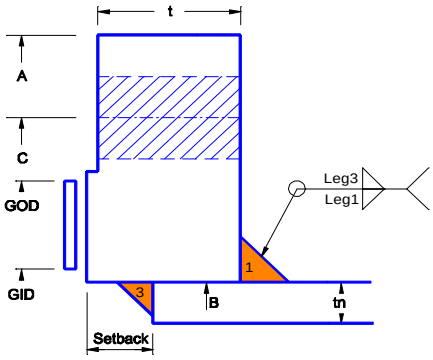


Fig 2-4 (3a)

Dimensions:

Fig2-4(3a)	**fd?** - Select a flange design
14.750	**A** [in] - flange OD
10.750	**Bn** [in] - ID, uncorroded
1.250	**t** [in] - flange thickness
0.365	**tn** [in] - nozzle wall thickness
0.055	**treq** [in] - required nozzle wall

Gasket:

12.125	**GOD** [in] - gasket OD
10.750	**GID** [in] - gasket ID
1.00	**m** - gasket factor
200	**gy** - gasket factor y

Bolting:

13.000	**varC** [in] - bolt circle dia
0.625	**BoltOD** [in] - bolt size
8.0	**Nbolt** - number of bolts
0.365	**Leg1** [in]
0.365	**Leg3** [in]

Operating Conditions:

0.000	**Corr** [in] - corrosion allowance
201.0	**P** [psi] - internal operating pressure
0.0	**Pe** [psi] - external operating pressure

Material Properties:

NonCast	**CastMaterial?** - Cast Or NonCast
18,600	**Sf** [psi] - allowable flange stress at DESIGN temp.
20,000	**Sfa** [psi] - Allowable Flange Stress at ASSEMBLY temp.
26,400,000	**Efo** [psi] -Operating Flange Modulus
28,300,000	**Efs** [psi] - Seating Flange Modulus
25,000	**Sb** [psi] - allowable bolt stress at DESIGN temp
25,000	**Sba** [psi] - allowable bolt stress at ASSEMBLY temp

Geometry Constraints:

tx =	max(1/4,2*treq)	MAX(1/4,2*0.055) =	**0.250**
c =	MIN(tn,tx)	MIN(0.365,0.25) =	**0.250**
mtc =	0.7*c Min Throat	0.7*0.25 =	**0.175**
ThroatLeg1 =	0.7*Leg1	0.7*0.365 =	**0.256**
ChTL1 =	ThroatLeg1 >= mtc	0.256 >= 0.175 =	**Acceptable**
ChTL3 =	0.7*Leg3 >= mtc	0.7*0.365 >= 0.175 =	**Acceptable**
MaxSetback =	c + 1/4	0.25 + 1/4 =	**0.500**
NutG [in] =	PVELookup("TEMATableD5","Lookup","NutWidth",BoltOD)		**1.175**
Rb [in] =	PVELookup("TEMATableD5","Lookup","Rb",BoltOD)		**0.750**
E [in] =	PVELookup("TEMATableD5","Lookup","E",BoltOD)		**0.750**
WrenchClearance =	varC/2-B/2-Leg1-Rb TEMA Table D-5	13/2-10.75/2-0.365-0.75 =	**0.010**
CkWrenchClr =	WrenchClearance > 0	0.01 > 0 =	**Acceptable**
NutClearance =	varC/2-B/2-Leg1-NutG/2 TEMA Table D-5	13/2-10.75/2-0.365-1.175/2 =	**0.173**
CkNutClr =	NutClearance > 0	0.173 > 0 =	**Acceptable**
EdgeClearance =	(A-E)-varC TEMA Table D-5	(14.75-0.75)-13 =	**1.000**
ckEdge =	EdgeClearance > 0	1 > 0 =	**Acceptable**

Calculated Dimensions:

B =	Bn+2*Corr		10.75+2*0 =	**10.750**
varN =	(GOD-GID)/2	Gasket width in contact	(12.125-10.75)/2 =	**0.688**
b0 =	varN / 2	Gasket seating width	0.688 / 2 =	**0.344**
varb =	IF(b0>0.25,Sqrt(b0)/2,b0)	Effective seating width		
			IF(0.344>0.25,SQRT(0.344)/2,0.344) =	**0.293**
varG =	IF(b0>0.25,GOD-2*varb,(GOD-GID)/2 + GID)			
			IF(0.344>0.25,12.125-2*0.293,(12.125-10.75)/2 + 10.75) =	**11.539**

Bolt Loads: (VIII App 2-5)

Bolt size and class: 5/8-11 UNC 2A

H =	0.785*varG^2*P	end load	0.785*11.539^2*201 =	**21,003**
He =	0.785*varG^2*Pe	end load external pressure	0.785*11.539^2*0 =	**0**
HP =	2*varb*3.14*varG*m*P	contact load	2*0.293*3.14*11.539*1*201 =	**4,269**
HD =	pi()/4 * B^2 * P	end load	PI()/4 * 10.75^2 * 201 =	**18,239**
HDe =	pi()/4 * B^2 * Pe	end load external pressure	PI()/4 * 10.75^2 * 0 =	**0**
HT =	H - HD	face load	21003 - 18239 =	**2,764**
HTe =	He - HDe	face load external	0 - 0 =	**0**
Wm1 =	H + HP	bolt load	21003 + 4269 =	**25,272**
Wm2 =	pi()*varb*varG*gy	seating load	PI()*0.293*11.539*200 =	**2,125**
Am =	Max(Wm1/Sb, Wm2/Sba)	Bolt area required		
			MAX(25272/25000, 2125/25000) =	**1.011**
RootArea [sq. in] =	PVELookup("BoltSizing","Lookup","Root Area",BoltOD)			**0.208**
Ab =	RootArea*Nbolt		0.208*8 =	**1.664**
CheckExcess =	Ab>=Am		1.664>=1.011 =	**Acceptable**

Flange Loads: (App 2-5)

W [lb] =	(Am + Ab)*Sba/2	seating conditions	(1.011 + 1.664)*25000/2 =	**33,436**
HG [lb] =	Wm1 - H	operating conditions	25272 - 21003 =	**4,269**
TBoltLoad [lb] =	(W+Wm1)/Nbolt		(33436+25272)/8 =	**7,338**

Flange Moment Arms: (Table App 2-6 - loose flanges)

mhD [in] =	(varC-B)/2		(13-10.75)/2 =	**1.125**
mhT [in] =	(mhD+mhG)/2		(1.125+0.731)/2 =	**0.928**
mhG [in] =	(varC-varG)/2		(13-11.539)/2 =	**0.731**

Flange Moments: (App 2-6)

MD [in-lb] =	HD * mhD	end pressure	18239 * 1.125 =	**20,519**
MT [in-lb] =	HT * mhT	face pressure	2764 * 0.928 =	**2,564**
MG [in-lb] =	HG * mhG	gasket load	4269 * 0.731 =	**3,119**
Mo1e [in-lb] =	HDe*(mhD-mhG)+HTe*(mhT-mhG)	total operating external		
			0*(1.125-0.731)+0*(0.928-0.731) =	**0**
Mo1 [in-lb] =	Max(MD+MT+MG,Mo1e)	total operating		
			MAX(20519+2564+3119,0) =	**26,202**
Mo2 [in-lb] =	W*(varC-varG)/2	total seating	33436*(13-11.539)/2 =	**24,430**

Graph: App 2-7.1 Value of Y

K =	A/B		14.75/10.75 =	**1.372**
Y =	PVELookup("Y","FlangeFactorK",K)			**6.299**

Flange Seating Stress: (App 2-7,8)

STs =	Y*ABS(Mo2) / (t^2*B)		6.299*ABS(24430) / (1.25^2*10.75) =	**9,161**
CheckSTs =	ABS(STs) <= Sfa		ABS(9161) <= 20000 =	**Acceptable**

Flange Operating Stress: (App 2-7,8)

STo =	Y*ABS(Mo1) / (t^2*B)		6.299*ABS(26202) / (1.25^2*10.75) =	**9,826**
CheckSTo =	STo <= Sf		9826 <= 18600 =	**Acceptable**

Flange Flexibility: (App 2-14)

Jseating =	(109.4*Mo2) / (Efs*t^3*ln(K)*0.2)		
		(109.4*24430) / (28300000*1.25^3*LN(1.372)*0.2) =	**0.764**

1	**CheckJSt** =	ABS(Jseating) <= 1	ABS(0.764) <= 1 =	**Acceptable**
2	**Joperating** =	(109.4*Mo1) / (Efo*t^3*ln(K)*0.2)		
3		(109.4*26202) / (26400000*1.25^3*LN(1.372)*0.2) =		**0.879**
4	**CheckJOp** =	ABS(Joperating) <= 1	ABS(0.879) <= 1 =	**Acceptable**

Flange ver 4.27

ASME VIII Div I Appendix 2

Swing Bolts on Pipe **Description**

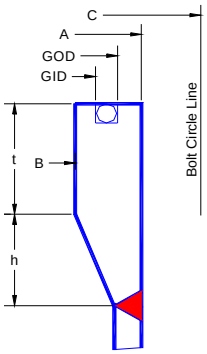


Fig. 2-4 (6) Modified

Dimensions:

Fig2-4(6)modified	**fd?** - Select a flange design
12.750	**A** [in] - flange OD
11.376	**Bn** [in] - ID, uncorroded
3.000	**t** [in] - flange thickness
1.500	**h** [in] - hub length
0.188	**g0f** [in] - hub thickness
0.625	**g1** [in] - hub base thickness

Gasket:

12.395	**GOD** [in] - gasket OD
11.855	**GID** [in] - gasket ID
0.00	**m** - gasket factor
0	**gy** - gasket factor y

Bolting:

14.750	**varC** [in] - bolt circle dia
0.750	**BoltOD** [in] - bolt size
6.0	**Nbolt** - number of bolts

Operating Conditions:

0.000	**Corr** [in] - corrosion allowance
201.0	**P** [psi] - internal operating pressure
0.0	**Pe** [psi] - external operating pressure

Material Properties:

NonCast	**CastMaterial?** - Cast Or NonCast
18,600	**Sf** [psi] - allowable flange stress at DESIGN temp.
20,000	**Sfa** [psi] - Allowable Flange Stress at ASSEMBLY temp.
26,400,000	**Efo** [psi] -Operating Flange Modulus
28,300,000	**Efs** [psi] - Seating Flange Modulus
25,000	**Sb** [psi] - allowable bolt stress at DESIGN temp
25,000	**Sba** [psi] - allowable bolt stress at ASSEMBLY temp

Geometry Constraints:

NutG [in] =	PVELookup("TEMATableD5","Lookup","NutWidth",BoltOD)		**1.383**
Rh [in] =	PVELookup("TEMATableD5","Lookup","Rh",BoltOD)		**1.125**
E [in] =	PVELookup("TEMATableD5","Lookup","E",BoltOD)		**0.813**
EdgeClearance =	(A-E)-varC TEMA Table D-5	(12.75-0.813)-14.75 =	**-2.813**

Calculated Dimensions:

g0 =	g0f-Corr	0.188-0 =	**0.188**
gOne =	g1-Corr	0.625-0 =	**0.625**
B =	Bn+2*Corr	11.376+2*0 =	**11.376**
varR =	(varC-B)/2 - gOne Gasket width in contact	(14.75-11.376)/2 - 0.625 =	**1.062**
varN =	(GOD-GID)/2 Gasket width in contact	(12.395-11.855)/2 =	**0.270**
b0 =	varN / 2 Gasket seating width	0.27 / 2 =	**0.135**
varb =	IF(b0>0.25,Sqrt(b0)/2,b0) Effective seating width	IF(0.135>0.25,SQRT(0.135)/2,0.135) =	**0.135**
varG =	IF(b0>0.25,GOD-2*varb,(GOD-GID)/2 + GID)	IF(0.135>0.25,12.395-2*0.135,(12.395-11.855)/2 + 11.855) =	**12.125**
hub =	h Length of Hub	1.5 =	**1.500**

Bolt Loads: (VIII App 2-5)

Bolt size and class: 3/4-10 UNC 2A

H =	0.785*varG^2*P end load	0.785*12.125^2*201 =	**23,191**

He =	0.785*varG^2*Pe	end load external pressure	0.785*12.125^2*0 =	**0**
HP =	2*varb*3.14*varG*m*P	contact load	2*0.135*3.14*12.125*0*201 =	**0**
HD =	pi()/4 * B^2 * P	end load	PI()/4 * 11.376^2 * 201 =	**20,425**
HDe =	pi()/4 * B^2 * Pe	end load external pressure	PI()/4 * 11.376^2 * 0 =	**0**
HT =	H - HD	face load	23191 - 20425 =	**2,766**
HTe =	He - HDe	face load external	0 - 0 =	**0**
Wm1 =	H + HP	bolt load	23191 + 0 =	**23,191**
Wm2 =	pi()*varb*varG*gy	seating load	PI()*0.135*12.125*0 =	**0**
Am =	Max(Wm1/Sb, Wm2/Sba)	Bolt area required		
			MAX(23191/25000, 0/25000) =	**0.928**
RootArea [sq. in] =	PVELookup("BoltSizing","Lookup","Root Area",BoltOD)			**0.311**
Ab =	RootArea*Nbolt		0.311*6 =	**1.866**
CheckExcess =	Ab>=Am		1.866>=0.928 =	**Acceptable**

Flange Loads: (App 2-5)

W [lb] =	(Am + Ab)*Sba/2	seating conditions	(0.928 + 1.866)*25000/2 =	**34,921**
HG [lb] =	Wm1 - H	operating conditions	23191 - 23191 =	**0**
TBoltLoad [lb] =	(W+Wm1)/Nbolt		(34921+23191)/6 =	**9,685**

Flange Moment Arms: (Table App 2-6 - Integral flanges)

mhD [in] =	varR+0.5*gOne		1.062+0.5*0.625 =	**1.375**
mhT [in] =	(varR+gOne+mhG)/2		(1.062+0.625+1.313)/2 =	**1.500**
mhG [in] =	(varC-varG)/2		(14.75-12.125)/2 =	**1.313**

Flange Moments: (App 2-6)

MD [in-lb] =	HD * mhD	end pressure	20425 * 1.375 =	**28,074**
MT [in-lb] =	HT * mhT	face pressure	2766 * 1.5 =	**4,149**
MG [in-lb] =	HG * mhG	gasket load	0 * 1.313 =	**0**
Mo1e [in-lb] =	HDe*(mhD-mhG)+HTe*(mhT-mhG)	total operating external		
			0*(1.375-1.313)+0*(1.5-1.313) =	**0**
Mo1 [in-lb] =	Max(MD+MT+MG,Mo1e)	total operating		
			MAX(28074+4149+0,0) =	**32,223**
Mo2 [in-lb] =	W*(varC-varG)/2	total seating	34921*(14.75-12.125)/2 =	**45,833**

Graphs: App 2-7.1-6 Values of F, f, T, U, V, Y and Z

h0 =	sqrt(B*g0)	SQRT(11.376*0.188) =	**1.462**
hh0 =	hub/h0	1.5/1.462 =	**1.026**
g1g0 =	gOne/g0	0.625/0.188 =	**3.324**
F =	PVELookup("F","FlangeFactor",hh0,g1g0)		**0.676**
V =	PVELookup("V","FlangeFactor",hh0,g1g0)		**0.069**
smallF =	MAX(PVELookup("smallF","FlangeFactor",hh0,g1g0),1)		**1.000**
K =	A/B	12.75/11.376 =	**1.121**
T =	PVELookup("T","FlangeFactorK",K)		**1.870**
U =	PVELookup("U","FlangeFactorK",K)		**18.713**
Y =	PVELookup("Y","FlangeFactorK",K)		**17.029**
Z =	PVELookup("Z","FlangeFactorK",K)		**8.808**
d =	(U/V)*h0*g0^2	(18.713/0.069)*1.462*0.188^2 =	**14.015**
e =	F / h0	0.676 / 1.462 =	**0.462**
L =	(t*e + 1)/T + t^3/d	(3*0.462 + 1)/1.87 + 3^3/14.015 =	**3.203**

Flange Seating Stress: (App 2-7,8)

SHs =	smallF*ABS(Mo2) / (L*gOne^2 * B)		
		1*ABS(45833) / (3.203*0.625^2 * 11.376) =	**3,220**
CheckSHs =	SHs <= 1.5*(Sfa)	3220 <= 1.5*(20000) =	**Acceptable**
SRs =	(1.33*t*e+1)*ABS(Mo2) / (L*t^2*B)		
		(1.33*3*0.462+1)*ABS(45833) / (3.203*3^2*11.376) =	**398**
CheckSRs =	SRs <= Sfa	398 <= 20000 =	**Acceptable**
STs =	(Y*ABS(Mo2) / (t^2*B)) - Z*SRs		
		(17.029*ABS(45833) / (3^2*11.376)) - 8.808*398 =	**4,122**

1	**CheckSTs** =	ABS(STs) <= Sfa	ABS(4122) <= 20000 =	**Acceptable**
2	**SAs** =	(SHs + Max(SRs, STs))/2	(3220 + MAX(398, 4122))/2 =	**3,671**
3	**CheckSAs** =	SAs <= Sfa	3671 <= 20000 =	**Acceptable**
4	***Flange Operating Stress:*** (App 2-7,8)			
5	**SHo** =	smallF*Mo1/(L*gOne^2*B)	1*32223/(3.203*0.625^2*11.376) =	**2,264**
6	**CheckSHo** =	SHo <= 1.5*(Sf)	2264 <= 1.5*(18600) =	**Acceptable**
7	**SRo** =	(1.33*t*e+1)*Mo1/(L*t^2*B)		
8			(1.33*3*0.462+1)*32223/(3.203*3^2*11.376) =	**279**
9	**CheckSRo** =	SRo <= Sf	279 <= 18600 =	**Acceptable**
10	**STo** =	Y*Mo1/(t^2*B)-Z*SRo	17.029*32223/(3^2*11.376)-8.808*279 =	**2,898**
11	**CheckSTo** =	STo <= Sf	2898 <= 18600 =	**Acceptable**
12	**SAo** =	(SHo+Max(SRo,STo))/2	(2264+MAX(279,2898))/2 =	**2,581**
13	**CheckSAo** =	SAo <= Sf	2581 <= 18600 =	**Acceptable**
14	***Flange Flexibility:*** (App 2-14)			
15	**Jseating** =	(52.14*Mo2*V) / (L*Efs*g0^2*h0*0.3)		
16			(52.14*45833*0.069) / (3.203*28300000*0.188^2*1.462*0.3) =	**0.117**
17	**CheckJSt** =	ABS(Jseating) <= 1	ABS(0.117) <= 1 =	**Acceptable**
18	**Joperating** =	(52.14*Mo1*V) / (L*Efo*g0^2*h0*0.3)		
19			(52.14*32223*0.069) / (3.203*26400000*0.188^2*1.462*0.3) =	**0.088**
20	**CheckJOp** =	ABS(Joperating) <= 1	ABS(0.088) <= 1 =	**Acceptable**

Swing Bolt and Cover ver 4.03

Cover Swing Bolts **Description**

Cover:

201.0	**P** [psi] - Pressure
12.395	**GOd** [in] - Gasket OD
12.750	**Dc** [in] - Cover OD
1.000	**tC** [in] - Cover Thickness
1.000	**wC** [in] - Tab Width
14.750	**BCD** [in] - Bolt Circle Diameter
SA-240 304	**Cover** Material
18,600	**CSA** [psi] - Allowable Stress

Eye Bolt:

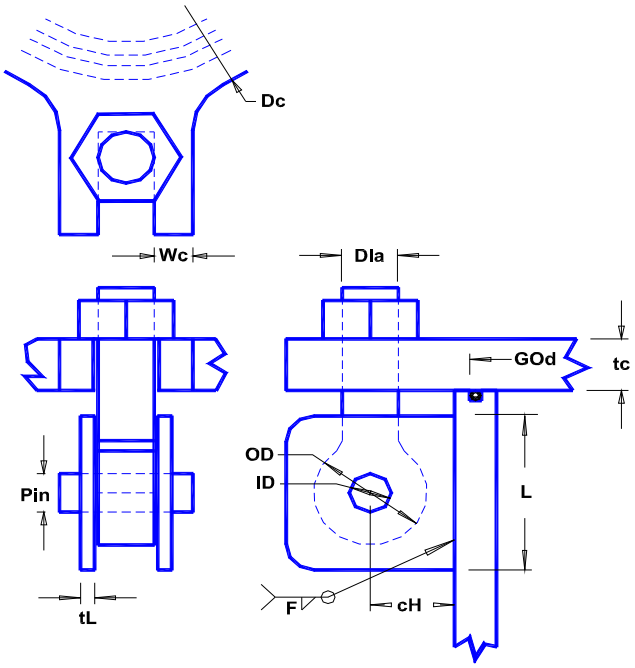
6	**n** - Number of bolts
0.750	**Dia** [in] - Bolt Diameter
0.627	**Rdia** [in] - Thread Root Diameter
0.750	**ID** [in] - ID of Eye
1.500	**OD** [in] - OD of Eye
SA-193 B7	**Bolt** Material
25,000	**BSA** [psi] - Allowable Stress

Pin:

SA-193 B7	**PinMat** - Pin Material
0.750	**Pin** [in] - Pin OD
25,000	**PSA** [psi] - Allowable Stress

Lugs:

2.500	**L** [in] - Height
1.000	**cH** [in] - Half Width
0.375	**tL** [in] - Thickness
0.250	**F** [in] - Weld Fillet Size
SA-240 304	**Lug** Material
18,600	**LSA** [psi] - Allowable Stress



Load: no gasket seating load, pF: Pressure Load

Do [in] =	BCD-2*cH	14.75-2*1 = **12.750**
pF [lb] =	(P*π*GOd^2)/4	(201*3.14*12.395^2)/4 = **24248.063**

Eye bolts: Baa: Actual Area 1, Bab: Actual Area 2, rA: Required Area, Ba: Minimum Area, SF: Seating Force, LpB: Load per Bolt

Baa [in²] =	n*π*Rdia^2/4	6*3.14*0.627^2/4 = **1.853**
Bab [in²] =	n*(OD-ID)*Dia	6*(1.5-0.75)*0.75 = **3.375**
rA [in²] =	pF/BSA	24248.063/25000 = **0.970**
CheckrA =	rA<=MIN(Baa,Bab)	0.97<=MIN(1.853,3.375) = **Acceptable**
Ba [in²] =	Min(Baa,Bab)	MIN(1.853,3.375) = **1.853**
SF [lb] =	Max(Ba*BSA/2,pF)	MAX(1.853*25000/2,24248.063) = **24248.063**
LpB [lb] =	SF/n	24248.063/6 = **4041.344**

Pin: PA: Pin Area, MSp: Max Sp, Sp: Shear

PA [in²] =	(π*Pin^2/4)	(3.14*0.75^2/4) = **0.442**
MSp [psi] =	0.8*PSA	0.8*25000 = **20000**
Sp [psi] =	LpB/(2*PA)	4041.344/(2*0.442) = **4574**
CheckShear =	Sp <= MSp	4574 <= 20000 = **Acceptable**

Lug: Ratio <= 1, msL: Max Shear, LL: Lug Load, LS: Lug Shear, rLS: Load Ratio, mbL: Max Bending, iL: Moment of Inertia mL: Moment, LB: Bending Load, rLB: Load Ratio, LugRatio: Factored Load

msL [psi] =	LSA*0.8	18600*0.8 =	**14880**
LL [lb] =	LpB/2	4041.344/2 =	**2020.672**
LS [psi] =	LL/(tL*L)	2020.672/(0.375*2.5) =	**2155**
rLS =	LS/msL	2155/14880 =	**0.145**
mbL [psi] =	LSA*1.5	18600*1.5 =	**27900**
cL [in] =	L/2	2.5/2 =	**1.250**
iL [in^4] =	(tL*L^3)/12	(0.375*2.5^3)/12 =	**0.488**
mL [in-lb] =	LL*cH	2020.672*1 =	**2020.672**
LB [lb] =	mL*cL/iL	2020.672*1.25/0.488 =	**5172.920**
rLB =	LB/mbL	5172.92/27900 =	**0.185**
LugRatio =	SQRT(rLS^2+rLB^2)	SQRT(0.145^2+0.185^2) =	**0.235**
CheckLug =	LugRatio <= 1	0.235 <= 1 =	**Acceptable**

Lug Weld: Factored load ratio must be less than 1, msW: Max Shear/Bending, WS: Weld Shear, rWS: Load Ratio WB: Bending Load, rWB: Load Ratio LugWeldRatio: Factored Load

msW [psi] =	0.49*MIN(LSA, PSA)	0.49*MIN(18600, 25000) =	**9114**
Wa [in^2] =	(L+2*F)*(tL+2*F)-tL*L	(2.5+2*0.25)*(0.375+2*0.25)-0.375*2.5 =	**1.688**
WS [psi] =	LL/Wa	2020.672/1.688 =	**1197**
rWS =	WS/msW	1197/9114 =	**0.131**
iW [in^4] =	(tL + 2*F)*(L + 2*F)^3/12 - iL	(0.375 + 2*0.25)*(2.5 + 2*0.25)^3/12 - 0.488 =	**1.480**
WB [psi] =	mL*(cL+F)/iW	2020.672*(1.25+0.25)/1.48 =	**2047**
rWB =	WB/msW	2047/9114 =	**0.225**
LugWeldRatio =	SQRT(rWS^2+rWB^2)	SQRT(0.131^2+0.225^2) =	**0.260**
CheckWeld =	LugWeldRatio <= 1	0.26 <= 1 =	**Acceptable**

Cover: mbC: Max Bending, mC1: Pressure Moment, mC2: Bolt Unit Moment, mCt: Total Moment, tca: Required Thickness Required thickness - Roarks Table 24 Case 10a and 13

mbC [psi] =	1.5*CSA	1.5*18600 =	**27900**
mC1 [in-lb] =	P*Do^2*3.3/64	201*12.75^2*3.3/64 =	**1684.412**
mC2 [in-lb] =	SF*cH/(Do*π)	24248.063*1/(12.75*3.14) =	**605.365**
mCt [in-lb] =	mC1 + mC2	1684.412 + 605.365 =	**2289.777**
tca [in] =	sqrt(6*mCt/mbC)	SQRT(6*2289.777/27900) =	**0.702**

Required thickness - Table UG-34 (j), C = 0.3, W = SF, hG = cH, S = CSA, d=Do, E=1

tcb [in] =	Do*sqrt((0.3*P)/(CSA*E)+(1.9*SF*cH)/(CSA*E*Do^3))	12.75*SQRT((0.3*201)/(18600*1)+(1.9*24248.063*1)/(18600*1*12.75^3)) =	**0.849**
ReqCThick [in] =	Max(tca, tcb)	MAX(0.702, 0.849) =	**0.849**
CheckThick =	ReqCThick <= tC	0.849 <= 1 =	**Acceptable**

Cover Tabs: iT: Moment of Inertia, mT: Moment, LT: Bending Load

cT [in] =	tC/2		1/2 =	**0.500**
iT [in^4] =	(wC*tC^3*2)/12	*Moment of Inertia*	(1*1^3*2)/12 =	**0.167**
mT [in-lb] =	LpB*(BCD-Dc)/4	*Moment*	4041.344*(14.75-12.75)/4 =	**2020.672**
LT [lb] =	mT*cT/iT	*Bending Load*	2020.672*0.5/0.167 =	**6062.016**
CheckLT =	LT <= mbC		6062.016 <= 27900 =	**Acceptable**

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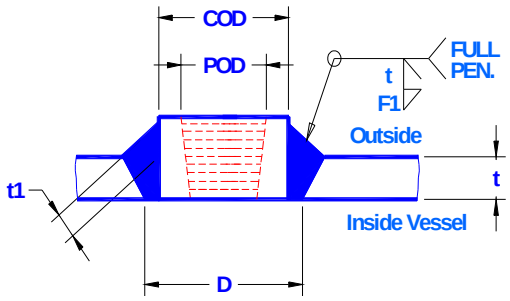
Vessel with Large Opening <- Vessel
2" Coupling E <- Description

Shell:

1.000 <- t, Shell Wall Thick (inch)
0.849 <- tMin, Min Required Wall at E=1 (inch)
3.125 <- D, Shell Opening Diameter (inch)
201.0 <- P,design Pressure (psi)



UW-16.1 (Z-1) (Modified)

Coupling:

2 inch 3000# <- Coupling
SA-182 F304 <- Coupling Material
17,400 <- Sn, Allowable Stress Level (Sn)
0.3125 <- F1, Weld Size
0.063 <- tmin16b, Min allowed wall per UG-16(b)
0.000 <- Corrc, Coupling Corrosion Allowance (inch)
3.000 <- COD - Coupling OD
2.375 <- POD - Pipe OD
11.500 <- n, Threads Per Inch
0.344 <- pt, Corresponding sch160 Wall Thickness (inch)
12.5% <- UT, Under Tolerence (%)

Geometry Restrictions Fig. UW-16.1

tcp =	(COD-POD)/2-CORRC	= (3-2.375)/2-0	Tcp = ***0.313***
Tmin =	Min(0.75,tcp,t)	= Min(0.75,0.313,1)	Tmin = ***0.313***
tcmin =	Min(0.25,0.7*Tmin)	= Min(0.25,0.7*0.313)	tcmin = ***0.219***
t1 =	0.7*F1	= 0.7*0.313	t1 = ***0.219***
t1 > =	tcMin	= 0.219 >= 0.219	**Acceptable**

Required Coupling Wall Thickness UG-44(c), B16.11 - 2.1.1 and UG-31(c)(2)

Ro =	POD/2-0.8/n	= 2.375/2-0.8/11.5	Ro = ***1.118***
tp =	(1-UT)*pt-Corrc-0.8/n	= (1-0.125)*0.344-0-0.8/11.5	tp = **0.231**
Min Thick =	P*Ro/(Sn*1+0.4*P)	= 201*1.118/(17400*1+0.4*200. **Acceptable**	trn = ***0.013***

Pressure Weld Stress UW-18(d) - Pressure Load only UW-16(f)(3)(a)(3)(b)

Load =	COD^2*(PI()/4)*P	= 3^2*(PI()/4)*200.953	Load = ***1420***
Weld Area =	pi()*((COD+F1)^2-COD^2)/4		Weld Area = ***1.549***
=	pi()*((3+0.313)^2-3^2)/4		
Max Stress =	Min(Sn,Sv) * 0.55	= Min(17400,0) * 0.55	Max Stress = ***9570***
Weld Stress =	Load / Area	= 1420 / 1.549	Weld Stress = ***917***
			Acceptable

UG-45

Tstd =	Standard pipe wall thickness from chart		Tstd = ***0.154***
Nact =	Pt * (1-UT)	*Actual Wall Thick.*	Nact = ***0.301***
Tt =	0.8/n	*Ug-31(c)(2) threads*	Tt = ***0.070***
UG45 =	Max(UG45a, UG45b) <= Nact		UG45 = ***0.135***
=	Max(0.082, 0.135) <= 0.301		**Acceptable**
UG45a =	trn + corrc + Tt		UG45a = ***0.082***
	0.013 + 0 + 0.07		
UB45b =	Min(UG45b1, UG45b4)		UB45b = ***0.135***
=	Min(0.849, 0.135)		
UG45b1 =	Max(tmin+ CORRC, Tmin16b + CORRC)		UG45b1 = ***0.849***
=	Max(0.849 + 0, 0.063 + 0)		
UG45b4 =	Tstd*0.875 + corrc	= 0.154*0.875 + 0	UG45b4 = ***0.135***

Vessel Weight and Volume ver 4.03

Vessel with Large Opening **Description**

Volume:

2	**nhead** - Number of heads?
1.00	**SG** - Fluid Specific Gravity
0.23	**VE** [ft3] - Volume of Each Head
1.39	**VS** [ft3] - Volume of Shell

Construction:

9	**Wh** [lb] - Weight of Each Head
42	**Ws** [lb] - Weight of Shell
100	**Wm** [lb] - Misc Weight

Calculations:

V [ft3] =	VE*nhead + VS	*total volume*	0.23*2 + 1.39 =	**1.85**
V2 [Imp. Gallons] =	V*6.229		1.85*6.229 =	**11.52**
V3 [US Gallons] =	V*7.4805		1.85*7.4805 =	**13.84**
Wf [lb] =	62.37*SG*V	*fluid weight*	62.37*1*1.85 =	**115.38**
WC [lb] =	Wh*nhead + Ws + Wm	*construction weight*	9*2 + 42 + 100 =	**160.00**
WT [lb] =	WC + Wf	*total weight*	160 + 115.38 =	**275.38**