INPUT VALUES, Nozzle Description: BOOT From : 20

Pressure for Reinforcement Calculations	P	11.016	kgf/cm²
Temperature for Internal Pressure	Temp	310	C
Design External Pressure	Pext	2.40	kgf/cm²
Temperature for External Pressure	Tempex	175	C
Maximum Allowable Pressure New & Cold		16.21	kgf/cm²

Shell Material [Normalized]		SA-516 70	
Shell Allowable Stress at Temperature	S	1368.19	kgf/cm²
Shell Allowable Stress At Ambient	Sa	1406.14	kgf/cm²

Inside Diameter of Cylindrical Shell	D	2600.00	mm
Design Length of Section	L	2345.0002	mm
Shell Finished (Minimum) Thickness	t	26.0000	mm
Shell Internal Corrosion Allowance	c	3.0000	mm
Shell External Corrosion Allowance	co	1.5000	mm

Physical Maximum for Diameter Limit	Dmax	2000.0000	mm
Physical Maximum for Thickness Limit	Tmax	0.0000	mm

Distance from Bottom/Left Tangent		3390.0000	mm

User Entered Minimum Design Metal Temperature		11.00	C

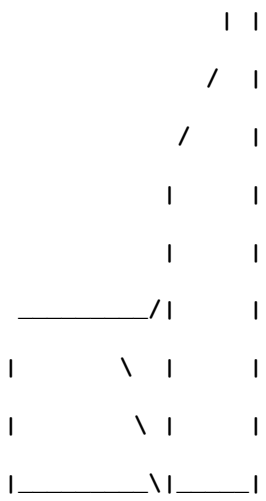
Type of Element Connected to the Shell : Nozzle

Material [Normalized]		SA-105
Material UNS Number		K03504
Material Specification/Type		Forgings

Allowable Stress at Temperature	Sn	1302.13	kgf/cm²
Allowable Stress At Ambient	Sna	1406.14	kgf/cm²
Diameter Basis (for tr calc only)		ID	
Layout Angle		180.00	deg
Diameter		47.2400	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	16.0000	mm
Hub Height of Integral Nozzle	h	80.0000	mm
Height of Beveled Transition	L`	100.0000	mm
Hub Thickness of Integral Nozzle (tn or x+tp)		80.0000	mm
Corrosion Allowance	can	7.5000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	2655.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	16.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	26.0000	mm
Inside Projection	h	0.0000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm
ASME Code Weld Type per UW-16		None	

The Pressure Design option was MAWP + static head (to the nozzle).

Nozzle Sketch (may not represent actual weld type/configuration)



Hub Nozzle

Reinforcement CALCULATION, Description: BOOT

ASME Code, Section VIII, Division 1, 2007, A-09 UG-37 to UG-45

Actual Inside Diameter Used in Calculation	47.240	in.
Actual Thickness Used in Calculation	0.630	in.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Int. Press]

= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)

= (11.02*1303.0001)/(1368*1.00-0.6*11.02)

= 10.5422 mm

Reqd thk per UG-37(a)of Cylindrical Shell, Tr [Mapnc]

= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)

= (16.21*1300.0001)/(1406*1.00-0.6*16.21)

= 15.0870 mm

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Int. Press]

```
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)

= (11.02*607.45)/(1302*1.00-0.6*11.02)

= 5.1653 mm
```

Reqd thk per UG-37(a)of Nozzle Wall, Trn [Mapnc]

```
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)

= (16.21*599.95)/(1406*1.00-0.6*16.21)

= 6.9626 mm
```

Required Nozzle thickness under External Pressure per UG-28 : 7.5360 mm

Intermediate Hub Nozzle Calculations:

Check to determine use of Sketch (e-1) or (e-2):

Height value from sketch (e-1) [te]:

```
= ( Hub Thickness - Neck Thickness ) / cos(30)

= 64.000 / 0.5773

= 110.8513 mm
```

Note: Hub Height was < 2.5 times Hub Thickness, use sketch UG-40 (e-1).

UG-40, Limits of Reinforcement : [Int. Press]

Parallel to Vessel Wall (Diameter Limit)	Dl	2000.0000	mm
Parallel to Vessel Wall, opening length	d	1000.0000	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	53.7500	mm

Intermediate Hub Nozzle Calculations:

Check to determine use of Sketch (e-1) or (e-2):

Height value from sketch (e-1) [te]:

= (Hub Thickness - Neck Thickness) / cos(30)

= 64.000 / 0.5773

= 110.8513 mm

Note: Hub Height was < 2.5 times Hub Thickness, use sketch UG-40 (e-1).

UG-40, Limits of Reinforcement : [Mapnc]

Parallel to Vessel Wall (Diameter Limit)	Dl	2000.0000	mm
Parallel to Vessel Wall, opening length	d	1000.0000	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	65.0000	mm

Weld Strength Reduction Factor [fr1]:

= min(1, Sn/S)

= min(1, 1302.1 /1368.2)

= 0.952

Weld Strength Reduction Factor [fr2]:

= min(1, Sn/S)

= min(1, 1302.1 /1368.2)

= 0.952

Weld Strength Reduction Factor [fr3]:

= min(fr2, fr4)

= min(1.0 , 1.0)

= 0.952

Results of Nozzle Reinforcement Area Calculations:

AREA AVAILABLE, A1 to A5		MAWP	External	Mapnc	
Area Required	Ar	128.815	68.572	181.029	cm^2

Area in Shell	A1	85.263	79.959	87.315	cm²
Area in Nozzle Wall	A2	3.412	0.986	11.749	cm²
Area in Inward Nozzle	A3	0.000	0.000	0.000	cm²
Area in Welds	A41+A42+A43	1.833	1.833	1.926	cm²
Area in Element	A5	0.000	0.000	0.000	cm²
Area in Hub	A6	65.478	65.478	83.200	cm²
TOTAL AREA AVAILABLE	Atot	155.986	148.257	184.190	cm²

The MAP(nc) Case Governs the Analysis.

Nozzle Angle Used in Area Calculations	90.00	Degs.

The area available without a pad is Sufficient.

Area Required [A]:

= (d * tr*F + 2 * tn * tr*F * (1-fr1)) UG-37(c)

= (1199.8960*15.0870*1.0+2*80.0000*15.0870*1.0*(1-1.00))

= 181.029 cm²

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:

= d(E1*t - F*tr) - 2 * tn(E1*t - F*tr) * (1 - fr1)

= 800.104 (1.00 * 26.0000 - 1.0 * 15.087) - 2 * 80.000

(1.00 * 26.0000 - 1.0 * 15.0870) * (1 - 1.000)

= 87.315 cm²

Area Available in Nozzle Projecting Outward [A2]:

= (2 * tlnp) * (tn - trn) * fr2

= (2 * 65.00) * (16.00 - 6.96) * 1.0000)

= 11.749 cm²

Area Available in Inward Weld + Outward Weld [A41 + A43]:

$= Wo^2 * fr2 + (Wi-can/0.707)^2 * fr2$

$= 13.8784^2 * 1.0000 + (0.0000)^2 * 1.0000$

$= 1.926\ cm^2$

Area Available in the Hub Section [A6]:

$= (2 * \min(Tlnp,ho,Hubht)) * (Hubtk - tn) * fr2$

$= (2 * \min(53.8 ,2655.0 ,80.0)) * (80.0 - 16.0) * 1.000)$

$= 83.200\ cm^2$

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]

Wall Thickness per UG45(a), tra = 15.0360 mm

Wall Thickness per UG16(b), tr16b = 9.0000 mm

Wall Thickness per UG45(b)(1), trb1 = 15.0422 mm

Wall Thickness per UG45(b)(2), trb2 = 6.7880 mm

Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 15.0422 mm

Std. Wall Pipe per UG45(b)(4), trb4 = 15.8344 mm

Wall Thickness per UG45(b), trb = Min(trb3, trb4) = 15.0422 mm

Final Required Thickness, tr45 = Max(tra, trb) = 15.0422 mm

Available Nozzle Neck Thickness = 16.0000 mm --> OK

UG-45 Minimum Nozzle Neck Thickness Requirement: [MAPnc]

Wall Thickness per UG45(a), tra = 6.9626 mm

Wall Thickness per UG16(b), tr16b = 1.5000 mm

Wall Thickness per UG45(b)(1), trb1 = 15.0870 mm

Wall Thickness per UG45(b)(3), trb3 = Max(trb1, trb2, tr16b) = 15.0870 mm

Std. Wall Pipe per UG45(b)(4), trb4 = 8.3344 mm

Wall Thickness per UG45(b), trb = Min(trb3, trb4) = 8.3344 mm

```
Final Required Thickness,      tr45 = Max(tra, trb) = 8.3344 mm

Available Nozzle Neck Thickness     = 16.0000 mm --> OK
```

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

MDMT of Nozzle-Shell/Head Weld for the Nozzle (UCS-66(a)1(b)), Curve: C

Govrn. thk, tg = 26.000 , tr = 10.256 , c = 4.5000 mm , E* = 1.00

Stress Ratio = tr * (E*) / (tg - c) = 0.477 , Temp. Reduction = 38 C

```
Min Metal Temp. w/o impact per UCS-66                    -20 C

Min Metal Temp. at Required thickness (UCS 66.1)         -48 C


Governing MDMT of all the sub-joints of this Junction  :   -48 C
```

Large Opening Calculations per Appendix 1-10

Thickness of Nozzle at Shell [tn]:

```
= hub thickness - corrosion allowance

= 80.000 - 7.500

= 72.500 mm
```

Thickness of Nozzle at Top [tn2]:

```
= thickness - corrosion allowance

= 16.000 - 7.500

= 8.500 mm
```

Effective Pressure Radius [Reff]:

```
= Di/2 + corrosion allowance

= 2600.000 /2 + 3.000
```

```
= 1303.000 mm
```

Effective Length of Vessel Wall [LR]:

```
= 8 * t
= 8 * 21.500
= 172.000 mm
```

Thickness Limit Candidate [LH1]:

```
= t + 0.78 * sqrt( Rn * tn )
= 21.500 + 0.78 * sqrt( 607.448 * 72.500 )
= 185.188 mm
```

Thickness Limit Candidate [LH2]:

```
= Lpr1 + t
= 2655.000 + 21.500
= 2676.500 mm
```

Thickness Limit Candidate [LH3]:

```
= 8 * ( t + te )
= 8 * ( 21.500 + 0.000 )
= 172.000 mm
```

Thickness Limit Candidate [LH4]:

```
= Lpr3 + t + 0.78 * ( TN2 / TN ) * sqrt( rn * tn2 )
= 80.00 + 21.50 + 0.78 * ( 8.50 / 72.50 ) * sqrt( 607.45 * 8.50 )
= 108.071 mm
```

Effective Nozzle Wall Length Outside the Vessel [LH]:

```
= min[ LH1, LH2, LH4 ]
= min[ 185.188 , 2676.500 , 108.071 )
= 108.071 mm
```

Effective Vessel Thickness [teff]:

= t

= 21.500 mm

Determine Parameter [Lamda]:

= min(10, (Dn + Tn)/(sqrt((Di + teff) * teff)))

= min(10, (1214.90 + 72.500)/(sqrt((2606.00 + 21.500) * 21.500)))

= 5.417

Compute Areas A1-A43 (No Pad) or A1-A5 (With Pad) :

Area Contributed by the Vessel Wall [A1]:

= t * LR * max(Lamda/4, 1)

= 21.500 * 172.000 * max(5.417 /4, 1)

= 50.076 cm²

Area Contributed by the Nozzle Outside the Vessel Wall [A2]:

= tn * (Lpr3 + t) + 0.78 * ($tn2^2$/tn) * sqrt(Rn * tn2)

= 72.500 * (80.000 + 21.500) + 0.78 * (8.500^2/ 72.500) * sqrt(6

= 74.146 cm²

Area Contributed by the Outside Fillet Weld [A41]:

= 0.5 * $Leg41^2$

= 0.5 * 16.000^2

= 1.280 cm²

The total area contributed by A1 through A43 [AT]:

= A1 + frn(A2 + A3) + A41 + A42 + A43

= 50.076+1.000(74.146+0.000)+1.280+0.000+0.000

= 125.502 cm²

Allowable Local Primary Membrane Stress [Sallow]:

= 1.5 * S * E

= 1.5 * 1368.194 * 1.000

= 2052.3 kgf/cm²

Determine Force acting on the Nozzle [fN]:

= P * Rn * (LH – t)

= 11.016 * 607.448 * (108.071 – 21.500)

= 5793.1 kgf

Determine Force acting on the Shell [fS]:

= P * Reff * (LR + tn)

= 11.016 * 1303.000 * (172.000 + 72.500)

= 35095.7 kgf

Discontinuity Force from Internal Pressure [fY]:

= P * Reff * Rnc

= 11.016 * 1303.000 * 607.448

= 87193.5 kgf

Area Resisting Internal Pressure [Ap]:

= Rn(LH – t) + Reff(LR + tn + Rnc)

= 607.448 (108.071 – 21.500) + 1303.000 (172.000 + 72.500 + 607.448

= 11626.8 cm²

Maximum Allowable Working Pressure Candidate [Pmax1]:

= Sallow /(2 * Ap/AT – Rxs/teff)

= 2052.291 /(2 * 11626.758 /125.502 – 1303.000 /21.500)

= 16.5 kgf/cm²

Maximum Allowable Working Pressure Candidate [Pmax2]:

= S[t/Reff]

= 1368.194 [21.500 /1303.000]

= 22.6 kgf/cm²

Maximum Allowable Working Pressure [Pmax]:

= min(Pmax1, Pmax2)

= min(16.461 , 22.576)

= 16.461 kgf/cm²

Average Primary Membrane Stress [SigmaAvg]:

= (fN + fS + fY) / AT

= (5793.119 + 35095.676 + 87193.453) / 125.502

= 1020.562 kgf/cm²

General Primary Membrane Stress [SigmaCirc]:

= P * Reff / teff

= 11.016 * 1303.000 / 21.500

= 667.6 kgf/cm²

Maximum Local Primary Membrane Stress [PL]:

= max(2 * SigmaAvg - SigmaCirc, SigmaCirc)

= max(2 * 1020.562 - 667.632 , 667.632)

= 1373.5 kgf/cm²

Summary of Nozzle Pressure/Stress Results:

Allowed Local Primary Membrane Stress	Sallow	2052.29	kgf/cm²
Local Primary Membrane Stress	PL	1373.49	kgf/cm²
Maximum Allowable Working Pressure	Pmax	16.46	kgf/cm²

Weld Size Calculations, Description: BOOT (HOLD)

Intermediate Calc. for nozzle/shell Welds Tmin 19.0000 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	6.0000 = Min per Code	11.3120 = 0.7 * Wo mm

Weld Strength and Weld Loads per UG-41.1, Sketch (a) or (b)

Weld Load [W]:

= (A-A1+2*tn*fr1*(E1*t-tr))*Sv

= (181.0288 - 87.3150 + 2 * 80.0000 * 0.9517 *

(1.00 * 24.5000 - 15.0870)) * 1368

= 147829.47 kgf

For hub type nozzles, A2 includes the area area of the hub.

Note: F is always set to 1.0 throughout the calculation.

Weld Load [W1]:

= $(A2+A4-(Wi-Can/.707)^2*fr2)*Sv$

= (94.9486 + 1.9261 - 0.0000 * 0.95) * 1368

= 132543.14 kgf

Weld Load [W2]:

= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv

= (94.9486 + 0.0000 + 1.9261 + (37.3072)) * 1368

= 183586.56 kgf

Weld Load [W3]:

= (A2+A3+A4+A5+(2*tn*t*fr1))*S

= (94.9486 + 0.0000 + 1.9261 + 0.0000 + (37.3072)) * 1368

= 183586.56 kgf

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

= (pi/2) * Dlo * Wo * 0.49 * Snw

= (3.1416 / 2.0) * 1359.8960 * 16.0000 * 0.49 * 1302

= 218070. kgf

Shear, Nozzle Wall [Snw]:

= (pi *(Dlr + Dlo)/4) * (Thk - Can) * 0.7 * Sn

= (3.1416 * 639.9481) * (80.0000 - 0.0000) * 0.7 * 1302

= 1466008. kgf

Tension, Shell Groove Weld [Tngw]:

= (pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng

= (3.1416 / 2.0) * 1359.8960 * (26.0000 - 1.5000) * 0.74 * 1368

= 529871. kgf

Strength of Failure Paths:

PATH11 = (SONW + SNW) = (218069 + 1466008) = 1684077 kgf

PATH22 = (Sonw + Tpgw + Tngw + Sinw)

= (218069 + 0 + 529871 + 0) = 747941 kgf

PATH33 = (Sonw + Tngw + Sinw)

= (218069 + 529871 + 0) = 747941 kgf

Summary of Failure Path Calculations:

Path 1-1 = 1684077 kgf, must exceed W = 147829 kgf or W1 = 132543 kgf

Path 2-2 = 747941 kgf, must exceed W = 147829 kgf or W2 = 183586 kgf

Path 3-3 = 747941 kgf, must exceed W = 147829 kgf or W3 = 183586 kgf

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Max. Allow. Pressure in Operating case	11.782	kgf/cm²

Note: The MAWP of this junction was limited by the parent Shell/Head.

Nozzle is O.K. for the External Pressure	2.400	kgf/cm²
Approximate M.A.P.(NC) for given geometry	16.375	kgf/cm²

The Drop for this Nozzle is : 191.9970 mm

The Cut Length for this Nozzle is, Drop + Ho + H + T : 2872.9968 mm