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DESIGN CALCULATION

ASME Code Version : 2007

Analysis Performed by : KEDKEP CONSULTING, INC.

Job File : E:\Valve\shell.cci

Date of Analysis : June 8,2008

PV Elite 2008, May 2008

Input Echo, Component 1, Description: Body Shell

Design Internal Pressure	P	150.00	psig
Temperature for Internal Pressure		200.00	F
User Entered Minimum Design Metal Temperature		-20.00	F
Include Hydrostatic Head Components		NO	
Material Specification		SB-283 M10	
Material UNS Number		C37700	
Material Form used		Forgings,brass	
Allowable Stress At Temperature	S	9000.00	psi
Allowable Stress At Ambient	SA	10000.00	psi
Yield Stress At Temperature	Sy	0.00	psi
Joint efficiency for Shell Joint	E	0.85	
Design Length of Section	L	0.0000	in
Inside Diameter of Cylindrical Shell	D	4.0000	in
Minimum Thickness of Pipe or Plate	T	0.2500	in
Nominal Thickness of Pipe or Plate	Tnom	0.2500	in
Shell/Head Int. Corrosion Allowance	CA	0.0000	in
Skip UG-16(b) Min. thickness calculation		NO	
Type of Element:		Cylindrical Shell	

Internal pressure results, Shell Number 1, Desc.: Body Shell

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Thickness Due to Internal Pressure (Tr):
= (P*(D/2+CA)) / (S*E-0.6*P) per UG-27 (c)(1)
= (150.00*(4.0000/2+0.0000))/(9000.00*0.85-0.6*150.00)
= 0.0397 + 0.0000 = 0.0397 in
= 0.0625 in (Per Ug 16b)

Max. All. Working Pressure at Given Thickness (MAWP):
= (S*E*(T-CA-CAE)) / ((D/2+CA)+0.6*(T-CA-CAE)) per UG-27 (c)(1)
= (9000.00*0.85*(0.2500))/((4.0000/2+0.0000)+0.6*0.2500)
= 889.53 psig

Maximum Allowable Pressure, New and Cold (MAPNC):
= (SA*E*T) / (D/2+0.6*T) per UG-27 (c)(1)
= (10000.00*0.85*0.2500)/(4.0000/2+0.6*0.2500)
= 988.37 psig

Actual stress at given pressure and thickness (Sact):
= (P*((D/2+CA)+0.6*(T-CA-CAE))) / (E*(T-CA-CAE))
= (150.00*((4.0000/2+0.0000)+0.6*(0.2500)))/(0.85*(0.2500))
= 1517.65 psi

SUMMARY OF INTERNAL PRESSURE RESULTS:

Required Thickness plus Corrosion Allowance, Trca		0.0625	in
Actual Thickness as Given in Input		0.2500	in
Maximum Allowable Working Pressure	MAWP	889.535	psig
Maximum Allowable Pressure, NC	MAPNC	988.372	psig
Design Pressure as Given in Input	P	150.000	psig

Hydrostatic Test Pressures (Measured at High Point):

Hydrotest per UG-99(b); 1.3 * MAWP * Sa/S	1284.88	psig
Hydrotest per UG-99(c); 1.3 * MAPNC	1284.88	psig
Pneumatic per UG-100 ; 1.1 * MAWP * Sa/S	1087.21	psig

Input Echo, Nozzle Item 1, Description: Opening

Design Internal Pressure (Case 1)	P	150.00	psig
Temperature for Internal Pressure	TEMP	200.00	F
Include Hydrostatic Head Components		NO	
Shell or Head Material (Not Normalized or NA)		SB-283 M10	
Material UNS Number		C37700	
Shell/Head Allowable Stress at Temperature	S	9000.00	psi
Shell/Head Allowable Stress At Ambient	SA	10000.00	psi
Shell/Head Yield Stress at Temperature	Sy	0.00	psi
Inside Diameter of Cylindrical Shell	D	4.0000	in
Actual Thickness of Shell or Head	T	0.2500	in
Corrosion Allowance for Shell or Head	CAS	0.0000	in
Is this Nozzle a Radial Nozzle		YES	
Distance from Cylinder/Head Centerline	L1	1.0000	in
Is this Nozzle a Lateral Nozzle (Y-angle)		NO	
Nozzle Material (Not Normalized or NA)		SB-283 M10	
Material UNS Number		C37700	
Nozzle Allowable Stress at Temperature	SN	9000.00	psi
Nozzle Allowable Stress At Ambient	SNA	10000.00	psi
Diameter Basis for Nozzle	BASISN	ID	
Inside Diameter of Nozzle	DIA	1.0000	in
Nozzle Size and Thickness Basis	DBN	Actual	
Actual Thickness of Nozzle	THK	0.2000	in
Corrosion Allowance for Nozzle	CAN	0.0000	in
Joint Efficiency of Shell Seam at Nozzle	ES	1.00	
Joint Efficiency of Nozzle Neck	EN	1.00	
Insert or Abutting Nozzle Type	NTYP	Insert	
Outward Projection of Nozzle	HO	1.0000	in
Weld leg size between Nozzle and Pad/Shell	WO	0.2500	in
Groove weld depth between Nozzle and Vessel	WGNV	0.2500	in
ASME Code Weld Type per UW-16.1		F-4	
Is this is Manway/Access/Inspection Opening		No	
Skip Iterative Failure Thickness Calculations		Yes	

NOZZLE CALCULATION, Description: Opening

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Actual Nozzle Inside Diameter Used in Calculation	1.000	in.
Actual Nozzle Thickness Used in Calculation	0.200	in.

Internal Pressure Results for SHELL / HEAD :

Reqd thk per UG-37(a) of Cylindrical Shell, Tr [Internal Press]
Thickness Due to Internal Pressure:
= (P*(D/2+CA)) / (S*E-0.6*P) per UG-27 (c)(1)
= (150.00*(4.0000/2+0.0000))/(9000.00*1.00-0.6*150.00)
= 0.0337 + 0.0000 = 0.0337 in

Internal Pressure Results for NOZZLE :

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Internal Press]
Thickness Due to Internal Pressure:
= (P*(D/2+CA)) / (S*E-0.6*P) per UG-27 (c)(1)

```
 = (150.00*(1.0000/2+0.0000))/(9000.00*1.00-0.6*150.00)
 = 0.0084 + 0.0000 = 0.0084 in
```

UG-40, Thickness and Diameter Limit Results : Internal Pressure

```
Effective material diameter limit,              DL     2.0000  in
Effective material thickness limit, no pad   TLNP     0.5000  in
```

NOTE : Taking a UG-36(c)(3)(a) exemption for Opening .
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. It may be necessary to force the program to print the areas per UG-37.

Opening size: 1.000, Shell/Head Req. thk.: 0.034 in

UG-45 Minimum Nozzle Neck Thickness Requirement:

```
Wall Thickness per UG45(a),     tra = 0.0084 in
Wall Thickness per UG16(b),   tr16b = 0.0938 in
Wall Thickness per UG45(b)(1), trb1 = 0.0337 in
Check UG16(b) Min. Thickness,  trb1 = Max(trb1, tr16b) = 0.0938 in
Std. Wall Pipe per UG45(b)(4), trb4 = 0.1225 in
Wall Thickness per UG45(b),     trb = Min(trb1, trb4) = 0.0938 in

Final Required Thickness,      tr45 = Max(tra, trb) = 0.0938 in
Available Nozzle Neck Thickness     = 0.2000 in --> OK

Weight of Nozzle, Nozzle Neck Only, Uncorroded          0.27  lbf
Weight of Nozzle, Nozzle Neck Only, Corroded            0.27  lbf
```

Weld Size Calculations, Nozzle Number 1, Desc.: Opening

```
Intermediate Calcs. for nozzle/shell welds           Tmin      0.2000  in
```

Results Per UW-16.1:

```
                      Required Thickness    Actual Thickness
Nozzle Weld         0.1400 = 0.7 * Tmin   0.1768 = 0.707 * WO      , in
```

M.A.W.P. Results Based on, Shell and Nozzle neck:

```
Converged M.A.W.P for given geometry      AMAWP   1046.500  psig
```

Input Echo, Flange Item 3, Description: Flanges

Description of Flange Geometry (Type)		Integral Weld Neck	
Description of Flange Analysis		Partial, Thickness	
Print Final Results for Given Thickness		Yes	
Design Pressure	P	150.00	psig
Design Temperature		200.00	F
Corrosion Allowance	ci	0.0000	in
Flange Inside Diameter	B	2.6250	in
Flange Outside Diameter	A	4.5000	in
Flange Thickness	t	1.0000	in
Thickness of Hub at Small End	g0	0.2500	in
Thickness of Hub at Large End	g1	0.2500	in
Length of Hub	h	1.0000	in
Perform thickness calcs. based on rigidity		Yes	
Flange Material		SB-283 M10	
Flange Material UNS Number		C37700	
Flange Allowable Stress At Temperature	Sfo	9000.00	psi
Flange Allowable Stress At Ambient	Sfa	10000.00	psi
Bolt Material		SA-675 45	
Bolt Allowable Stress At Temperature	Sb	12900.00	psi
Bolt Allowable Stress At Ambient	Sa	12900.00	psi
Diameter of Bolt Circle	C	5.0000	in
Nominal Bolt Diameter	dB	1.0000	in
Type of Thread Series		TEMA Thread Series	
Number of Bolts	n	6	
Compute Full Flange Design Bolt Load (S*ab) ?		No	
Flange Face Outside Diameter	Fod	4.5000	in
Flange Face Inside Diameter	Fid	2.6250	in
Flange Facing Sketch		Code Sketch 1a	
Gasket Outside Diameter	Go	4.3000	in
Gasket Inside Diameter	Gi	4.1000	in
Gasket Factor,	m	0.0000	
Gasket Design Seating Stress	y	0.00	psi
Column for Gasket Seating		2, Code Column II	
Shell Material		SB-283 M10	
Shell Material UNS Number		C37700	
Shell Allowable Stress At Temperature	So	9000.00	psi
Shell Allowable Stress At Ambient	Sa	10000.00	psi
Full face Gasket Flange Option		Program Selects	

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Hub Small End Required Thickness due to Internal Pressure:
= (P*(D/2+Ca))/(S*E-0.6*P) per UG-27 (c)(1)
= (150.00*(2.6250/2+0.0000))/(9000.00*1.00-0.6*150.00)+Ca
= 0.0221 in

Flange analysis, Flange number 3, Description: Flanges
ASME Code, Section VIII, Division 1, App. 2, 2007

Corroded Flange ID,	Bcor = B+2.0*ci	2.625	in

```
Corroded Large Hub,     g1cor = g1-ci                    0.250  in
Corroded Small Hub,     g0cor = g0-ci                    0.250  in
Code R Dimension,           R = (C-B)/2.0 - g1           0.938  in

Gasket Contact Width,       N = (Goc-Gic) / 2            0.100  in
Basic Gasket Width,        b0 = N / 2.0                  0.050  in
Effective Gasket Width,     b = b0                       0.050  in
Gasket Reaction Diameter,   G = Go (Self-Energizing)     4.300  in
```

Basic Flange and Bolt loads:

Hydrostatic End Load due to Pressure[H]:
```
 = 0.785 * G * G * Peq
 = 0.7854 * 4.3000 *4.3000 *150.0000
 = 2178.302 lbf
```

Contact Load on Gasket Surfaces[Hp]:
```
 = 2 * b * PI * G * m * P
 = 2 * 0.0500 * 3.1416 * 4.3000 * 0.0000 * 150.00
 = 0.000 lbf
```

Hydrostatic End Load at Flange ID[Hd]:
```
 = 0.785 * Bcor * Bcor * P
 = 0.785 * 2.6250 * 2.6250 *150.0000
 = 811.783 lbf
```

Pressure Force on Flange Face[Ht]:
```
 = H - Hd
 = 2178 - 811
 = 1366.519 lbf
```

Operating Bolt Load[Wm1]:
```
 = H + Hp +  H'p (cannot be < 0)
 = ( 2178 + 0 + 0 )
 = 2178.302 lbf
```

Gasket Seating Bolt Load[Wm2]:
```
 = y * b * PI * G  + yPart * bPart * lp
 = 0.00*0.0500*3.141*4.300+0.00*0.0000*0.00
 = 0.000 lbf
```

Required Bolt Area[Am]:
```
 = Maximum of Wm1/Sb, Wm2/Sa
 = Maximum of 2178 / 12900 , 0 / 12900
 = 0.168861 in^2
```

Bolting Information for TEMA Imperial Thread Series (Non Mandatory):

	Minimum	Actual	Maximum
Bolt Area, in^2	0.169	3.306	
Radial distance bet. hub and bolts	1.375	0.938	
Radial distance bet. bolts and the edge	1.062	-0.250	
Circumferential spacing between bolts	2.250	2.500	14.000

Flange Design Bolt Load, Gasket Seating[W]:
```
 = Sa * ( Am + Ab ) / 2.0
 = 12900.00 * ( 0.1689 + 3.3060 ) / 2.0
 = 22412.85 lbf
```

Gasket Seating Force[Hg]:
```
 = Wm1 - H
 = 2178 - 2178
 = 0.00 lbf
```

Moment Arm Calculations:

Distance to Hub Large End[R]:
= (C - Bcor) / 2 - g1cor
= (5.000 - 2.625) / 2 - 0.250
= 0.9375 in

Distance to Gasket Load Reaction[hg]:
= (C - G) / 2.0
= (5.0000 - 4.3000) / 2.0
= 0.3500 in

Distance to Face Pressure Reaction[ht]:
= (R + g1cor + hg) / 2.0
= (0.9375 + 0.2500 + 0.3500) / 2.0
= 0.7687 in

Distance to End Pressure Reaction[hd]:
= R + (g1cor / 2.0)
= 0.9375 + (0.2500 / 2.0)
= 1.0625 in

Summary of Moments for Internal Pressure:

Loading		Force	Distance	Bolt Corr	Moment	
End Pressure,	Md	812.	1.0625	1.0000	72.	ft-lbf
Face Pressure,	Mt	1367.	0.7687	1.0000	88.	ft-lbf
Gasket Load,	Mg	0.	0.3500	1.0000	0.	ft-lbf
Gasket Seating,	Ma	22413.	0.3500	1.0000	654.	ft-lbf

Total Moment for Operation,	Mo	159.	ft-lbf
Total Moment for Gaket Seating,	Ma	654.	ft-lbf

Effective Hub Length,	ho = SQRT(Bcor*g0cor)			0.810	in
Hub Ratio,	h/ho = h / ho			1.234	
Thickness Ratio,	g1/g0 = (g1cor/g0cor)			1.000	

Flange Factors for Integral Flange:

Factor F per 2-7.2				0.909	
Factor V per 2-7.3				0.550	
Factor f per 2-7.6				1.000	
Factors from Figure 2-7.1			K =	1.714	
	T =	1.619	U =	4.149	
	Y =	3.776	Z =	2.032	
	d =	0.382 in ^3	e =	1.1220	in ^-1
Stress Factors			Alpha =	2.122	
	Beta =	2.496	Gamma =	1.310	
	Delta =	2.619	Lambda =	3.929	

Longitudinal Hub Stress, Operating[Sho]:
= (f * Mo / Bcor) / (Rlambda * g1cor^2)
= (1.0000 *1913 / 2.6250) / (3.9290 *0.2500^2)
= 2967.8 psi

Longitudinal Hub Stress, Seating[Sha]:
= (f * Ma / Bcor) / (Rlambda * g1cor^2)
= (1.0000 * 7844 / 2.6250) / (3.9290 * 0.2500^2)
= 12169.5 psi

Radial Flange Stress, Operating[Sro]:
= (Beta * Mo / Bcor) / (Rlambda * t^2)
= (2.4960 *1913 / 2.6250) / (3.9290 *1.0000^2)
= 463.0 psi

Radial Flange Stress, Seating[Sra]:
= (Beta * Ma / Bcor) / (Rlambda * t^2)

```
 = ( 2.4960 *7844 /2.6250 ) / ( 3.9290 *1.0000^2)
 = 1898.4 psi
```

Tangential Flange Stress, Operating[Sto]:

```
 = ( Y* Mo / (t^2* Bcor) ) - Z * Sro
 = ( 3.7757 *1913 / (1.0000^2*2.6250 ) ) - 2.0316 *462
 = 1811.1 psi
```

Tangential Flange Stress, Seating[Sta]:

```
 = ( Y * Ma / (t^2* Bcor) ) - Z * Sra
 = ( 3.7757 *7844 / (1.0000^2*2.6250 ) ) - 2.0316 *1898
 = 7426.4 psi
```

Average Flange Stress, Operating[Sao]:

```
 = ( Sho + MAX( Sro, Sto ) ) / 2
 = ( 2967 + MAX( 462 , 1811 ))/ 2
 = 2389.4 psi
```

Average Flange Stress, Seating[Saa]:

```
 = ( Sha + MAX( Sra, Sta ) ) / 2
 = ( 12169 + MAX( 1898 , 7426 ))/ 2
 = 9797.9 psi
```

Bolt Stress, Operating[Bso]:

```
 = ( Wm1 / Ab )
 = ( 2178 / 3.3060 )
 = 658.9 psi
```

Bolt Stress, Seating[Bsa]:

```
 = ( Wm2 / Ab )
 = ( 0  / 3.3060 )
 = 0.0 psi
```

Stress Computation Results:

	Operating		Gasket Seating		
	Actual	Allowed	Actual	Allowed	
Longitudinal Hub	2968.	13500.	12169.	15000.	psi
Radial Flange	463.	9000.	1898.	10000.	psi
Tangential Flange	1811.	9000.	7426.	10000.	psi
Maximum Average	2389.	9000.	9798.	10000.	psi
Bolting	659.	12900.	0.	12900.	psi

Minimum Required Flange Thickness + CA	0.989	in
Estimated M.A.W.P. (Operating)	564.99	psig
Estimated Finished Weight of Flange	3.6	lbf
Estimated Unfinished Weight of Forging	5.9	lbf

Flange Rigidity Index, Seating (rotation check) per APP. 2 [Js]:

```
 = 52.14 * Ma * Cnv_fac * V / ( Lambda * Eamb * go^2 * ho * Ki )
 = 52.14 * 653 * 12.000 * 0.550 / ( 3.929 * .14000E+08 * 0.250 ^2
   * 0.810 * 0.300 )
 = 0.269  (should be <= 1)
```

Flange Rigidity Index Operating (rotation check) per APP. 2 [J]:

```
 = 52.14 * Mo * Cnv_fac * V / ( Lambda * Eop * goc^2 * ho * Ki )
 = 52.14 * 159 * 12.000 * 0.550 / ( 3.929 * .13700E+08 * 0.250 ^2
   * 0.810 * 0.300 )
 = 0.067  (should be <= 1)
```

Minimum Design Metal Temperature Results:

Summary for shell/head, Div 1:

Description	MAPNC psig	MAWP psig	Min. T in	Tr-int in	Tr-ext in	EMAWP psig
Body Shell	988.372	889.535	0.250	0.063	---	---
Minimum MAWP	988.372	889.535				---

Note: Reqd. thk. reported above includes Corrosion Allowance.

Total Shell/Head weight is (New-Cold) 0.0 lbf
Total Shell/Head weight is (Corroded) 0.0 lbf
Total Shell/Head weight, filled with Water (New) 0.0 lbf
Total Shell/Head volume is (New-Cold) 0.0 in **3
Total Shell/Head volume is (Corroded) 0.0 in **3

Summary for Nozzles :

Description	MAWP psig	FLG. MAWP	EXT. P CHECK	MAWPNC	UG-45 CHECK	WLD CHECK	
Opening	*1046.50*	*---*	*OK*	*---*	*OK*	*--*	*90°*
Min. Press.	1046.50	---		0.00			

Flange Results Summary for Item 3 : Flanges
Flange Type: Integral Weld Neck Analyze Option: Partial, Thk
Design Pressure : 150.00 psig

Flange Diameters id: 2.625 od: 4.500 in
Gasket Diameters id: 4.100 od: 4.300 in
Gasket Factors m: 0.000 y: 0.000 psi

Flange has 6 Bolts 1.000 in at BCD 5.000 in
Min. Required Flange Thickness per ASME + CA 0.989 in

	Operating	Seating
MAWP	564.990	213.650
Rigidity Index	0.032	0.130

Note: The Flange passed, for the Internal Pressure.

The finished weight of the flange 3.608 lbf
The unfinished weight of the flange 5.939 lbf

Least MAWP and Overall Weight Results :
The Least MAWP (N C) for Body Shell was 988.37 psig .
The Least MAWP (Cor) for Flanges was 213.65 psig .

The total sum of the Weights (N C) was 5.94 lbf .
The total sum of the Weights (Cor) was 3.61 lbf .