STYRENE PARK OFFSITE

Document Title:

Strength Calculation-Cartridge Filter

00	2024 / Feb. / 27	Issued for Approval	A. Azodi	E. Malek	M. Shariati
Rev.	**Issued Date**	**DESCRIPTION**	**PREPARED**	**CHECKED**	**APPROVED**

پتروشیمی توسعه پارک صنعتی گوهر افق

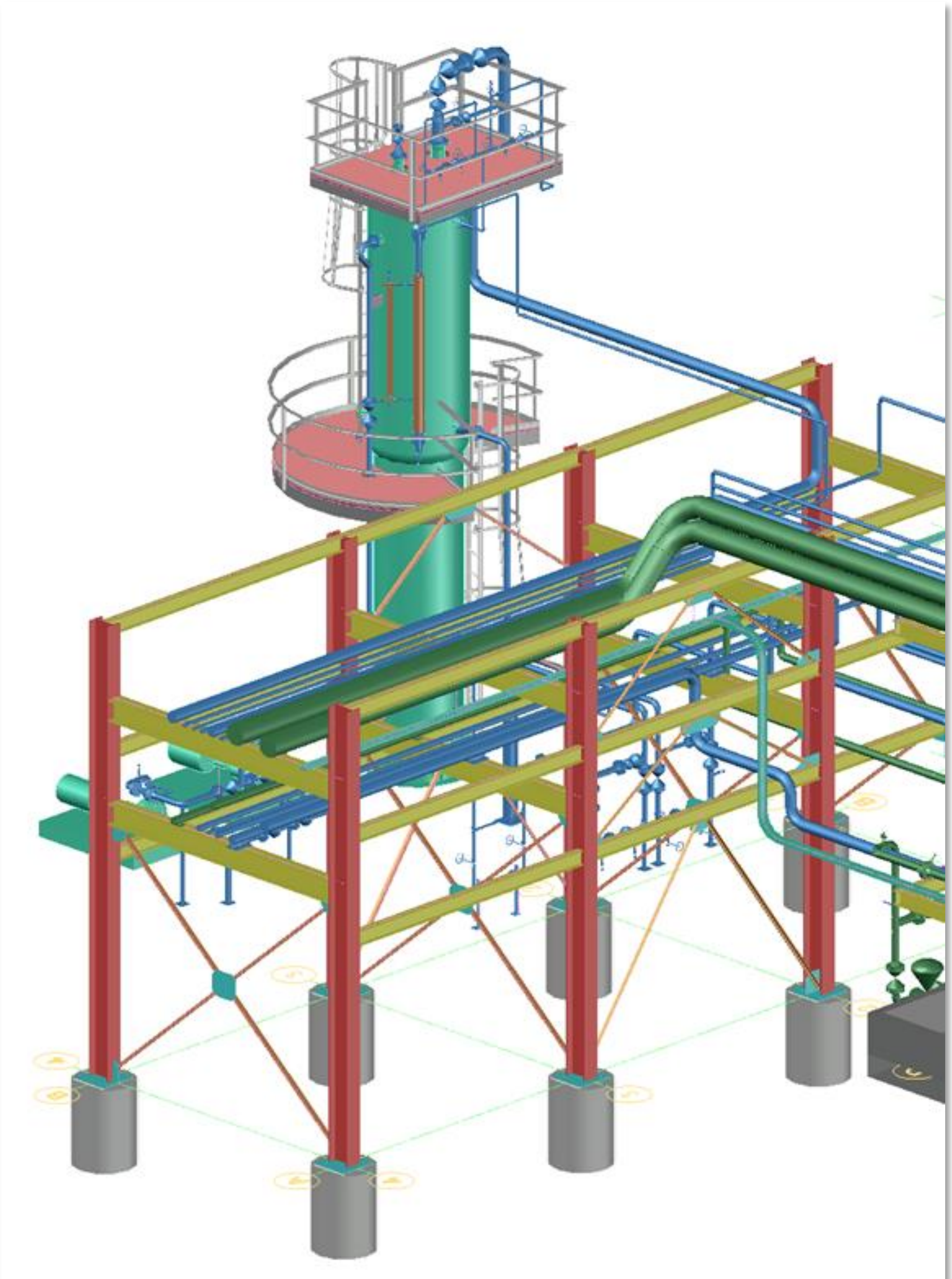
BINA EPC Contractor Co.
(Executor of Oil, Gas, Petrochemical & Power Industries)

ENER TEKNOLOJi

HAMOON RAH

Page	Revisions							Page	Revisions						
	00	01	02	03	04	05	06		00	01	02	03	04	05	06
1	X							41	X						
2	X							42	X						
3	X							43	X						
4	X							44	X						
5	X							45	X						
6	X							46	X						
7	X							47	X						
8	X							48	X						
9	X							49	X						
10	X							50	X						
11	X							51	X						
12	X							52	X						
13	X							53	X						
14	X							54	X						
15	X							55	X						
16	X							56	X						
17	X							57	X						
18	X							58	X						
19	X							59	X						
20	X							60	X						
21	X							61	X						
22	X							62	X						
23	X							63	X						
24	X							64	X						
25	X							65	X						
26	X							66	X						
27	X							67	X						
28	X							68	X						
29	X							69	X						
30	X							70	X						
31	X							71	X						
32	X							72	X						
33	X							73	X						
34	X							74	X						
35	X							75	X						
36	X							76	X						
37	X							.	X						
38	X							.	X						
39	X							.	X						
40	X							122	X						

Project Data Page:



Strength Calculation-Cartridge Filter
Design by A. Azodi
Rev.00

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DESIGN CALCULATION

In Accordance with ASME Section VIII Division 1

ASME Code Version : 2017

Analysis Performed by : SPLM Licensed User

Job File : C:\USERS\A.AZODI\DESKTOP\EI0127-HRC-VD-ME-CAL-00

Date of Analysis : Feb 27,2024 7:18pm

PV Elite 2019 SP1, March 2019

Title Page

Note:
PV Elite performs all calculations internally in Imperial Units
to remain compliant with the ASME Code and any built in assumptions
in the ASME Code formulas. The finalized results are reflected to show
the user's set of selected units.

Class From To : Basic Element Checks.
==

Class From To: Check of Additional Element Data
==

There were no geometry errors or warnings.

- **PV Elite Vessel Analysis Program: Input Data**

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Design Internal Pressure (for Hydrotest)	0.2	bars
Design Internal Temperature	85.0	°C
Type of Hydrotest	UG-99(b)	
Hydrotest Position	Vertical	
Projection of Nozzle from Vessel Top	0	mm.
Projection of Nozzle from Vessel Bottom	0	mm.
Minimum Design Metal Temperature	-5.0	°C
Type of Construction	Welded	
Special Service	None	
Degree of Radiography	RT-1	
Use Higher Longitudinal Stresses (Flag)	Y	
Select t for Internal Pressure (Flag)	N	
Select t for External Pressure (Flag)	N	
Select t for Axial Stress (Flag)	N	
Select Location for Stiff. Rings (Flag)	N	
Consider Vortex Shedding	N	
Perform a Corroded Hydrotest	Y	

Load Case 1	NP+EW+WI+FW+BW
Load Case 2	NP+EW+EE+FS+BS
Load Case 3	NP+OW+WI+FW+BW
Load Case 4	NP+OW+EQ+FS+BS
Load Case 5	NP+HW+HI
Load Case 6	NP+HW+HE
Load Case 7	IP+OW+WI+FW+BW
Load Case 8	IP+OW+EQ+FS+BS
Load Case 9	EP+OW+WI+FW+BW
Load Case 10	EP+OW+EQ+FS+BS
Load Case 11	HP+HW+HI
Load Case 12	HP+HW+HE
Load Case 13	IP+WE+EW
Load Case 14	IP+WF+CW
Load Case 15	IP+VO+OW
Load Case 16	IP+VE+EW
Load Case 17	NP+VO+OW
Load Case 18	FS+BS+IP+OW
Load Case 19	FS+BS+EP+OW

Wind Design Code	UBC-94/97	
UBC Design Wind Speed	125	Km/hr
UBC Exposure Constant	C: Open Terrain	
UBC Importance Factor	1.15	
UBC Base Elevation	0	mm.
UBC Percent Wind for Hydrotest	33.0	
Using User defined Wind Press. Vs Elev.	N	
Damping Factor (Beta) for Wind (Ope)	0.0100	
Damping Factor (Beta) for Wind (Empty)	0.0000	
Damping Factor (Beta) for Wind (Filled)	0.0000	

Seismic Design Code	ASCE/SEI 7-16

Seismic Load Reduction Scale Factor		0.700
Importance Factor		1.250
Table Value Fa		1.050
Table Value Fv		1.100
Max. Mapped Res. Acceleration	[Ss]	1.310
Max. Eff. Ground Acceleration	[S]	0.460
Force Modification Factor R		2.000
Site Class		C
Component Elevation Ratio	z/h	0.000
Amplification Factor	Ap	0.000
Force Factor		0.000
Consider Vertical Acceleration		No
Minimum Acceleration Multiplier		0.000
User Value of Sds (used if > 0)		0.920
User Value of Sd1 (used if > 0)		0.340
Moment Reduction Factor Tau		1.000

Design Pressure + Static Head	Y
Consider MAP New and Cold in Noz. Design	N
Consider External Loads for Nozzle Des.	Y
Use ASME VIII-1 Appendix 1-9	N

Material Database Year Current w/Addenda or Code Year

Configuration Directives:

Do not use Nozzle MDMT Interpretation VIII-1 01-37	No
Use Table G instead of exact equation for "A"	Yes
Shell Head Joints are Tapered	Yes
Compute "K" in corroded condition	Yes
Use Code Case 2286	No
Use the MAWP to compute the MDMT	Yes
For thickness ratios <= 0.35, MDMT will be -155F (-104C)	Yes
For PWHT & P1 Materials the MDMT can be < -55F (-48C)	No
Using Metric Material Databases, ASME II D	No
Calculate B31.3 type stress for Nozzles with Loads	Yes
Reduce the MDMT due to lower membrane stress	Yes
Consider Longitudinal Stress in MDMT calcs. (Div. 1)	Yes

Complete Listing of Vessel Elements and Details:

Element From Node	10	
Element To Node	20	
Element Type	Elliptical	
Description	Cap - 18" (sch.10)	
Distance "FROM" to "TO"	85.5	mm.
Element Outside Diameter	457.2	mm.
Element Thickness	5.5563	mm.
Internal Corrosion Allowance	3	mm.
Nominal Thickness	6.35	mm.
External Corrosion Allowance	0	mm.
Design Internal Pressure	0.2	bars
Design Temperature Internal Pressure	85	°C
Design External Pressure	0.1	bars
Design Temperature External Pressure	85	°C
Effective Diameter Multiplier	1.2	

Material Name	SA-234 WPB	
Allowable Stress, Ambient	117.9	N./mm²
Allowable Stress, Operating	117.9	N./mm²
Allowable Stress, Hydrotest	217.19	N./mm²
Material Density	0.00775	kg./cm³
P Number Thickness	31.75	mm.
Yield Stress, Operating	222.99	N./mm²
UCS-66 Chart Curve Designation	B	
External Pressure Chart Name	CS-2	
UNS Number	K03006	
Product Form	Smls. & wld. fittings	
Efficiency, Longitudinal Seam	1.0	
Efficiency, Circumferential Seam	0.85	
Elliptical Head Factor	2.0	
Weld is pre-Heated	No	

Element From Node	10	
Detail Type	Liquid	
Detail ID	Liquid: 10	
Dist. from "FROM" Node / Offset dist	-111.52	mm.
Height/Length of Liquid	197.02	mm.
Liquid Density	0.12995E-05	kg./cm³

Element From Node	10	
Detail Type	Nozzle	
Detail ID	Drain - 2"	
Dist. from "FROM" Node / Offset dist	0	mm.
Nozzle Diameter	2	in.
Nozzle Schedule	80	
Nozzle Class	150	
Layout Angle	0.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	6.3272	Kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	

Element From Node	10	
Detail Type	For./Mom.	
Detail ID	Drain - 2"	
Dist. from "FROM" Node / Offset dist	-114	mm.
Force in X Direction	64.858	Kgf
Force in Y Direction	-51.805	Kgf
Force in Z Direction	64.858	Kgf
Moment about X Axis	13.868	Kg-m.
Moment about Y Axis	0	Kg-m.
Moment about Z Axis	13.868	Kg-m.
Force/Moment Combination Method	SRSS	

Element From Node	10	
Detail Type	For./Mom.	
Detail ID	Gas In - 6" T	
Dist. from "FROM" Node / Offset dist	85.5	mm.
Force in X Direction	144.4	Kgf
Force in Y Direction	-180.71	Kgf
Force in Z Direction	144.4	Kgf
Moment about X Axis	136.23	Kg-m.
Moment about Y Axis	0	Kg-m.

Moment about Z Axis	136.23	Kg-m.
Force/Moment Combination Method	SRSS	

Element From Node	20	
Element To Node	30	
Element Type	Cylinder	
Description	Shell #1 - 18"	
Distance "FROM" to "TO"	450	mm.
Element Outside Diameter	457.2	mm.
Element Thickness	8	mm.
Internal Corrosion Allowance	3	mm.
Nominal Thickness	8	mm.
External Corrosion Allowance	0	mm.
Design Internal Pressure	0.2	bars
Design Temperature Internal Pressure	85	°C
Design External Pressure	0.1	bars
Design Temperature External Pressure	85	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-516 70	
Allowable Stress, Ambient	137.9	N./mm²
Allowable Stress, Operating	137.9	N./mm²
Allowable Stress, Hydrotest	235.81	N./mm²
Material Density	0.00775	kg./cm³
P Number Thickness	31.75	mm.
Yield Stress, Operating	241.81	N./mm²
UCS-66 Chart Curve Designation	B	
External Pressure Chart Name	CS-2	
UNS Number	K02700	
Product Form	Plate	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Weld is pre-Heated	No	

Element From Node	20	
Detail Type	Liquid	
Detail ID	Liquid: 20	
Dist. from "FROM" Node / Offset dist	0	mm.
Height/Length of Liquid	450	mm.
Liquid Density	0.12995E-05	kg./cm³

Element From Node	20	
Detail Type	Nozzle	
Detail ID	Gas In - 6"	
Dist. from "FROM" Node / Offset dist	200	mm.
Nozzle Diameter	6	in.
Nozzle Schedule	STD	
Nozzle Class	150	
Layout Angle	180.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	24.822	Kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	

Element From Node	20	
Detail Type	Leg	

Detail ID	LEGS	
Dist. from "FROM" Node / Offset dist	250	mm.
Diameter at Leg Centerline	593.2	mm.
Leg Orientation	1	
Number of Legs	2	
Section Identifier	IPE120	
Length of Legs	1000	mm.

Element From Node	30	
Element To Node	40	
Element Type	Cylinder	
Description	Shell #2 - 18"	
Distance "FROM" to "TO"	964.5	mm.
Element Outside Diameter	457.2	mm.
Element Thickness	6	mm.
Internal Corrosion Allowance	3	mm.
Nominal Thickness	6	mm.
External Corrosion Allowance	0	mm.
Design Internal Pressure	0.2	bars
Design Temperature Internal Pressure	85	°C
Design External Pressure	0.1	bars
Design Temperature External Pressure	85	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-516 70	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Weld is pre-Heated	No	

Element From Node	30	
Detail Type	Liquid	
Detail ID	Liquid: 30	
Dist. from "FROM" Node / Offset dist	0	mm.
Height/Length of Liquid	964.5	mm.
Liquid Density	0.12995E-05	kg./cm³

Element From Node	30	
Detail Type	Nozzle	
Detail ID	Vent - 1"	
Dist. from "FROM" Node / Offset dist	800	mm.
Nozzle Diameter	1	in.
Nozzle Schedule	160	
Nozzle Class	150	
Layout Angle	180.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2.7673	Kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	

Element From Node	30	
Detail Type	Nozzle	
Detail ID	Gas Out - 6"	
Dist. from "FROM" Node / Offset dist	700	mm.
Nozzle Diameter	6	in.
Nozzle Schedule	STD	
Nozzle Class	150	

Layout Angle	0.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	26.179	Kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-106 B	

Element From Node	30	
Detail Type	Weight	
Detail ID	CARTRIDGE	
Dist. from "FROM" Node / Offset dist	200	mm.
Miscellaneous Weight	100	Kgf
Offset from Element Centerline	0	mm.

Element From Node	30	
Detail Type	For./Mom.	
Detail ID	Gas Out - 6"	
Dist. from "FROM" Node / Offset dist	700	mm.
Force in X Direction	144.4	Kgf
Force in Y Direction	-180.71	Kgf
Force in Z Direction	144.4	Kgf
Moment about X Axis	136.23	Kg-m.
Moment about Y Axis	0	Kg-m.
Moment about Z Axis	136.23	Kg-m.
Force/Moment Combination Method	SRSS	

Element From Node	40	
Element To Node	50	
Element Type	Flange	
Description	Body Flange - 18"	
Distance "FROM" to "TO"	68.072	mm.
Flange Inside Diameter	457.2	mm.
Element Thickness	39.624	mm.
Internal Corrosion Allowance	3	mm.
Nominal Thickness	6.35	mm.
External Corrosion Allowance	0	mm.
Design Internal Pressure	0.2	bars
Design Temperature Internal Pressure	85	°C
Design External Pressure	0.1	bars
Design Temperature External Pressure	85	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-105	
Allowable Stress, Ambient	137.9	N./mm²
Allowable Stress, Operating	137.9	N./mm²
Allowable Stress, Hydrotest	223.4	N./mm²
Material Density	0.00775	kg./cm³
P Number Thickness	31.75	mm.
Yield Stress, Operating	229.19	N./mm²
UCS-66 Chart Curve Designation	B	
External Pressure Chart Name	CS-2	
UNS Number	K03504	
Product Form	Forgings	
Perform Flange Stress Calculation (Y/N)	Y	
Weight of ANSI B16.5/B16.47 Flange	0	Kgf
Class of ANSI B16.5/B16.47 Flange		
Grade of ANSI B16.5/B16.47 Flange		

Weld is pre-Heated	No	

Element From Node	50	
Element To Node	60	
Element Type	Flange	
Description	Blind Flange - 18"	
Distance "FROM" to "TO"	39.624	mm.
Flange Inside Diameter	457.2	mm.
Element Thickness	39.624	mm.
Internal Corrosion Allowance	3	mm.
Nominal Thickness	6.35	mm.
External Corrosion Allowance	0	mm.
Design Internal Pressure	0.2	bars
Design Temperature Internal Pressure	85	°C
Design External Pressure	0.1	bars
Design Temperature External Pressure	85	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-105	
Perform Flange Stress Calculation (Y/N)	Y	
Weight of ANSI B16.5/B16.47 Flange	0	Kgf
Class of ANSI B16.5/B16.47 Flange		
Grade of ANSI B16.5/B16.47 Flange		
Weld is pre-Heated	No	

Element From Node	50	
Detail Type	Weight	
Detail ID	DAVIT	
Dist. from "FROM" Node / Offset dist	0	mm.
Miscellaneous Weight	50	Kgf
Offset from Element Centerline	0	mm.

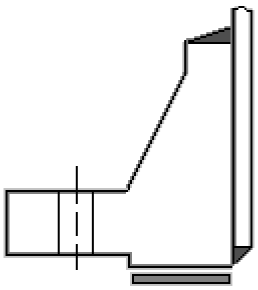
XY Coordinate Calculations:

From	To	X (Horiz.) mm.	Y (Vert.) mm.	DX (Horiz.) mm.	DY (Vert.) mm.
Cap - 18" (sch.		...	85.5	...	85.5
Shell #1 - 18"		...	535.5	...	450
Shell #2 - 18"		...	1500	...	964.5
Body Flange - 1		...	1500	...	-68.072
Blind Flange -		...	1549.15	...	39.624

Flange Input Data Values **Description: FLANGE :**

Body Flange - 18"

Description of Flange Geometry (Type)		Loose Slip On	
Design Pressure	P	0.20	bars
Design Temperature		85	°C
Internal Corrosion Allowance	ci	3.0000	mm.
External Corrosion Allowance	ce	0.0000	mm.
Use Corrosion Allowance in Thickness Calcs.		Yes	
Flange Inside Diameter	B	457.200	mm.
Flange Outside Diameter	A	635.000	mm.
Flange Thickness	t	39.6240	mm.
Thickness of Hub at Small End	go	18.0970	mm.
Thickness of Hub at Large End	g1	21.5900	mm.
Length of Hub	h	28.4480	mm.
Flange Material		SA-105	
Flange Material UNS number		K03504	
Flange Allowable Stress At Temperature	Sfo	137.90	N./mm²
Flange Allowable Stress At Ambient	Sfa	137.90	N./mm²
Bolt Material		SA-193 B7	
Bolt Allowable Stress At Temperature	Sb	172.38	N./mm²
Bolt Allowable Stress At Ambient	Sa	172.38	N./mm²
Diameter of Bolt Circle	C	577.850	mm.
Nominal Bolt Diameter	a	28.5750	mm.
Type of Threads		TEMA Thread Series	
Number of Bolts		16	
Flange Face Outside Diameter	Fod	533.400	mm.
Flange Face Inside Diameter	Fid	457.200	mm.
Flange Facing Sketch		1, Code Sketch 1a	
Gasket Outside Diameter	Go	527.050	mm.
Gasket Inside Diameter	Gi	457.200	mm.
Gasket Factor	m	2.5000	
Gasket Design Seating Stress	y	68.95	N./mm²
Column for Gasket Seating		2, Code Column II	
Gasket Thickness	tg	3.1750	mm.
Flange Class		150	
Flange Grade		GR 1.1	



ASME Code, Section VIII Division 1, 2017

```
Corroded Flange Thickness, tc = T-ci                  36.624  mm.
Code R Dimension,           R = (C-B)/2 - g1          38.735  mm.

Gasket Contact Width,       N = (Go - Gi) / 2         34.925  mm.
Basic Gasket Width,        bo = N / 2                 17.462  mm.
Effective Gasket Width,     b = Cb sqrt(bo)           10.530  mm.
Gasket Reaction Diameter,   G = Go - 2 * b           505.989  mm.
```

Basic Flange and Bolt Loads:

Hydrostatic End Load due to Pressure [H]:
```
 = 0.785 * G² * Peq
 = 0.785 * 506² * 0.2
 = 410.109 Kgf
```
Contact Load on Gasket Surfaces [Hp]:
```
 = 2 * b * Pi * G * m * P
 = 2 * 10.53 * 3.142 * 506 * 2.5 * 0.2
 = 170.698 Kgf
```
Hydrostatic End Load at Flange ID [Hd]:
```
 = Pi * Bcor² * P  / 4
 = 3.142 * 457.2² *0.2/4
 = 334.833 Kgf
```
Pressure Force on Flange Face [Ht]:
```
 = H - Hd
 = 410.1 - 334.8
 = 75.276 Kgf
```
Operating Bolt Load [Wm1]:
```
 = max( H + Hp + H'p, 0 )
 = max( 410.1 + 170.7 + 0, 0 )
 = 580.807 Kgf
```
Gasket Seating Bolt Load [Wm2]:
```
 = y * b * Pi * G  + yPart * bPart * lp
 = 68.95*10.53*3.141*506+0*0*0
 = 117689.297 Kgf
```
Required Bolt Area [Am]:
```
 = Maximum of Wm1/Sb, Wm2/Sa
 = Maximum of 580.8/172.4, 117689/172.4
 = 66.956 cm²
```

ASME Maximum Circumferential Spacing between Bolts per App. 2 eq. (3) [Bsmax]:
```
 = 2a + 6t/(m + 0.5)
 = 2 * 28.57 + 6 * 36.62/(2.5 + 0.5)
 = 130.398 mm.
```

Actual Circumferential Bolt Spacing [Bs]:
```
 = C * sin( pi / n )
 = 577.8 * sin( 3.142/16 )
 = 112.733 mm.
```

ASME Moment Multiplier for Bolt Spacing per App. 2 eq. (7) [Bsc]:
```
 = max( sqrt( Bs/( 2a + t )), 1 )
 = max( sqrt( 112.7/( 2 * 28.57 + 36.62 )), 1 )
 = 1.0964
```

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

	Minimum	Actual	Maximum
Bolt Area, cm²	66.956	75.148	
Radial Distance between Hub and Bolts:	38.100	38.735	
Radial Distance between Bolts and Edge:	28.575	28.575	
Circ. Spacing between the Bolts:	63.500	112.733	130.398

Min. Gasket Contact Width (Brownell Young) [Not an ASME Calc] [Nmin]:
```
 = Ab * Sa/( y * Pi * (Go + Gi) )
 = 75.15 * 172.4/(68.95 * 3.142 * (527 + 457.2 ) )
 = 6.076 mm.
```

Flange Design Bolt Load, Gasket Seating [W]:
```
 = Sa * ( Am + Ab ) / 2
 = 172.4 * ( 66.96 + 75.15 )/2
 = 124888.80 Kgf
```
Gasket Load for the Operating Condition [HG]:
```
 = Wm1 - H
 = 580.8 - 410.1
 = 170.70 Kgf
```

Moment Arm Calculations:

Distance to Gasket Load Reaction [hg]:
```
 = (C - G ) / 2
 = ( 577.8 - 506 )/2
 = 35.9303 mm.
```
Distance to Face Pressure Reaction [ht]:
```
 = ( hD + hG ) / 2
 = ( 60.33 + 35.93 )/2
 = 48.1276 mm.
```
Distance to End Pressure Reaction [hd]:
```
 = ( C - Bcor )/ 2
 = ( 577.8 - 457.2 )/2
 = 60.3250 mm.
```

Summary of Moments for Internal Pressure: (Kg-m.)

Loading	Force	Distance	Bolt Corr	Moment
End Pressure, Md	335.	60.3250	1.0964	22.
Face Pressure, Mt	75.	48.1276	1.0964	4.
Gasket Load, Mg	171.	35.9303	1.0964	7.
Gasket Seating, Matm	124889.	35.9303	1.0964	4920.

```
Total Moment for Operation,       Mop                              33. Kg-m.
Total Moment for Gasket seating, Matm                            4920. Kg-m.
```

Note: User choose not to perform Stress Calculations on this Standard Flange.
Pressure rating of the flange will be used to check code compliance.

```
Estimated Finished Weight of Flange at given Thk.       53.4  kg.
Estimated Unfinished Weight of Forging at given Thk     80.5  kg.
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c)      -29 °C
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b)       -104 °C
Flange MDMT with Temp reduction per UCS-66(b)(1)(-c)        -48 °C
```

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :
Design Pressure/Ambient Rating = 0.20/19.60 = 0.010

Note:
Using the min value from (b)(1)(-b) and (b)(1)(-c) above as the computed nozzle flange MDMT.

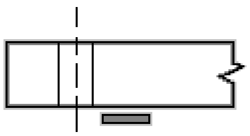
Minimum Attachment Weld Size for Slip on Flanges, UW-21, [xmin]:
```
 = min( 1.4 * tn, G0 )
 = min( 1.4 * 3, 18.1 )
 = 4.200 mm.
```

Minimum Attachment Weld Size for Slip on Flanges, UW-21, [ymin]:
```
 = min( tn, (6 mm or 1/4 inch ))
 = min( 3, 6 )
 = 3.000 mm.
```

Flange Input Data Values **Description: FLANGE :**

Blind Flange - 18"

Description of Flange Geometry (Type)		Blind	
Design Pressure	P	0.20	bars
Design Temperature		85	°C
Internal Corrosion Allowance	ci	3.0000	mm.
External Corrosion Allowance	ce	0.0000	mm.
Use Corrosion Allowance in Thickness Calcs.		Yes	
Flange Outside Diameter	A	635.000	mm.
Flange Thickness	t	39.6240	mm.
Flange Material		SA-105	
Flange Material UNS number		K03504	
Flange Allowable Stress At Temperature	Sfo	137.90	N./mm²
Flange Allowable Stress At Ambient	Sfa	137.90	N./mm²
Bolt Material		SA-193 B7	
Bolt Allowable Stress At Temperature	Sb	172.38	N./mm²
Bolt Allowable Stress At Ambient	Sa	172.38	N./mm²
Diameter of the Load Reaction, Long Span	D	0.000	mm.
Diameter of the Load Reaction, Short Span	d	0.000	mm.
Perimeter along the Center of the Bolts	L	1815.369	mm.
Diameter of Bolt Circle	C	577.850	mm.
Nominal Bolt Diameter	a	28.5750	mm.
Type of Threads		TEMA Thread Series	
Number of Bolts		16	
Flange Face Outside Diameter	Fod	533.400	mm.
Flange Face Inside Diameter	Fid	438.150	mm.
Flange Facing Sketch		1, Code Sketch 1a	
Gasket Outside Diameter	Go	527.050	mm.
Gasket Inside Diameter	Gi	474.726	mm.
Gasket Factor	m	2.5000	
Gasket Design Seating Stress	y	68.95	N./mm²
Column for Gasket Seating		2, Code Column II	
Gasket Thickness	tg	3.1750	mm.
Flange Class		150	
Flange Grade		GR 1.1	



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Gasket Contact Width,	N = (Go - Gi) / 2	26.162	mm.
Basic Gasket Width,	bo = N / 2	13.081	mm.
Effective Gasket Width,	b = Cb sqrt(bo)	9.114	mm.
Gasket Reaction Diameter,	G = Go - 2 * b	508.822	mm.

Basic Flange and Bolt Loads:

Hydrostatic End Load due to Pressure [H]:
= 0.785 * G^2 * Peq
= 0.785 * 508.8^2 * 0.2
= 414.714 Kgf

Contact Load on Gasket Surfaces [Hp]:
= 2 * b * Pi * G * m * P
= 2 * 9.114 * 3.142 * 508.8 * 2.5 * 0.2
= 148.566 Kgf

Operating Bolt Load [Wm1]:
= max(H + Hp + H'p, 0)
= max(414.7 + 148.6 + 0, 0)
= 563.280 Kgf

Gasket Seating Bolt Load [Wm2]:
= y * b * Pi * G + yPart * bPart * lp
= 68.95*9.114*3.141*508.8+0*0*0
= 102430.352 Kgf

Required Bolt Area [Am]:
= Maximum of Wm1/Sb, Wm2/Sa
= Maximum of 563.3/172.4, 102430/172.4
= 58.275 cm^2

ASME Maximum Circumferential Spacing between Bolts per App. 2 eq. (3) [Bsmax]:
= 2a + 6t/(m + 0.5)
= 2 * 28.57 + 6 * 36.62/(2.5 + 0.5)
= 130.398 mm.

Actual Circumferential Bolt Spacing [Bs]:
= C * sin(pi / n)
= 577.8 * sin(3.142/16)
= 112.733 mm.

ASME Moment Multiplier for Bolt Spacing per App. 2 eq. (7) [Bsc]:
= max(sqrt(Bs/(2a + t)), 1)
= max(sqrt(112.7/(2 * 28.57 + 36.62)), 1)
= 1.0964

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

	Minimum	Actual	Maximum
Bolt Area, cm²	58.275	75.148	
Radial Distance between Bolts and Edge:	28.575	28.575	
Circ. Spacing between the Bolts:	63.500	112.733	130.398

Min. Gasket Contact Width (Brownell Young) [Not an ASME Calc] [Nmin]:
= Ab * Sa/(y * Pi * (Go + Gi))
= 75.15 * 172.4/(68.95 * 3.142 * (527 + 474.7))
= 5.970 mm.

Flange Design Bolt Load, Gasket Seating [W]:
= Sa * (Am + Ab) / 2
= 172.4 * (58.28 + 75.15)/2
= 117259.34 Kgf

Gasket Load for the Operating Condition [HG]:
= Wm1
= 563.28 Kgf

Moment Arm Calculations:

Distance to Gasket Load Reaction [hg]:
= (C - G) / 2
= (577.8 - 508.8)/2
= 34.5140 mm.

Note: User choose not to perform Stress Calculations on this Standard Flange.
Pressure rating of the flange will be used to check code compliance.

Estimated Finished Weight of Flange at given Thk. 97.3 kg.
Estimated Unfinished Weight of Forging at given Thk 97.3 kg.

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) -29 °C
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b) -104 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :
Design Pressure/Ambient Rating = 0.20/19.60 = 0.010

Element Thickness, Pressure, Diameter and Allowable Stress :

From	To	Int. Press + Liq. Hd bars	Nominal Thickness mm.	Total Corr Allowance mm.	Element Diameter mm.	Allowable Stress(SE) N./mm²
Cap - 18" (sch.1		0.2002	6.35	3	457.2	117.9
Shell #1 - 18"		0.2002	8	3	457.2	117.22
Shell #2 - 18"		0.2001	6	3	457.2	117.22
Body Flange - 18		0.2	6.35	3	457.2	137.9
Blind Flange - 1		0.2	6.35	3	457.2	137.9

Element Required Thickness and MAWP :

From	To	Design Pressure bars	M.A.W.P. Corroded bars	M.A.P. New & Cold bars	Minimum Thickness mm.	Required Thickness mm.
Cap - 18" (sch.1		0.2	13.5522	29.2965	5.55625	4.5
Shell #1 - 18"		0.2	25.8622	41.6001	8	4.5
Shell #2 - 18"		0.2	15.4627	31.0897	6	4.5
Body Flange - 18		0.2	18.1501	19.6001	39.624	No Calc
Blind Flange - 1		0.2	18.1501	19.6001	39.624	No Calc

Minimum 13.552 19.600

MAWP: 9.825 bars, limited by: Nozzle Reinforcement.

Internal Pressure Calculation Results :

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Elliptical Head From 10 To 20 SA-234 WPB , UCS-66 Crv. B at 85 °C

Cap - 18" (sch.10)

Material UNS Number: K03006

Required Thickness due to Internal Pressure [tr]:
```
 = (P*Do*Kcor)/(2*S*E+2*P*(Kcor-0.1)) per Appendix 1-4 (c)
 = (0.2*457.2*0.983)/(2*117.9*1+2*0.2*(0.983-0.1))
 = 0.0381 + 3.0000 = 3.0381 mm.
```

Note: The thickness required was less than the Code Minimum, therefore the Code Minimum value of 1.5000 mm. per UG-16 will be used.

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
Less Operating Hydrostatic Head Pressure of 0.000 bars
```
 = (2*S*E*t)/(Kcor*Do-2*t*(Kcor-0.1)) per Appendix 1-4 (c)
 = (2*117.9*1*2.556)/(0.983*457.2-2*2.556*(0.983-0.1))
 = 13.552 - 0.000 = 13.552  bars
```

Maximum Allowable Pressure, New and Cold [MAPNC]:
```
 = (2*S*E*t)/(K*Do-2*t*(K-0.1)) per Appendix 1-4 (c)
```

```
 = (2*117.9*1*5.556)/(1*457.2-2*5.556*(1-0.1))
 = 29.297 bars
```

Actual stress at given pressure and thickness, corroded [Sact]:

```
 = (P*(Kcor*Do-2*t*(Kcor-0.1)))/(2*E*t)
 = (0.2*(0.983*457.2-2*2.556*(0.983-0.1)))/(2*1*2.556)
 = 1.742 N./mm²
```

Straight Flange Required Thickness:

```
 = (P*Ro)/(S*E+0.4*P) + ca   per Appendix 1-1 (a)(1)
 = (0.2*228.6)/(117.9*1+0.4*0.2)+3
 = 3.039 mm.
```

Straight Flange Maximum Allowable Working Pressure:
Less Operating Hydrostatic Head Pressure of 0.000 bars

```
 = (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
 = (117.9 * 1 * 3.35 )/(228.6 - 0.4 * 3.35 )
 = 17.379 - 0.000 = 17.379  bars
```

Factor K, corroded condition [Kcor]:

```
 = ( 2 + ( Inside Diameter/( 2 * Inside Head Depth ))^(2))/6
 = ( 2 + ( 452.1/( 2 * 114.5 ))^(2))/6
 = 0.982651
```

MDMT Calculations in the Knuckle Portion:

Govrn. thk, tg = 5.556, tr = 1.858, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.727, Temp. Reduction = 15 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve B            -29 °C
Min Metal Temp. at Required thickness (UCS 66.1)          -44 °C
```

MDMT Calculations in the Head Straight Flange:

Govrn. thk, tg = 6.35, tr = 1.899, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.567, Temp. Reduction = 25 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve B            -29 °C
Min Metal Temp. at Required thickness (UCS 66.1)          -48 °C
```

Cylindrical Shell From 20 To 30 SA-516 70 , UCS-66 Crv. B at 85 °C

Shell #1 - 18"

Material UNS Number: K02700

Required Thickness due to Internal Pressure [tr]:

```
 = (P*Ro) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
 = (0.2*228.6)/(137.9*0.85+0.4*0.2)
 = 0.0390 + 3.0000 = 3.0390 mm.
```

*Note: The thickness required was less than the Code Minimum, therefore
the Code Minimum value of 1.5000 mm. per UG-16 will be used.*

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
Less Operating Hydrostatic Head Pressure of 0.000 bars

```
 = (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
 = (137.9*0.85*5)/(228.6-0.4*5)
 = 25.862 - 0.000 = 25.862  bars
```

Maximum Allowable Pressure, New and Cold [MAPNC]:

```
 = (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
 = (137.9*0.85*8)/(228.6-0.4*8)
 = 41.600 bars
```

Actual stress at given pressure and thickness, corroded [Sact]:

```
 = (P*(Ro-0.4*t))/(E*t)
 = (0.2*((228.6-0.4*5))/(0.85*5)
 = 1.067 N./mm²
```

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 1.781 %

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 8, tr = 1.91, c = 3 mm., E* = 0.85
Thickness Ratio = tr * (E*)/(tg - c) = 0.325, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve B              -29 °C
Min Metal Temp. at Required thickness (UCS 66.1)          -104 °C
```

Cylindrical Shell From 30 To 40 SA-516 70 , UCS-66 Crv. B at 85 °C

Shell #2 - 18"

Material UNS Number: K02700

Required Thickness due to Internal Pressure [tr]:

```
 = (P*Ro) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
 = (0.2*228.6)/(137.9*0.85+0.4*0.2)
 = 0.0390 + 3.0000 = 3.0390 mm.
```

Note: The thickness required was less than the Code Minimum, therefore the Code Minimum value of 1.5000 mm. per UG-16 will be used.

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
Less Operating Hydrostatic Head Pressure of 0.000 bars

```
 = (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
 = (137.9*0.85*3)/(228.6-0.4*3)
 = 15.463 - 0.000 = 15.463  bars
```

Maximum Allowable Pressure, New and Cold [MAPNC]:

```
 = (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
 = (137.9*0.85*6)/(228.6-0.4*6)
 = 31.090 bars
```

Actual stress at given pressure and thickness, corroded [Sact]:

```
 = (P*(Ro-0.4*t))/(E*t)
 = (0.2*((228.6-0.4*3))/(0.85*3)
 = 1.785 N./mm²
```

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 1.330 %

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 6, tr = 1.91, c = 3 mm., E* = 0.85
Thickness Ratio = tr * (E*)/(tg - c) = 0.541, Temp. Reduction = 28 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve B          -29 °C
Min Metal Temp. at Required thickness (UCS 66.1)        -48 °C
```

Note: Heads and Shells Exempted to -20F (-29C) by paragraph UG-20F

Hydrostatic Test Pressure Results:

```
Pressure per UG99b      = 1.30 * M.A.W.P. * Sa/S        12.772  bars
Pressure per UG99b[36]  = 1.30 * Design Pres * Sa/S      0.260  bars
Pressure per UG99c      = 1.30 * M.A.P. - Head(Hyd)     25.476  bars
Pressure per UG100      = 1.10 * M.A.W.P. * Sa/S        10.807  bars
Pressure per PED        = max(1.43*DP, 1.25*DP*ratio)    0.286  bars
Pressure per App 27-4   = M.A.W.P.                       9.825  bars
```

UG-99(b), Test Pressure Calculation:
 = Test Factor * MAWP * Stress Ratio
 = 1.3 * 9.825 * 1
 = 12.772 bars

Vertical Test performed per: UG-99b

Please note that Nozzle, Shell, Head, Flange, etc MAWPs are all considered when determining the hydrotest pressure for those test types that are based on the MAWP of the vessel.

Stresses on Elements due to Test Pressure (N./mm² & bars):

From To	Stress	Allowable	Ratio	Pressure
Cap - 18" (sch.10)	112.5	217.2	0.518	12.93
Shell #1 - 18"	68.9	235.8	0.292	12.91
Shell #2 - 18"	114.8	235.8	0.487	12.87

Stress ratios for Nozzle and Pad Materials (N./mm²):

Description	Pad/Nozzle	Ambient	Operating	Ratio
Drain - 2"	Nozzle	117.90	117.90	1.000
Drain - 2"	Pad	137.90	137.90	1.000
Gas In - 6"	Nozzle	117.90	117.90	1.000
Vent - 1"	Nozzle	117.90	117.90	1.000
Gas Out - 6"	Nozzle	117.90	117.90	1.000
Gas Out - 6"	Pad	137.90	137.90	1.000

Minimum 1.000

Stress ratios for Pressurized Vessel Elements (N./mm²):

Description	Ambient	Operating	Ratio

Strength Calculation-Cartridge Filter
Design by A. Azodi
Rev.00
PV Elite 2019 SP1 Licensee: SPLM Licensed User
FileName : EI0127-HRC-VD-ME-CAL-004-00
Internal Pressure Calculations: Step: 5 7:18pm Feb 27,2024

Cap - 18" (sch.10)	117.90	117.90	1.000
Shell #1 - 18"	137.90	137.90	1.000
Shell #2 - 18"	137.90	137.90	1.000
Body Flange - 18"	137.90	137.90	1.000
Blind Flange - 18"	137.90	137.90	1.000

Minimum 1.000

Hoop Stress in Nozzle Wall during Pressure Test (N./mm²):

Description	Ambient	Operating	Ratio
Drain - 2"	20.63	217.19	0.095
Gas In - 6"	33.15	217.19	0.153
Vent - 1"	7.85	217.19	0.036
Gas Out - 6"	32.91	217.19	0.152

Elements Suitable for Internal Pressure.

External Pressure Calculation Results :

External Pressure Calculations:

From	To	Section Length mm.	Outside Diameter mm.	Corroded Thickness mm.	Factor A	Factor B N./mm²
10	20	No Calc	457.2	2.55625	0.00077654	77.1443
20	30	1537.17	457.2	5	0.00042423	42.4136
30	40	1537.17	457.2	3	0.00019777	19.7722
40	50	No Calc	...	36.624	No Calc	No Calc
50	60	No Calc	...	36.624	No Calc	No Calc

External Pressure Calculations:

From	To	External Actual T. mm.	External Required T. mm.	External Design Pressure bars	External M.A.W.P. bars
10	20	5.55625	4.5	0.1	4.79218
20	30	8	3.951	0.1	6.18419
30	40	6	3.951	0.1	1.72975
40	50	39.624	No Calc	0.1	No Calc
50	60	39.624	No Calc	0.1	No Calc

Minimum 1.730

External Pressure Calculations:

From	To	Actual Length Bet. Stiffeners mm.	Allowable Length Bet. Stiffeners mm.	Ring Inertia Required cm**4	Ring Inertia Available cm**4
10	20	No Calc	No Calc	No Calc	No Calc
20	30	1537.17	53487.8	No Calc	No Calc
30	40	1537.17	56834.1	No Calc	No Calc
40	50	No Calc	No Calc	No Calc	No Calc
50	60	No Calc	No Calc	No Calc	No Calc

Elements Suitable for External Pressure.

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Elliptical Head From 10 to 20 Ext. Chart: CS-2 at 85 °C

Cap - 18" (sch.10)

Elastic Modulus from Chart: CS-2 at 85 °C : 0.200E+09 KPa.

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	D/t	Factor A	B
2.556	457.20	178.86	0.0007765	77.14

EMAP = B/(K0*D/t) = 77.14/(0.9 *178.9) = 4.792 bars

Results for Required Thickness (Tca):

```
    Tca          OD         D/t     Factor A          B
  0.368      457.20     1242.04   0.0001118       11.18
EMAP = B/(K0*D/t) = 11.18/(0.9 *1242 ) = 0.1 bars
```

*Check the requirements of UG-33(a)(1) using P = 1.67 * External Design pressure for this head.*

Material UNS Number: K03006

Required Thickness due to Internal Pressure [tr]:

```
 = (P*D*Kcor)/(2*S*E-0.2*P) Appendix 1-4(c)
 = (0.167*452.1*0.983)/(2*117.9*1-0.2*0.167)
 = 0.0315 + 3.0000 = 3.0315 mm.
```

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:

```
 = ((2*S*E*t)/(Kcor*D+0.2*t))/1.67 per Appendix 1-4 (c)
 = ((2*117.9*1*2.556)/(0.983*452.1+0.2*2.556))/1.67
 = 8.115 bars
```

Maximum Allowable External Pressure [MAEP]:

```
 = min( MAEP, MAWP )
 = min( 4.792, 8.115 )
 = 4.792 bars
```

Thickness requirements per UG-33(a)(1) govern the required thickness of this head.

Cylindrical Shell From 20 to 30 Ext. Chart: CS-2 at 85 °C

Shell #1 - 18"

Elastic Modulus from Chart: CS-2 at 85 °C : 0.200E+09 KPa.

Results for Maximum Allowable External Pressure (MAEP):

```
    Tca          OD        SLEN        D/t        L/D   Factor A         B
  5.000      457.20     1537.17      91.44     3.3621  0.0004242     42.41
EMAP = (4*B)/(3*(D/t)) = (4*42.41 )/(3*91.44 ) = 6.184 bars
```

Results for Required Thickness (Tca):

```
    Tca          OD        SLEN        D/t        L/D   Factor A         B
  0.951      457.20     1537.17     480.76     3.3621  0.0000361      3.61
EMAP = (4*B)/(3*(D/t)) = (4*3.606 )/(3*480.8 ) = 0.1 bars
```

Results for Maximum Stiffened Length (Slen):

```
    Tca          OD        SLEN        D/t        L/D   Factor A         B
  5.000      457.20    53487.79      91.44    50.0000  0.0001341     13.40
EMAP = (4*B)/(3*(D/t)) = (4*13.4 )/(3*91.44 ) = 1.954 bars
```

Cylindrical Shell From 30 to 40 Ext. Chart: CS-2 at 85 °C

Shell #2 - 18"

Elastic Modulus from Chart: CS-2 at 85 °C : 0.200E+09 KPa.

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
3.000	457.20	1537.17	152.40	3.3621	0.0001978	19.77

EMAP = (4*B)/(3*(D/t)) = (4*19.77)/(3*152.4) = 1.73 bars

Results for Required Thickness (Tca):

Tca	OD	SLEN	D/t	L/D	Factor A	B
0.951	457.20	1537.17	480.76	3.3621	0.0000361	3.61

EMAP = (4*B)/(3*(D/t)) = (4*3.606)/(3*480.8) = 0.1 bars

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
3.000	457.20	56834.09	152.40	50.0000	0.0000476	4.76

EMAP = (4*B)/(3*(D/t)) = (4*4.761)/(3*152.4) = 0.417 bars

Element and Detail Weights:

From	To	Element Metal Wgt. kg.	Element ID Volume Cm.	Corroded Metal Wgt. kg.	Corroded ID Volume Cm.	Extra due Misc % kg.
10	20	18.0387	24987	9.51647	25824.3	1.80387
20	30	39.3751	68809.9	24.7737	70694.2	3.93751
30	40	63.5773	150169	31.9998	154244	6.35773
40	50	53.3965	...	53.3965	...	5.33965
50	60	97.2581	...	97.2581	...	9.72581
Total		271	243965.95	216	250762.44	27

Weight of Details:

From	Type	Weight of Detail kg.	X Offset, Dtl. Cent. mm.	Y Offset, Dtl. Cent. mm.	Description
10	Liqd	0.032463	...	-55.761	Liquid: 10
10	Nozl	6.95996	...	-247.022	Drain - 2"
10	Forc	...	...	-114	Drain - 2"
10	Forc	...	...	85.5	Gas In - 6" T
20	Liqd	0.089398	...	225	Liquid: 20
20	Nozl	27.3044	304.737	200	Gas In - 6"
20	Legs	61.2835	...	-250	LEGS
30	Liqd	0.1951	...	482.25	Liquid: 30
30	Nozl	3.044	239.301	800	Vent - 1"
30	Nozl	28.7971	306.737	700	Gas Out - 6"
30	Wght	100	...	200	CARTRIDGE
30	Forc	...	...	700	Gas Out - 6"
50	Wght	50	...	...	DAVIT

Total Weight of Each Detail Type:

Liquid	0.3
Nozzles	66.1
Legs	61.3
Weights	150.0
Sum of the Detail Weights	277.7 kg.

Weight Summation Results: (kg.)

	Fabricated	Shop Test	Shipping	Erected	Empty	Operating
Main Elements	298.8	298.8	298.8	298.8	298.8	298.8
Nozzles	66.1	66.1	66.1	66.1	66.1	66.1
Legs	61.3	61.3	61.3	61.3	61.3	61.3
Wld Weights	50.0	50.0	50.0	50.0	50.0	50.0
Empty Weights	...	...	...	100.0	100.0	...
Ope Weights	...	...	...	...	...	100.0
Ope. Liquid	...	...	...	...	...	0.3
Test Liquid	...	243.8	...	...	...	...

Totals	476.2	720.0	476.2	576.2	576.2	576.5

Miscellaneous Weight Percent: 10.0 %

Note that the above value for the miscellaneous weight percent has been applied to the shells/heads/flange/tubesheets/tubes etc. in the weight calculations for metallic components.

Weight Summary:

Fabricated Wt.	- Bare Weight without Removable Internals	476.2 kg.
Shop Test Wt.	- Fabricated Weight + Water (Full)	720.0 kg.
Shipping Wt.	- Fab. Weight + removable Intls.+ Shipping App.	476.2 kg.
Erected Wt.	- Fab. Wt + or - loose items (trays,platforms etc.)	576.2 kg.
Ope. Wt. no Liq	- Fab. Weight + Internals. + Details + Weights	576.2 kg.
Operating Wt.	- Empty Weight + Operating Liq. Uncorroded	576.5 kg.
Field Test Wt.	- Empty Weight + Water (Full)	666.6 kg.
Mass of the Upper 1/3 of the Vertical Vessel		264.7 kg.

Note: The Field Test weight as computed in the corroded condition.

Outside Surface Areas of Elements:

From	To	Surface Area cm^2
10	20	3513.97
20	30	6463.51
30	40	13853.5
40	50	2762.85
50	60	3957.39

Total 30551.184 cm^2

Element and Detail Weights:

From	To To	Total Ele. Empty Wgt. kg.	Total. Ele. Oper. Wgt. kg.	Total. Ele. Hydro. Wgt. kg.	Total Dtl. Offset Mom. Kg-m.	Oper. Wgt. No Liquid kg.
10	20	26.8025	26.835	43.2366	...	26.8025
20	Legs	39.2317	39.2814	69.5592	4.62269	39.2317
Legs	30	31.3854	31.4251	55.6474	3.69815	31.3854
30	40	201.776	201.971	221.191	9.56178	201.776
40	50	58.7362	58.7362	58.7362	...	58.7362
50	60	156.984	156.984	156.984	...	156.984

Empty Support Force + the Sum of the Y forces	928.13	Kgf
Operating Support Force + the Sum of the Y forces	928.45	Kgf
Hydro Support Force + the Sum of the Y forces	1018.57	Kgf

Cumulative Vessel Weight

		Cumulative Ope	Cumulative	Cumulative

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From	To	Wgt. No Liquid kg.	Oper. Wgt. kg.	Hydro. Wgt. kg.
10	20	...	...	...
20	Legs	-26.8025	-26.835	-43.2366
Legs	30	448.882	449.116	492.558
30	40	417.496	417.691	436.911
40	50	215.72	215.72	215.72
50	60	156.984	156.984	156.984

Note: The cumulative operating weights no liquid in the column above are the cumulative operating weights minus the operating liquid weight minus any weights absent in the empty condition.

Cumulative Vessel Moment

From	To	Cumulative Empty Mom. Kg-m.	Cumulative Oper. Mom. Kg-m.	Cumulative Hydro. Mom. Kg-m.
10	20	...	...	...
20	Legs	4.62269	4.62269	4.62269
Legs	30	13.2599	13.2599	13.2599
30	40	9.56178	9.56178	9.56178
40	50	...	...	...
50	60	...	...	...

Nozzle Flange MAWP Results:

Nozzle Description	Flange Rating Ope. bars	Ambient bars	Design Temp °C	Class	Grade/ Group	Equiv. Press	- - - - - - Max Pressure PVP	50%	DNV bars
Drain - 2"	18.15	19.60	85	150	GR 1.1	...	...	...	...
Gas In - 6"	18.15	19.60	85	150	GR 1.1	...	...	...	...
Vent - 1"	18.15	19.60	85	150	GR 1.1	...	...	...	...
Gas Out - 6"	18.15	19.60	85	150	GR 1.1	...	...	...	...
Min Rating	18.150	19.600 bars [for Core Elements]					0.000	0.000	0.000

Selected Method for Derating ANSI B16.5 Flange MAWP: None Selected

ANSI Ratings are per ANSI/ASME B16.5 2013 Metric Edition

The Natural Frequencies for the vessel have been computed iteratively by solving a system of matrices. These matrices describe the mass and the stiffness of the vessel. This is the generalized eigenvalue/ eigenvector problem and is referenced in some mathematical texts.

The Natural Frequency for the Vessel (Empty.) is 1.66694 Hz.

The Natural Frequency for the Vessel (Ope...) is 1.66664 Hz.

The Natural Frequency for the Vessel (Filled) is 1.62775 Hz.

Forces/Moments Applied to Vessel (Combined w/Wind Loads)

From	To	X and Z Dir Force Res. Kgf	X,Z Moment and For Res Kg-m.
10	20	295.937	230.566
20	30	...	...
30	40	204.214	335.608
40	50	...	...
50	60	...	...

Forces/Moments Applied to Vessel (Combined w/Seismic Loads)

From	To	X and Z Dir Force Res. Kgf	X,Z Moment and For Res Kg-m.
10	20	295.937	230.566
20	30	...	...
30	40	204.214	335.608
40	50	...	...
50	60	...	...

User Input Forces and Moments:

From Node	Distance From	Forces Fx	Fy	Fz	Moments Mx	My	Mz
10	-114.00	65.	-52.	65.	14.		14.
10	85.50	144.	-181.	144.	136.		136.
30	700.00	144.	-181.	144.	136.		136.

Wind Analysis Results per UBC 1994 or UBC 1997

```
Importance Factor as Entered by the User is          1.150
Wind Stagnation Pressure (qs) from Table 16-F       75.6      Kgs/m²
Pressure Coefficient from Table 16-H             Cq 0.800
User Entered Basic Wind Speed                        125.0      Km/hr
```

P(height) = Ce(height,Exp) * Cq * qs * Imp Fact. [18-1](1994) or [20-1](1997)

The values of Ce are shown as the in the table below:

Element	Ce
Cap - 18" (sch.1	1.0600
Shell #1 - 18"	1.0600
Shell #2 - 18"	1.0600
Body Flange - 18	1.0600
Blind Flange - 1	1.0600

Wind Vibration Calculations

This evaluation is based on work by Kanti Mahajan and Ed Zorilla

Nomenclature

```
Cf  - Correction factor for natural frequency
 D  - Average internal diameter of vessel mm.
Df  - Damping Factor < 0.75 Unstable,  > 0.95 Stable
Dr  - Average internal diameter of top half of vessel mm.
 f  - Natural frequency of vibration (Hertz)
f1  - Natural frequency of bare vessel based on a unit value of (D/L²)(10^(4))
 L  - Total height of structure mm.
Lc  - Total length of conical section(s) of vessel mm.
tb  - Uncorroded plate thickness at bottom of vessel mm.
V30 - Design Wind Speed provided by user Km/hr
Vc  - Critical wind velocity Km/hr
Vw  - Maximum wind speed at top of structure Km/hr
W   - Total corroded weight of structure Kgf
Ws  - Cor. vessel weight excl. weight of parts which do not effect stiff. Kgf
 Z  - Maximum amplitude of vibration at top of vessel mm.
Dl  - Logarithmic decrement ( taken as 0.03 for Welded Structures )
Vp  - Vib. Chance, <= 0.32037E-06 (High); 0.32037E-06 < 0.40047E-06 (Probable)
P30 - wind pressure 30 feet above the base
```

Check other Conditions and Basic Assumptions:

```
#1 - Total Cone Length / Total Length < 0.5
     0/1549 = 0

#2 - ( D / L² ) * 10^(4) < 8.0 (English Units)
   - ( 1.557/5.083² ) * 10^(4) = 602.6 [Geometry Violation]
```

Compute the vibration possibility. If Vp > 0.40047E-06 no chance. [Vp]:

```
 = W / ( L * Dr²)
 = 516.3/( 1549 * 452.8² )
 = 0.16260E-05
```

```
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```

Since Vp is > 0.40047E-06 no further vibration analysis is required !

Platform Load Calculations

ID	Wind Area cm²	Elevation mm.	Pressure Kgs/m²	Force Kgf	Cf

Wind Loads on Masses/Equipment/Piping

ID	Wind Area cm²	Elevation mm.	Pressure Kgs/m²	Force Kgf
CARTRIDGE	0.00	735.50	73.70	0.00
DAVIT	0.00	1509.52	73.70	0.00

The Natural Frequency for the Vessel (Ope...) is 1.66664 Hz.

Wind Load Calculation:

From	To	Wind Height mm.	Wind Diameter mm.	Wind Area cm²	Wind Pressure Kgs/m²	Element Wind Load Kgf
10	20	111.928	548.64	973.578	73.6976	7.17505
20	30	422.022	548.64	2468.88	73.6976	18.1951
30	40	1129.27	548.64	5291.63	73.6976	38.9981
40	50	1577.49	548.64	373.47	73.6976	2.75239
50	60	1640.86	548.64	217.393	73.6976	1.60214

Earthquake Load Calculation:

Input Values:

```
Seismic Design Code                                       ASCE/SEI 7-16
Seismic Load Reduction Scale Factor                               0.700
Importance Factor                                                 1.250
Table Value Fa                                                    1.050
Table Value Fv                                                    1.100
Max. Mapped Res. Acceleration        [Ss]                         1.310
Max. Eff. Ground Acceleration         [S]                         0.460
Force Modification Factor R                                       2.000
Site Class                                                            C
Component Elevation Ratio             z/h                         0.000
Amplification Factor                   Ap                         0.000
Force Factor                                                      0.000
Consider Vertical Acceleration                                       No
Minimum Acceleration Multiplier                                   0.000
User Value of Sds (used if > 0 )                                  0.920
User Value of Sd1 (used if > 0 )                                  0.340
Moment Reduction Factor Tau                                       1.000
```

Seismic Analysis Results:

```
 Sms = Fa * Ss = 1.05 * 1.31 = 1.375
 Sm1 = Fv * S1 = 1.1 * 0.46 = 0.506
 Sds = 2/3 * Sms = 2/3 * 1.375 = 0.917

 Sds = Max( 0.8*Sds, SdsUser )
     = Max( 0.734, 0.92 )
     = 0.920

 Sd1 = 2/3 * Sm1 = 2/3 * 0.506 = 0.337

 Sd1 = Max( 0.8*Sd1, Sd1User )
     = Max( 0.27, 0.34 )
     = 0.340
```

Check Approximate Fundamental Period from 12.8-7 [Ta]:

```
 = Ct * hn^(x) where Ct = 0.020, x = 0.75 and hn = Structural Height (ft.)
 = 0.020 * ( 7.008^(0.75))
 = 0.086 seconds
```

The Coefficient Cu from Table 12.8-1 is : 1.400

Fundamental Period (1/Frequency) [T]:

```
 = ( 1/Natural Frequency ) = ( 1/1.667 )
 = 0.600
```

Check the Value of T which is the smaller of Cu*Ta and T:

```
 = Minimum Value of (1.4 * 0.0861, 0.6 ) per 12.8.2
 = 0.121
```

Compute the Seismic Response Coefficient per equation 12.8-2 [Cs]:

```
 = Sds / ( R / I )
 = 0.92/( 2/1.25 )
```

= 0.575

Check the Maximum value of Cs per equation 12.8-3 [Cs]:
= Sd1 / (T * (R / Ie))
= 0.34/(0.121 * (2/1.25))
= 1.762

Check the Minimum value of Cs per equation 15.4-1 [Cs]:
= max((0.044 * SDS * Ie), 0.030)
= max((0.044 * 0.92 * 1.25), 0.030)
= 0.051

Total Base Shear [V]:
= Cs * W (Equation 12.8-1):
= 0.575 * 515.2
= 296.259 Kgf

Final Base Shear, V = 207.38 Kgf

Distribute the Base shear force to each element according to the equations
Fx = Cvx * V (eqn. 12.8-11) and the vertical distribution factor
Cvx = Wx*hx^(k)/(Sum of Wi*hi^(k)) and k is an exponent which is related
to the period of Vibration.

In this case, the value of k was 1.05

The Natural Frequency for the Vessel (Ope...) is 1.66664 Hz.

Earthquake Load Calculation:

From	To	Earthquake Height mm.	Earthquake Weight Kgf	Element Ope Load Kgf	Element Emp Load Kgf
10	20	42.75	26.835	0.35675	0.35631
20	Legs	335.5	39.2814	4.5431	4.53672
Legs	30	435.5	31.4251	4.77973	4.77295
30	40	1017.75	201.971	74.9036	74.8165
40	50	1534.04	58.7362	33.5138	33.5065
50	60	1529.34	156.984	89.2841	89.2646

Note:
The Earthquake Loads calculated and printed in the Earthquake
Load calculation report have been factored by the input
scalar/load reduction factor of: 0.700.

Bending Moments due to user defined forces and moments.

User Force / Moment Shear and Bending

From	To	Distance to Support mm.	Cumulative Shr Wind Cas Kgf	Cumulative Shr Eqk Cas Kgf	Wind Bending Kg-m.	Earthquake Bending Kg-m.
10	20	340.65	...	...	...	...
20	Legs	125	295.937	295.937	230.566	230.566
Legs	30	100	500.151	500.151	681.004	681.004
30	40	682.25	204.214	204.214	335.608	335.608
40	50	1130.46	...	...	...	...
50	60	1193.84	...	...	...	...

Note:
The Wind Shears/Moments and the Earthquake Shears/Moments calculated and printed in the Wind/Earthquake Shear and Bending report have been factored by the input Scalar/Load reductions factors of;
Wind: 1.000; Earthquake: 0.700.

Note:
Review the Vessel Design Summary for the cumulative shear force and bending moment on the support.

The following table is for the Operating Case.

Wind/Earthquake Shear, Bending:

From	To	Distance to Support mm.	Cumulative Wind Shear Kgf	Earthquake Shear Kgf	Wind Bending Kg-m.	Earthquake Bending Kg-m.
10	20	340.65	...	...	...	...
20	Legs	125	7.17505	0.35675	0.65043	0.032341
Legs	30	100	58.6144	202.838	28.7321	195.372
30	40	682.25	43.3527	197.702	22.9606	156.043
40	50	1130.46	4.35453	122.798	0.24975	9.83795
50	60	1193.84	1.60214	89.2841	0.031742	1.76893

Note:
The Wind Shears/Moments and the Earthquake Shears/Moments calculated and printed in the Wind/Earthquake Shear and Bending report have been factored by the input Scalar/Load reductions factors of;
Wind: 1.000; Earthquake: 0.700.

Note:
Review the Vessel Design Summary for the cumulative shear force and bending moment on the support.

Wind Deflection Calculations:

The following table is for the Applied Forces Case.

Wind Deflection:

From	To	Cumulative Wind Shear Kgf	Centroid Deflection mm.	Elem. End Deflection mm.	Elem. Ang. Rotation
10	20	...	2.31888	2.31888	0.0034386
20	Legs	295.937	2.32049	2.32517	0.0034878
Legs	30	500.151	2.33061	2.33703	0.0035073
30	40	204.214	2.37377	2.41345	0.0035213
40	50	...	2.41064	2.40782	0.0035213
50	60	...	2.40946	2.4111	0.0035213

Allowable deflection at the Tower Top (For)(6.000"/100ft. Criteria)
Allowable deflection : 7.746 Actual deflection : 2.413 mm.

The following table is for the Operating Case.

Wind Deflection:

From	To	Cumulative Wind Shear Kgf	Centroid Deflection mm.	Elem. End Deflection mm.	Elem. Ang. Rotation
10	20	...	0.2722	0.2722	0.00040644
20	Legs	7.17505	0.27227	0.27249	0.00040874
Legs	30	58.6144	0.27277	0.27311	0.00041025
30	40	43.3527	0.27584	0.27937	0.00041396
40	50	4.35453	0.27912	0.27886	0.00041396
50	60	1.60214	0.27901	0.27916	0.00041396

Critical Wind Velocity for Tower Vibration:

From	To	1st Crit. Wind Speed Km/hr	2nd Crit. Wind Speed Km/hr
10	20	16.4146	102.592
20	30	16.4146	102.592
30	40	16.4146	102.592
40	50	16.4146	102.592
50	60	16.4146	102.592

Allowable deflection at the Tower Top (Ope)(6.000"/100ft. Criteria)
Allowable deflection : 7.746 Actual deflection : 0.279 mm.

Total Deflection in the Operating Condition + Applied Forces :

Allowable deflection : 7.746 Actual deflection : 2.693 mm.

Longitudinal Stress Constants:

From	To	Metal Area New cm^2	Metal Area Corroded cm^2	Section Modulus New $mm.^3$	Section Modulus Corroded $mm.^3$
10	20	78.8366	36.5108	879466	412679
20	30	112.896	71.0312	1246035	794323
30	40	85.0492	42.8071	946932	482907
40	50	85.0492	42.8071	946932	482907
50	60	85.0492	42.8071	946932	482907

Longitudinal Allowable Stresses:

From	To	Tensile N./mm²	Hydrotest Tensile N./mm²	Compressive N./mm²	Hydrotest Compressive N./mm²
10	20	120.263	221.536	-113.916	-113.916
20	Legs	140.658	240.525	-132.255	-132.255
Legs	30	140.658	240.525	-132.255	-132.255
30	40	140.658	240.525	-118.874	-118.874
40	50	165.48	268.078	-118.874	-118.874
50	60	165.48	268.078	-118.874	-118.874

Longitudinal Stress Report

Note: Longitudinal Operating and Empty Stresses are computed in the corroded condition. Stresses due to loads in the hydrostatic test cases have also been computed in the corroded condition.

Longitudinal Pressure Stresses due to:

From	To	Longitudinal Stress Internal Pressure N./mm²	Longitudinal Stress External Pressure N./mm²	Longitudinal Stress Hydrotest Pressure N./mm²
10	20	0.88033	-0.44968	56.2184
20	30	0.44323	-0.23114	28.3047
30	40	0.74804	-0.38354	47.7705
40	50	...	...	...
50	60	...	...	...

Longitudinal Stresses due to Weight Loads for these Conditions:

From	To	Wght. Str. Empty N./mm²	Wght. Str. Operating N./mm²	Wght. Str. Hydrotest N./mm²	Wght. Str. Emp. Mom. N./mm²	Wght. Str. Opr. Mom. N./mm²
10	20	...	...	...	...	...
20	Legs	0.037005	0.037049	0.059694	0.057071	0.057071
Legs	30	-0.61974	-0.61967	-0.61974	0.16371	0.16371
30	40	-0.95646	-0.95646	-0.95646	0.19418	0.19418
40	50	-0.4942	-0.4942	-0.4942	...	...
50	60	-0.35964	-0.35964	-0.35964	...	...

Longitudinal Stresses due to Weight Loads and Bending for these Conditions:

From	To	Wght. Str. Hyd. Mom. N./mm²	Bend. Str. Oper. Wind N./mm²	Bend. Str. Oper. Equ. N./mm²	Bend. Str. Hyd. Wind N./mm²	Bend. Str. Hyd. Equ. N./mm²
10	20	...	...	...	...	...
20	Legs	0.057071	0.0080302	0.00039927	0.00265	...
Legs	30	0.16371	0.35472	2.41205	0.11706	...
30	40	0.19418	0.46627	3.16884	0.15387	...
40	50	...	0.0050718	0.19978	0.0016737	...
50	60	...	0.00064461	0.035923	0.00021272	...

Longitudinal Stresses due to these Conditions:

From	To	Vortex Shedding Operating Case N./mm²	Vortex Shedding Empty Case N./mm²	Vortex Shedding Test Case N./mm²	Earthquake Empty Case N./mm²
10	20	...	...	...	...
20	Legs	...	...	...	0.00039878
Legs	30	...	...	...	2.41093

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30	40	...	...	...	3.16745
40	50	...	...	...	0.19974
50	60	...	...	...	0.035915

Longitudinal Stresses due to Applied Axial Forces:

From	To	Longitudinal Stress Y Forces Wind N./mm²	Longitudinal Stress Y Forces Seismic N./mm²
10	20	0.62453	0.62453
20	Legs	0.5705	0.5705
Legs	30	-0.24949	-0.24949
30	40	-0.41399	-0.41399
40	50	...	...
50	60	...	...

Longitudinal Stresses due to User Forces and Moments:

From	To	Wind For/Mom Corroded N./mm²	Earthquake For/Mom Corroded N./mm²	Wind For/Mom No Corrosion N./mm²	Earthquake For/Mom No Corrosion N./mm²
10	20	...	...	...	...
20	Legs	2.84655	2.84655	1.81462	1.81462
Legs	30	8.40761	8.40761	5.35968	5.35968
30	40	6.81536	6.81536	3.47563	3.47563
40	50	...	...	...	...
50	60	...	...	...	...

Stress Combination Load Cases for Vertical Vessels:

Load Case Definition Key

```
IP = Longitudinal Stress due to Internal  Pressure
EP = Longitudinal Stress due to External  Pressure
HP = Longitudinal Stress due to Hydrotest Pressure
NP = No Pressure
EW = Longitudinal Stress due to Weight (No Liquid)
OW = Longitudinal Stress due to Weight (Operating)
HW = Longitudinal Stress due to Weight (Hydrotest)
WI = Bending Stress due to Wind Moment (Operating)
EQ = Bending Stress due to Earthquake Moment (Operating)
EE = Bending Stress due to Earthquake Moment (Empty)
HI = Bending Stress due to Wind Moment (Hydrotest)
HE = Bending Stress due to Earthquake Moment (Hydrotest)
WE = Bending Stress due to Wind Moment (Empty) (no CA)
WF = Bending Stress due to Wind Moment (Filled) (no CA)
CW = Longitudinal Stress due to Weight (Empty) (no CA)
VO = Bending Stress due to Vortex Shedding Loads ( Ope )
VE = Bending Stress due to Vortex Shedding Loads ( Emp )
VF = Bending Stress due to Vortex Shedding Loads ( Test No CA. )
FW = Axial Stress due to Vertical Forces for the Wind Case
FS = Axial Stress due to Vertical Forces for the Seismic Case
BW = Bending Stress due to Lat. Forces for the Wind Case, Corroded
BS = Bending Stress due to Lat. Forces for the Seismic Case, Corroded
BN = Bending Stress due to Lat. Forces for the Wind Case, UnCorroded
BU = Bending Stress due to Lat. Forces for the Seismic Case, UnCorroded
```

General Notes:

Case types HI and HE are in the Corroded condition.

Case types WE, WF, and CW are in the Un-Corroded condition.

A blank stress and stress ratio indicates that the corresponding stress comprising those components that did not contribute to that type of stress.

An asterisk (*) in the final column denotes overstress.

Analysis of Load Case 1 : NP+EW+WI+FW+BW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	0.62	120.26		113.92	0.0052	
20	3.52	140.66	-2.30	132.25	0.0250	0.0174
20	8.06	140.66	-9.80	132.25	0.0573	0.0741
30	6.11	140.66	-8.85	118.87	0.0434	0.0744

Analysis of Load Case 2 : NP+EW+EE+FS+BS

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	0.62	120.26		113.92	0.0052	
20	3.51	140.66	-2.30	132.25	0.0250	0.0174
20	10.11	140.66	-11.85	132.25	0.0719	0.0896
30	8.81	140.66	-11.55	118.87	0.0626	0.0971

Analysis of Load Case 3 : NP+OW+WI+FW+BW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	0.62	120.26		113.92	0.0052	
20	3.52	140.66	-2.30	132.25	0.0250	0.0174
20	8.06	140.66	-9.80	132.25	0.0573	0.0741
30	6.11	140.66	-8.85	118.87	0.0434	0.0744

Analysis of Load Case 4 : NP+OW+EQ+FS+BS

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	0.62	120.26		113.92	0.0052	
20	3.51	140.66	-2.30	132.25	0.0250	0.0174
20	10.11	140.66	-11.85	132.25	0.0719	0.0896
30	8.81	140.66	-11.55	118.87	0.0626	0.0972

Analysis of Load Case 5 : NP+HW+HI

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	0.00	221.54	0.00	113.92	0.0000	0.0000
20	0.12	240.53	-0.00	132.25	0.0005	0.0000
20		240.53	-0.90	132.25		0.0068
30		240.53	-1.30	118.87		0.0110

Analysis of Load Case 6 : NP+HW+HE

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	0.00	221.54	0.00	113.92	0.0000	0.0000
20	0.12	240.53		132.25	0.0005	
20		240.53	-0.78	132.25		0.0059
30		240.53	-1.15	118.87		0.0097

Analysis of Load Case 7 : IP+OW+WI+FW+BW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	1.50	120.26		113.92	0.0125	
20	3.96	140.66	-1.86	132.25	0.0282	0.0141
20	8.50	140.66	-9.35	132.25	0.0604	0.0707
30	6.85	140.66	-8.10	118.87	0.0487	0.0681

Analysis of Load Case 8 : IP+OW+EQ+FS+BS

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	1.50	120.26		113.92	0.0125	
20	3.95	140.66	-1.85	132.25	0.0281	0.0140
20	10.56	140.66	-11.41	132.25	0.0751	0.0863
30	9.56	140.66	-10.80	118.87	0.0679	0.0909

Analysis of Load Case 9 : EP+OW+WI+FW+BW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	0.17	120.26		113.92	0.0015	
20	3.29	140.66	-2.54	132.25	0.0234	0.0192
20	7.83	140.66	-10.03	132.25	0.0556	0.0758
30	5.72	140.66	-9.23	118.87	0.0407	0.0776

Analysis of Load Case 10 : EP+OW+EQ+FS+BS

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	0.17	120.26		113.92	0.0015	
20	3.28	140.66	-2.53	132.25	0.0233	0.0191
20	9.88	140.66	-12.08	132.25	0.0703	0.0914
30	8.42	140.66	-11.93	118.87	0.0599	0.1004

Analysis of Load Case 11 : HP+HW+HI

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	56.22	221.54		113.92	0.2538	
20	28.42	240.53		132.25	0.1182	
20	27.97	240.53		132.25	0.1163	
30	47.16	240.53		118.87	0.1961	

Analysis of Load Case 12 : HP+HW+HE

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	56.22	221.54		113.92	0.2538	
20	28.42	240.53		132.25	0.1182	
20	27.85	240.53		132.25	0.1158	
30	47.01	240.53		118.87	0.1954	

Analysis of Load Case 13 : IP+WE+EW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	0.88	120.26		113.92	0.0073	
20	0.54	140.66		132.25	0.0038	
20		140.66	-0.34	132.25		0.0026
30		140.66	-0.40	118.87		0.0034

Analysis of Load Case 14 : IP+WF+CW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	0.88	120.26		113.92	0.0073	
20	0.47	140.66		132.25	0.0033	
20	0.05	140.66		132.25	0.0004	
30	0.27	140.66		118.87	0.0019	

Analysis of Load Case 15 : IP+VO+OW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	0.88	120.26		113.92	0.0073	
20	0.54	140.66		132.25	0.0038	
20		140.66	-0.34	132.25		0.0026
30		140.66	-0.40	118.87		0.0034

Analysis of Load Case 16 : IP+VE+EW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	0.88	120.26		113.92	0.0073	
20	0.54	140.66		132.25	0.0038	
20		140.66	-0.34	132.25		0.0026
30		140.66	-0.40	118.87		0.0034

Analysis of Load Case 17 : NP+VO+OW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	0.00	120.26	0.00	113.92	0.0000	0.0000
20	0.09	140.66	-0.02	132.25	0.0007	0.0002
20		140.66	-0.78	132.25		0.0059
30		140.66	-1.15	118.87		0.0097

Analysis of Load Case 18 : FS+BS+IP+OW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	1.50	120.26		113.92	0.0125	
20	3.95	140.66	-1.85	132.25	0.0281	0.0140
20	8.15	140.66	-9.00	132.25	0.0579	0.0680
30	6.39	140.66	-7.63	118.87	0.0454	0.0642

Analysis of Load Case 19 : FS+BS+EP+OW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	0.17	120.26		113.92	0.0015	
20	3.28	140.66	-2.53	132.25	0.0233	0.0191
20	7.47	140.66	-9.67	132.25	0.0531	0.0731
30	5.26	140.66	-8.76	118.87	0.0374	0.0737

Absolute Maximum of the all of the Stress Ratio's 0.2538

Governing Element: Cap - 18" (sch.10)
Governing Load Case 11 : HP+HW+HI

Shop/Field Installation Options :

Note : The CG is computed from the first Element From Node

Center of Gravity of Liquid	708.323 mm.
Center of Gravity of Nozzles	691.625 mm.
Center of Gravity of Legs	-164.500 mm.
Center of Gravity of Added Weights (Operating)	993.508 mm.
Center of Gravity of Added Weights (Empty)	993.508 mm.
Center of Gravity of Bare Shell New and Cold	1118.164 mm.
Center of Gravity of Bare Shell Corroded	1231.511 mm.
Vessel CG in the Operating Condition	927.241 mm.
Vessel CG in the Fabricated (Shop/Empty) Condition	900.356 mm.
Vessel CG in the Test Condition	844.610 mm.

RESULTS FOR LEGS : Operating Case Description: LEGS

Legs attached to: Shell #1 - 18"

Section Properties : I Beam IPE120

European Structural Steel Data

Overall Leg Length		1000.000	mm.
Effective Leg Length	Leglen	800.000	mm.
Distance Leg Up Side of Vessel		250.000	mm.
Number of Legs	Nleg	2	
Cross Sectional Area for IPE120	Aleg	13.200	cm^2
Section Inertia (strong axis)		317.998	cm**4
Section Inertia (weak axis)		27.700	cm**4
Section Modulus (strong axis)		53000.219	$mm.^3$
Section Modulus (weak axis)		8650.034	$mm.^3$
Radius of Gyration (strong axis)		49.000	mm.
Radius of Gyration (weak axis)		14.500	mm.

Leg Orientation - Strong Axis

Overturning Moment at top of Legs		876.4	Kg-m.
Total Weight Load at top of Legs	W	934.0	Kgf
Total Shear force at top of Legs		707.5	Kgf
Additional force in Leg due to Bracing	Fadd	0.0	Kgf
Occasional Load Factor	Occfac	1.000	
Effective Leg End Condition Factor	k	0.650	

Note: The Legs are Not Cross Braced
The Leg Shear Force includes Wind and Seismic Effects

Pad Width along Circumference	C11P	150.000	mm.
Pad Length along Vessel Axis	C22P	250.000	mm.
Pad Thickness	Tpad	8.000	mm.

Maximum Shear at top of one Leg [Vleg]:
= (max(Wind, Seismic) + applied forces)(Imax / Itot)
= (707.5)(316.9/344.7)
= 650.56 Kgf

Axial Compression, Leg furthest from the Neutral Axis [Sma]:
= W/Nleg + (Mleg/(Nlegm*Rn))/Aleg
= 9159/2 + (8593630/(1 * 296.6))/1320
= 25.42 $N./mm^2$

Axial Compression, Leg closest to the Neutral Axis [Sva]:
= (W / Nleg) / Aleg
= (934/2)/13.2
= 3.47 $N./mm^2$

Allowable Comp. for the Selected Leg (KL/r < Cc) [Sa]:
$= Occfac * (1-(kl/r)^2/(2*Cc^2))*Fy /$
$(5/3+3*(Kl/r)/(8*Cc)-(Kl/r^3)/(8*Cc^3))$
$= 1 * (1-(35.86)^2/(2 * 127.2^2)) * 248.2/$
$(5/3+3*(35.86)/(8* 127.2)-(35.86^3)/(8* 127.2^3)$

= 134.69 N./mm²

Bending at the Bottom of the Leg closest to the N.A. [S]:
= (Vleg * Leglen / Smdsa)
= (650.6 * 800/53000)
= 96.30 N./mm²

Allowable Bending Stress[Sb]:
= (0.6 * Fy * Occfac)
= (0.6 * 248.2 * 1)
= 148.93 N./mm²

AISC Unity Check [Sc](must be < or = to 1.00) :
= (Sma/Sa)+(0.85*S)/((1-Sma/Spex)*Sb)
= (25.42/134.7)+(0.85 *96.3)/((1 -25.42/814.4) *148.9)
= 0.7561

WRC 107 Stress Analysis for Leg to Shell Junction, Ope Condition

Rectangular Attachment Parameter	C11	64.000	mm.
Rectangular Attachment Parameter	C22	230.950	mm.

Input Echo, WRC107/537 Item 1, Description: LEGS

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	3.0000	mm.
Vessel Diameter	Dv	441.200	mm.
Vessel Thickness	Tv	8.000	mm.
Design Temperature	T1	85.0	°C
Attachment Type	Type	Rectangular	
Parameter C11	C11	64.00	mm.
Parameter C22	C22	230.95	mm.
Thickness of Reinforcing Pad	Tpad	8.000	mm.
Pad Parameter C11P	C11p	150.000	mm.
Pad Parameter C22P	C22p	250.000	mm.
Design Internal Pressure	Dp	0.200	bars
Include Pressure Thrust		No	
Vessel Centerline Direction Cosine	Vx	0.000	
Vessel Centerline Direction Cosine	Vy	1.000	
Vessel Centerline Direction Cosine	Vz	0.000	
Nozzle Centerline Direction Cosine	Nx	1.000	
Nozzle Centerline Direction Cosine	Ny	0.000	
Nozzle Centerline Direction Cosine	Nz	0.000	
Global Force (SUS)	Fx	325.2	Kgf
Global Force (SUS)	Fy	467.0	Kgf
Global Force (SUS)	Fz	325.2	Kgf
Global Moment (SUS)	Mx	0.0	Kg-m.
Global Moment (SUS)	My	0.0	Kg-m.
Global Moment (SUS)	Mz	215.7	Kg-m.

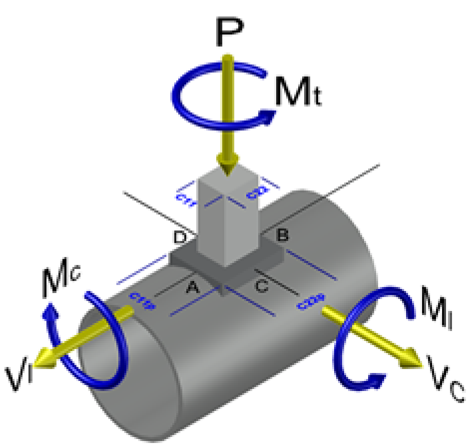
Internal Pressure (SUS)	P	0.20	bars
Include Pressure Thrust		No	

Global Force (OCC)	Fx	650.6	Kgf
Global Force (OCC)	Fy	2954.7	Kgf
Global Force (OCC)	Fz	0.0	Kgf
Global Moment (OCC)	Mx	0.0	Kg-m.
Global Moment (OCC)	My	0.0	Kg-m.
Global Moment (OCC)	Mz	461.2	Kg-m.
Occasional Internal Pressure (OCC)	Pvar	0.00	bars

Use Interactive Control		No
WRC107 Version	Version	March 1979

Include Pressure Stress Indices per Div. 2	No
Compute Pressure Stress per WRC-368	No
Local Loads applied at end of Nozzle/Attachment	No

Note:
WRC Bulletin 537 provides equations for the dimensionless curves found in bulletin 107. As noted in the foreword to bulletin 537, "537 is equivalent to WRC 107". Where 107 is printed in the results below, "537" can be interchanged with "107".



WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	325.2	Kgf
Circumferential Shear	VC	-325.2	Kgf
Longitudinal Shear	VL	467.0	Kgf
Circumferential Moment	MC	0.0	Kg-m.
Longitudinal Moment	ML	-215.7	Kg-m.
Torsional Moment	MT	0.0	Kg-m.

Dimensionless Parameters used : Gamma = 17.70

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location

N(PHI) / (P/Rm)	0.386	4C	2.138	(A,B)
N(PHI) / (P/Rm)	0.386	3C	1.260	(C,D)
M(PHI) / (P)	0.234	2C1	0.049	(A,B)
M(PHI) / (P)	0.234	1C	0.078	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.213	3A	0.693	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.273	1A	0.083	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.327	3B	1.727	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.296	1B	0.025	(A,B,C,D)
N(x) / (P/Rm)	0.315	3C	1.561	(A,B)
N(x) / (P/Rm)	0.315	4C	2.404	(C,D)
M(x) / (P)	0.328	1C1	0.053	(A,B)
M(x) / (P)	0.328	2C !	0.031	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.213	4A	1.124	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.378	2A	0.034	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.327	4B	0.727	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.397	2B	0.029	(A,B,C,D)

Note - The ! mark next to the figure name denotes curve value exceeded.

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction (N./mm²)

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-2.3	-2.3	-2.3	-2.3	-1.3	-1.3	-1.3	-1.3
Circ. Bend. P	-5.5	5.5	-5.5	5.5	-8.8	8.8	-8.8	8.8
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. ML	11.6	11.6	-11.6	-11.6	0.0	0.0	0.0	0.0
Circ. Bend. ML	28.1	-28.1	-28.1	28.1	0.0	0.0	0.0	0.0
Tot. Circ. Str.	31.9	-13.3	-47.4	19.8	-10.1	7.4	-10.1	7.4
Long. Memb. P	-1.7	-1.7	-1.7	-1.7	-2.6	-2.6	-2.6	-2.6
Long. Bend. P	-6.0	6.0	-6.0	6.0	-3.5	3.5	-3.5	3.5
Long. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. ML	8.3	8.3	-8.3	-8.3	0.0	0.0	0.0	0.0
Long. Bend. ML	24.2	-24.2	-24.2	24.2	0.0	0.0	0.0	0.0
Tot. Long. Str.	24.8	-11.5	-40.2	20.3	-6.1	0.9	-6.1	0.9
Shear VC	-1.9	-1.9	1.9	1.9	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-0.8	-0.8	0.8	0.8
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	-1.9	-1.9	1.9	1.9	-0.8	-0.8	0.8	0.8
Str. Int.	32.4	14.5	47.9	22.0	10.3	7.5	10.3	7.5

Dimensionless Parameters used : Gamma = 45.22

Dimensionless Loads for Cylindrical Shells at Pad edge:

Curves read for 1979	Beta	Figure		Value	Location
N(PHI) / (P/Rm)	0.538	4C	!	2.833	(A,B)
N(PHI) / (P/Rm)	0.538	3C	!	1.020	(C,D)
M(PHI) / (P)	0.401	2C1		0.008	(A,B)
M(PHI) / (P)	0.401	1C	!	0.064	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.393	3A		1.209	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.427	1A		0.059	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.466	3B		1.673	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.447	1B		0.005	(A,B,C,D)
N(x) / (P/Rm)	0.474	3C		1.114	(A,B)
N(x) / (P/Rm)	0.474	4C		3.037	(C,D)
M(x) / (P)	0.485	1C1		0.013	(A,B)
M(x) / (P)	0.485	2C	!	0.033	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.393	4A		4.338	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.509	2A	!	0.024	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.466	4B		1.032	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.507	2B	!	0.007	(A,B,C,D)

Note - The ! mark next to the figure name denotes curve value exceeded.

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Edge of Reinforcing Pad (N./mm²)

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-8.0	-8.0	-8.0	-8.0	-2.9	-2.9	-2.9	-2.9
Circ. Bend. P	-6.2	6.2	-6.2	6.2	-48.9	48.9	-48.9	48.9
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. ML	25.8	25.8	-25.8	-25.8	0.0	0.0	0.0	0.0
Circ. Bend. ML	26.0	-26.0	-26.0	26.0	0.0	0.0	0.0	0.0
Tot. Circ. Str.	37.6	-1.9	-66.0	-1.6	-51.8	46.0	-51.8	46.0
Long. Memb. P	-3.1	-3.1	-3.1	-3.1	-8.6	-8.6	-8.6	-8.6
Long. Bend. P	-9.9	9.9	-9.9	9.9	-25.1	25.1	-25.1	25.1
Long. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. ML	20.8	20.8	-20.8	-20.8	0.0	0.0	0.0	0.0
Long. Bend. ML	31.2	-31.2	-31.2	31.2	0.0	0.0	0.0	0.0
Tot. Long. Str.	38.9	-3.7	-65.0	17.2	-33.7	16.6	-33.7	16.6
Shear VC	-2.1	-2.1	2.1	2.1	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-1.8	-1.8	1.8	1.8
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Strength Calculation-Cartridge Filter
Design by A. Azodi
Rev.00
PV Elite 2019 SP1 Licensee: SPLM Licensed User
FileName : EI0127-HRC-VD-ME-CAL-004-00
Leg Check, (Operating Case): Step: 21 7:18pm Feb 27,2024

Tot. Shear	-2.1	-2.1	2.1	2.1	-1.8	-1.8	1.8	1.8
Str. Int.	40.5	5.1	67.7	19.2	52.0	46.1	52.0	46.1

WRC 107 Stress Calculation for OCCasional loads:

Radial Load	P	650.6	Kgf
Circumferential Shear	VC	0.0	Kgf
Longitudinal Shear	VL	2954.7	Kgf
Circumferential Moment	MC	0.0	Kg-m.
Longitudinal Moment	ML	-461.2	Kg-m.
Torsional Moment	MT	0.0	Kg-m.

Dimensionless Parameters used : Gamma = 17.70
Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction (N./mm²)

Type of Stress Load	Stress Intensity Values at							
	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-4.6	-4.6	-4.6	-4.6	-2.7	-2.7	-2.7	-2.7
Circ. Bend. P	-11.0	11.0	-11.0	11.0	-17.6	17.6	-17.6	17.6
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. ML	24.7	24.7	-24.7	-24.7	0.0	0.0	0.0	0.0
Circ. Bend. ML	60.0	-60.0	-60.0	60.0	0.0	0.0	0.0	0.0
Tot. Circ. Str.	69.2	-28.9	-100.3	41.8	-20.2	14.9	-20.2	14.9
Long. Memb. P	-3.3	-3.3	-3.3	-3.3	-5.1	-5.1	-5.1	-5.1
Long. Bend. P	-12.1	12.1	-12.1	12.1	-7.0	7.0	-7.0	7.0
Long. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. ML	17.7	17.7	-17.7	-17.7	0.0	0.0	0.0	0.0
Long. Bend. ML	51.8	-51.8	-51.8	51.8	0.0	0.0	0.0	0.0
Tot. Long. Str.	54.1	-25.3	-84.9	42.8	-12.1	1.9	-12.1	1.9
Shear VC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-4.8	-4.8	4.8	4.8
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	0.0	0.0	0.0	0.0	-4.8	-4.8	4.8	4.8
Str. Int.	69.2	28.9	100.3	42.8	22.5	16.5	22.5	16.5

Dimensionless Parameters used : Gamma = 45.22
Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Edge of Reinforcing Pad (N./mm²)

Type of Stress Load	Stress Intensity Values at							
	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-16.0	-16.0	-16.0	-16.0	-5.8	-5.8	-5.8	-5.8

Circ. Bend. P	-12.4	12.4	-12.4	12.4	-97.9	97.9	-97.9	97.9
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. ML	55.2	55.2	-55.2	-55.2	0.0	0.0	0.0	0.0
Circ. Bend. ML	55.5	-55.5	-55.5	55.5	0.0	0.0	0.0	0.0
Tot. Circ. Str.	82.3	-3.9	-139.1	-3.2	-103.6	92.1	-103.6	92.1
Long. Memb. P	-6.3	-6.3	-6.3	-6.3	-17.1	-17.1	-17.1	-17.1
Long. Bend. P	-19.8	19.8	-19.8	19.8	-50.3	50.3	-50.3	50.3
Long. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. ML	44.4	44.4	-44.4	-44.4	0.0	0.0	0.0	0.0
Long. Bend. ML	66.7	-66.7	-66.7	66.7	0.0	0.0	0.0	0.0
Tot. Long. Str.	85.0	-8.8	-137.1	35.8	-67.4	33.1	-67.4	33.1
Shear VC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-11.6	-11.6	11.6	11.6
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	0.0	0.0	0.0	0.0	-11.6	-11.6	11.6	11.6
Str. Int.	85.0	8.8	139.1	39.0	107.0	94.3	107.0	94.3

WRC 107 / 537 Stress Summations:

Vessel Stress Summation at Attachment Junction (N./mm²)

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	0.3	0.4	0.3	0.4	0.3	0.4	0.3	0.4
Circ. Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Pm(TOTAL)	0.3	0.4	0.3	0.4	0.3	0.4	0.3	0.4
Circ. Pl (SUS)	9.3	9.3	-13.8	-13.8	-1.3	-1.3	-1.3	-1.3
Circ. Pl (OCC)	20.1	20.1	-29.3	-29.3	-2.7	-2.7	-2.7	-2.7
Circ. Pl(TOTAL)	29.4	29.4	-43.1	-43.1	-4.0	-4.0	-4.0	-4.0
Circ. Q (SUS)	22.6	-22.6	-33.6	33.6	-8.8	8.8	-8.8	8.8
Circ. Q (OCC)	49.0	-49.0	-71.0	71.0	-17.6	17.6	-17.6	17.6
Circ. Q (TOTAL)	71.6	-71.6	-104.6	104.6	-26.3	26.3	-26.3	26.3
Long. Pm (SUS)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Long. Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Pm(TOTAL)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Long. Pl (SUS)	6.6	6.6	-10.0	-10.0	-2.6	-2.6	-2.6	-2.6
Long. Pl (OCC)	14.4	14.4	-21.1	-21.1	-5.1	-5.1	-5.1	-5.1
Long. Pl(TOTAL)	21.0	21.0	-31.0	-31.0	-7.7	-7.7	-7.7	-7.7
Long. Q (SUS)	18.2	-18.2	-30.2	30.2	-3.5	3.5	-3.5	3.5
Long. Q (OCC)	39.7	-39.7	-63.8	63.8	-7.0	7.0	-7.0	7.0
Long. Q (TOTAL)	57.9	-57.9	-94.1	94.1	-10.5	10.5	-10.5	10.5
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Shear Pm(TOTAL)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	-1.9	-1.9	1.9	1.9	-0.8	-0.8	0.8	0.8
Shear Pl (OCC)	0.0	0.0	0.0	0.0	-4.8	-4.8	4.8	4.8
Shear Pl(TOTAL)	-1.9	-1.9	1.9	1.9	-5.6	-5.6	5.6	5.6
Shear Q (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Q (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Q (TOTAL)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pm (SUS)	0.3	0.4	0.3	0.4	0.3	0.4	0.3	0.4
Pm (SUS+OCC)	0.3	0.4	0.3	0.4	0.3	0.4	0.3	0.4
Pm+Pl (SUS)	10.6	10.6	14.3	14.3	2.7	2.7	2.7	2.7
Pm+Pl (SUS+OCC)	30.2	30.2	43.1	43.1	11.8	11.8	11.8	11.8
Pm+Pl+Q (Total)	101.6	42.5	147.6	64.6	32.2	24.1	32.2	24.1

Vessel Stress Summation Comparison (N./mm²):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	0.35	137.90	Passed
Pm (SUS+OCC)	0.35	165.48	Passed
Pm+Pl (SUS)	14.31	206.85	Passed
Pm+Pl (SUS+OCC)	43.07	248.22	Passed
Pm+Pl+Q (TOTAL)	147.57	413.70	Passed

The Pm+Pl+Q allowable was based on a temperature range cycling from ambient to design temperature.
This allowable is computed per ASME VIII-2, 5.5.6.1(1) Part 5, 3((Smc + Smh)/2).

WRC 107 / 537 Stress Summations:

Vessel Stress Summation at Reinforcing Pad Edge (N./mm²)

Type of Stress Load	Stress Intensity Values at							
	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Circ. Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Pm(TOTAL)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Circ. Pl (SUS)	17.8	17.8	-33.8	-33.8	-2.9	-2.9	-2.9	-2.9
Circ. Pl (OCC)	39.2	39.2	-71.2	-71.2	-5.8	-5.8	-5.8	-5.8
Circ. Pl(TOTAL)	57.0	57.0	-105.0	-105.0	-8.6	-8.6	-8.6	-8.6
Circ. Q (SUS)	19.8	-19.8	-32.2	32.2	-48.9	48.9	-48.9	48.9
Circ. Q (OCC)	43.1	-43.1	-68.0	68.0	-97.9	97.9	-97.9	97.9
Circ. Q (TOTAL)	62.8	-62.8	-100.1	100.1	-146.8	146.8	-146.8	146.8
Long. Pm (SUS)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Long. Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Pm(TOTAL)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Long. Pl (SUS)	17.6	17.6	-23.9	-23.9	-8.6	-8.6	-8.6	-8.6
Long. Pl (OCC)	38.1	38.1	-50.7	-50.7	-17.1	-17.1	-17.1	-17.1

Long. Pl(TOTAL)	55.7	55.7	-74.6	-74.6	-25.7	-25.7	-25.7	-25.7
Long. Q (SUS)	21.3	-21.3	-41.1	41.1	-25.1	25.1	-25.1	25.1
Long. Q (OCC)	46.9	-46.9	-86.4	86.4	-50.3	50.3	-50.3	50.3
Long. Q (TOTAL)	68.2	-68.2	-127.5	127.5	-75.4	75.4	-75.4	75.4
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pm(TOTAL)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	-2.1	-2.1	2.1	2.1	-1.8	-1.8	1.8	1.8
Shear Pl (OCC)	0.0	0.0	0.0	0.0	-11.6	-11.6	11.6	11.6
Shear Pl(TOTAL)	-2.1	-2.1	2.1	2.1	-13.4	-13.4	13.4	13.4
Shear Q (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Q (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Q (TOTAL)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pm (SUS)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Pm (SUS+OCC)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Pm+Pl (SUS)	20.5	20.5	33.4	33.3	8.6	8.6	8.6	8.6
Pm+Pl (SUS+OCC)	59.3	59.3	104.2	104.2	32.5	32.5	32.5	32.5
Pm+Pl+Q (Total)	125.4	12.6	205.4	57.4	157.7	141.0	157.7	141.0

Vessel Stress Summation Comparison (N./mm²):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	0.90	137.90	Passed
Pm (SUS+OCC)	0.90	165.48	Passed
Pm+Pl (SUS)	33.37	206.85	Passed
Pm+Pl (SUS+OCC)	104.22	248.22	Passed
Pm+Pl+Q (TOTAL)	205.42	413.70	Passed

The Pm+Pl+Q allowable was based on a temperature range cycling from ambient to design temperature.
This allowable is computed per ASME VIII-2, 5.5.6.1(1) Part 5, 3((Smc + Smh)/2).

Bolting Size Requirement for Leg Baseplates :

Baseplate Material		SA-283 C	
Baseplate Allowable Stress	SBA	108.25	N./mm²
Baseplate Length	B	300.0000	mm.
Baseplate Width	D	300.0000	mm.
Baseplate Thickness	BTHK	25.0000	mm.
Leg Dimension Along Baseplate Length	d	119.9998	mm.
Leg Dimension Along Baseplate Width	b	63.9999	mm.
Dist. from the Leg Edge to Bolt Hole Center	z	80.0000	mm.
Bolt Material		SA-36	
Bolt Allowable Tensile Stress	STBA	114.46	N./mm²
Bolt Allowable Shear Stress	SBShear	68.67	N./mm²
Anchor Bolt Nominal Diameter	BOD	20.0000	mm.
Number of Anchor Bolts in Tension per Leg	NB	2	
Total Number of Anchors Bolt per Leg	NBT	4	
Ultimate 28-day Concrete Strength	FCPRIME	20.685	N./mm²

Shear Stress in a Single Bolt [taub]:
```
 = Shear Force / ( 2 * Bolt Area * Number of Bolts )
 = 707.5/( 2 * 2.171 * 4 )
 = 4.0 N./mm².  Must be less than 68.7 N./mm².
```

LEG BASEPLATE and BOLTING Analysis, including Moments

I-Beam Leg

Base Plate Available Area (AA):
```
   = B * D
   = 300 * 300
   = 900.00  cm²
```

Clearance Between The Bolt And The Leg Edge (BCL):
```
   = z - BOD / 2
   = 80 - 20/2
   = 70.00  mm.
```

Moment at Baseplate (MOMENT):
```
   = Vleg * Lleg
   = 650.6 * 1000
   = 650.58  Kg-m.
```

Axial Load on the baseplate (P):
```
   = Operating Weight per leg  (as Seismic + Operating case is controlling)
   = 288.26  Kgf
```

Eccentricity (e):
```
   = MOMENT * Conv_Factor / P
   = 650.6 *9806.64/288.3
   = 2256.88 mm. > D/6 [Plate Uplift Condition]
```

```
a  = (D - d) / 2
   = (300 - 120 )/2
   = 90.00  mm.
```

Modular Ratio Of Steel/Concrete (n):
```
   = ES / EC
   = 203402/21526
   = 9.45
```

```
F  = 0.5 * d + z
   = 0.5 * 120 + 80
   = 140.00  mm.

K1 = 3.0 (e - 0.5*D)
   = 3.0 (2257 - 0.5*300 )
   = 6320.64

K2 = 6 * n * Ast / B * (F + e)
   = 6 * 9.449 * 4.341/300 * (140 + 2257 )
   = 1966.32

K3 = -K2 * (0.5 * D + F)
   = -1966 * (0.5 * 300 + 140 )
```

```
    = -570232.98
```

Solving For The Effective Bearing Length Using Iteration:

```
Y³ + K1 * Y² + K2 * Y + K3 = 0
Y³ + 248.8 * Y² + 304.8 * Y - 3480 = 0
Y  = 80.27  mm.

NUM = (D / 2 - Y / 3 - e)
    = (300/2 - 80.27/3 - 2257 )
    = -2133.64

DENOM = (D / 2 - Y / 3 + F)
      = (300/2 - 80.27/3 + 140 )
      = 263.24
```

Total Bolt Tension Force (T):

```
   = - P * NUM / DENOM
   = - 288.3 * -2134/263.2
   = 2336.38  Kgf
```

Overturning Moment Due To Bolt In Tension (Mt):

```
   = T * (0.5 * D + F - Y)
   = 2336 * (0.5 * 300 + 140 - 80.27 )
   = 490.02  Kg-m.
```

Bearing Pressure (FC):

```
   = 2 * (P + T) / (Y * B)
   = 2 * (288.3 + 2336 )/(80.27 * 300 )
   = 21.38 bars [ <= FCPRIME ( 206.84)]
```

Equivalent Bearing Pressure (f1):

```
   = FC * (Y - a) / Y
   = 21.38 * (80.27 - 90 )/80.27
   = -2.59  bars
```

Overturning Moment Due To Bearing Pressure (Mc):

```
   = (a² * B / 6) * (f1 + 2 * FC)
   = (90² * 300/6) * (-2.592 + 2 * 21.38 )
   = 165.87  Kg-m.
```

The Baseplate Required Thickness (TREQ):

```
   = (6 * MAX(Mt,Mc) / (B * 1.5 * SBA))½
   = (6 * 490/(300 * 162.4 ))½
   = 24.33  mm.
```

Required bolt area (ABREQM): per D. Moss

```
   = T / STBA
   = 2336/114.5
   = 2.0018 cm² [ < Ast ( 4.34) --> PASSED]
```

Distance from Top of Legs to Vessel CG (CD_DIST):

```
   = 591.7 mm.
```

Total Overturning Moment at Baseplate (Mbb):

```
   = ( Mleg / max([CD_DIST], minDist) )* ( CD_DIST + Lleg )
   = ( 876.4/max( 591.7, 38.1 ) ) * ( 591.7 + 1000 )
   = 2357.39  Kg-m.
```

Required Total Bolt Area per Leg (ABREQB): per H. Bednar

```
= (1 / (Nleg * STBA)) * ((4 * Mbb / (Rn * 2) ) - W )
= (1/(2 * 114.5 )) * ((4 * 2357/(593.2 )) - 576.5 )
= 6.5629 cm²
```

Available Total Bolt Corr. Area per Leg (ABAVL):

```
= As * NBT
= 2.171 * 4
= 8.6820 cm² [ > ABREQB ( 6.56) --> PASSED]
```

Summary of Results:

		Actual	Required	Pass/Fail
Baseplate Thickness	(mm.):	25.000	24.329	Pass
Bolt Root Area (Bednar)	(cm²):	8.68	6.56	Pass
Bolt Root Area (D. Moss)	(cm²):	4.34	2.00	Pass

Note: The required thickness calculation is performed based on:
- Strong axis orientation of the beam leg
- Even number of bolts installed only on the B dimension sides

RESULTS FOR LEGS : HydroTest Case Description: LEGS

Legs attached to: Shell #1 - 18"

Section Properties : I Beam IPE120

European Structural Steel Data

Overall Leg Length		1000.000	mm.
Effective Leg Length	Leglen	800.000	mm.
Distance Leg Up Side of Vessel		250.000	mm.
Number of Legs	Nleg	2	
Cross Sectional Area for IPE120	Aleg	13.200	cm²
Section Inertia (strong axis)		317.998	cm**4
Section Inertia (weak axis)		27.700	cm**4
Section Modulus (strong axis)		53000.219	mm.³
Section Modulus (weak axis)		8650.034	mm.³
Radius of Gyration (strong axis)		49.000	mm.
Radius of Gyration (weak axis)		14.500	mm.

Leg Orientation - Strong Axis

Overturning Moment at top of Legs		9.5	Kg-m.
Total Weight Load at top of Legs	W	664.3	Kgf
Total Shear force at top of Legs		22.7	Kgf
Additional force in Leg due to Bracing	Fadd	0.0	Kgf
Occasional Load Factor	Occfac	1.000	
Effective Leg End Condition Factor	k	0.650	

Note: The Legs are Not Cross Braced
The Leg Shear Force includes Wind and Seismic Effects

Pad Width along Circumference	C11P	150.000	mm.
Pad Length along Vessel Axis	C22P	250.000	mm.
Pad Thickness	Tpad	8.000	mm.

Maximum Shear at top of one Leg [Vleg]:
= (max(Wind, Seismic) + applied forces)(Imax / Itot)
= (22.68)(316.9/344.7)
= 20.85 Kgf

Axial Compression, Leg furthest from the Neutral Axis [Sma]:
= W/Nleg + (Mleg/(Nlegm*Rn))/Aleg
= 6515/2 + (92975/(1 * 296.6))/1320
= 2.71 N./mm²

Axial Compression, Leg closest to the Neutral Axis [Sva]:
= (W / Nleg) / Aleg
= (664.3/2)/13.2
= 2.47 N./mm²

Allowable Comp. for the Selected Leg (KL/r < Cc) [Sa]:
= Occfac * (1-(kl/r)²/(2*Cc²))*Fy /
(5/3+3*(Kl/r)/(8*Cc)-(Kl/r³)/(8*Cc³)
= 1 * (1-(35.86)²/(2 * 127.2²)) * 248.2/
(5/3+3*(35.86)/(8* 127.2)-(35.86³)/(8* 127.2³)

= 134.69 N./mm²

Bending at the Bottom of the Leg closest to the N.A. [S]:
= (Vleg * Leglen / Smdsa)
= (20.85 * 800/53000)
= 3.09 N./mm²

Allowable Bending Stress[Sb]:
= (0.6 * Fy * Occfac)
= (0.6 * 248.2 * 1)
= 148.93 N./mm²

AISC Unity Check [Sc](must be < or = to 1.00) :
= (Sma/Sa)+(0.85*S)/((1-Sma/Spex)*Sb)
= (2.705/134.7)+(0.85 *3.087)/((1 -2.705/814.4) *148.9)
= 0.0378

<u>WRC 107 Stress Analysis for Leg to Shell Junction, Test Condition</u>

Rectangular Attachment Parameter	C11	64.000	mm.
Rectangular Attachment Parameter	C22	230.950	mm.

Input Echo, WRC107/537 Item 1, Description: LEGS

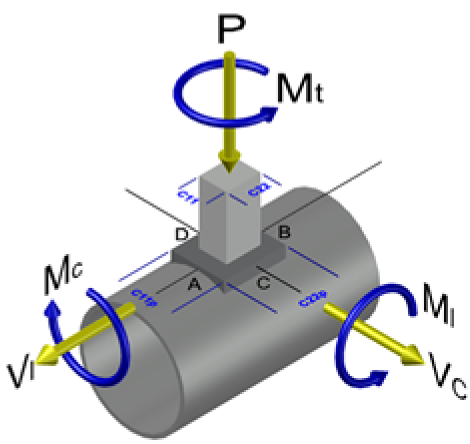
Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	0.0000	mm.
Vessel Diameter	Dv	441.200	mm.
Vessel Thickness	Tv	8.000	mm.
Design Temperature	T1	85.0	°C
Attachment Type	Type	Rectangular	
Parameter C11	C11	64.00	mm.
Parameter C22	C22	230.95	mm.
Thickness of Reinforcing Pad	Tpad	8.000	mm.
Pad Parameter C11P	C11p	150.000	mm.
Pad Parameter C22P	C22p	250.000	mm.
Design Internal Pressure	Dp	0.200	bars
Include Pressure Thrust		No	
Vessel Centerline Direction Cosine	Vx	0.000	
Vessel Centerline Direction Cosine	Vy	1.000	
Vessel Centerline Direction Cosine	Vz	0.000	
Nozzle Centerline Direction Cosine	Nx	1.000	
Nozzle Centerline Direction Cosine	Ny	0.000	
Nozzle Centerline Direction Cosine	Nz	0.000	
Global Force (SUS)	Fx	325.2	Kgf
Global Force (SUS)	Fy	332.2	Kgf
Global Force (SUS)	Fz	325.2	Kgf
Global Moment (SUS)	Mx	0.0	Kg-m.
Global Moment (SUS)	My	0.0	Kg-m.
Global Moment (SUS)	Mz	206.5	Kg-m.

Internal Pressure (SUS)	P	0.20	bars
Include Pressure Thrust		No	
Global Force (OCC)	Fx	20.9	Kgf
Global Force (OCC)	Fy	32.0	Kgf
Global Force (OCC)	Fz	0.0	Kgf
Global Moment (OCC)	Mx	0.0	Kg-m.
Global Moment (OCC)	My	0.0	Kg-m.
Global Moment (OCC)	Mz	10.5	Kg-m.
Occasional Internal Pressure (OCC)	Pvar	0.00	bars

Use Interactive Control		No
WRC107 Version	Version	March 1979

Include Pressure Stress Indices per Div. 2	No
Compute Pressure Stress per WRC-368	No
Local Loads applied at end of Nozzle/Attachment	No

Note:
WRC Bulletin 537 provides equations for the dimensionless curves found in bulletin 107. As noted in the foreword to bulletin 537, "537 is equivalent to WRC 107". Where 107 is printed in the results below, "537" can be interchanged with "107".



WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	325.2	Kgf
Circumferential Shear	VC	-325.2	Kgf
Longitudinal Shear	VL	332.2	Kgf
Circumferential Moment	MC	0.0	Kg-m.
Longitudinal Moment	ML	-206.5	Kg-m.
Torsional Moment	MT	0.0	Kg-m.

Dimensionless Parameters used : Gamma = 14.29

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location

```
N(PHI) / ( P/Rm )                  0.389   4C       1.863   (A,B)
N(PHI) / ( P/Rm )                  0.389   3C       1.186   (C,D)
M(PHI) / ( P )                     0.235   2C1      0.055   (A,B)
M(PHI) / ( P )                     0.235   1C       0.083   (C,D)
N(PHI) / ( MC/(Rm**2 * Beta) )     0.215   3A   !   0.533   (A,B,C,D)
M(PHI) / ( MC/(Rm    * Beta) )     0.276   1A       0.085   (A,B,C,D)
N(PHI) / ( ML/(Rm**2 * Beta) )     0.329   3B   !   1.530   (A,B,C,D)
M(PHI) / ( ML/(Rm    * Beta) )     0.299   1B       0.028   (A,B,C,D)

N(x)   / ( P/Rm )                  0.317   3C       1.447   (A,B)
N(x)   / ( P/Rm )                  0.317   4C       2.070   (C,D)
M(x)   / ( P )                     0.330   1C1      0.058   (A,B)
M(x)   / ( P )                     0.330   2C       0.033   (C,D)
N(x)   / ( MC/(Rm**2 * Beta) )     0.215   4A   !   0.855   (A,B,C,D)
M(x)   / ( MC/(Rm    * Beta) )     0.384   2A       0.036   (A,B,C,D)
N(x)   / ( ML/(Rm**2 * Beta) )     0.329   4B   !   0.598   (A,B,C,D)
M(x)   / ( ML/(Rm    * Beta) )     0.401   2B       0.033   (A,B,C,D)
```

Note - The ! mark next to the figure name denotes curve value exceeded.

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction (N./mm²)

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-1.6	-1.6	-1.6	-1.6	-1.0	-1.0	-1.0	-1.0
Circ. Bend. P	-4.1	4.1	-4.1	4.1	-6.2	6.2	-6.2	6.2
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. ML	8.1	8.1	-8.1	-8.1	0.0	0.0	0.0	0.0
Circ. Bend. ML	19.5	-19.5	-19.5	19.5	0.0	0.0	0.0	0.0
Tot. Circ. Str.	21.8	-8.9	-33.2	13.9	-7.3	5.2	-7.3	5.2
Long. Memb. P	-1.3	-1.3	-1.3	-1.3	-1.8	-1.8	-1.8	-1.8
Long. Bend. P	-4.4	4.4	-4.4	4.4	-2.5	2.5	-2.5	2.5
Long. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. ML	5.4	5.4	-5.4	-5.4	0.0	0.0	0.0	0.0
Long. Bend. ML	17.3	-17.3	-17.3	17.3	0.0	0.0	0.0	0.0
Tot. Long. Str.	17.1	-8.9	-28.3	15.1	-4.3	0.7	-4.3	0.7
Shear VC	-1.6	-1.6	1.6	1.6	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-0.4	-0.4	0.4	0.4
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	-1.6	-1.6	1.6	1.6	-0.4	-0.4	0.4	0.4
Str. Int.	22.3	10.4	33.7	16.1	7.3	5.2	7.3	5.2

Dimensionless Parameters used : Gamma = 28.08

Dimensionless Loads for Cylindrical Shells at Pad edge:

Curves read for 1979	Beta	Figure		Value	Location
N(PHI) / (P/Rm)	0.541	4C	!	2.271	(A,B)
N(PHI) / (P/Rm)	0.541	3C	!	0.946	(C,D)
M(PHI) / (P)	0.404	2C1		0.013	(A,B)
M(PHI) / (P)	0.404	1C	!	0.060	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.396	3A		0.971	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.433	1A		0.066	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.469	3B		1.388	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.453	1B		0.009	(A,B,C,D)
N(x) / (P/Rm)	0.477	3C		1.015	(A,B)
N(x) / (P/Rm)	0.477	4C		2.386	(C,D)
M(x) / (P)	0.489	1C1		0.020	(A,B)
M(x) / (P)	0.489	2C	!	0.030	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.396	4A		2.739	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.521	2A	!	0.027	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.469	4B		0.774	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.514	2B	!	0.013	(A,B,C,D)

Note - The ! mark next to the figure name denotes curve value exceeded.

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Edge of Reinforcing Pad (N./mm²)

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-4.0	-4.0	-4.0	-4.0	-1.7	-1.7	-1.7	-1.7
Circ. Bend. P	-3.8	3.8	-3.8	3.8	-17.9	17.9	-17.9	17.9
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. ML	13.0	13.0	-13.0	-13.0	0.0	0.0	0.0	0.0
Circ. Bend. ML	17.4	-17.4	-17.4	17.4	0.0	0.0	0.0	0.0
Tot. Circ. Str.	22.6	-4.7	-38.3	4.3	-19.6	16.2	-19.6	16.2
Long. Memb. P	-1.8	-1.8	-1.8	-1.8	-4.2	-4.2	-4.2	-4.2
Long. Bend. P	-5.8	5.8	-5.8	5.8	-9.1	9.1	-9.1	9.1
Long. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. ML	9.6	9.6	-9.6	-9.6	0.0	0.0	0.0	0.0
Long. Bend. ML	21.4	-21.4	-21.4	21.4	0.0	0.0	0.0	0.0
Tot. Long. Str.	23.3	-7.7	-38.6	15.8	-13.3	4.8	-13.3	4.8
Shear VC	-1.3	-1.3	1.3	1.3	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-0.8	-0.8	0.8	0.8
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Tot. Shear	-1.3	-1.3	1.3	1.3	-0.8	-0.8	0.8	0.8
Str. Int.	24.3	8.2	39.8	16.0	19.7	16.3	19.7	16.3

WRC 107 Stress Calculation for OCCasional loads:

Radial Load	P	20.9	Kgf
Circumferential Shear	VC	0.0	Kgf
Longitudinal Shear	VL	32.0	Kgf
Circumferential Moment	MC	0.0	Kg-m.
Longitudinal Moment	ML	-10.5	Kg-m.
Torsional Moment	MT	0.0	Kg-m.

Dimensionless Parameters used : Gamma = 14.29
Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction (N./mm²)

Type of Stress Load	Stress Intensity Values at							
	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
Circ. Bend. P	-0.3	0.3	-0.3	0.3	-0.4	0.4	-0.4	0.4
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. ML	0.4	0.4	-0.4	-0.4	0.0	0.0	0.0	0.0
Circ. Bend. ML	1.0	-1.0	-1.0	1.0	0.0	0.0	0.0	0.0
Tot. Circ. Str.	1.0	-0.4	-1.8	0.7	-0.5	0.3	-0.5	0.3
Long. Memb. P	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
Long. Bend. P	-0.3	0.3	-0.3	0.3	-0.2	0.2	-0.2	0.2
Long. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. ML	0.3	0.3	-0.3	-0.3	0.0	0.0	0.0	0.0
Long. Bend. ML	0.9	-0.9	-0.9	0.9	0.0	0.0	0.0	0.0
Tot. Long. Str.	0.8	-0.4	-1.5	0.8	-0.3	0.0	-0.3	0.0
Shear VC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-0.0	-0.0	0.0	0.0
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	0.0	0.0	0.0	0.0	-0.0	-0.0	0.0	0.0
Str. Int.	1.0	0.4	1.8	0.8	0.5	0.3	0.5	0.3

Dimensionless Parameters used : Gamma = 28.08
Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Edge of Reinforcing Pad (N./mm²)

Type of Stress Load	Stress Intensity Values at							
	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-0.3	-0.3	-0.3	-0.3	-0.1	-0.1	-0.1	-0.1

Circ. Bend. P	-0.2	0.2	-0.2	0.2	-1.1	1.1	-1.1	1.1
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. ML	0.7	0.7	-0.7	-0.7	0.0	0.0	0.0	0.0
Circ. Bend. ML	0.9	-0.9	-0.9	0.9	0.0	0.0	0.0	0.0
Tot. Circ. Str.	1.0	-0.2	-2.1	0.2	-1.3	1.0	-1.3	1.0
Long. Memb. P	-0.1	-0.1	-0.1	-0.1	-0.3	-0.3	-0.3	-0.3
Long. Bend. P	-0.4	0.4	-0.4	0.4	-0.6	0.6	-0.6	0.6
Long. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. ML	0.5	0.5	-0.5	-0.5	0.0	0.0	0.0	0.0
Long. Bend. ML	1.1	-1.1	-1.1	1.1	0.0	0.0	0.0	0.0
Tot. Long. Str.	1.1	-0.3	-2.1	0.9	-0.9	0.3	-0.9	0.3
Shear VC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-0.1	-0.1	0.1	0.1
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	0.0	0.0	0.0	0.0	-0.1	-0.1	0.1	0.1
Str. Int.	1.1	0.3	2.1	0.9	1.3	1.0	1.3	1.0

WRC 107/537 Stress Summations:

Vessel Stress Summation at Attachment Junction (N./mm²)

Type of Stress Load	Stress Intensity Values at							
	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Circ. Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Pm(TOTAL)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Circ. Pl (SUS)	6.4	6.4	-9.7	-9.7	-1.0	-1.0	-1.0	-1.0
Circ. Pl (OCC)	0.3	0.3	-0.5	-0.5	-0.1	-0.1	-0.1	-0.1
Circ. Pl(TOTAL)	6.8	6.8	-10.2	-10.2	-1.1	-1.1	-1.1	-1.1
Circ. Q (SUS)	15.4	-15.4	-23.6	23.6	-6.2	6.2	-6.2	6.2
Circ. Q (OCC)	0.7	-0.7	-1.3	1.3	-0.4	0.4	-0.4	0.4
Circ. Q (TOTAL)	16.1	-16.1	-24.8	24.8	-6.6	6.6	-6.6	6.6
Long. Pm (SUS)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Long. Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Pm(TOTAL)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Long. Pl (SUS)	4.1	4.1	-6.6	-6.6	-1.8	-1.8	-1.8	-1.8
Long. Pl (OCC)	0.2	0.2	-0.4	-0.4	-0.1	-0.1	-0.1	-0.1
Long. Pl(TOTAL)	4.3	4.3	-7.0	-7.0	-1.9	-1.9	-1.9	-1.9
Long. Q (SUS)	13.0	-13.0	-21.7	21.7	-2.5	2.5	-2.5	2.5
Long. Q (OCC)	0.6	-0.6	-1.2	1.2	-0.2	0.2	-0.2	0.2
Long. Q (TOTAL)	13.6	-13.6	-22.9	22.9	-2.6	2.6	-2.6	2.6
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Shear Pm(TOTAL)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	-1.6	-1.6	1.6	1.6	-0.4	-0.4	0.4	0.4
Shear Pl (OCC)	0.0	0.0	0.0	0.0	-0.0	-0.0	0.0	0.0
Shear Pl(TOTAL)	-1.6	-1.6	1.6	1.6	-0.5	-0.5	0.5	0.5
Shear Q (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Q (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Q (TOTAL)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pm (SUS)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Pm (SUS+OCC)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Pm+Pl (SUS)	7.5	7.5	10.1	10.1	1.9	1.8	1.9	1.8
Pm+Pl (SUS+OCC)	7.8	7.8	10.6	10.6	2.0	2.0	2.0	2.0
Pm+Pl+Q (Total)	23.5	10.7	35.2	17.1	7.5	5.9	7.5	5.9

Vessel Stress Summation Comparison (N./mm²):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	0.29	235.81	Passed
Pm (SUS+OCC)	0.29	282.97	Passed
Pm+Pl (SUS)	10.10	353.71	Passed
Pm+Pl (SUS+OCC)	10.59	424.46	Passed
Pm+Pl+Q (TOTAL)	35.19	707.43	Passed

The Pm+Pl+Q allowable was based on a temperature range cycling from ambient to design temperature.
This allowable is computed per ASME VIII-2, 5.5.6.1(1) Part 5, 3((Smc + Smh)/2).

WRC 107/537 Stress Summations:

Vessel Stress Summation at Reinforcing Pad Edge (N./mm²)

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	0.5	0.6	0.5	0.6	0.5	0.6	0.5	0.6
Circ. Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Pm(TOTAL)	0.5	0.6	0.5	0.6	0.5	0.6	0.5	0.6
Circ. Pl (SUS)	8.9	8.9	-17.0	-17.0	-1.7	-1.7	-1.7	-1.7
Circ. Pl (OCC)	0.4	0.4	-0.9	-0.9	-0.1	-0.1	-0.1	-0.1
Circ. Pl(TOTAL)	9.3	9.3	-17.9	-17.9	-1.8	-1.8	-1.8	-1.8
Circ. Q (SUS)	13.6	-13.6	-21.3	21.3	-17.9	17.9	-17.9	17.9
Circ. Q (OCC)	0.6	-0.6	-1.1	1.1	-1.1	1.1	-1.1	1.1
Circ. Q (TOTAL)	14.3	-14.3	-22.4	22.4	-19.1	19.1	-19.1	19.1
Long. Pm (SUS)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Long. Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Pm(TOTAL)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Long. Pl (SUS)	7.8	7.8	-11.4	-11.4	-4.2	-4.2	-4.2	-4.2
Long. Pl (OCC)	0.4	0.4	-0.6	-0.6	-0.3	-0.3	-0.3	-0.3

Long. Pl(TOTAL)	8.2	8.2	-12.0	-12.0	-4.5	-4.5	-4.5	-4.5
Long. Q (SUS)	15.5	-15.5	-27.2	27.2	-9.1	9.1	-9.1	9.1
Long. Q (OCC)	0.7	-0.7	-1.5	1.5	-0.6	0.6	-0.6	0.6
Long. Q (TOTAL)	16.2	-16.2	-28.7	28.7	-9.7	9.7	-9.7	9.7
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pm(TOTAL)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	-1.3	-1.3	1.3	1.3	-0.8	-0.8	0.8	0.8
Shear Pl (OCC)	0.0	0.0	0.0	0.0	-0.1	-0.1	0.1	0.1
Shear Pl(TOTAL)	-1.3	-1.3	1.3	1.3	-0.9	-0.9	0.9	0.9
Shear Q (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Q (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Q (TOTAL)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pm (SUS)	0.5	0.6	0.5	0.6	0.5	0.6	0.5	0.6
Pm (SUS+OCC)	0.5	0.6	0.5	0.6	0.5	0.6	0.5	0.6
Pm+Pl (SUS)	10.3	10.3	16.8	16.7	4.2	4.2	4.2	4.2
Pm+Pl (SUS+OCC)	10.7	10.7	17.7	17.7	4.5	4.5	4.5	4.5
Pm+Pl+Q (Total)	25.8	8.3	41.5	17.1	20.4	17.9	20.4	17.9

Vessel Stress Summation Comparison (N./mm²):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	0.56	235.81	Passed
Pm (SUS+OCC)	0.56	282.97	Passed
Pm+Pl (SUS)	16.77	353.71	Passed
Pm+Pl (SUS+OCC)	17.67	424.46	Passed
Pm+Pl+Q (TOTAL)	41.46	707.43	Passed

The Pm+Pl+Q allowable was based on a temperature range cycling from ambient to design temperature.
This allowable is computed per ASME VIII-2, 5.5.6.1(1) Part 5, 3((Smc + Smh)/2).

Bolting Size Requirement for Leg Baseplates :

Baseplate Material		SA-283 C	
Baseplate Allowable Stress	SBA	108.25	N./mm²
Baseplate Length	B	300.0000	mm.
Baseplate Width	D	300.0000	mm.
Baseplate Thickness	BTHK	25.0000	mm.
Leg Dimension Along Baseplate Length	d	119.9998	mm.
Leg Dimension Along Baseplate Width	b	63.9999	mm.
Dist. from the Leg Edge to Bolt Hole Center	z	80.0000	mm.
Bolt Material		SA-36	
Bolt Allowable Tensile Stress	STBA	114.46	N./mm²
Bolt Allowable Shear Stress	SBShear	68.67	N./mm²
Anchor Bolt Nominal Diameter	BOD	20.0000	mm.
Number of Anchor Bolts in Tension per Leg	NB	2	
Total Number of Anchors Bolt per Leg	NBT	4	
Ultimate 28-day Concrete Strength	FCPRIME	20.685	N./mm²

Shear Stress in a Single Bolt [taub]:
= Shear Force / (2 * Bolt Area * Number of Bolts)
= 707.5/(2 * 2.171 * 4)
= 4.0 N./mm². Must be less than 68.7 N./mm².

LEG BASEPLATE and BOLTING Analysis, including Moments

I-Beam Leg

Base Plate Available Area (AA):
= B * D
= 300 * 300
= 900.00 cm²

Clearance Between The Bolt And The Leg Edge (BCL):
= z - BOD / 2
= 80 - 20/2
= 70.00 mm.

Moment at Baseplate (MOMENT):
= Vleg * Lleg
= 20.85 * 1000
= 20.85 Kg-m.

Axial Load on the baseplate (P):
= Operating Weight per leg (as Seismic + Operating case is controlling)
= 288.26 Kgf

Eccentricity (e):
= MOMENT * Conv_Factor / P
= 20.85 *9806.64/288.3
= 72.34 mm. > D/6 [Plate Uplift Condition]

a = (D - d) / 2
= (300 - 120)/2
= 90.00 mm.

Modular Ratio Of Steel/Concrete (n):
= ES / EC
= 203402/21526
= 9.45

F = 0.5 * d + z
= 0.5 * 120 + 80
= 140.00 mm.

K1 = 3.0 (e - 0.5*D)
= 3.0 (72.34 - 0.5*300)
= -232.98

K2 = 6 * n * Ast / B * (F + e)
= 6 * 9.449 * 4.341/300 * (140 + 72.34)
= 174.20

K3 = -K2 * (0.5 * D + F)
= -174.2 * (0.5 * 300 + 140)

= -50516.96

Solving For The Effective Bearing Length Using Iteration:
Y^3 + K1 * Y^2 + K2 * Y + K3 = 0
Y^3 + -9.172 * Y^2 + 27 * Y - 308.3 = 0
Y = 245.75 mm.

NUM = (D / 2 - Y / 3 - e)
= (300/2 - 245.7/3 - 72.34)
= -4.25

DENOM = (D / 2 - Y / 3 + F)
= (300/2 - 245.7/3 + 140)
= 208.08

Total Bolt Tension Force (T):
= - P * NUM / DENOM
= - 288.3 * -4.255/208.1
= 5.89 Kgf

Overturning Moment Due To Bolt In Tension (Mt):
= T * (0.5 * D + F - Y)
= 5.894 * (0.5 * 300 + 140 - 245.7)
= 0.26 Kg-m.

Bearing Pressure (FC):
= 2 * (P + T) / (Y * B)
= 2 * (288.3 + 5.894)/(245.7 * 300)
= 0.78 bars [<= FCPRIME (206.84)]

Equivalent Bearing Pressure (f1):
= FC * (Y - a) / Y
= 0.783 * (245.7 - 90)/245.7
= 0.50 bars

Overturning Moment Due To Bearing Pressure (Mc):
= (a^2 * B / 6) * (f1 + 2 * FC)
= (90^2 * 300/6) * (0.496 + 2 * 0.783)
= 8.51 Kg-m.

The Baseplate Required Thickness (TREQ):
= (6 * MAX(Mt,Mc) / (B * 1.5 * SBA))½
= (6 * 8.512/(300 * 162.4))½
= 3.21 mm.

Required bolt area (ABREQM): per D. Moss
= T / STBA
= 5.894/114.5
= 0.0051 cm^2 [< Ast (4.34) --> PASSED]

Distance from Top of Legs to Vessel CG (CD_DIST):
= 509.1 mm.

Total Overturning Moment at Baseplate (Mbb):
= (Mleg / max([CD_DIST], minDist))* (CD_DIST + Lleg)
= (9.482/max(509.1, 38.1)) * (509.1 + 1000)
= 28.11 Kg-m.

Required Total Bolt Area per Leg (ABREQB): per H. Bednar

```
   = (1 / (Nleg * STBA)) * ((4 * Mbb / (Rn * 2) ) - W )
   = (1/(2 * 114.5 )) * ((4 * 28.11/(593.2 )) - 576.5 )
   = -0.1658 cm² --> (No tension in bolts)
```

Summary of Results:

		Actual	Required	Pass/Fail
Baseplate Thickness	(mm.):	25.000	3.206	Pass
Bolt Root Area (D. Moss)	(cm²):	4.34	0.01	Pass

Note: The required thickness calculation is performed based on:
- Strong axis orientation of the beam leg
- Even number of bolts installed only on the B dimension sides

Nozzle Calculation Summary:

Description	MAWP bars	Ext	MAPNC bars	UG-45	[tr] mm.	Weld Path	Areas or Stresses
Drain - 2"	9.82	OK	...	OK	4.50	OK	Passed
Gas In - 6"		...	...	OK	4.50	OK	No Calc[*]
Vent - 1"		...	...	OK	4.50	OK	No Calc[*]
Gas Out - 6"		...	...	OK	4.50	OK	No Calc[*]

MAWP Summary:

```
Minimum MAWP Nozzles          :          9.825 Nozzle  : Drain - 2"
Minimum MAWP Shells/Flanges   :         13.552 Element : Cap - 18" (sch.10)
Minimum MAPnc Shells/Flanges  :         19.600 Element : Blind Flange - 18"

Computed Vessel M.A.W.P.      :          9.825 bars
```

[*] - This was a small opening and the areas were not computed or
the MAWP of this connection could not be computed because
the longitudinal bending stress was greater than the hoop stress.

Note: MAWPs (Internal Case) shown above are at the High Point.

Warning: A Nozzle Reinforcement is governing the MAWP of this Vessel.

Check the Spatial Relationship between the Nozzles

From Node	Nozzle Description	Y Coordinate mm.	Layout Angle deg	Dia. Limit mm.
10	Drain - 2"	0.000	0.000	113.270
20	Gas In - 6"	285.500	180.000	323.658
30	Vent - 1"	1335.500	180.000	56.577
30	Gas Out - 6"	1235.500	0.000	323.658

The nozzle spacing is computed by the following:

= Sqrt($ll^2 + lc^2$) where
ll - Arc length along the inside vessel surface in the long. direction.
lc - Arc length along the inside vessel surface in the circ. direction

If any interferences/violations are found, they will be noted below.
No interference violations have been detected !

Input, Nozzle Desc: Drain - 2" **From: 10**

Pressure for Reinforcement Calculations	P	0.200	bars
Temperature for Internal Pressure	Temp	85	°C
Design External Pressure	Pext	0.10	bars
Temperature for External Pressure	Tempex	85	°C
Shell Material		SA-234 WPB	
Shell Allowable Stress at Temperature	Sv	117.90	N./mm²
Shell Allowable Stress At Ambient	Sva	117.90	N./mm²
Inside Diameter of Elliptical Head	D	446.09	mm.
Aspect Ratio of Elliptical Head	Ar	2.00	
Head Finished (Minimum) Thickness	t	5.5563	mm.
Head Internal Corrosion Allowance	c	3.0000	mm.
Head External Corrosion Allowance	co	0.0000	mm.
Distance from Head Centerline	L1	0.0000	mm.
User Entered Minimum Design Metal Temperature		-5.00	°C

Type of Element Connected to the Shell : Nozzle

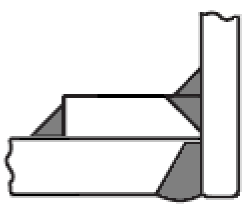
Material		SA-106 B	
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	117.90	N./mm²
Allowable Stress At Ambient	Sna	117.90	N./mm²
Diameter Basis (for tr calc only)		OD	
Layout Angle		0.00	deg
Diameter		2.0000	in.
Size and Thickness Basis		Minimum	
Nominal Thickness	tn	80	
Flange Material		SA-105	
Flange Type		Slip on	
Corrosion Allowance	can	3.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	100.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	3.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	4.8000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Pad Material		SA-516 70	
Pad Allowable Stress at Temperature	Sp	137.90	N./mm²
Pad Allowable Stress At Ambient	Spa	137.90	N./mm²
Diameter of Pad along vessel surface	Dp	162.0000	mm.
Thickness of Pad	te	5.0000	mm.
Weld leg size between Pad and Shell	Wp	3.0000	mm.
Groove weld depth between Pad and Nozzle	Wgpn	4.8000	mm.

```
Reinforcing Pad Width                                50.8375  mm.

Class of attached Flange                            150
Grade of attached Flange                            GR 1.1
```

The Pressure Design option was Design Pressure + static head.

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



Insert/Set-in Nozzle With Pad, no Inside projection

Reinforcement CALCULATION, Description: Drain - 2"

ASME Code, Section VIII, Div. 1, 2017, UG-37 to UG-45

```
Actual Outside Diameter Used in Calculation           2.375  in.
Actual Thickness Used in Calculation                  0.191  in.
```

Nozzle input data check completed without errors.

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

```
 = (P*K1*D))/(2*Sv*E-0.2*P) per UG-37(a)(3)
 = (0.2*0.889*452.1)/(2 *117.9*1-0.2*0.2)
 = 0.0341 mm.
```

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

```
 = (P*Ro)/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
 = (0.2*30.16)/(117.9*1+0.4*0.2)
 = 0.0051 mm.
```

Required Nozzle thickness under External Pressure per UG-28 : 0.0935 mm.

UG-40, Limits of Reinforcement : [Internal Pressure]

```
Parallel to Vessel Wall (Diameter Limit)            Dl   113.2698  mm.
Parallel to Vessel Wall, opening length              d    56.6349  mm.
Normal to Vessel Wall (Thickness Limit), pad side Tlwp     6.3906  mm.
```

Note: The Pad diameter is greater than the Diameter Limit. The excess will not be considered.

Weld Strength Reduction Factor [fr1]:

```
 = min( 1, Sn/Sv )
 = min( 1, 117.9/117.9 )
 = 1.000
```

Weld Strength Reduction Factor [fr2]:

```
 = min( 1, Sn/Sv )
```

= min(1, 117.9/117.9)
= 1.000

Weld Strength Reduction Factor [fr4]:
= min(1, Sp/Sv)
= min(1, 137.9/117.9)
= 1.000

Weld Strength Reduction Factor [fr3]:
= min(fr2, fr4)
= min(1, 1)
= 1.000

Results of Nozzle Reinforcement Area Calculations: (cm^2)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	0.019	0.425	NA
Area in Shell	A1	1.428	0.598	NA
Area in Nozzle Wall	A2	0.235	0.224	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	0.064	0.064	NA
Area in Element	A5	1.985	1.985	NA
TOTAL AREA AVAILABLE	Atot	3.713	2.872	NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Sufficient.
The area available with the given pad is Sufficient.

Area Required [A]:
= 0.5(d * tr*F + 2 * tn * tr*F(1-fr1)) per UG-37(d)
= 0.5(56.63*1.5*1+2*1.845*1.5*1(1-1))
= 0.425 cm^2

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)
= 56.63 (1 * 2.556 - 1 * 1.5) - 2 * 1.845
(1 * 2.556 - 1 * 1.5) * (1 - 1)
= 0.598 cm^2

Area Available in Nozzle Wall Projecting Outward [A2]:
= (2 * Tlwp) * (tn - trn) * fr2
= (2 * 6.391) * (1.845 - 0.0935) * 1
= 0.224 cm^2

Area Available in Welds [A41 + A42 + A43]:
= $(Wo^2$ - Ar Lost)*Fr3+((Wi-can/0.707$)^2$ - Ar Lost)*fr2 + Wp^2*fr4
= (0.0641) * 1 + (0) * 1 + 0^2 * 1
= 0.064 cm^2

Area Available in Element, also see UG-37(h) [A5]:
= (min(Dp,DL)-(Nozzle OD))(min(tp,Tlwp,te)) * fr4 * 0.75

```
 = ( 113.3 - 60.33 )5 * 1 * 0.75
 = 1.985 cm²
```

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

```
Wall Thickness for Internal/External pressures      ta = 3.0935 mm.
Wall Thickness per UG16(b),                      tr16b = 4.5000 mm.
Wall Thickness, shell/head, internal pressure     trb1 = 3.0377 mm.
Wall Thickness                 tb1 = max(trb1, tr16b) = 4.5000 mm.
Wall Thickness                 tb2 = max(trb2, tr16b) = 4.5000 mm.
Wall Thickness per table UG-45                     tb3 = 6.4200 mm.
```

Determine Nozzle Thickness candidate [tb]:

```
 = min[ tb3, max( tb1,tb2) ]
 = min[ 6.42, max( 4.5, 4.5 ) ]
 = 4.5000 mm.
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:

```
 = max( ta, tb )
 = max( 3.094, 4.5 )
 = 4.5000 mm.
```

Available Nozzle Neck Thickness = 4.8450 mm. --> OK

Stresses on Nozzle due to External and Pressure Loads per the ASME B31.3 Piping Code (see 319.4.4 and 302.3.5):

```
Sustained  :     34.8,  Allowable :    117.9 N./mm²  Passed
Expansion  :      0.0,  Allowable :    260.0 N./mm²  Passed
Occasional :      0.1,  Allowable :    156.8 N./mm²  Passed
Shear      :     24.0,  Allowable :     82.5 N./mm²  Passed
```

Note : The number of cycles on this nozzle was assumed to be 7000 or less for the determination of the expansion stress allowable.

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld, Curve: B

Govrn. thk, tg = 4.845, tr = 0.00512, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.00278, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve B            -29 °C
Min Metal Temp. at Required thickness (UCS 66.1)         -104 °C
```

Nozzle Neck to Pad Weld for the Nozzle, Curve: B

Govrn. thk, tg = 4.845, tr = 0.00512, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.00278, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve B            -29 °C
Min Metal Temp. at Required thickness (UCS 66.1)         -104 °C
```

Nozzle Neck to Pad Weld for Reinforcement pad, Curve: B

Govrn. thk, tg = 4.845, tr = 0.00512, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.00278, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve B            -29 °C
```

```
Min Metal Temp. at Required thickness (UCS 66.1)          -104 °C
```

Shell to Pad Weld Junction at Pad OD, Curve: B

Govrn. thk, tg = 5, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.0133, Temp. Reduction = 78 °C
Pad governing, Conservatively assuming Pad stress = Shell stress(Div. 1 L-9.3).

```
Min Metal Temp. w/o impact per UCS-66, Curve B             -29 °C
Min Metal Temp. at Required thickness (UCS 66.1)          -104 °C
```

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: B

Govrn. thk, tg = 4.845, tr = 0.00512, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.00278, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve B             -29 °C
Min Metal Temp. at Required thickness (UCS 66.1)          -104 °C

Governing MDMT of the Nozzle                           :  -104 °C
Governing MDMT of the Reinforcement Pad                :  -104 °C
Governing MDMT of all the sub-joints of this Junction  :  -104 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c)     -29 °C
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b)      -104 °C
Flange MDMT with Temp reduction per UCS-66(b)(1)(-c)      -104 °C
```

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :
Design Pressure/Ambient Rating = 0.20/19.60 = 0.010

Note:
Using the min value from (b)(1)(-b) and (b)(1)(-c) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: Drain - 2"

```
Intermediate Calc. for nozzle/shell Welds    Tmin       1.8450   mm.
Intermediate Calc. for pad/shell Welds    TminPad       3.3500   mm.
```

Results Per UW-16.1:

```
                      Required Thickness    Actual Thickness
Nozzle Weld          1.2915 = 0.7 * tmin.  2.1210 = 0.7 * Wo mm.
Pad Weld             1.6750 = 0.5*TminPad  2.1210 = 0.7 * Wp mm.
```

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

Weld Load [W]:

```
 = max( 0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)
 = max( 0, (0.425 - 0.598 + 2 * 1.845 * 1 *
   (1 * 2.556 - 1.5 ) )117.9 )
 = max( 0, -161.67) Kgf
```

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

Weld Load [W1]:

```
 = (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
```

```
 = ( 0.224 + 1.985 + 0.0641 - 0 * 1 ) * 117.9
 = 2733.24 Kgf
```

Weld Load [W2]:

```
 = (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
 = ( 0.224 + 0 + 0.09 + ( 0.0943 ) ) * 117.9
 = 490.76 Kgf
```

Weld Load [W3]:

```
 = (A2+A3+A4+A5+(2*tn*t*fr1))*S
 = ( 0.224 + 0 + 0.0641 + 1.985 + ( 0.0943 ) ) * 117.9
 = 2846.64 Kgf
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

```
 = (pi/2) * Dlo * Wo * 0.49 * Snw
 = ( 3.142/2.0 ) * 60.33 * 3 * 0.49 * 117.9
 = 1675. Kgf
```

Shear, Pad Element Weld [Spew]:

```
 = (pi/2) * DP * WP * 0.49 * SEW
 = ( 3.142/2.0 ) * 162 * 3 * 0.49 * 117.9
 = 4497. Kgf
```

Shear, Nozzle Wall [Snw]:

```
 = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
 = (3.142 * 29.24 ) * ( 4.845 - 3 ) * 0.7 * 117.9
 = 1426. Kgf
```

Tension, Pad Groove Weld [Tpgw]:

```
 = ( pi/2) * Dlo * Wgpn * 0.74 * Seg
 =  (3.142/2 ) * 60.33 * 4.8 * 0.74 * 137.9
 = 4733. Kgf
```

Tension, Shell Groove Weld [Tngw]:

```
 = (pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
 = ( 3.142/2.0 ) * 60.33 * ( 4.8 - 3 ) * 0.74 * 117.9
 = 1517. Kgf
```

Strength of Failure Paths:

```
 PATH11 = ( SPEW + SNW ) = ( 4497 + 1426 ) = 5924 Kgf
 PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
        = ( 1675 + 4733 + 1517 + 0 ) = 7925 Kgf
 PATH33 = ( Spew + Tngw + Sinw )
        = ( 4497 + 1517 + 0 ) = 6015 Kgf
```

Summary of Failure Path Calculations:

```
Path 1-1 = 5923 Kgf, must exceed W = 0 Kgf or W1 = 2733 Kgf
Path 2-2 = 7925 Kgf, must exceed W = 0 Kgf or W2 = 490 Kgf
Path 3-3 = 6014 Kgf, must exceed W = 0 Kgf or W3 = 2846 Kgf
```

Maximum Allowable Pressure for this Nozzle at this Location:

```
Converged Max. Allow. Pressure in Operating case        9.825  bars
```

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

Nozzle is O.K. for the External Pressure 0.100 bars

The Drop for this Nozzle is : 1.1222 mm.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 106.6784 mm.

Input Echo, WRC107/537 Item 1, Description: Drain - 2" :

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Spherical	
Internal Corrosion Allowance	Cas	3.0000	mm.
Vessel Diameter	Dv	802.957	mm.
Vessel Thickness	Tv	5.556	mm.
Design Temperature	T1	85.0	°C
Vessel Material		SA-234 WPB	
Vessel UNS Number		K03006	
Vessel Cold S.I. Allowable	Smc	117.90	N./mm²
Vessel Hot S.I. Allowable	Smh	117.90	N./mm²

Note:
Using 2 * Yield for Discontinuity Stress Allowable (Div 2, 4.1.6.3), Sps.
Make sure that material properties at this temperature are not
time-dependent for Material: SA-234 WPB

Attachment Type	Type	Round	
WRC107 Attachment Classification	Holsol	Hollow	
Diameter Basis for Nozzle	Nbasis	OD	
Corrosion Allowance for Nozzle	Can	3.0000	mm.
Nozzle Diameter	Dn	60.325	mm.
Nozzle Thickness	Tn	4.845	mm.
Nozzle Material		SA-106 B	
Nozzle UNS Number		K03006	
Nozzle Cold S.I. Allowable	SNmc	117.90	N./mm²
Nozzle Hot S.I. Allowable	SNmh	117.90	N./mm²
Thickness of Reinforcing Pad	Tpad	5.000	mm.
Diameter of Reinforcing Pad	Dpad	162.000	mm.
Design Internal Pressure	Dp	0.200	bars
Include Pressure Thrust		No	

External Forces and Moments in WRC 107/537 Convention:

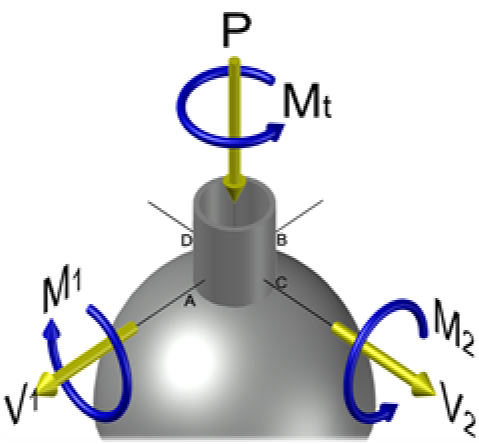
Radial Load	(SUS)		P	-51.8	Kgf
Longitudinal Shear	(SUS)	(Vl)	V1	64.9	Kgf
Circumferential Shear	(SUS)	(Vc)	V2	64.9	Kgf
Circumferential Moment	(SUS)	(Mc)	M1	-11.0	Kg-m.
Longitudinal Moment	(SUS)	(Ml)	M2	13.9	Kg-m.
Torsional Moment	(SUS)		Mt	17.5	Kg-m.

Use Interactive Control No
WRC107 Version Version March 1979

Include Pressure Stress Indices per Div. 2 No

Compute Pressure Stress per WRC-368	No
Local Loads applied at end of Nozzle/Attachment	No

Note:
WRC Bulletin 537 provides equations for the dimensionless curves found in bulletin 107. As noted in the foreword to bulletin 537, "537 is equivalent to WRC 107". Where 107 is printed in the results below, "537" can be interchanged with "107".



Stress Attenuation Diameter (for Insert Plates) per WRC 297:
= NozzleOD + 2 * 1.65 * sqrt(Rmean(t - ca))
= 60.325 + 2 * 1.65 * sqrt(405.757 (5.556 - 3.0))
= 166.604 mm.

WRC 107 Stress Calculation for SUStained loads:

Radial Load		P	-51.8	Kgf
Circumferential Shear	(VC)	V2	64.9	Kgf
Longitudinal Shear	(VL)	V1	64.9	Kgf
Circumferential Moment	(MC)	M1	-11.0	Kg-m.
Longitudinal Moment	(ML)	M2	13.9	Kg-m.
Torsional Moment		MT	17.5	Kg-m.

Dimensionless Parameters: U = 0.54 TAU = 15.85 RHO = 4.10

Dimensionless Loads for Spherical Shells at Attachment Junction:

Curves read for 1979	Figure	Value	Location
N(x) * T / P	SP 7	0.03318	(A,B,C,D)
M(x) / P	SP 7	0.01759	(A,B,C,D)
N(x) * T * SQRT(Rm * T) / MC	SM 7	0.08158	(A,B,C,D)
M(x) * SQRT(Rm * T) / MC	SM 7	0.04551	(A,B,C,D)
N(x) * T * SQRT(Rm * T) / ML	SM 7	0.08158	(A,B,C,D)
M(x) * SQRT(Rm * T) / ML	SM 7	0.04551	(A,B,C,D)
N(y) * T / P	SP 7	0.30040	(A,B,C,D)
M(y) / P	SP 7	0.07006	(A,B,C,D)
N(y) * T * SQRT(Rm * T) / MC	SM 7	0.38018	(A,B,C,D)
M(y) * SQRT(Rm * T) / MC	SM 7	0.21405	(A,B,C,D)
N(y) * T * SQRT(Rm * T) / ML	SM 7	0.38018	(A,B,C,D)
M(y) * SQRT(Rm * T) / ML	SM 7	0.21405	(A,B,C,D)

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction (N./mm²)

Type of Stress Load	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Rad. Memb. P	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Rad. Bend. P	0.9	-0.9	0.9	-0.9	0.9	-0.9	0.9	-0.9
Rad. Memb. MC	0.0	0.0	0.0	0.0	2.8	2.8	-2.8	-2.8
Rad. Memb. MC	0.0	0.0	0.0	0.0	9.3	-9.3	-9.3	9.3
Rad. Memb. ML	-3.5	-3.5	3.5	3.5	0.0	0.0	0.0	0.0
Rad. Bend. ML	-11.7	11.7	11.7	-11.7	0.0	0.0	0.0	0.0
Tot. Rad. Str.	-14.0	7.6	16.4	-8.9	13.3	-7.2	-10.8	5.9
Tang. Memb. P	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
Tang. Bend. P	3.7	-3.7	3.7	-3.7	3.7	-3.7	3.7	-3.7
Tang. Memb. MC	0.0	0.0	0.0	0.0	12.9	12.9	-12.9	-12.9
Tang. Bend. MC	0.0	0.0	0.0	0.0	43.7	-43.7	-43.7	43.7
Tang. Memb. ML	-16.3	-16.3	16.3	16.3	0.0	0.0	0.0	0.0
Tang. Bend. ML	-55.1	55.1	55.1	-55.1	0.0	0.0	0.0	0.0
Tot. Tang. Str.	-65.0	37.7	77.8	-39.8	63.1	-31.9	-50.3	29.7
Shear VC	0.9	0.9	-0.9	-0.9	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-0.9	-0.9	0.9	0.9
Shear MT	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Tot. Shear	4.9	4.9	3.1	3.1	3.1	3.1	4.9	4.9
Str. Int.	65.4	38.5	77.9	40.1	63.3	32.2	50.9	30.7

Unitless Prm: U = 2.52 TAU = 0.00 (43.40) RHO = 0.00 (1.39)

Dimensionless Loads for Spherical Shells at Pad edge:

Curves read for 1979	Figure	Value	Location
N(x) * T / P	SR 2	0.02175	(A,B,C,D)
M(x) / P	SR 2	0.00990	(A,B,C,D)
N(x) * T * SQRT(Rm * T) / MC	SR 3	0.01691	(A,B,C,D)
M(x) * SQRT(Rm * T) / MC	SR 3	0.01053	(A,B,C,D)
N(x) * T * SQRT(Rm * T) / ML	SR 3	0.01691	(A,B,C,D)
M(x) * SQRT(Rm * T) / ML	SR 3	0.01053	(A,B,C,D)
N(y) * T / P	SR 2	0.00650	(A,B,C,D)
M(y) / P	SR 2	0.00300	(A,B,C,D)
N(y) * T * SQRT(Rm * T) / MC	SR 3	0.00507	(A,B,C,D)
M(y) * SQRT(Rm * T) / MC	SR 3	0.00317	(A,B,C,D)
N(y) * T * SQRT(Rm * T) / ML	SR 3	0.00507	(A,B,C,D)
M(y) * SQRT(Rm * T) / ML	SR 3	0.00317	(A,B,C,D)

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Edge of Reinforcing Pad (N./mm²)

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Rad. Memb. P	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Rad. Bend. P	4.6	-4.6	4.6	-4.6	4.6	-4.6	4.6	-4.6
Rad. Memb. MC	0.0	0.0	0.0	0.0	8.7	8.7	-8.7	-8.7
Rad. Memb. MC	0.0	0.0	0.0	0.0	32.4	-32.4	-32.4	32.4
Rad. Memb. ML	-10.9	-10.9	10.9	10.9	0.0	0.0	0.0	0.0
Rad. Bend. ML	-40.8	40.8	40.8	-40.8	0.0	0.0	0.0	0.0
Tot. Rad. Str.	-45.4	27.0	58.1	-32.8	47.4	-26.7	-34.8	20.8
Tang. Memb. P	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Tang. Bend. P	1.4	-1.4	1.4	-1.4	1.4	-1.4	1.4	-1.4
Tang. Memb. MC	0.0	0.0	0.0	0.0	2.6	2.6	-2.6	-2.6
Tang. Bend. MC	0.0	0.0	0.0	0.0	9.8	-9.8	-9.8	9.8
Tang. Memb. ML	-3.3	-3.3	3.3	3.3	0.0	0.0	0.0	0.0
Tang. Bend. ML	-12.3	12.3	12.3	-12.3	0.0	0.0	0.0	0.0
Tot. Tang. Str.	-13.7	8.1	17.5	-9.9	14.3	-8.1	-10.5	6.3
Shear VC	1.0	1.0	-1.0	-1.0	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-1.0	-1.0	1.0	1.0
Shear MT	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Tot. Shear	2.6	2.6	0.7	0.7	0.7	0.7	2.6	2.6
Str. Int.	45.7	27.3	58.1	32.8	47.4	26.7	35.1	21.3

WRC 107/537 Stress Summations:

Vessel Stress Summation at Attachment Junction (N./mm²)

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Rad. Pm (SUS)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Rad. Pl (SUS)	-3.2	-3.2	3.8	3.8	3.1	3.1	-2.5	-2.5
Rad. Q (SUS)	-10.8	10.8	12.6	-12.6	10.2	-10.2	-8.4	8.4
Long. Pm (SUS)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Long. Pl (SUS)	-13.6	-13.6	19.0	19.0	15.6	15.6	-10.3	-10.3
Long. Q (SUS)	-51.3	51.3	58.8	-58.8	47.5	-47.5	-40.0	40.0
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	0.9	0.9	-0.9	-0.9	-0.9	-0.9	0.9	0.9
Shear Q (SUS)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Pm (SUS)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Pm+Pl (SUS)	13.2	13.2	19.6	19.6	16.2	16.2	9.8	9.8

Pm+Pl+Q (Total)	64.9	39.0	78.5	39.6	63.8	31.7	50.3	31.2

Vessel Stress Summation Comparison (N./mm²):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	0.54	117.90	Passed
Pm+Pl (SUS)	19.56	176.86	Passed
Pm+Pl+Q (TOTAL)	78.48	353.71	Passed

*Because only sustained loads were specified, the Pm+Pl+Q allowable was 3 * Smh.*

WRC 107/537 Stress Summations:

Vessel Stress Summation at Reinforcing Pad Edge (N./mm²)

Type of Stress Load	Stress Intensity Values at							
	Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Rad. Pm (SUS)	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Rad. Pl (SUS)	-9.2	-9.2	12.6	12.6	10.4	10.4	-7.0	-7.0
Rad. Q (SUS)	-36.2	36.2	45.4	-45.4	37.0	-37.0	-27.8	27.8
Long. Pm (SUS)	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Long. Pl (SUS)	-2.8	-2.8	3.8	3.8	3.1	3.1	-2.1	-2.1
Long. Q (SUS)	-10.9	10.9	13.7	-13.7	11.2	-11.2	-8.4	8.4
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	1.0	1.0	-1.0	-1.0	-1.0	-1.0	1.0	1.0
Shear Q (SUS)	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Pm (SUS)	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Pm+Pl (SUS)	7.8	7.8	14.3	14.3	12.1	12.1	5.6	5.6
Pm+Pl+Q (Total)	44.1	28.9	59.7	31.2	49.0	25.1	33.5	22.8

Vessel Stress Summation Comparison (N./mm²):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	1.58	117.90	Passed
Pm+Pl (SUS)	14.31	176.86	Passed
Pm+Pl+Q (TOTAL)	59.65	353.71	Passed

*Because only sustained loads were specified, the Pm+Pl+Q allowable was 3 * Smh.*

Input, Nozzle Desc: Gas In - 6" From: 20

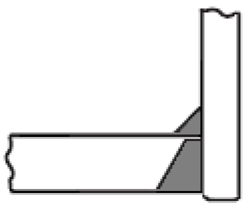
Pressure for Reinforcement Calculations	P	0.200	bars
Temperature for Internal Pressure	Temp	85	°C
Design External Pressure	Pext	0.10	bars
Temperature for External Pressure	Tempex	85	°C
Shell Material		SA-516 70	
Shell Allowable Stress at Temperature	Sv	137.90	N./mm²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm²
Inside Diameter of Cylindrical Shell	D	441.20	mm.
Design Length of Section	L	1537.1740	mm.
Shell Finished (Minimum) Thickness	t	8.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		285.50	mm.
User Entered Minimum Design Metal Temperature		-5.00	°C

Type of Element Connected to the Shell : Nozzle

Material		SA-106 B	
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	117.90	N./mm²
Allowable Stress At Ambient	Sna	117.90	N./mm²
Diameter Basis (for tr calc only)		OD	
Layout Angle		180.00	deg
Diameter		6.0000	in.
Size and Thickness Basis		Minimum	
Nominal Thickness	tn	STD	
Flange Material		SA-105	
Flange Type		Slip on	
Corrosion Allowance	can	3.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	150.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	4.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	6.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Class of attached Flange		150	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

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



Insert/Set-in Nozzle No Pad, no Inside projection

Reinforcement CALCULATION, Description: Gas In - 6"

ASME Code, Section VIII, Div. 1, 2017, UG-37 to UG-45

```
Actual Outside Diameter Used in Calculation            6.625  in.
Actual Thickness Used in Calculation                   0.245  in.
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, Tr [Int. Press]
```
 = (P*R)/(Sv*E-0.6*P) per UG-27 (c)(1)
 = (0.2*223.6)/(137.9*1-0.6*0.2)
 = 0.0325 mm.
```

The Longitudinal Stress Governs over the Hoop Stress on the shell course where this nozzle is located. The Maximum stress ratio times the Shell thickness will be used in the calculation of the Area required.

The Stress Ratio is 0.0282 and the shell thk. is 8.0000 mm.

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]
```
 = (P*Ro)/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
 = (0.2*84.14)/(117.9*1+0.4*0.2)
 = 0.0143 mm.
```

Required Nozzle thickness under External Pressure per UG-28 : 0.2031 mm.

UG-40, Limits of Reinforcement : [Internal Pressure]
```
Parallel to Vessel Wall (Diameter Limit)            Dl   323.6580  mm.
Parallel to Vessel Wall, opening length              d   161.8290  mm.
Normal to Vessel Wall (Thickness Limit), no pad   Tlnp     8.0575  mm.
```

Weld Strength Reduction Factor [fr1]:
```
 = min( 1, Sn/Sv )
 = min( 1, 117.9/137.9 )
 = 0.855
```

Weld Strength Reduction Factor [fr2]:
```
 = min( 1, Sn/Sv )
 = min( 1, 117.9/137.9 )
 = 0.855
```

Weld Strength Reduction Factor [fr3]:
```
 = min( fr2, fr4 )
```

```
 = min( 0.855, 1 )
 = 0.855
```

Results of Nozzle Reinforcement Area Calculations: (cm^2)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	0.229	0.774	NA
Area in Shell	A1	7.818	6.515	NA
Area in Nozzle Wall	A2	0.442	0.416	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	0.137	0.137	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	8.397	7.068	NA

The External Pressure Case Governs the Analysis.

```
Nozzle Angle Used in Area Calculations                      90.00  Degs.
```

The area available without a pad is Sufficient.

Area Required [A]:
```
 = 0.5( d * tr*F + 2 * tn * tr*F(1-fr1) ) per UG-37(d)
 = 0.5(161.8*0.951*1+2*3.223*0.951*1(1-0.855))
 = 0.774 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 )
 = 161.8 ( 1 * 5 - 1 * 0.951 ) - 2 * 3.223
   ( 1 * 5 - 1 * 0.951 ) * ( 1 - 0.855 )
 = 6.515 cm²
```

Area Available in Nozzle Projecting Outward [A2]:
```
 = ( 2 * tlnp )( tn - trn )fr2
 = ( 2 * 8.057 )( 3.223 - 0.203 )0.855
 = 0.416 cm²
```

Area Available in Inward Weld + Outward Weld [A41 + A43]:
```
 = Wo² * fr2 + ( Wi-can/0.707 )² * fr2
 = 4² * 0.855 + ( 0 )² * 0.855
 = 0.137 cm²
```

UG-45 Minimum Nozzle Neck Thickness Requirement: [Int. Press.]
```
Wall Thickness for Internal/External pressures      ta = 3.2031 mm.
Wall Thickness per UG16(b),                      tr16b = 4.5000 mm.
Wall Thickness, shell/head, internal pressure     trb1 = 3.0325 mm.
Wall Thickness                 tb1 = max(trb1, tr16b) = 4.5000 mm.
Wall Thickness                 tb2 = max(trb2, tr16b) = 4.5000 mm.
Wall Thickness per table UG-45                     tb3 = 9.2200 mm.
```

Determine Nozzle Thickness candidate [tb]:
```
 = min[ tb3, max( tb1,tb2) ]
 = min[ 9.22, max( 4.5, 4.5 ) ]
 = 4.5000 mm.
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:

```
 = max( ta, tb )
 = max( 3.203, 4.5 )
 = 4.5000 mm.
```

Available Nozzle Neck Thickness = 6.2230 mm. --> OK

Stresses on Nozzle due to External and Pressure Loads per the ASME B31.3 Piping Code (see 319.4.4 and 302.3.5):

```
Sustained  :     19.1,  Allowable :    117.9 N./mm²  Passed
Expansion  :      0.0,  Allowable :    275.6 N./mm²  Passed
Occasional :      0.2,  Allowable :    156.8 N./mm²  Passed
Shear      :     13.1,  Allowable :     82.5 N./mm²  Passed
```

Note : The number of cycles on this nozzle was assumed to be 7000 or less for the determination of the expansion stress allowable.

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld, Curve: B

Govrn. thk, tg = 6.223, tr = 0.0143, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.00443, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve B             -29 °C
Min Metal Temp. at Required thickness (UCS 66.1)          -104 °C
```

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: B

Govrn. thk, tg = 6.223, tr = 0.0143, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.00443, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve B             -29 °C
Min Metal Temp. at Required thickness (UCS 66.1)          -104 °C

Governing MDMT of all the sub-joints of this Junction  :  -104 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c)     -29 °C
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b)      -104 °C
Flange MDMT with Temp reduction per UCS-66(b)(1)(-c)      -104 °C
```

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :
Design Pressure/Ambient Rating = 0.20/19.60 = 0.010

Note:
Using the min value from (b)(1)(-b) and (b)(1)(-c) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: Gas In - 6"

```
Intermediate Calc. for nozzle/shell Welds   Tmin      3.2230  mm.
```

Results Per UW-16.1:

```
                      Required Thickness    Actual Thickness
Nozzle Weld          2.2561 = 0.7 * tmin.  2.8280 = 0.7 * Wo mm.
```

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

Weld Load [W]:
```
 = max( 0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)
 = max( 0, (0.774 - 6.515 + 2 * 3.223 * 0.855 *
   (1 * 5 - 0.951 ) )137.9 )
 = max( 0, -7758.53) Kgf
```

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

Weld Load [W1]:
```
 = (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
 = ( 0.416 + 0 + 0.137 - 0 * 0.855 ) * 137.9
 = 777.46 Kgf
```

Weld Load [W2]:
```
 = (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
 = ( 0.416 + 0 + 0.137 + ( 0.276 ) ) * 137.9
 = 1164.96 Kgf
```

Weld Load [W3]:
```
 = (A2+A3+A4+A5+(2*tn*t*fr1))*S
 = ( 0.416 + 0 + 0.137 + 0 + ( 0.276 ) ) * 137.9
 = 1164.96 Kgf
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:
```
 = (pi/2) * Dlo * Wo * 0.49 * Snw
 = ( 3.142/2.0 ) * 168.3 * 4 * 0.49 * 117.9
 = 6229. Kgf
```

Shear, Nozzle Wall [Snw]:
```
 = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
 = (3.142 * 82.53 ) * ( 6.223 - 3 ) * 0.7 * 117.9
 = 7032. Kgf
```

Tension, Shell Groove Weld [Tngw]:
```
 = (pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
 = ( 3.142/2.0 ) * 168.3 * ( 6 - 3 ) * 0.74 * 137.9
 = 8251. Kgf
```

Strength of Failure Paths:

```
 PATH11 = ( SONW + SNW ) = ( 6229 + 7032 ) = 13261 Kgf
 PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
        = ( 6229 + 0 + 8251 + 0 ) = 14480 Kgf
 PATH33 = ( Sonw + Tngw + Sinw )
        = ( 6229 + 8251 + 0 ) = 14480 Kgf
```

Summary of Failure Path Calculations:
```
Path 1-1 = 13261 Kgf, must exceed W = 0 Kgf or W1 = 777 Kgf
Path 2-2 = 14480 Kgf, must exceed W = 0 Kgf or W2 = 1164 Kgf
Path 3-3 = 14480 Kgf, must exceed W = 0 Kgf or W3 = 1164 Kgf
```

Maximum Allowable Pressure for this Nozzle at this Location:
```
Converged Max. Allow. Pressure in Operating case      16.024  bars
```

The Drop for this Nozzle is : 16.6754 mm.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 174.6754 mm.

Input Echo, WRC107/537 Item 1, Description: Gas In - 6" :

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	3.0000	mm.
Vessel Diameter	Dv	441.200	mm.
Vessel Thickness	Tv	8.000	mm.
Design Temperature	T1	85.0	°C
Vessel Material		SA-516 70	
Vessel UNS Number		K02700	
Vessel Cold S.I. Allowable	Smc	137.90	N./mm²
Vessel Hot S.I. Allowable	Smh	137.90	N./mm²

Note:
Using 2 * Yield for Discontinuity Stress Allowable (Div 2, 4.1.6.3), Sps.
Make sure that material properties at this temperature are not
time-dependent for Material: SA-516 70

Attachment Type	Type	Round	
Diameter Basis for Nozzle	Nbasis	OD	
Corrosion Allowance for Nozzle	Can	3.0000	mm.
Nozzle Diameter	Dn	168.275	mm.
Nozzle Thickness	Tn	6.223	mm.
Nozzle Material		SA-106 B	
Nozzle UNS Number		K03006	
Nozzle Cold S.I. Allowable	SNmc	117.90	N./mm²
Nozzle Hot S.I. Allowable	SNmh	117.90	N./mm²
Design Internal Pressure	Dp	0.200	bars
Include Pressure Thrust		No	

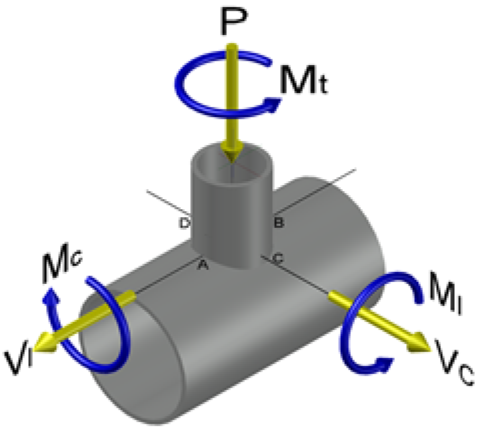
External Forces and Moments in WRC 107/537 Convention:

Radial Load	(SUS)	P	-144.4	Kgf
Longitudinal Shear	(SUS)	Vl	180.7	Kgf
Circumferential Shear	(SUS)	Vc	180.7	Kgf
Circumferential Moment	(SUS)	Mc	-84.4	Kg-m.
Longitudinal Moment	(SUS)	Ml	106.9	Kg-m.
Torsional Moment	(SUS)	Mt	136.2	Kg-m.

Use Interactive Control		No
WRC107 Version	Version	March 1979
Include Pressure Stress Indices per Div. 2		No
Compute Pressure Stress per WRC-368		No
Local Loads applied at end of Nozzle/Attachment		No

Note:
WRC Bulletin 537 provides equations for the dimensionless curves
found in bulletin 107. As noted in the foreword to bulletin 537,

"537 is equivalent to WRC 107". Where 107 is printed in the results below, "537" can be interchanged with "107".



Stress Attenuation Diameter (for Insert Plates) per WRC 297:
= NozzleOD + 2 * 1.65 * sqrt(Rmean(t - ca))
= 168.275 + 2 * 1.65 * sqrt(226.1 (8.0 - 3.0))
= 279.231 mm.

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	-144.4	Kgf
Circumferential Shear	VC	180.7	Kgf
Longitudinal Shear	VL	180.7	Kgf
Circumferential Moment	MC	-84.4	Kg-m.
Longitudinal Moment	ML	106.9	Kg-m.
Torsional Moment	MT	136.2	Kg-m.

Dimensionless Parameters used : Gamma = 45.22

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.326	4C	4.512	(A,B)
N(PHI) / (P/Rm)	0.326	3C	2.025	(C,D)
M(PHI) / (P)	0.326	2C1	0.012	(A,B)
M(PHI) / (P)	0.326	1C !	0.064	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.326	3A	1.424	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.326	1A	0.062	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.326	3B	2.834	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.326	1B	0.010	(A,B,C,D)
N(x) / (P/Rm)	0.326	3C	2.025	(A,B)
N(x) / (P/Rm)	0.326	4C	4.512	(C,D)
M(x) / (P)	0.326	1C1	0.031	(A,B)
M(x) / (P)	0.326	2C !	0.033	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.326	4A	4.341	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.326	2A	0.025	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.326	4B	1.534	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.326	2B	0.015	(A,B,C,D)

Note - The ! mark next to the figure name denotes curve value exceeded.

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction (N./mm²)

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	5.7	5.7	5.7	5.7	2.5	2.5	2.5	2.5
Circ. Bend. P	4.2	-4.2	4.2	-4.2	21.7	-21.7	21.7	-21.7
Circ. Memb. MC	0.0	0.0	0.0	0.0	14.2	14.2	-14.2	-14.2
Circ. Memb. MC	0.0	0.0	0.0	0.0	168.0	-168.0	-168.0	168.0
Circ. Memb. ML	-35.7	-35.7	35.7	35.7	0.0	0.0	0.0	0.0
Circ. Bend. ML	-33.1	33.1	33.1	-33.1	0.0	0.0	0.0	0.0
Tot. Circ. Str.	-59.0	-1.1	78.7	4.0	206.5	-173.1	-157.9	134.7
Long. Memb. P	2.5	2.5	2.5	2.5	5.7	5.7	5.7	5.7
Long. Bend. P	10.5	-10.5	10.5	-10.5	11.2	-11.2	11.2	-11.2
Long. Memb. MC	0.0	0.0	0.0	0.0	43.2	43.2	-43.2	-43.2
Long. Bend. MC	0.0	0.0	0.0	0.0	67.0	-67.0	-67.0	67.0
Long. Memb. ML	-19.3	-19.3	19.3	19.3	0.0	0.0	0.0	0.0
Long. Bend. ML	-52.7	52.7	52.7	-52.7	0.0	0.0	0.0	0.0
Tot. Long. Str.	-59.0	25.5	85.1	-41.4	127.0	-29.3	-93.3	18.3
Shear VC	1.3	1.3	-1.3	-1.3	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-1.3	-1.3	1.3	1.3
Shear MT	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Tot. Shear	7.3	7.3	4.7	4.7	4.7	4.7	7.3	7.3
Str. Int.	66.4	30.4	87.5	46.3	206.7	173.2	158.8	135.1

WRC 107/537 Stress Summations:

Vessel Stress Summation at Attachment Junction (N./mm²)

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Circ. Pl (SUS)	-30.0	-30.0	41.3	41.3	16.7	16.7	-11.6	-11.6
Circ. Q (SUS)	-28.9	28.9	37.3	-37.3	189.8	-189.8	-146.3	146.3
Long. Pm (SUS)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Long. Pl (SUS)	-16.8	-16.8	21.9	21.9	48.8	48.8	-37.5	-37.5
Long. Q (SUS)	-42.3	42.3	63.2	-63.2	78.1	-78.1	-55.8	55.8
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	1.3	1.3	-1.3	-1.3	-1.3	-1.3	1.3	1.3

Shear Q (SUS)	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Pm (SUS)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Pm+Pl (SUS)	29.3	29.3	42.3	42.3	49.3	49.3	37.2	37.2
Pm+Pl+Q (Total)	65.7	30.0	88.1	46.8	207.6	172.3	157.9	136.1

Vessel Stress Summation Comparison (N./mm²):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	0.91	137.90	Passed
Pm+Pl (SUS)	49.34	206.85	Passed
Pm+Pl+Q (TOTAL)	207.61	413.70	Passed

*Because only sustained loads were specified, the Pm+Pl+Q allowable was 3 * Smh.*

Input, Nozzle Desc: Vent - 1" **From: 30**

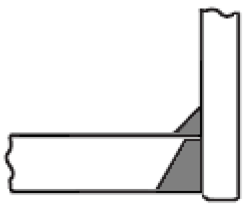
Pressure for Reinforcement Calculations	P	0.200	bars
Temperature for Internal Pressure	Temp	85	°C
Design External Pressure	Pext	0.10	bars
Temperature for External Pressure	Tempex	85	°C
Shell Material		SA-516 70	
Shell Allowable Stress at Temperature	Sv	137.90	N./mm²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm²
Inside Diameter of Cylindrical Shell	D	445.20	mm.
Design Length of Section	L	1537.1738	mm.
Shell Finished (Minimum) Thickness	t	6.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		1335.50	mm.
User Entered Minimum Design Metal Temperature		-5.00	°C

Type of Element Connected to the Shell : Nozzle

Material		SA-106 B	
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	117.90	N./mm²
Allowable Stress At Ambient	Sna	117.90	N./mm²
Diameter Basis (for tr calc only)		OD	
Layout Angle		180.00	deg
Diameter		1.0000	in.
Size and Thickness Basis		Minimum	
Nominal Thickness	tn	160	
Flange Material		SA-105	
Flange Type		Slip on	
Corrosion Allowance	can	3.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	150.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	3.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	5.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Class of attached Flange		150	
Grade of attached Flange		GR 1.1	

The Pressure Design option was Design Pressure + static head.

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



Insert/Set-in Nozzle No Pad, no Inside projection

Reinforcement CALCULATION, Description: Vent - 1"

ASME Code, Section VIII, Div. 1, 2017, UG-37 to UG-45

```
Actual Outside Diameter Used in Calculation          1.315  in.
Actual Thickness Used in Calculation                 0.219  in.
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, Tr [Int. Press]
```
 = (P*R)/(Sv*E-0.6*P) per UG-27 (c)(1)
 = (0.2*225.6)/(137.9*1-0.6*0.2)
 = 0.0327 mm.
```

The Longitudinal Stress Governs over the Hoop Stress on the shell course where this nozzle is located. The Maximum stress ratio times the Shell thickness will be used in the calculation of the Area required.

The Stress Ratio is 0.0914 and the shell thk. is 6.0000 mm.

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]
```
 = (P*Ro)/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
 = (0.2*16.7)/(117.9*1+0.4*0.2)
 = 0.0028 mm.
```

Required Nozzle thickness under External Pressure per UG-28 : 0.0784 mm.

UG-40, Limits of Reinforcement : [Internal Pressure]
```
Parallel to Vessel Wall (Diameter Limit)            Dl    56.5770  mm.
Parallel to Vessel Wall, opening length              d    28.2885  mm.
Normal to Vessel Wall (Thickness Limit), no pad   Tlnp     6.3906  mm.
```

Weld Strength Reduction Factor [fr1]:
```
 = min( 1, Sn/Sv )
 = min( 1, 117.9/137.9 )
 = 0.855
```

Weld Strength Reduction Factor [fr2]:
```
 = min( 1, Sn/Sv )
 = min( 1, 117.9/137.9 )
 = 0.855
```

Weld Strength Reduction Factor [fr3]:
```
 = min( fr2, fr4 )
```

= min(0.855, 1)
= 0.855

Results of Nozzle Reinforcement Area Calculations: (cm^2)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	0.080	0.138	NA
Area in Shell	A1	0.751	0.564	NA
Area in Nozzle Wall	A2	0.279	0.271	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	0.077	0.077	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	1.107	0.912	NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Sufficient.

Area Required [A]:
= 0.5(d * tr*F + 2 * tn * tr*F(1-fr1)) per UG-37(d)
= 0.5(28.29*0.951*1+2*2.556*0.951*1(1-0.855))
= 0.138 cm^2

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)
= 28.29 (1 * 3 - 1 * 0.951) - 2 * 2.556
(1 * 3 - 1 * 0.951) * (1 - 0.855)
= 0.564 cm^2

Area Available in Nozzle Projecting Outward [A2]:
= (2 * tlnp)(tn - trn)fr2
= (2 * 6.391)(2.556 - 0.0784)0.855
= 0.271 cm^2

Area Available in Inward Weld + Outward Weld [A41 + A43]:
= Wo^2 * fr2 + (Wi-can/0.707)^2 * fr2
= 3^2 * 0.855 + (0)^2 * 0.855
= 0.077 cm^2

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

Wall Thickness for Internal/External pressures ta = 3.0784 mm.
Wall Thickness per UG16(b), tr16b = 4.5000 mm.
Wall Thickness, shell/head, internal pressure trb1 = 3.0327 mm.
Wall Thickness tb1 = max(trb1, tr16b) = 4.5000 mm.
Wall Thickness tb2 = max(trb2, tr16b) = 4.5000 mm.
Wall Thickness per table UG-45 tb3 = 5.9464 mm.

Determine Nozzle Thickness candidate [tb]:
= min[tb3, max(tb1,tb2)]
= min[5.946, max(4.5, 4.5)]
= 4.5000 mm.

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
```
 = max( ta, tb )
 = max( 3.078, 4.5 )
 = 4.5000 mm.
```

Available Nozzle Neck Thickness = 5.5563 mm. --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld, Curve: B

Govrn. thk, tg = 5.556, tr = 0.00283, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.00111, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve B          -29 °C
Min Metal Temp. at Required thickness (UCS 66.1)       -104 °C
```

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: B

Govrn. thk, tg = 5.556, tr = 0.00283, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.00111, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve B          -29 °C
Min Metal Temp. at Required thickness (UCS 66.1)       -104 °C

Governing MDMT of all the sub-joints of this Junction  :  -104 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c)     -29 °C
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b)      -104 °C
Flange MDMT with Temp reduction per UCS-66(b)(1)(-c)      -104 °C
```

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :
Design Pressure/Ambient Rating = 0.20/19.60 = 0.010

Note:
Using the min value from (b)(1)(-b) and (b)(1)(-c) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: Vent - 1"

```
Intermediate Calc. for nozzle/shell Welds   Tmin      2.5562  mm.
```

Results Per UW-16.1:

```
                      Required Thickness    Actual Thickness
Nozzle Weld          1.7894 = 0.7 * tmin.  2.1210 = 0.7 * Wo mm.
```

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

Weld Load [W]:
```
 = max( 0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)
 = max( 0, (0.138 - 0.564 + 2 * 2.556 * 0.855 *
   (1 * 3 - 0.951 ) )137.9 )
 = max( 0, -473.65) Kgf
```

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

```
Weld Load [W1]:
 = (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
 = ( 0.271 + 0 + 0.077 - 0 * 0.855 ) * 137.9
 = 488.97 Kgf

Weld Load [W2]:
 = (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
 = ( 0.271 + 0 + 0.077 + ( 0.131 ) ) * 137.9
 = 673.36 Kgf

Weld Load [W3]:
 = (A2+A3+A4+A5+(2*tn*t*fr1))*S
 = ( 0.271 + 0 + 0.077 + 0 + ( 0.131 ) ) * 137.9
 = 673.36 Kgf
```

Strength of Connection Elements for Failure Path Analysis

```
Shear, Outward Nozzle Weld [Sonw]:
 = (pi/2) * Dlo * Wo * 0.49 * Snw
 = ( 3.142/2.0 ) * 33.4 * 3 * 0.49 * 117.9
 = 927. Kgf

Shear, Nozzle Wall [Snw]:
 = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
 = (3.142 * 15.42 ) * ( 5.556 - 3 ) * 0.7 * 117.9
 = 1042. Kgf

Tension, Shell Groove Weld [Tngw]:
 = (pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
 = ( 3.142/2.0 ) * 33.4 * ( 5 - 3 ) * 0.74 * 137.9
 = 1092. Kgf
```

Strength of Failure Paths:

```
 PATH11 = ( SONW + SNW ) = ( 927.3 + 1042 ) = 1970 Kgf
 PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
        = ( 927.3 + 0 + 1092 + 0 ) = 2019 Kgf
 PATH33 = ( Sonw + Tngw + Sinw )
        = ( 927.3 + 1092 + 0 ) = 2019 Kgf
```

Summary of Failure Path Calculations:

```
Path 1-1 = 1969 Kgf, must exceed W = 0 Kgf or W1 = 488 Kgf
Path 2-2 = 2019 Kgf, must exceed W = 0 Kgf or W2 = 673 Kgf
Path 3-3 = 2019 Kgf, must exceed W = 0 Kgf or W3 = 673 Kgf
```

Maximum Allowable Pressure for this Nozzle at this Location:

```
Converged Max. Allow. Pressure in Operating case       12.499  bars
```

The Drop for this Nozzle is : 0.6274 mm.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 156.6273 mm.

Input, Nozzle Desc: Gas Out - 6" From: 30

Pressure for Reinforcement Calculations	P	0.200	bars
Temperature for Internal Pressure	Temp	85	°C
Design External Pressure	Pext	0.10	bars
Temperature for External Pressure	Tempex	85	°C
Shell Material		SA-516 70	
Shell Allowable Stress at Temperature	Sv	137.90	N./mm²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm²
Inside Diameter of Cylindrical Shell	D	445.20	mm.
Design Length of Section	L	1537.1738	mm.
Shell Finished (Minimum) Thickness	t	6.0000	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		1235.50	mm.
User Entered Minimum Design Metal Temperature		-5.00	°C

Type of Element Connected to the Shell : Nozzle

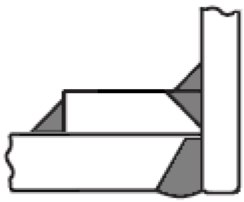
Material		SA-106 B	
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	117.90	N./mm²
Allowable Stress At Ambient	Sna	117.90	N./mm²
Diameter Basis (for tr calc only)		OD	
Layout Angle		0.00	deg
Diameter		6.0000	in.
Size and Thickness Basis		Minimum	
Nominal Thickness	tn	STD	
Flange Material		SA-105	
Flange Type		Slip on	
Corrosion Allowance	can	3.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	150.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	4.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	5.0000	mm.
Inside Projection	h	0.0000	mm.
Weld leg size, Inside Element to Shell	Wi	0.0000	mm.
Pad Material		SA-516 70	
Pad Allowable Stress at Temperature	Sp	137.90	N./mm²
Pad Allowable Stress At Ambient	Spa	137.90	N./mm²
Diameter of Pad along vessel surface	Dp	270.0000	mm.
Thickness of Pad	te	5.0000	mm.
Weld leg size between Pad and Shell	Wp	3.0000	mm.
Groove weld depth between Pad and Nozzle	Wgpn	5.0000	mm.

```
Reinforcing Pad Width                                50.8625  mm.

Class of attached Flange                            150
Grade of attached Flange                            GR 1.1
```

The Pressure Design option was Design Pressure + static head.

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



Insert/Set-in Nozzle With Pad, no Inside projection

Reinforcement CALCULATION, Description: Gas Out - 6"

ASME Code, Section VIII, Div. 1, 2017, UG-37 to UG-45

```
Actual Outside Diameter Used in Calculation            6.625  in.
Actual Thickness Used in Calculation                   0.245  in.
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, Tr [Int. Press]
```
 = (P*R)/(Sv*E-0.6*P) per UG-27 (c)(1)
 = (0.2*225.6)/(137.9*1-0.6*0.2)
 = 0.0327 mm.
```

The Longitudinal Stress Governs over the Hoop Stress on the shell course where this nozzle is located. The Maximum stress ratio times the Shell thickness will be used in the calculation of the Area required.

The Stress Ratio is 0.0914 and the shell thk. is 6.0000 mm.

Reqd thk per UG-37(a) of Nozzle Wall, Trn [Int. Press]
```
 = (P*Ro)/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
 = (0.2*84.14)/(117.9*1+0.4*0.2)
 = 0.0143 mm.
```

Required Nozzle thickness under External Pressure per UG-28 : 0.2031 mm.

UG-40, Limits of Reinforcement : [Internal Pressure]
```
Parallel to Vessel Wall (Diameter Limit)            Dl   323.6580  mm.
Parallel to Vessel Wall, opening length              d   161.8290  mm.
Normal to Vessel Wall (Thickness Limit), pad side Tlwp     7.5000  mm.
```

Weld Strength Reduction Factor [fr1]:
```
 = min( 1, Sn/Sv )
 = min( 1, 117.9/137.9 )
```

= 0.855

Weld Strength Reduction Factor [fr2]:
= min(1, Sn/Sv)
= min(1, 117.9/137.9)
= 0.855

Weld Strength Reduction Factor [fr4]:
= min(1, Sp/Sv)
= min(1, 137.9/137.9)
= 1.000

Weld Strength Reduction Factor [fr3]:
= min(fr2, fr4)
= min(0.855, 1)
= 0.855

Results of Nozzle Reinforcement Area Calculations: (cm^2)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	0.446	0.774	NA
Area in Shell	A1	4.386	3.297	NA
Area in Nozzle Wall	A2	0.412	0.387	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	0.208	0.208	NA
Area in Element	A5	3.815	3.815	NA
TOTAL AREA AVAILABLE	Atot	8.820	7.706	NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Sufficient.
The area available with the given pad is Sufficient.

Area Required [A]:
= 0.5(d * tr*F + 2 * tn * tr*F(1-fr1)) per UG-37(d)
= 0.5(161.8*0.951*1+2*3.223*0.951*1(1-0.855))
= 0.774 cm^2

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)
= 161.8 (1 * 3 - 1 * 0.951) - 2 * 3.223
(1 * 3 - 1 * 0.951) * (1 - 0.855)
= 3.297 cm^2

Area Available in Nozzle Wall Projecting Outward [A2]:
= (2 * Tlwp) * (tn - trn) * fr2
= (2 * 7.5) * (3.223 - 0.203) * 0.855
= 0.387 cm^2

Area Available in Welds [A41 + A42 + A43]:
= $(Wo^2$ - Ar Lost)*Fr3+((Wi-can/0.707)^2 - Ar Lost)*fr2 + Wp^2*fr4
= (0.138) * 0.855 + (0) * 0.855 + 76.2^2 * 1

= 0.208 cm²

Area Available in Element, also see UG-37(h) [A5]:
= (min(Dp,DL)-(Nozzle OD))(min(tp,Tlwp,te)) * fr4 * 0.75
= (270 - 168.3)5 * 1 * 0.75
= 3.815 cm²

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

```
Wall Thickness for Internal/External pressures      ta = 3.2031 mm.
Wall Thickness per UG16(b),                       tr16b = 4.5000 mm.
Wall Thickness, shell/head, internal pressure      trb1 = 3.0327 mm.
Wall Thickness                   tb1 = max(trb1, tr16b) = 4.5000 mm.
Wall Thickness                   tb2 = max(trb2, tr16b) = 4.5000 mm.
Wall Thickness per table UG-45                      tb3 = 9.2200 mm.
```

Determine Nozzle Thickness candidate [tb]:
= min[tb3, max(tb1,tb2)]
= min[9.22, max(4.5, 4.5)]
= 4.5000 mm.

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
= max(ta, tb)
= max(3.203, 4.5)
= 4.5000 mm.

Available Nozzle Neck Thickness = 6.2230 mm. --> OK

Stresses on Nozzle due to External and Pressure Loads per the ASME B31.3 Piping Code (see 319.4.4 and 302.3.5):

```
Sustained  :     19.1,  Allowable :    117.9 N./mm²  Passed
Expansion  :      0.0,  Allowable :    275.6 N./mm²  Passed
Occasional :      0.2,  Allowable :    156.8 N./mm²  Passed
Shear      :     13.1,  Allowable :     82.5 N./mm²  Passed
```

Note : The number of cycles on this nozzle was assumed to be 7000 or less for the determination of the expansion stress allowable.

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld, Curve: B

Govrn. thk, tg = 6.223, tr = 0.0143, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.00443, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve B            -29 °C
Min Metal Temp. at Required thickness (UCS 66.1)         -104 °C
```

Nozzle Neck to Pad Weld for the Nozzle, Curve: B

Govrn. thk, tg = 5, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.0109, Temp. Reduction = 78 °C
Pad governing, Conservatively assuming Pad stress = Shell stress(Div. 1 L-9.3).

```
Min Metal Temp. w/o impact per UCS-66, Curve B            -29 °C
Min Metal Temp. at Required thickness (UCS 66.1)         -104 °C
```

Nozzle Neck to Pad Weld for Reinforcement pad, Curve: B

Govrn. thk, tg = 5, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.0109, Temp. Reduction = 78 °C
Pad governing, Conservatively assuming Pad stress = Shell stress(Div. 1 L-9.3).

```
Min Metal Temp. w/o impact per UCS-66, Curve B              -29 °C
Min Metal Temp. at Required thickness (UCS 66.1)           -104 °C
```

Shell to Pad Weld Junction at Pad OD, Curve: B

Govrn. thk, tg = 5, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.0109, Temp. Reduction = 78 °C
Pad governing, Conservatively assuming Pad stress = Shell stress(Div. 1 L-9.3).

```
Min Metal Temp. w/o impact per UCS-66, Curve B              -29 °C
Min Metal Temp. at Required thickness (UCS 66.1)           -104 °C
```

Nozzle-Shell/Head Weld (UCS-66(a)1(b)), Curve: B

Govrn. thk, tg = 6, tr = 0.0327, c = 3 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.0109, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve B              -29 °C
Min Metal Temp. at Required thickness (UCS 66.1)           -104 °C

Governing MDMT of the Nozzle                            :  -104 °C
Governing MDMT of the Reinforcement Pad                 :  -104 °C
Governing MDMT of all the sub-joints of this Junction   :  -104 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c)      -29 °C
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b)       -104 °C
Flange MDMT with Temp reduction per UCS-66(b)(1)(-c)       -104 °C
```

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :
Design Pressure/Ambient Rating = 0.20/19.60 = 0.010

Note:
Using the min value from (b)(1)(-b) and (b)(1)(-c) above as the computed nozzle flange MDMT.

Weld Size Calculations, Description: Gas Out - 6"

```
Intermediate Calc. for nozzle/shell Welds   Tmin      3.2230  mm.
Intermediate Calc. for pad/shell Welds   TminPad      3.0000  mm.
```

Results Per UW-16.1:

```
                      Required Thickness    Actual Thickness
Nozzle Weld          2.2561 = 0.7 * tmin.  2.8280 = 0.7 * Wo mm.
Pad Weld             1.5000 = 0.5*TminPad  2.1210 = 0.7 * Wp mm.
```

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

Weld Load [W]:

```
 = max( 0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)
 = max( 0, (0.774 - 3.297 + 2 * 3.223 * 0.855 *
   (1 * 3 - 0.951 ) )137.9 )
```

```
 = max( 0, -3388.64) Kgf
```

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

Weld Load [W1]:

```
 = (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
 = ( 0.387 + 3.815 + 0.208 - 0 * 0.855 ) * 137.9
 = 6200.56 Kgf
```

Weld Load [W2]:

```
 = (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
 = ( 0.387 + 0 + 0.137 + ( 0.165 ) ) * 137.9
 = 969.48 Kgf
```

Weld Load [W3]:

```
 = (A2+A3+A4+A5+(2*tn*t*fr1))*S
 = ( 0.387 + 0 + 0.208 + 3.815 + ( 0.165 ) ) * 137.9
 = 6433.05 Kgf
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

```
 = (pi/2) * Dlo * Wo * 0.49 * Snw
 = ( 3.142/2.0 ) * 168.3 * 4 * 0.49 * 117.9
 = 6229. Kgf
```

Shear, Pad Element Weld [Spew]:

```
 = (pi/2) * DP * WP * 0.49 * SEW
 = ( 3.142/2.0 ) * 270 * 3 * 0.49 * 137.9
 = 8767. Kgf
```

Shear, Nozzle Wall [Snw]:

```
 = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
 = (3.142 * 82.53 ) * ( 6.223 - 3 ) * 0.7 * 117.9
 = 7032. Kgf
```

Tension, Pad Groove Weld [Tpgw]:

```
 = ( pi/2) * Dlo * Wgpn * 0.74 * Seg
 =  (3.142/2 ) * 168.3 * 5 * 0.74 * 137.9
 = 13752. Kgf
```

Tension, Shell Groove Weld [Tngw]:

```
 = (pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
 = ( 3.142/2.0 ) * 168.3 * ( 5 - 3 ) * 0.74 * 137.9
 = 5501. Kgf
```

Strength of Failure Paths:

```
 PATH11 = ( SPEW + SNW ) = ( 8767 + 7032 ) = 15799 Kgf
 PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
        = ( 6229 + 13752 + 5501 + 0 ) = 25482 Kgf
 PATH33 = ( Spew + Tngw + Sinw )
        = ( 8767 + 5501 + 0 ) = 14268 Kgf
```

Summary of Failure Path Calculations:

```
Path 1-1 = 15799 Kgf, must exceed W = 0 Kgf or W1 = 6200 Kgf
Path 2-2 = 25481 Kgf, must exceed W = 0 Kgf or W2 = 969 Kgf
```

Path 3-3 = 14267 Kgf, must exceed W = 0 Kgf or W3 = 6433 Kgf

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Max. Allow. Pressure in Operating case 15.463 bars

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

The Drop for this Nozzle is : 16.5135 mm.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 172.5135 mm.

Input Echo, WRC107/537 Item 1, Description: Gas Out - 6" :

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	3.0000	mm.
Vessel Diameter	Dv	445.200	mm.
Vessel Thickness	Tv	6.000	mm.
Design Temperature	T1	85.0	°C
Vessel Material		SA-516 70	
Vessel UNS Number		K02700	
Vessel Cold S.I. Allowable	Smc	137.90	N./mm²
Vessel Hot S.I. Allowable	Smh	137.90	N./mm²

Note:
Using 2 * Yield for Discontinuity Stress Allowable (Div 2, 4.1.6.3), Sps.
Make sure that material properties at this temperature are not
time-dependent for Material: SA-516 70

Attachment Type	Type	Round	
Diameter Basis for Nozzle	Nbasis	OD	
Corrosion Allowance for Nozzle	Can	3.0000	mm.
Nozzle Diameter	Dn	168.275	mm.
Nozzle Thickness	Tn	6.223	mm.
Nozzle Material		SA-106 B	
Nozzle UNS Number		K03006	
Nozzle Cold S.I. Allowable	SNmc	117.90	N./mm²
Nozzle Hot S.I. Allowable	SNmh	117.90	N./mm²
Thickness of Reinforcing Pad	Tpad	5.000	mm.
Diameter of Reinforcing Pad	Dpad	270.000	mm.
Design Internal Pressure	Dp	0.200	bars
Include Pressure Thrust		No	

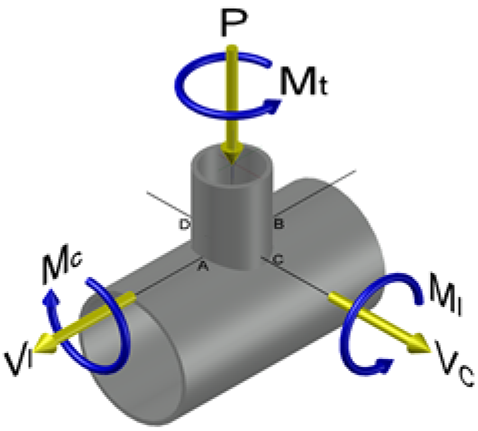
External Forces and Moments in WRC 107/537 Convention:

Radial Load	(SUS)	P	-144.4	Kgf
Longitudinal Shear	(SUS)	Vl	180.7	Kgf
Circumferential Shear	(SUS)	Vc	180.7	Kgf
Circumferential Moment	(SUS)	Mc	-84.4	Kg-m.
Longitudinal Moment	(SUS)	Ml	106.9	Kg-m.
Torsional Moment	(SUS)	Mt	136.2	Kg-m.

Use Interactive Control No

WRC107 Version	Version March	1979
Include Pressure Stress Indices per Div. 2		No
Compute Pressure Stress per WRC-368		No
Local Loads applied at end of Nozzle/Attachment		No

Note:
WRC Bulletin 537 provides equations for the dimensionless curves found in bulletin 107. As noted in the foreword to bulletin 537, "537 is equivalent to WRC 107". Where 107 is printed in the results below, "537" can be interchanged with "107".



Stress Attenuation Diameter (for Insert Plates) per WRC 297:
= NozzleOD + 2 * 1.65 * sqrt(Rmean(t - ca))
= 168.275 + 2 * 1.65 * sqrt(227.1 (6.0 - 3.0))
= 254.411 mm.

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	-144.4	Kgf
Circumferential Shear	VC	180.7	Kgf
Longitudinal Shear	VL	180.7	Kgf
Circumferential Moment	MC	-84.4	Kg-m.
Longitudinal Moment	ML	106.9	Kg-m.
Torsional Moment	MT	136.2	Kg-m.

Dimensionless Parameters used : Gamma = 28.70

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.321	4C	3.329	(A,B)
N(PHI) / (P/Rm)	0.321	3C	1.750	(C,D)
M(PHI) / (P)	0.321	2C1	0.019	(A,B)
M(PHI) / (P)	0.321	1C !	0.060	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.321	3A	1.136	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.321	1A	0.072	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.321	3B	2.289	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.321	1B	0.016	(A,B,C,D)
N(x) / (P/Rm)	0.321	3C	1.750	(A,B)

```
N(x)   / ( P/Rm )                0.321   4C        3.329   (C,D)
M(x)   / ( P )                   0.321   1C1       0.042   (A,B)
M(x)   / ( P )                   0.321   2C  !     0.030   (C,D)
N(x)   / ( MC/(Rm**2 * Beta) )   0.321   4A        2.607   (A,B,C,D)
M(x)   / ( MC/(Rm    * Beta) )   0.321   2A        0.030   (A,B,C,D)
N(x)   / ( ML/(Rm**2 * Beta) )   0.321   4B        1.107   (A,B,C,D)
M(x)   / ( ML/(Rm    * Beta) )   0.321   2B        0.027   (A,B,C,D)
```

Note - The ! mark next to the figure name denotes curve value exceeded.

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction (N./mm²)

Type of Stress	Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb.	P	2.6	2.6	2.6	2.6	1.3	1.3	1.3	1.3
Circ. Bend.	P	2.5	-2.5	2.5	-2.5	8.0	-8.0	8.0	-8.0
Circ. Memb.	MC	0.0	0.0	0.0	0.0	7.0	7.0	-7.0	-7.0
Circ. Memb.	MC	0.0	0.0	0.0	0.0	76.4	-76.4	-76.4	76.4
Circ. Memb.	ML	-17.7	-17.7	17.7	17.7	0.0	0.0	0.0	0.0
Circ. Bend.	ML	-21.4	21.4	21.4	-21.4	0.0	0.0	0.0	0.0
Tot. Circ. Str.		-34.0	3.7	44.2	-3.6	92.6	-76.0	-74.0	62.8
Long. Memb.	P	1.3	1.3	1.3	1.3	2.6	2.6	2.6	2.6
Long. Bend.	P	5.6	-5.6	5.6	-5.6	4.0	-4.0	4.0	-4.0
Long. Memb.	MC	0.0	0.0	0.0	0.0	16.0	16.0	-16.0	-16.0
Long. Bend.	MC	0.0	0.0	0.0	0.0	31.8	-31.8	-31.8	31.8
Long. Memb.	ML	-8.6	-8.6	8.6	8.6	0.0	0.0	0.0	0.0
Long. Bend.	ML	-35.4	35.4	35.4	-35.4	0.0	0.0	0.0	0.0
Tot. Long. Str.		-37.1	22.6	50.9	-31.0	54.4	-17.3	-41.1	14.3
Shear	VC	0.8	0.8	-0.8	-0.8	0.0	0.0	0.0	0.0
Shear	VL	0.0	0.0	0.0	0.0	-0.8	-0.8	0.8	0.8
Shear	MT	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Tot. Shear		4.6	4.6	2.9	2.9	2.9	2.9	4.6	4.6
Str. Int.		40.4	23.7	52.0	31.3	92.9	76.2	74.6	63.2

WARNING: Ratio of Pad Radius/Rm (.594) is not between 0.01 and 0.571.

Dimensionless Parameters used : Gamma = 75.70

Dimensionless Loads for Cylindrical Shells at Pad edge:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.520	4C !	3.541	(A,B)
N(PHI) / (P/Rm)	0.520	3C !	1.086	(C,D)
M(PHI) / (P)	0.520	2C1 !	0.003	(A,B)
M(PHI) / (P)	0.520	1C !	0.068	(C,D)

Strength Calculation-Cartridge Filter
Design by A. Azodi
Rev.00
PV Elite 2019 SP1 Licensee: SPLM Licensed User
FileName : EI0127-HRC-VD-ME-CAL-004-00 Page 109 of 118
Nozzle Calcs.: Gas Out - 6" Nozl: 8 7:18pm Feb 27,2024

```
N(PHI) / ( MC/(Rm**2 * Beta) )   0.520   3A  !    1.062   (A,B,C,D)
M(PHI) / ( MC/(Rm    * Beta) )   0.520   1A  !    0.054   (A,B,C,D)
N(PHI) / ( ML/(Rm**2 * Beta) )   0.520   3B  !    1.799   (A,B,C,D)
M(PHI) / ( ML/(Rm    * Beta) )   0.520   1B  !    0.002   (A,B,C,D)

N(x)   / ( P/Rm )                0.520   3C  !    1.086   (A,B)
N(x)   / ( P/Rm )                0.520   4C  !    3.541   (C,D)
M(x)   / ( P )                   0.520   1C1 !    0.007   (A,B)
M(x)   / ( P )                   0.520   2C  !    0.036   (C,D)
N(x)   / ( MC/(Rm**2 * Beta) )   0.520   4A  !    5.587   (A,B,C,D)
M(x)   / ( MC/(Rm    * Beta) )   0.520   2A  !    0.021   (A,B,C,D)
N(x)   / ( ML/(Rm**2 * Beta) )   0.520   4B  !    1.001   (A,B,C,D)
M(x)   / ( ML/(Rm    * Beta) )   0.520   2B  !    0.004   (A,B,C,D)
```

Note - The ! mark next to the figure name denotes curve value exceeded.

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Edge of Reinforcing Pad (N./mm²)

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	7.4	7.4	7.4	7.4	2.3	2.3	2.3	2.3
Circ. Bend. P	2.6	-2.6	2.6	-2.6	64.2	-64.2	64.2	-64.2
Circ. Memb. MC	0.0	0.0	0.0	0.0	10.9	10.9	-10.9	-10.9
Circ. Memb. MC	0.0	0.0	0.0	0.0	253.7	-253.7	-253.7	253.7
Circ. Memb. ML	-23.4	-23.4	23.4	23.4	0.0	0.0	0.0	0.0
Circ. Bend. ML	-14.0	14.0	14.0	-14.0	0.0	0.0	0.0	0.0
Tot. Circ. Str.	-27.4	-4.7	47.4	14.2	331.1	-304.8	-198.2	180.8
Long. Memb. P	2.3	2.3	2.3	2.3	7.4	7.4	7.4	7.4
Long. Bend. P	6.4	-6.4	6.4	-6.4	33.8	-33.8	33.8	-33.8
Long. Memb. MC	0.0	0.0	0.0	0.0	57.5	57.5	-57.5	-57.5
Long. Bend. MC	0.0	0.0	0.0	0.0	99.0	-99.0	-99.0	99.0
Long. Memb. ML	-13.0	-13.0	13.0	13.0	0.0	0.0	0.0	0.0
Long. Bend. ML	-21.5	21.5	21.5	-21.5	0.0	0.0	0.0	0.0
Tot. Long. Str.	-25.9	4.4	43.2	-12.6	197.7	-68.0	-115.3	15.1
Shear VC	1.4	1.4	-1.4	-1.4	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-1.4	-1.4	1.4	1.4
Shear MT	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9
Tot. Shear	5.3	5.3	2.5	2.5	2.5	2.5	5.3	5.3
Str. Int.	32.0	13.9	48.5	27.2	331.2	304.8	198.5	181.0

WRC 107/537 Stress Summations:

Vessel Stress Summation at Attachment Junction (N./mm²)

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Circ. Pl (SUS)	-15.2	-15.2	20.3	20.3	8.3	8.3	-5.6	-5.6
Circ. Q (SUS)	-18.9	18.9	23.9	-23.9	84.3	-84.3	-68.4	68.4
Long. Pm (SUS)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Long. Pl (SUS)	-7.2	-7.2	9.9	9.9	18.5	18.5	-13.4	-13.4
Long. Q (SUS)	-29.9	29.9	41.0	-41.0	35.8	-35.8	-27.7	27.7
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	0.8	0.8	-0.8	-0.8	-0.8	-0.8	0.8	0.8
Shear Q (SUS)	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Pm (SUS)	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Pm+Pl (SUS)	14.7	14.7	20.9	20.9	18.9	18.9	13.2	13.2
Pm+Pl+Q (Total)	40.0	24.0	52.3	31.1	93.4	75.6	74.1	63.8

Vessel Stress Summation Comparison (N./mm²):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	0.57	137.90	Passed
Pm+Pl (SUS)	20.95	206.85	Passed
Pm+Pl+Q (TOTAL)	93.41	413.70	Passed

*Because only sustained loads were specified, the Pm+Pl+Q allowable was 3 * Smh.*

WRC 107 / 537 Stress Summations:

Vessel Stress Summation at Reinforcing Pad Edge (N./mm²)

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Circ. Pl (SUS)	-16.1	-16.1	30.8	30.8	13.2	13.2	-8.7	-8.7
Circ. Q (SUS)	-11.3	11.3	16.6	-16.6	317.9	-317.9	-189.5	189.5
Long. Pm (SUS)	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Long. Pl (SUS)	-10.8	-10.8	15.3	15.3	64.8	64.8	-50.1	-50.1
Long. Q (SUS)	-15.2	15.2	27.9	-27.9	132.8	-132.8	-65.2	65.2
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	1.4	1.4	-1.4	-1.4	-1.4	-1.4	1.4	1.4
Shear Q (SUS)	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9
Pm (SUS)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

Pm+Pl (SUS)	15.0	14.9	32.4	32.4	65.6	65.6	49.4	49.4
Pm+Pl+Q (Total)	30.8	13.5	49.9	28.0	332.7	303.3	197.0	182.5

Vessel Stress Summation Comparison (N./mm²):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	1.51	137.90	Passed
Pm+Pl (SUS)	65.62	206.85	Passed
Pm+Pl+Q (TOTAL)	332.67	413.70	Passed

*Because only sustained loads were specified, the Pm+Pl+Q allowable was 3 * Smh.*

Nozzle Schedule:

Description	Nominal or Actual Size	Schd or FVC Type	Flg Type	Nozzle O/Dia in	Wall Thk mm.	Reinforcing Pad Diameter mm.	Reinforcing Pad Thk mm.	Cut Length mm.	Flg Class
Vent - 1"	1.000 in	160	SlipOn	1.315	6.350	...	...	156.63	150
Drain - 2"	2.000 in	80	SlipOn	2.375	5.537	162.00	5.00	106.68	150
Gas In - 6"	6.000 in	STD	SlipOn	6.625	7.112	...	...	174.68	150
Gas Out - 6"	6.000 in	STD	SlipOn	6.625	7.112	270.00	5.00	172.51	150

General Notes for the above table:

The Cut Length is the Outside Projection + Inside Projection + Drop +
In Plane Shell Thickness. This value does not include weld gaps,
nor does it account for shrinkage.

In the case of Oblique Nozzles, the Outside Diameter must
be increased. The Re-Pad WIDTH around the nozzle is calculated as follows:
Width of Pad = (Pad Outside Dia. (per above) - Nozzle Outside Dia.)/2

For hub nozzles, the thickness and diameter shown are those of the smaller
and thinner section.

Nozzle Material and Weld Fillet Leg Size Details (mm.):

Description	Material	Shl Grve Weld	Noz Shl/Pad Weld	Pad OD Weld	Pad Grve Weld	Inside Weld
Vent - 1"	SA-106 B	5.000	3.000	...	...	...
Drain - 2"	SA-106 B	4.800	3.000	3.000	4.800	...
Gas In - 6"	SA-106 B	6.000	4.000	...	...	...
Gas Out - 6	SA-106 B	5.000	4.000	3.000	5.000	...

Note: The Outside projections below do not include the flange thickness.

Nozzle Miscellaneous Data:

Description	Elev/Distance From Datum mm.	Layout Angle deg	Proj Outside mm.	Proj Inside mm.	Installed in Component
Vent - 1"	1335.500	180.0	150.00	0.00	Shell #2 - 18"
Drain - 2"	...	0.0	100.00	0.00	Cap - 18" (sch.1
Gas In - 6"	285.500	180.0	150.00	0.00	Shell #1 - 18"
Gas Out - 6"	1235.500	0.0	150.00	0.00	Shell #2 - 18"

Weld Sizes for Slip On / Socket Weld Nozzle Flanges per UW-21:

Nozzle to Flange Fillet Weld Leg dimension [xmin]:
= min(1.4 * tn, Hub Thickness)

The Nozzle Wall thicknesses shown below are in the corroded condition. Hubs are considered to be straight.

Nominal or Actual	Schd	Flg	Noz.	Wall	Hub	Throat	xmin

Nozzle Schedule: Step: 27 7:18pm Feb 27,2024

Description	Size	or FVC Type	Type	O/Dia in	Thk mm.	Thk mm.	Thk mm.	Thk mm.
Vent - 1"	1.000 in	160	SlipOn	1.315	3.350	7.366	3.283	4.690
Drain - 2"	2.000 in	80	SlipOn	2.375	2.537	7.874	2.486	3.552
Gas In - 6"	6.000 in	STD	SlipOn	6.625	4.112	10.287	4.030	5.757
Gas Out - 6"	6.000 in	STD	SlipOn	6.625	4.112	10.287	4.030	5.757

Minimum Design Metal Temperature Results Summary :

Description / Notes		Curve	Basic MDMT °C	Reduced MDMT °C	UG-20(f) MDMT °C	Thickness ratio	Gov Thk mm.	E*	PWHT reqd
Nozzle Flg	[5]	B	-29	-104					
Nozzle Flg	[5]	B	-29	-104					
Cap - 18" (sc	[10]	B	-29	-44	-29	0.727	5.556	1.00	No
Cap - 18" (sch	[7]	B	-29	-48	-29	0.567	6.350	1.00	No
Shell #1 - 18"	[8]	B	-29	-104	-29	0.325	8.000	0.85	No
Shell #2 - 18"	[8]	B	-29	-48	-29	0.541	6.000	0.85	No
Drain - 2"	[1]	B	-29	-104		0.003	4.845	1.00	No
Nozzle Flg	[4]	B	-29	-104					
Gas In - 6"	[1]	B	-29	-104		0.004	6.223	1.00	No
Nozzle Flg	[4]	B	-29	-104					
Vent - 1"	[1]	B	-29	-104		0.001	5.556	1.00	No
Nozzle Flg	[4]	B	-29	-104					
Gas Out - 6"	[1]	B	-29	-104		0.004	6.223	1.00	No
Nozzle Flg	[4]	B	-29	-104					
Bolting	[21]		-48						
Warmest MDMT:			-29	-44					

Required Minimum Design Metal Temperature -5.0 °C
Warmest Computed Minimum Design Metal Temperature -44.0 °C

Notes:
[!] - This was an impact tested material.
[1] - Governing Nozzle Weld.
[4] - ANSI Flange MDMT Calcs; Thickness ratio per UCS-66(b)(1)(-c).
[5] - ANSI Flange MDMT Calcs; Thickness ratio per UCS-66(b)(1)(-b).
[6] - MDMT Calculations at the Shell/Head Joint.
[7] - MDMT Calculations for the Straight Flange.
[8] - Cylinder/Cone/Flange Junction MDMT.
[9] - Calculations in the Spherical Portion of the Head.
[10] - Calculations in the Knuckle Portion of the Head.
[11] - Calculated (Body Flange) Flange MDMT.
[12] - Calculated Flat Head MDMT per UCS-66.3
[13] - Tubesheet MDMT, shell side, if applicable
[14] - Tubesheet MDMT, tube side, if applicable
[15] - Nozzle Material
[16] - Shell or Head Material
[17] - Impact Testing required
[18] - Impact Testing not required, see UCS-66(b)(3)
[20] - Cylinder/Cone Junction MDMT based on Longitudinal Stress considerations
[21] - Bolting Material

UG-84(b)(2) was not considered.
UCS-66(g) was not considered.
UCS-66(i) was not considered.

Notes:
Impact test temps were not entered in and not considered in the analysis.
UCS-66(i) applies to impact tested materials not by specification and
UCS-66(g) applies to materials impact tested per UG-84.1 General Note (c).

The Basic MDMT includes the (30F) PWHT credit if applicable.

ASME Code, Section VIII Division 1, 2017

Diameter Spec : 457.200 mm. OD
Vessel Design Length, Tangent to Tangent 1549.15 mm.

Distance of Bottom Tangent above Grade 0.00 mm.
Specified Datum Line Distance 0.00 mm.

Internal Design Temperature 85 °C
Internal Design Pressure 0.200 bars

External Design Temperature 85 °C
External Design Pressure 0.100 bars

Maximum Allowable Working Pressure 9.825 bars
External Max. Allowable Working Pressure 1.730 bars
Hydrostatic Test Pressure 12.772 bars

Required Minimum Design Metal Temperature -5.0 °C
Warmest Computed Minimum Design Metal Temperature -44.0 °C

Wind Design Code UBC
Earthquake Design Code ASCE/SEI 7-16

Materials of Construction:

Component Type	Material	Class	Thickness	UNS #	Normalized	Impact Tested
Shell	SA-516 70	...	...	K02700	No	No
Head	SA-234 WPB	...	...	K03006	No	No
Flange	SA-105	...	...	K03504	No	No
Nozzle	SA-106 B	...	...	K03006	No	No
Re-Pad	SA-516 70	...	...	K02700	No	No
Nozzle Flg	SA-105	...	...	K03504	No	No
Leg Baseplate	SA-283 C	...	...	K02401	No	No
Flg Bolting	SA-193 B7	...	<= 2 1/2	G41400	No	No
Leg Bolting	SA-36	...	...	K02600	No	No

- Normalized is determined based on the UCS-66 material curve selection and Figure UCS-66.
- Impact Tested is based on material selection and material data properties.

Element Pressures and MAWP (bars & mm.):

Element Description or Type	Design Pressure + Stat. head	Ext. Press.	Element M.A.W.P	Corrosion Allowance	Str. Flg. Gov.	In Creep Range
Cap - 18" (sch.10)	0.200	0.10	13.552	3.0000	No	No
Shell #1 - 18"	0.200	0.10	25.862	3.0000	N/A	No
Shell #2 - 18"	0.200	0.10	15.463	3.0000	N/A	No
Body Flange - 18"	0.200	0.10	18.150	3.0000	N/A	No
Blind Flange - 18"	0.200	0.10	18.150	3.0000	N/A	No

Liquid Level: 1611.52 mm. Dens.: 0.000 kg./cm³ Sp. Gr.: 0.001

Strength Calculation-Cartridge Filter
Design by A. Azodi
Rev.00
PV Elite 2019 SP1 Licensee: SPLM Licensed User
FileName : EI0127-HRC-VD-ME-CAL-004-00
Vessel Design Summary: Step: 30 7:18pm Feb 27,2024

Element Types and Properties:

Element Type	"To" Elev mm.	Element Length mm.	Nominal Thickness mm.	Finished Thickness mm.	Reqd Thk Internal mm.	Reqd Thk External mm.	Long Eff	Circ Eff
Ellipse	85.5	85.5	6.3	5.6	4.5	4.5	1.00	0.85
Cylinder	535.5	450.0	8.0	8.0	4.5	4.0	0.85	0.85
Cylinder	1500.0	964.5	6.0	6.0	4.5	4.0	0.85	0.85
Body Flg	1500.0	68.1	6.3	39.6	...	...	1.00	1.00
Body Flg	1549.1	39.6	6.3	39.6	...	...	1.00	1.00

Loads for Foundation/Support Design:

Factored Loads:

Total Wind Shear on top of all Legs	569.	Kgf
Total Earthquake Shear on top of all Legs	708.	Kgf
Total Wind Moment at top of all Legs	710.	Kg-m.
Total Earthquake Moment at top of all Legs	876.	Kg-m.
Max. Wind Shear on one Leg (top & bottom)	523.	Kgf
Max. Earthq. Shear on one Leg (top & bottom)	651.	Kgf
Max. Wind Moment at base of one Leg	523.	Kg-m.
Max. Earthquake Moment at base of one Leg	651.	Kg-m.
Max. Vertical Load (Wt. + Wind) on one Leg	2860.	Kgf
Max. Vertical Load (Wt. + Eq.) on one Leg	3422.	Kgf

Un-Factored Loads:

Total Earthquake Shear on top of all Legs	1011.	Kgf
Total Wind Moment at top of all Legs	710.	Kg-m.
Total Earthquake Moment at top of all Legs	1252.	Kg-m.
Max. Wind Shear on one Leg (top & bottom)	523.	Kgf
Max. Earthq. Shear on one Leg (top & bottom)	929.	Kgf
Max. Wind Moment at base of one Leg	523.	Kg-m.
Max. Earthquake Moment at base of one Leg	929.	Kg-m.
Max. Vertical Load (Wt. + Wind) on one Leg	2860.	Kgf
Max. Vertical Load (Wt. + Eq.) on one Leg	4888.	Kgf

Note:
Wind and Earthquake moments include the effects of user defined forces and moments if any exist in the job and were specified to act (compute loads and stresses) during these cases. Also included are moment effects due to eccentric weights if any are present in the input.

Local Stress Analysis Results:

Description	Analysis Type	Max Stress Ratio	Pass Fail
LEGS	WRC-107/537	0.497	Passed
LEGS	WRC-107/537	0.059	Passed
Drain - 2"	WRC-107/537	0.222	Passed
Gas In - 6"	WRC-107/537	0.502	Passed
Gas Out - 6"	WRC-107/537	0.804	Passed

Weights:

Fabricated	- Bare W/O Removable Internals	476.2	kg.
Shop Test	- Fabricated + Water (Full)	720.0	kg.
Shipping	- Fab. + Rem. Intls.+ Shipping App.	476.2	kg.
Erected	- Fab. + Rem. Intls.+ Insul. (etc)	576.2	kg.
Empty	- Fab. + Intls. + Details + Wghts.	576.2	kg.
Operating	- Empty + Operating Liquid (No CA)	576.5	kg.
Field Test	- Empty Weight + Water (Full)	666.6	kg.