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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 : D:\2-PAYAM\1-PROJECTS\MICROTEC PROJECT\13-MICROT

Date of Analysis : Feb 20,2026 4:14pm

PV Elite 2019 SP1, March 2019

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

Design Internal Pressure (for Hydrotest)	0.5	bars
Design Internal Temperature	170.0	°C
Type of Hydrotest	not Specified	
Hydrotest Position	Horizontal	
Projection of Nozzle from Vessel Top	0	mm.
Projection of Nozzle from Vessel Bottom	0	mm.
Minimum Design Metal Temperature	-28.9	°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	N	

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		ASCE-7 93	
Basic Wind Speed	[V]	112.65	Km/hr
Surface Roughness Category		C: Open Terrain	
Importance Factor		1.0	
Type of Surface		Moderately Smooth	
Base Elevation		0	mm.
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	UBC 94
UBC Seismic Zone (1=1,2=2a,3=2b,4=3,5=4)	0.000
UBC Importance Factor	1.000
UBC Soil Type	S1
UBC Horizontal Force Factor	3.000
UBC Percent Seismic for Hydrotest	0.000

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)	No

Complete Listing of Vessel Elements and Details:

Element From Node	10	
Element To Node	20	
Element Type	Cylinder	
Description		
Distance "FROM" to "TO"	8052	mm.
Inside Diameter	1300	mm.
Element Thickness	3	mm.
Internal Corrosion Allowance	0	mm.
Nominal Thickness	3	mm.
External Corrosion Allowance	0	mm.
Design Internal Pressure	0.5	bars
Design Temperature Internal Pressure	170	°C
Design External Pressure	0.1	bars
Design Temperature External Pressure	50	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-240 316	
Allowable Stress, Ambient	137.9	N./mm²
Allowable Stress, Operating	104.16	N./mm²
Allowable Stress, Hydrotest	179.27	N./mm²
Material Density	0.008027	kg./cm³
P Number Thickness	0	mm.
Yield Stress, Operating	156.11	N./mm²
External Pressure Chart Name	HA-2	
UNS Number	S31600	
Product Form	Plate	
Efficiency, Longitudinal Seam	1.0	
Efficiency, Circumferential Seam	1.0	
Weld is pre-Heated	No	

Element From Node	10	
Detail Type	Ring	
Detail ID	Ring:[1 of 1]	
Dist. from "FROM" Node / Offset dist	3958	mm.
Inside Diameter of Ring	1306	mm.
Thickness of Ring	10	mm.
Outside Diameter of Ring	1400	mm.
Material Name	SA-240 316	
Height of Section Ring	0	mm.
Using Custom Stiffener Section	No	

Element From Node	10	
Detail Type	Ring	
Detail ID	Ring:[2 of 2]	
Dist. from "FROM" Node / Offset dist	5946	mm.
Inside Diameter of Ring	1306	mm.
Thickness of Ring	10	mm.

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    Outside Diameter of Ring                         1400  mm.
    Material Name                              SA-240 316
    Height of Section Ring                              0  mm.
    Using Custom Stiffener Section                     No

    Element From Node                                  10
    Detail Type                                      Ring
    Detail ID                                Ring:[3 of 3]
    Dist. from "FROM" Node / Offset dist             7939  mm.
    Inside Diameter of Ring                          1306  mm.
    Thickness of Ring                                  10  mm.
    Outside Diameter of Ring                         1400  mm.
    Material Name                              SA-240 316
    Height of Section Ring                              0  mm.
    Using Custom Stiffener Section                     No

    Element From Node                                  10
    Detail Type                                      Ring
    Detail ID                                Ring:[4 of 4]
    Dist. from "FROM" Node / Offset dist             7952  mm.
    Inside Diameter of Ring                          1306  mm.
    Thickness of Ring                                  10  mm.
    Outside Diameter of Ring                         1400  mm.
    Material Name                              SA-240 316
    Height of Section Ring                              0  mm.
    Using Custom Stiffener Section                     No

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Element From Node                                      20
Element To Node                                        30
Element Type                                      Conical
Description
Distance "FROM" to "TO"                              2000  mm.
Inside Diameter                                      1300  mm.
Element Thickness                                       3  mm.
Internal Corrosion Allowance                            0  mm.
Nominal Thickness                                       3  mm.
External Corrosion Allowance                            0  mm.
Design Internal Pressure                              0.5  bars
Design Temperature Internal Pressure                  170  °C
Design External Pressure                              0.1  bars
Design Temperature External Pressure                   50  °C
Effective Diameter Multiplier                         1.2
Material Name                                  SA-240 316
Efficiency, Longitudinal Seam                         1.0
Efficiency, Circumferential Seam                      1.0
Cone Diameter at "To" End                            1730  mm.
Design Length of Cone                                2000  mm.
Half Apex Angle of Cone                         6.1357331  degrees
Toriconical (Y/N)                                       N
Weld is pre-Heated                                     No

    Element From Node                                  20
    Detail Type                                      Ring
    Detail ID                                     Ring 16
    Dist. from "FROM" Node / Offset dist                0  mm.
    Inside Diameter of Ring                          1306  mm.
    Thickness of Ring                                  10  mm.
    Outside Diameter of Ring                         1500  mm.
    Material Name                              SA-240 304
    Height of Section Ring                              0  mm.
    Using Custom Stiffener Section                     No

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Element From Node	30	
Element To Node	40	
Element Type	Cylinder	
Description		
Distance "FROM" to "TO"	800	mm.
Inside Diameter	1730	mm.
Element Thickness	3	mm.
Internal Corrosion Allowance	0	mm.
Nominal Thickness	3	mm.
External Corrosion Allowance	0	mm.
Design Internal Pressure	0.5	bars
Design Temperature Internal Pressure	170	°C
Design External Pressure	0.1	bars
Design Temperature External Pressure	50	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-240 316	
Efficiency, Longitudinal Seam	1.0	
Efficiency, Circumferential Seam	1.0	
Weld is pre-Heated	No	

Element From Node	30	
Detail Type	Ring	
Detail ID	Ring5	
Dist. from "FROM" Node / Offset dist	0	mm.
Inside Diameter of Ring	1736	mm.
Thickness of Ring	10	mm.
Outside Diameter of Ring	1830	mm.
Material Name	SA-240 304	
Height of Section Ring	0	mm.
Using Custom Stiffener Section	No	

Element From Node	40	
Element To Node	50	
Element Type	Conical	
Description		
Distance "FROM" to "TO"	1200	mm.
Inside Diameter	1730	mm.
Element Thickness	3	mm.
Internal Corrosion Allowance	0	mm.
Nominal Thickness	3	mm.
External Corrosion Allowance	0	mm.
Design Internal Pressure	0.5	bars
Design Temperature Internal Pressure	170	°C
Design External Pressure	0.1	bars
Design Temperature External Pressure	50	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-240 316	
Efficiency, Longitudinal Seam	1.0	
Efficiency, Circumferential Seam	1.0	
Cone Diameter at "To" End	1400	mm.
Design Length of Cone	1200	mm.
Half Apex Angle of Cone	7.8290772	degrees
Toriconical (Y/N)	N	
Weld is pre-Heated	No	

Element From Node	40	
Detail Type	Ring	
Detail ID	Ring:17	
Dist. from "FROM" Node / Offset dist	1199	mm.
Inside Diameter of Ring	1406.3	mm.
Thickness of Ring	10	mm.
Outside Diameter of Ring	1500	mm.
Material Name	SA-240 304	
Height of Section Ring	0	mm.

Using Custom Stiffener Section	No	

Element From Node	40	
Detail Type	Ring	
Detail ID	Ring 21	
Dist. from "FROM" Node / Offset dist	0	mm.
Inside Diameter of Ring	1736	mm.
Thickness of Ring	10	mm.
Outside Diameter of Ring	1836	mm.
Material Name	SA-240 304	
Height of Section Ring	0	mm.
Using Custom Stiffener Section	No	

Element From Node	50	
Element To Node	60	
Element Type	Cylinder	
Description		
Distance "FROM" to "TO"	4500	mm.
Inside Diameter	1400	mm.
Element Thickness	3	mm.
Internal Corrosion Allowance	0	mm.
Nominal Thickness	3	mm.
External Corrosion Allowance	0	mm.
Design Internal Pressure	0.5	bars
Design Temperature Internal Pressure	170	°C
Design External Pressure	0.1	bars
Design Temperature External Pressure	50	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-240 316	
Efficiency, Longitudinal Seam	1.0	
Efficiency, Circumferential Seam	1.0	
Weld is pre-Heated	No	

Element From Node	50	
Detail Type	Ring	
Detail ID	Ring 6	
Dist. from "FROM" Node / Offset dist	90	mm.
Inside Diameter of Ring	1406	mm.
Thickness of Ring	10	mm.
Outside Diameter of Ring	1500	mm.
Material Name	SA-240 304	
Height of Section Ring	0	mm.
Using Custom Stiffener Section	No	

Element From Node	50	
Detail Type	Ring	
Detail ID	Ring 7	
Dist. from "FROM" Node / Offset dist	103	mm.
Inside Diameter of Ring	1406	mm.
Thickness of Ring	10	mm.
Outside Diameter of Ring	1500	mm.
Material Name	SA-240 304	
Height of Section Ring	0	mm.
Using Custom Stiffener Section	No	

Element From Node	50	
Detail Type	Ring	
Detail ID	Ring 8	
Dist. from "FROM" Node / Offset dist	1513	mm.
Inside Diameter of Ring	1406	mm.
Thickness of Ring	10	mm.
Outside Diameter of Ring	1500	mm.
Material Name	SA-240 304	
Height of Section Ring	0	mm.

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    Using Custom Stiffener Section                         No

    Element From Node                                      50
    Detail Type                                          Ring
    Detail ID                                          Ring 9
    Dist. from "FROM" Node / Offset dist                 2913  mm.
    Inside Diameter of Ring                              1406  mm.
    Thickness of Ring                                      10  mm.
    Outside Diameter of Ring                             1500  mm.
    Material Name                                  SA-240 304
    Height of Section Ring                                  0  mm.
    Using Custom Stiffener Section                         No

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 Element From Node                                         60
 Element To Node                                           70
 Element Type                                        Conical
 Description
 Distance "FROM" to "TO"                                 2000  mm.
 Inside Diameter                                         1400  mm.
 Element Thickness                                          3  mm.
 Internal Corrosion Allowance                               0  mm.
 Nominal Thickness                                          3  mm.
 External Corrosion Allowance                               0  mm.
 Design Internal Pressure                                 0.5  bars
 Design Temperature Internal Pressure                     170  °C
 Design External Pressure                                 0.1  bars
 Design Temperature External Pressure                      50  °C
 Effective Diameter Multiplier                            1.2
 Material Name                                     SA-240 316
 Efficiency, Longitudinal Seam                            1.0
 Efficiency, Circumferential Seam                         1.0
 Cone Diameter at "To" End                               1730  mm.
 Design Length of Cone                                   2000  mm.
 Half Apex Angle of Cone                            4.7162204  degrees
 Toriconical (Y/N)                                          N
 Weld is pre-Heated                                        No

    Element From Node                                      60
    Detail Type                                          Ring
    Detail ID                                         Ring 18
    Dist. from "FROM" Node / Offset dist                    0  mm.
    Inside Diameter of Ring                              1406  mm.
    Thickness of Ring                                      10  mm.
    Outside Diameter of Ring                             1500  mm.
    Material Name                                  SA-240 304
    Height of Section Ring                                  0  mm.
    Using Custom Stiffener Section                         No

    Element From Node                                      60
    Detail Type                                          Ring
    Detail ID                                         Ring 23
    Dist. from "FROM" Node / Offset dist                 1999  mm.
    Inside Diameter of Ring                            1735.8  mm.
    Thickness of Ring                                      10  mm.
    Outside Diameter of Ring                           1829.8  mm.
    Material Name                                  SA-240 304
    Height of Section Ring                                  0  mm.
    Using Custom Stiffener Section                         No

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 Element From Node                                         70
 Element To Node                                           80
 Element Type                                        Cylinder
```

```
 Description
 Distance "FROM" to "TO"                         800  mm.
 Inside Diameter                                1730  mm.
 Element Thickness                                 3  mm.
 Internal Corrosion Allowance                      0  mm.
 Nominal Thickness                                 3  mm.
 External Corrosion Allowance                      0  mm.
 Design Internal Pressure                        0.5  bars
 Design Temperature Internal Pressure            170  °C
 Design External Pressure                        0.1  bars
 Design Temperature External Pressure             50  °C
 Effective Diameter Multiplier                   1.2
 Material Name                           SA-240 316
 Efficiency, Longitudinal Seam                   1.0
 Efficiency, Circumferential Seam                1.0
 Weld is pre-Heated                               No

     Element From Node                            70
     Detail Type                                Ring
     Detail ID                               Ring 10
     Dist. from "FROM" Node / Offset dist        737  mm.
     Inside Diameter of Ring                    1736  mm.
     Thickness of Ring                            10  mm.
     Outside Diameter of Ring                   1830  mm.
     Material Name                       SA-240 304
     Height of Section Ring                        0  mm.
     Using Custom Stiffener Section               No

     Element From Node                            70
     Detail Type                                Ring
     Detail ID                               Ring 11
     Dist. from "FROM" Node / Offset dist        750  mm.
     Inside Diameter of Ring                    1736  mm.
     Thickness of Ring                            10  mm.
     Outside Diameter of Ring                   1830  mm.
     Material Name                       SA-240 304
     Height of Section Ring                        0  mm.
     Using Custom Stiffener Section               No

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 Element From Node                                80
 Element To Node                                  90
 Element Type                                Conical
 Description
 Distance "FROM" to "TO"                        1200  mm.
 Inside Diameter                                1730  mm.
 Element Thickness                                 3  mm.
 Internal Corrosion Allowance                      0  mm.
 Nominal Thickness                                 3  mm.
 External Corrosion Allowance                      0  mm.
 Design Internal Pressure                        0.5  bars
 Design Temperature Internal Pressure            170  °C
 Design External Pressure                        0.1  bars
 Design Temperature External Pressure             50  °C
 Effective Diameter Multiplier                   1.2
 Material Name                           SA-240 316
 Efficiency, Longitudinal Seam                   1.0
 Efficiency, Circumferential Seam                1.0
 Cone Diameter at "To" End                      1400  mm.
 Design Length of Cone                          1200  mm.
 Half Apex Angle of Cone                   7.8290772  degrees
 Toriconical (Y/N)                                 N
 Weld is pre-Heated                               No

     Element From Node                            80
```

Detail Type	Ring	
Detail ID	Ring 24	
Dist. from "FROM" Node / Offset dist	0	mm.
Inside Diameter of Ring	1736	mm.
Thickness of Ring	10	mm.
Outside Diameter of Ring	1829.7	mm.
Material Name	SA-240 304	
Height of Section Ring	0	mm.
Using Custom Stiffener Section	No	

Element From Node	80	
Detail Type	Ring	
Detail ID	Ring 26	
Dist. from "FROM" Node / Offset dist	1199	mm.
Inside Diameter of Ring	1406.3	mm.
Thickness of Ring	10	mm.
Outside Diameter of Ring	1499.9	mm.
Material Name	SA-240 304	
Height of Section Ring	0	mm.
Using Custom Stiffener Section	No	

Element From Node	90	
Element To Node	100	
Element Type	Cylinder	
Description		
Distance "FROM" to "TO"	3500	mm.
Inside Diameter	1400	mm.
Element Thickness	3	mm.
Internal Corrosion Allowance	0	mm.
Nominal Thickness	3	mm.
External Corrosion Allowance	0	mm.
Design Internal Pressure	0.5	bars
Design Temperature Internal Pressure	170	°C
Design External Pressure	0.1	bars
Design Temperature External Pressure	50	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-240 316	
Efficiency, Longitudinal Seam	1.0	
Efficiency, Circumferential Seam	1.0	
Weld is pre-Heated	No	

Element From Node	90	
Detail Type	Ring	
Detail ID	Ring 12	
Dist. from "FROM" Node / Offset dist	375	mm.
Inside Diameter of Ring	1406	mm.
Thickness of Ring	10	mm.
Outside Diameter of Ring	1500	mm.
Material Name	SA-240 304	
Height of Section Ring	0	mm.
Using Custom Stiffener Section	No	

Element From Node	90	
Detail Type	Ring	
Detail ID	Ring 13]	
Dist. from "FROM" Node / Offset dist	1745	mm.
Inside Diameter of Ring	1406	mm.
Thickness of Ring	10	mm.
Outside Diameter of Ring	1500	mm.
Material Name	SA-240 304	
Height of Section Ring	0	mm.
Using Custom Stiffener Section	No	

Element From Node	100	
Element To Node	110	
Element Type	Conical	
Description		
Distance "FROM" to "TO"	2000	mm.
Inside Diameter	1400	mm.
Element Thickness	3	mm.
Internal Corrosion Allowance	0	mm.
Nominal Thickness	3	mm.
External Corrosion Allowance	0	mm.
Design Internal Pressure	0.5	bars
Design Temperature Internal Pressure	170	°C
Design External Pressure	0.1	bars
Design Temperature External Pressure	50	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-240 316	
Efficiency, Longitudinal Seam	1.0	
Efficiency, Circumferential Seam	1.0	
Cone Diameter at "To" End	950	mm.
Design Length of Cone	2000	mm.
Half Apex Angle of Cone	6.4187856	degrees
Toriconical (Y/N)	N	
Weld is pre-Heated	No	

Element From Node	100	
Detail Type	Ring	
Detail ID	Ring 22	
Dist. from "FROM" Node / Offset dist	1999	mm.
Inside Diameter of Ring	956.22	mm.
Thickness of Ring	10	mm.
Outside Diameter of Ring	1057.1	mm.
Material Name	SA-240 304	
Height of Section Ring	0	mm.
Using Custom Stiffener Section	No	

Element From Node	100	
Detail Type	Ring	
Detail ID	Ring 28	
Dist. from "FROM" Node / Offset dist	0	mm.
Inside Diameter of Ring	1406	mm.
Thickness of Ring	10	mm.
Outside Diameter of Ring	1506.8	mm.
Material Name	SA-240 304	
Height of Section Ring	0	mm.
Using Custom Stiffener Section	No	

XY Coordinate Calculations:

From	To	X (Horiz.) mm.	Y (Vert.) mm.	DX (Horiz.) mm.	DY (Vert.) mm.
10	20	...	8052	...	8052
20	30	...	10052	...	2000
30	40	...	10852	...	800
40	50	...	12052	...	1200
50	60	...	16552	...	4500
60	70	...	18552	...	2000
70	80	...	19352	...	800
80	90	...	20552	...	1200
90	100	...	24052	...	3500
100	110	...	26052	...	2000

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
10	20	0.5	3	...	1300	104.16
20	30	0.5	3	...	1730	104.16
30	40	0.5	3	...	1730	104.16
40	50	0.5	3	...	1730	104.16
50	60	0.5	3	...	1400	104.16
60	70	0.5	3	...	1730	104.16
70	80	0.5	3	...	1730	104.16
80	90	0.5	3	...	1730	104.16
90	100	0.5	3	...	1400	104.16
100	110	0.5	3	...	1400	104.16

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.
10	20	0.5	4.79375	6.34667	3	1.5
20	30	0.5	3.58411	4.74517	3	1.5
30	40	0.5	3.60472	4.77245	3	1.5
40	50	0.5	3.57118	4.72806	3	1.5
50	60	0.5	4.45222	5.8945	3	1.5
60	70	0.5	3.59254	4.75633	3	1.5
70	80	0.5	3.60472	4.77245	3	1.5
80	90	0.5	3.57118	4.72806	3	1.5
90	100	0.5	4.45222	5.8945	3	1.5
100	110	0.5	4.42438	5.85764	3	1.5
Minimum			3.571	4.728		

MAWP: 3.571 bars, limited by: Cone.

Internal Pressure Calculation Results :

ASME Code, Section VIII Division 1, 2017

Cylindrical Shell From 10 To 20 SA-240 316 at 170 °C

Material UNS Number: S31600

Required Thickness due to Internal Pressure [tr]:
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (0.5*650.0)/(104.16*1.0-0.6*0.5)
= 0.3121 + 0.0000 = 0.3121 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]:
= (S*E*t)/(R+0.6*t) per UG-27 (c)(1)
= (104.16*1.0*3.0)/(650.0+0.6*3.0)
= 4.794 bars

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (S*E*t)/(R+0.6*t) per UG-27 (c)(1)
= (137.9*1.0*3.0)/(650.0+0.6*3.0)

= 6.347 bars

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(R+0.6*t))/(E*t)
= (0.5*(650.0+0.6*3.0))/(1.0*3.0)
= 10.864 N./mm²

% Elongation per Table UG-79-1 (50*tnom/Rf)*(1-Rf/Ro) 0.230 %
Note: Please Check Requirements of Table UHA-44 for Elongation limits.

SA-240 316, Min Metal Temp without impact per UHA-51: -196 °C

Conical Section From 20 To 30 SA-240 316 at 170 °C

Material UNS Number: S31600

Required Thickness due to Internal Pressure [tr]:
= (P*D)/(2*cos(a)*(S*E-0.6*P)) per Appendix 1-4 (e)
= (0.5*1730.0)/(2*0.9943*(104.16*1.0-0.6*0.5))
= 0.4178 + 0.0000 = 0.4178 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]:
= (2*S*E*t*cos(a))/(D+1.2*t*cos(a)) per App 1-4(e)
= (2*104.16*1.0*3.0*0.994)/(1730.0+1.2*3.0*0.994)
= 3.584 bars

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (2*S*E*t*cos(a))/(D+1.2*t*cos(a)) per App 1-4(e)
= (2*137.9*1.0*3.0*0.9943)/(1730.0+1.2*3.0*0.9943)
= 4.745 bars

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(D+1.2*t*cos(a)))/(2*E*t*cos(a))
= (0.5*(1730.0+1.2*3.0*0.9943))/(2*1.0*3.0*0.9943)
= 14.531 N./mm²

% Elongation per Table UG-79-1 (50*tnom/Rf)*(1-Rf/Ro) 0.230 %
Note: Please Check Requirements of Table UHA-44 for Elongation limits.

Note: The Pressure at the Large Diameter is used in the TR calculation.

SA-240 316, Min Metal Temp without impact per UHA-51: -196 °C

Cylindrical Shell From 30 To 40 SA-240 316 at 170 °C

Material UNS Number: S31600

Required Thickness due to Internal Pressure [tr]:
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (0.5*865.0)/(104.16*1.0-0.6*0.5)
= 0.4154 + 0.0000 = 0.4154 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]:
= (S*E*t)/(R+0.6*t) per UG-27 (c)(1)
= (104.16*1.0*3.0)/(865.0+0.6*3.0)
= 3.605 bars

Maximum Allowable Pressure, New and Cold [MAPNC]:

```
= (S*E*t)/(R+0.6*t) per UG-27 (c)(1)
= (137.9*1.0*3.0)/(865.0+0.6*3.0)
= 4.772 bars
```

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

```
= (P*(R+0.6*t))/(E*t)
= (0.5*(865.0+0.6*3.0))/(1.0*3.0)
= 14.448 N./mm²
```

% Elongation per Table UG-79-1 (50*tnom/Rf)*(1-Rf/Ro) 0.173 %
Note: Please Check Requirements of Table UHA-44 for Elongation limits.

SA-240 316, Min Metal Temp without impact per UHA-51: -196 °C

Conical Section From 40 To 50 SA-240 316 at 170 °C

Material UNS Number: S31600

Required Thickness due to Internal Pressure [tr]:

```
= (P*D)/(2*cos(a)*(S*E-0.6*P)) per Appendix 1-4 (e)
= (0.5*1730.0)/(2*0.9907*(104.16*1.0-0.6*0.5))
= 0.4193 + 0.0000 = 0.4193 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]:

```
= (2*S*E*t*cos(a))/(D+1.2*t*cos(a)) per App 1-4(e)
= (2*104.16*1.0*3.0*0.991)/(1730.0+1.2*3.0*0.991)
= 3.571 bars
```

Maximum Allowable Pressure, New and Cold [MAPNC]:

```
= (2*S*E*t*cos(a))/(D+1.2*t*cos(a)) per App 1-4(e)
= (2*137.9*1.0*3.0*0.9907)/(1730.0+1.2*3.0*0.9907)
= 4.728 bars
```

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

```
= (P*(D+1.2*t*cos(a)))/(2*E*t*cos(a))
= (0.5*(1730.0+1.2*3.0*0.9907))/(2*1.0*3.0*0.9907)
= 14.583 N./mm²
```

% Elongation per Table UG-79-1 (50*tnom/Rf)*(1-Rf/Ro) 0.214 %
Note: Please Check Requirements of Table UHA-44 for Elongation limits.

SA-240 316, Min Metal Temp without impact per UHA-51: -196 °C

Cylindrical Shell From 50 To 60 SA-240 316 at 170 °C

Material UNS Number: S31600

Required Thickness due to Internal Pressure [tr]:

```
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (0.5*700.0)/(104.16*1.0-0.6*0.5)
= 0.3361 + 0.0000 = 0.3361 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]:

```
= (S*E*t)/(R+0.6*t) per UG-27 (c)(1)
= (104.16*1.0*3.0)/(700.0+0.6*3.0)
```

= 4.452 bars

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (S*E*t)/(R+0.6*t) per UG-27 (c)(1)
= (137.9*1.0*3.0)/(700.0+0.6*3.0)
= 5.894 bars

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(R+0.6*t))/(E*t)
= (0.5*(700.0+0.6*3.0))/(1.0*3.0)
= 11.697 N./mm²

% Elongation per Table UG-79-1 (50*tnom/Rf)*(1-Rf/Ro) 0.214 %
Note: Please Check Requirements of Table UHA-44 for Elongation limits.

SA-240 316, Min Metal Temp without impact per UHA-51: -196 °C

Conical Section From 60 To 70 SA-240 316 at 170 °C

Material UNS Number: S31600

Required Thickness due to Internal Pressure [tr]:
= (P*D)/(2*cos(a)*(S*E-0.6*P)) per Appendix 1-4 (e)
= (0.5*1730.0)/(2*0.9966*(104.16*1.0-0.6*0.5))
= 0.4168 + 0.0000 = 0.4168 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]:
= (2*S*E*t*cos(a))/(D+1.2*t*cos(a)) per App 1-4(e)
= (2*104.16*1.0*3.0*0.997)/(1730.0+1.2*3.0*0.997)
= 3.593 bars

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (2*S*E*t*cos(a))/(D+1.2*t*cos(a)) per App 1-4(e)
= (2*137.9*1.0*3.0*0.9966)/(1730.0+1.2*3.0*0.9966)
= 4.756 bars

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(D+1.2*t*cos(a)))/(2*E*t*cos(a))
= (0.5*(1730.0+1.2*3.0*0.9966))/(2*1.0*3.0*0.9966)
= 14.496 N./mm²

% Elongation per Table UG-79-1 (50*tnom/Rf)*(1-Rf/Ro) 0.214 %
Note: Please Check Requirements of Table UHA-44 for Elongation limits.

Note: The Pressure at the Large Diameter is used in the TR calculation.

SA-240 316, Min Metal Temp without impact per UHA-51: -196 °C

Cylindrical Shell From 70 To 80 SA-240 316 at 170 °C

Material UNS Number: S31600

Required Thickness due to Internal Pressure [tr]:
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (0.5*865.0)/(104.16*1.0-0.6*0.5)
= 0.4154 + 0.0000 = 0.4154 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]:
```
  = (S*E*t)/(R+0.6*t) per UG-27 (c)(1)
  = (104.16*1.0*3.0)/(865.0+0.6*3.0)
  = 3.605 bars
```

Maximum Allowable Pressure, New and Cold [MAPNC]:
```
  = (S*E*t)/(R+0.6*t) per UG-27 (c)(1)
  = (137.9*1.0*3.0)/(865.0+0.6*3.0)
  = 4.772 bars
```

Actual stress at given pressure and thickness, corroded [Sact]:
```
  = (P*(R+0.6*t))/(E*t)
  = (0.5*(865.0+0.6*3.0))/(1.0*3.0)
  = 14.448 N./mm²
```

% Elongation per Table UG-79-1 (50*tnom/Rf)*(1-Rf/Ro) 0.173 %
Note: Please Check Requirements of Table UHA-44 for Elongation limits.

SA-240 316, Min Metal Temp without impact per UHA-51: -196 °C

Conical Section From 80 To 90 SA-240 316 at 170 °C

Material UNS Number: S31600

Required Thickness due to Internal Pressure [tr]:
```
  = (P*D)/(2*cos(a)*(S*E-0.6*P)) per Appendix 1-4 (e)
  = (0.5*1730.0)/(2*0.9907*(104.16*1.0-0.6*0.5))
  = 0.4193 + 0.0000 = 0.4193 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]:
```
  = (2*S*E*t*cos(a))/(D+1.2*t*cos(a)) per App 1-4(e)
  = (2*104.16*1.0*3.0*0.991)/(1730.0+1.2*3.0*0.991)
  = 3.571 bars
```

Maximum Allowable Pressure, New and Cold [MAPNC]:
```
  = (2*S*E*t*cos(a))/(D+1.2*t*cos(a)) per App 1-4(e)
  = (2*137.9*1.0*3.0*0.9907)/(1730.0+1.2*3.0*0.9907)
  = 4.728 bars
```

Actual stress at given pressure and thickness, corroded [Sact]:
```
  = (P*(D+1.2*t*cos(a)))/(2*E*t*cos(a))
  = (0.5*(1730.0+1.2*3.0*0.9907))/(2*1.0*3.0*0.9907)
  = 14.583 N./mm²
```

% Elongation per Table UG-79-1 (50*tnom/Rf)*(1-Rf/Ro) 0.214 %
Note: Please Check Requirements of Table UHA-44 for Elongation limits.

SA-240 316, Min Metal Temp without impact per UHA-51: -196 °C

Cylindrical Shell From 90 To 100 SA-240 316 at 170 °C

Material UNS Number: S31600

Required Thickness due to Internal Pressure [tr]:
```
  = (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
  = (0.5*700.0)/(104.16*1.0-0.6*0.5)
  = 0.3361 + 0.0000 = 0.3361 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]:

```
= (S*E*t)/(R+0.6*t) per UG-27 (c)(1)
= (104.16*1.0*3.0)/(700.0+0.6*3.0)
= 4.452 bars
```

Maximum Allowable Pressure, New and Cold [MAPNC]:

```
= (S*E*t)/(R+0.6*t) per UG-27 (c)(1)
= (137.9*1.0*3.0)/(700.0+0.6*3.0)
= 5.894 bars
```

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

```
= (P*(R+0.6*t))/(E*t)
= (0.5*(700.0+0.6*3.0))/(1.0*3.0)
= 11.697 N./mm²
```

% Elongation per Table UG-79-1 (50*tnom/Rf)*(1-Rf/Ro) 0.214 %
Note: Please Check Requirements of Table UHA-44 for Elongation limits.

SA-240 316, Min Metal Temp without impact per UHA-51: -196 °C

Conical Section From 100 To 110 SA-240 316 at 170 °C

Material UNS Number: S31600

Required Thickness due to Internal Pressure [tr]:

```
= (P*D)/(2*cos(a)*(S*E-0.6*P)) per Appendix 1-4 (e)
= (0.5*1400.0)/(2*0.9937*(104.16*1.0-0.6*0.5))
= 0.3383 + 0.0000 = 0.3383 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]:

```
= (2*S*E*t*cos(a))/(D+1.2*t*cos(a)) per App 1-4(e)
= (2*104.16*1.0*3.0*0.994)/(1400.0+1.2*3.0*0.994)
= 4.424 bars
```

Maximum Allowable Pressure, New and Cold [MAPNC]:

```
= (2*S*E*t*cos(a))/(D+1.2*t*cos(a)) per App 1-4(e)
= (2*137.9*1.0*3.0*0.9937)/(1400.0+1.2*3.0*0.9937)
= 5.858 bars
```

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

```
= (P*(D+1.2*t*cos(a)))/(2*E*t*cos(a))
= (0.5*(1400.0+1.2*3.0*0.9937))/(2*1.0*3.0*0.9937)
= 11.771 N./mm²
```

% Elongation per Table UG-79-1 (50*tnom/Rf)*(1-Rf/Ro) 0.315 %
Note: Please Check Requirements of Table UHA-44 for Elongation limits.

SA-240 316, Min Metal Temp without impact per UHA-51: -196 °C

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	Ring	3958	1306	3	0.46719E-04	4.48502
Ring	Ring	1988	1306	3	0.95296E-04	9.14839
Ring	Ring	1993	1306	3	0.95050E-04	9.12477
Ring	Ring	12.9998	1306	3	0.0047922	91.4355
Ring	20	100	1306	3	0.0026	83.9018
20	Ring	1679.94	1306.03	3	0.00011239	10.7893
Ring	30	1752.3	1736.03	3	0.93196E-04	8.94674
30	Ring	No Calc	...	3	No Calc	No Calc
Ring	40	800	1736	3	0.00021156	20.3093
40	Ring	1752.3	1736.06	3	0.92641E-04	8.89351
Ring	Ring	1085.13	1736.06	3	0.00015138	14.5319
Ring	50	0.99994	1406.33	3	0.0041294	89.7316
50	Ring	90	1406	3	0.0029414	85.5356
Ring	Ring	13	1406	3	0.0042047	89.9431
Ring	Ring	1410	1406	3	0.000131	12.5764
Ring	Ring	1400	1406	3	0.00013196	12.6681
Ring	60	1587	1406	3	0.00011601	11.1366
60	Ring	0.99994	1406.02	3	0.004178	89.8686
Ring	Ring	1809.08	1735.86	3	0.90550E-04	8.69271
Ring	70	0.99989	1736.02	3	0.0028755	85.24
70	Ring	737	1736	3	0.00023058	22.1352
Ring	Ring	13	1736	3	0.0028938	85.3229
Ring	80	50	1736	3	0.0028938	85.3229
80	Ring	0.99989	1736.06	3	0.0028434	85.0923
Ring	Ring	1085.13	1736.06	3	0.00015138	14.5319
Ring	90	0.99994	1406.33	3	0.0041294	89.7316
90	Ring	375	1406	3	0.00052804	50.6919
Ring	Ring	1370	1406	3	0.0001349	12.9498
Ring	100	1755	1406	3	0.00010461	10.0421
100	Ring	0.99994	1406.04	3	0.0041551	89.8045
Ring	Ring	1679.26	1406.04	3	0.00010837	10.4036
Ring	110	0.99982	956.263	3	0.0083163	97.0162

External Pressure Calculations:

From	To	External Actual T. mm.	External Required T. mm.	External Design Pressure bars	External M.A.W.P. bars
10	Ring	3	2.64879	0.1	0.13736
Ring	Ring	3	1.98494	0.1	0.28018
Ring	Ring	3	1.98708	0.1	0.27946
Ring	Ring	3	0.47257	0.1	2.80031
Ring	20	3	0.57319	0.1	2.56958
20	Ring	3	1.86049	0.1	0.32853
Ring	30	3	2.24961	0.1	0.20495
30	Ring	3	No Calc	0.1	No Calc
Ring	40	3	1.62103	0.1	0.46793
40	Ring	3	2.25778	0.1	0.20299
Ring	Ring	3	1.85593	0.1	0.33169
Ring	50	3	0.51366	0.1	2.52828
50	Ring	3	0.56956	0.1	2.4333
Ring	Ring	3	0.50876	0.1	2.55869
Ring	Ring	3	1.80715	0.1	0.35777
Ring	Ring	3	1.80239	0.1	0.36038
Ring	60	3	1.89031	0.1	0.31681

60	Ring	3	0.51049	0.1	2.54788
Ring	Ring	3	2.27117	0.1	0.19962
Ring	70	3	0.6303	0.1	1.95727
70	Ring	3	1.56614	0.1	0.51
Ring	Ring	3	0.62816	0.1	1.96585
Ring	80	3	0.62816	0.1	1.96585
80	Ring	3	0.63409	0.1	1.9422
Ring	Ring	3	1.85593	0.1	0.33169
Ring	90	3	0.51366	0.1	2.52828
90	Ring	3	1.04348	0.1	1.44208
Ring	Ring	3	1.78809	0.1	0.3684
Ring	100	3	1.96728	0.1	0.28568
100	Ring	3	0.51198	0.1	2.53866
Ring	Ring	3	1.94504	0.1	0.2941
Ring	110	3	0.34821	0.1	4.03247
Minimum					0.137

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	Ring	3958	5366.66	No Calc	No Calc
Ring	Ring	1988	5367.77	4.74696	17.6358
Ring	Ring	1993	5367.78	3.17821	17.6358
Ring	Ring	12.9998	362.283	1.60148	17.6358
Ring	20	100	3105.85	0.090213	17.6358
20	Ring	1679.94	1679.94	No Calc	No Calc
Ring	30	1752.3	1752.3	2.74012	118.645
30	Ring	No Calc	No Calc	No Calc	No Calc
Ring	40	800	3576.41	1.50003	18.5486
40	Ring	1752.3	1752.3	No Calc	No Calc
Ring	Ring	1085.13	1085.13	5.32031	21.7628
Ring	50	0.99994	0.99994	1.08257	17.7314
50	Ring	90	2782.45	No Calc	No Calc
Ring	Ring	13	332.63	0.1026	17.8679
Ring	Ring	1410	4840.94	1.41706	17.8679
Ring	Ring	1400	4840.92	2.80393	17.8679
Ring	60	1587	4841.33	2.96283	17.8679
60	Ring	0.99994	0.99994	No Calc	No Calc
Ring	Ring	1809.08	1809.08	1.80308	17.8679
Ring	70	0.99989	0.99989	3.39301	18.5482
70	Ring	737	3576.31	No Calc	No Calc
Ring	Ring	13	979.513	1.41118	18.5486
Ring	80	50	1799.98	0.11813	18.5486
80	Ring	0.99989	0.99989	No Calc	No Calc
Ring	Ring	1085.13	1085.13	2.0298	18.381
Ring	90	0.99994	0.99994	1.08257	17.7021
90	Ring	375	4840.98	No Calc	No Calc
Ring	Ring	1370	4840.85	1.73585	17.8679
Ring	100	1755	4841.66	3.11292	17.8679
100	Ring	0.99994	0.99994	No Calc	No Calc
Ring	Ring	1679.26	1679.26	1.67377	21.4269
Ring	110	0.99982	0.99982	0.52653	20.0339

Elements Suitable for External Pressure.

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Cylindrical Shell From 10 to Ring:[1 of 1] Ext. Chart: HA-2 at 50 °C

Elastic Modulus from Chart: HA-2 at 50 °C : 0.192E+09 KPa.

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
3.000	1306.00	3958.00	435.33	3.0306	0.0000467	4.49

EMAP = (4*B)/(3*(D/t)) = (4*4.485)/(3*435.3333) = 0.1374 bars

Results for Required Thickness (Tca):

Tca	OD	SLEN	D/t	L/D	Factor A	B
2.649	1306.00	3958.00	493.06	3.0306	0.0000385	3.70

EMAP = (4*B)/(3*(D/t)) = (4*3.6983)/(3*493.0556) = 0.1 bars

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
3.000	1306.00	5366.66	435.33	4.1092	0.0000340	3.27

EMAP = (4*B)/(3*(D/t)) = (4*3.268)/(3*435.3333) = 0.1001 bars

Cylindrical Shell From Ring:[1 of 1] to Ring:[2 of 2] Ext. Chart: HA-2 at 50 °C

Elastic Modulus from Chart: HA-2 at 50 °C : 0.192E+09 KPa.

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
3.000	1306.00	1988.00	435.33	1.5222	0.0000953	9.15

EMAP = (4*B)/(3*(D/t)) = (4*9.1484)/(3*435.3333) = 0.2802 bars

Results for Required Thickness (Tca):

Tca	OD	SLEN	D/t	L/D	Factor A	B
1.985	1306.00	1988.00	657.96	1.5222	0.0000514	4.94

EMAP = (4*B)/(3*(D/t)) = (4*4.9351)/(3*657.9558) = 0.1 bars

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
3.000	1306.00	5367.77	435.33	4.1101	0.0000340	3.27

EMAP = (4*B)/(3*(D/t)) = (4*3.2673)/(3*435.3333) = 0.1001 bars

Cylindrical Shell From Ring:[2 of 2] to Ring:[3 of 3] Ext. Chart: HA-2 at 50 °C

Elastic Modulus from Chart: HA-2 at 50 °C : 0.192E+09 KPa.

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
3.000	1306.00	1993.00	435.33	1.5260	0.0000951	9.12

EMAP = (4*B)/(3*(D/t)) = (4*9.1248)/(3*435.3333) = 0.2795 bars

Results for Required Thickness (Tca):

Tca	OD	SLEN	D/t	L/D	Factor A	B
1.987	1306.00	1993.00	657.25	1.5260	0.0000514	4.93

EMAP = (4*B)/(3*(D/t)) = (4*4.9298)/(3*657.2463) = 0.1 bars

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
3.000	1306.00	5367.78	435.33	4.1101	0.0000340	3.27

EMAP = (4*B)/(3*(D/t)) = (4*3.2673)/(3*435.3333) = 0.1001 bars

Cone From Ring 16 to 30 Ext. Chart: HA-2 at 50 °C

Elastic Modulus from Chart: HA-2 at 50 °C : 0.192E+09 KPa.

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
2.983	1736.03	1752.30	582.01	1.0094	0.0000932	8.95

EMAP = (4*B)/(3*(D/t)) = (4*8.9467)/(3*582.0123) = 0.2049 bars

Note: The cone thickness used in the calculation has been modified
per UG-33(f), te = t * cos(alpha).

Results for Required Thickness (Tca):

Tca	OD	SLEN	D/t	L/D	Factor A	B
2.237	1736.03	1752.30	776.15	1.0094	0.0000606	5.82

EMAP = (4*B)/(3*(D/t)) = (4*5.8216)/(3*776.1512) = 0.1 bars

Note: The cone thickness used in the calculation has been modified
per UG-33(f), te = t * cos(alpha).

Cylindrical Shell From Ring5 to 40 Ext. Chart: HA-2 at 50 °C

Elastic Modulus from Chart: HA-2 at 50 °C : 0.192E+09 KPa.

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
3.000	1736.00	800.00	578.67	0.4608	0.0002116	20.31

EMAP = (4*B)/(3*(D/t)) = (4*20.3093)/(3*578.6667) = 0.4679 bars

Results for Required Thickness (Tca):

Tca	OD	SLEN	D/t	L/D	Factor A	B
1.621	1736.00	800.00	1070.92	0.4608	0.0000837	8.03

EMAP = (4*B)/(3*(D/t)) = (4*8.0326)/(3*1070.9225) = 0.1 bars

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
3.000	1736.00	3576.41	578.67	2.0601	0.0000452	4.34

EMAP = (4*B)/(3*(D/t)) = (4*4.3427)/(3*578.6667) = 0.1001 bars

Cone From Ring 21 to Ring:17 Ext. Chart: HA-2 at 50 °C

Elastic Modulus from Chart: HA-2 at 50 °C : 0.192E+09 KPa.

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
2.972	1736.06	1085.13	584.13	0.6251	0.0001514	14.53

EMAP = (4*B)/(3*(D/t)) = (4*14.5319)/(3*584.1302) = 0.3317 bars

Note: The cone thickness used in the calculation has been modified
per UG-33(f), te = t * cos(alpha).

Results for Required Thickness (Tca):

Tca	OD	SLEN	D/t	L/D	Factor A	B
1.839	1736.06	1085.13	944.21	0.6251	0.0000738	7.08

EMAP = (4*B)/(3*(D/t)) = (4*7.0822)/(3*944.2127) = 0.1 bars

Note: The cone thickness used in the calculation has been modified
per UG-33(f), te = t * cos(alpha).

Cone From Ring:17 to 50 Ext. Chart: HA-2 at 50 °C

Cylindrical Shell From Ring 7 to Ring 8 Ext. Chart: HA-2 at 50 °C

Elastic Modulus from Chart: HA-2 at 50 °C : 0.192E+09 KPa.

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
3.000	1406.00	1410.00	468.67	1.0028	0.0001310	12.58

EMAP = (4*B)/(3*(D/t)) = (4*12.5764)/(3*468.6667) = 0.3578 bars

Results for Required Thickness (Tca):

Tca	OD	SLEN	D/t	L/D	Factor A	B
1.807	1406.00	1410.00	778.02	1.0028	0.0000608	5.84

EMAP = (4*B)/(3*(D/t)) = (4*5.8358)/(3*778.0202) = 0.1 bars

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
3.000	1406.00	4840.94	468.67	3.4431	0.0000366	3.52

EMAP = (4*B)/(3*(D/t)) = (4*3.5182)/(3*468.6667) = 0.1001 bars

Cylindrical Shell From Ring 8 to Ring 9 Ext. Chart: HA-2 at 50 °C

Elastic Modulus from Chart: HA-2 at 50 °C : 0.192E+09 KPa.

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
3.000	1406.00	1400.00	468.67	0.9957	0.0001320	12.67

EMAP = (4*B)/(3*(D/t)) = (4*12.6681)/(3*468.6667) = 0.3604 bars

Results for Required Thickness (Tca):

Tca	OD	SLEN	D/t	L/D	Factor A	B
1.802	1406.00	1400.00	780.07	0.9957	0.0000610	5.85

EMAP = (4*B)/(3*(D/t)) = (4*5.8512)/(3*780.0737) = 0.1 bars

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
3.000	1406.00	4840.92	468.67	3.4430	0.0000366	3.52

EMAP = (4*B)/(3*(D/t)) = (4*3.5182)/(3*468.6667) = 0.1001 bars

Cylindrical Shell From Ring 9 to 60 Ext. Chart: HA-2 at 50 °C

Elastic Modulus from Chart: HA-2 at 50 °C : 0.192E+09 KPa.

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
3.000	1406.00	1587.00	468.67	1.1287	0.0001160	11.14

EMAP = (4*B)/(3*(D/t)) = (4*11.1366)/(3*468.6667) = 0.3168 bars

Results for Required Thickness (Tca):

Tca	OD	SLEN	D/t	L/D	Factor A	B
1.890	1406.00	1587.00	743.79	1.1287	0.0000581	5.58

EMAP = (4*B)/(3*(D/t)) = (4*5.5789)/(3*743.7935) = 0.1 bars

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
3.000	1406.00	4841.33	468.67	3.4433	0.0000366	3.52

EMAP = (4*B)/(3*(D/t)) = (4*3.5179)/(3*468.6667) = 0.1001 bars

Cone From Ring 18 to Ring 23 Ext. Chart: HA-2 at 50 °C

Elastic Modulus from Chart: HA-2 at 50 °C : 0.192E+09 KPa.

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
2.990	1735.86	1809.08	580.58	1.0422	0.0000905	8.69

EMAP = (4*B)/(3*(D/t)) = (4*8.6927)/(3*580.5842) = 0.1996 bars

Note: The cone thickness used in the calculation has been modified
per UG-33(f), te = t * cos(alpha).

Results for Required Thickness (Tca):

Tca	OD	SLEN	D/t	L/D	Factor A	B
2.263	1735.86	1809.08	766.90	1.0422	0.0000599	5.75

EMAP = (4*B)/(3*(D/t)) = (4*5.7522)/(3*766.8951) = 0.1 bars

Note: The cone thickness used in the calculation has been modified
per UG-33(f), te = t * cos(alpha).

Cone From Ring 23 to 70 Ext. Chart: HA-2 at 50 °C

Cylindrical Shell From 70 to Ring 10 Ext. Chart: HA-2 at 50 °C

Elastic Modulus from Chart: HA-2 at 50 °C : 0.192E+09 KPa.

Results for Maximum Allowable External Pressure (MAEP):

```
     Tca          OD          SLEN         D/t         L/D    Factor A         B
   3.000     1736.00       737.00      578.67     0.4245   0.0002306     22.14
 EMAP = (4*B)/(3*(D/t)) = (4*22.1352)/(3*578.6667) = 0.51 bars
```

Results for Required Thickness (Tca):

```
     Tca          OD          SLEN         D/t         L/D    Factor A         B
   1.566     1736.00       737.00     1108.46     0.4245   0.0000866      8.31
 EMAP = (4*B)/(3*(D/t)) = (4*8.3142)/(3*1108.459) = 0.1 bars
```

Results for Maximum Stiffened Length (Slen):

```
     Tca          OD          SLEN         D/t         L/D    Factor A         B
   3.000     1736.00      3576.31      578.67     2.0601   0.0000452      4.34
 EMAP = (4*B)/(3*(D/t)) = (4*4.3428)/(3*578.6667) = 0.1001 bars
```

Cone From Ring 24 to Ring 26 Ext. Chart: HA-2 at 50 °C

Elastic Modulus from Chart: HA-2 at 50 °C : 0.192E+09 KPa.

Results for Maximum Allowable External Pressure (MAEP):

```
     Tca          OD          SLEN         D/t         L/D    Factor A         B
   2.972     1736.06      1085.13      584.13     0.6251   0.0001514     14.53
 EMAP = (4*B)/(3*(D/t)) = (4*14.5319)/(3*584.1302) = 0.3317 bars
```

Note: The cone thickness used in the calculation has been modified
per UG-33(f), te = t * cos(alpha).

Results for Required Thickness (Tca):

```
     Tca          OD          SLEN         D/t         L/D    Factor A         B
   1.839     1736.06      1085.13      944.21     0.6251   0.0000738      7.08
 EMAP = (4*B)/(3*(D/t)) = (4*7.0822)/(3*944.2127) = 0.1 bars
```

Note: The cone thickness used in the calculation has been modified
per UG-33(f), te = t * cos(alpha).

Cone From Ring 26 to 90 Ext. Chart: HA-2 at 50 °C

Cylindrical Shell From 90 to Ring 12 Ext. Chart: HA-2 at 50 °C

Elastic Modulus from Chart: HA-2 at 50 °C : 0.192E+09 KPa.

Results for Maximum Allowable External Pressure (MAEP):

```
     Tca          OD          SLEN         D/t         L/D    Factor A         B
   3.000     1406.00       375.00      468.67     0.2667   0.0005280     50.69
 EMAP = (4*B)/(3*(D/t)) = (4*50.6919)/(3*468.6667) = 1.4421 bars
```

Results for Required Thickness (Tca):

```
     Tca          OD          SLEN         D/t         L/D    Factor A         B
   1.043     1406.00       375.00     1347.41     0.2667   0.0001053     10.11
 EMAP = (4*B)/(3*(D/t)) = (4*10.1068)/(3*1347.4142) = 0.1 bars
```

Results for Maximum Stiffened Length (Slen):

```
     Tca          OD          SLEN         D/t         L/D    Factor A         B
   3.000     1406.00      4840.98      468.67     3.4431   0.0000366      3.52
 EMAP = (4*B)/(3*(D/t)) = (4*3.5182)/(3*468.6667) = 0.1001 bars
```

Cylindrical Shell From Ring 12 to Ring 13] Ext. Chart: HA-2 at 50 °C

Elastic Modulus from Chart: HA-2 at 50 °C : 0.192E+09 KPa.

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
3.000	1406.00	1370.00	468.67	0.9744	0.0001349	12.95

EMAP = (4*B)/(3*(D/t)) = (4*12.9498)/(3*468.6667) = 0.3684 bars

Results for Required Thickness (Tca):

Tca	OD	SLEN	D/t	L/D	Factor A	B
1.788	1406.00	1370.00	786.31	0.9744	0.0000614	5.90

EMAP = (4*B)/(3*(D/t)) = (4*5.898)/(3*786.3148) = 0.1 bars

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
3.000	1406.00	4840.85	468.67	3.4430	0.0000366	3.52

EMAP = (4*B)/(3*(D/t)) = (4*3.5183)/(3*468.6667) = 0.1001 bars

Cylindrical Shell From Ring 13] to 100 Ext. Chart: HA-2 at 50 °C

Elastic Modulus from Chart: HA-2 at 50 °C : 0.192E+09 KPa.

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
3.000	1406.00	1755.00	468.67	1.2482	0.0001046	10.04

EMAP = (4*B)/(3*(D/t)) = (4*10.0421)/(3*468.6667) = 0.2857 bars

Results for Required Thickness (Tca):

Tca	OD	SLEN	D/t	L/D	Factor A	B
1.967	1406.00	1755.00	714.69	1.2482	0.0000558	5.36

EMAP = (4*B)/(3*(D/t)) = (4*5.3608)/(3*714.6927) = 0.1 bars

Results for Maximum Stiffened Length (Slen):

Tca	OD	SLEN	D/t	L/D	Factor A	B
3.000	1406.00	4841.66	468.67	3.4436	0.0000366	3.52

EMAP = (4*B)/(3*(D/t)) = (4*3.5177)/(3*468.6667) = 0.1001 bars

Cone From Ring 28 to Ring 22 Ext. Chart: HA-2 at 50 °C

Elastic Modulus from Chart: HA-2 at 50 °C : 0.192E+09 KPa.

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
2.981	1406.04	1679.26	471.64	1.1943	0.0001084	10.40

EMAP = (4*B)/(3*(D/t)) = (4*10.4036)/(3*471.6358) = 0.2941 bars

Note: The cone thickness used in the calculation has been modified
per UG-33(f), te = t * cos(alpha).

Results for Required Thickness (Tca):

Tca	OD	SLEN	D/t	L/D	Factor A	B
1.933	1406.04	1679.26	727.44	1.1943	0.0000568	5.46

EMAP = (4*B)/(3*(D/t)) = (4*5.4564)/(3*727.4449) = 0.1 bars

Note: The cone thickness used in the calculation has been modified
per UG-33(f), te = t * cos(alpha).

Cone From Ring 22 to the end: Ext. Chart: HA-2 at 50 °C

Stiffening Ring Calcs for : Ring:[1 of 1] , SA-240 316 , Bar Ring: 47 x 10 mm.

Effective Length of Shell: 69 mm.

	Area (cm²)	Distance (mm.)	Area*Dist

```
Shell:              2.066         1.5000           3.098
Ring :              4.700        26.5000         124.550
Total:              6.766                        127.648
--------------------------------------------------------
Centroid of Ring plus Shell:                          19 mm.

                 Inertia        Distance         A*Dist²
--------------------------------------------------------
Shell:              0.015        17.3673         623.030
Ring :              8.652        -7.6327         273.815
Total:              8.667                        896.845
--------------------------------------------------------
Available Moment of Inertia, Ring plus Shell:         18 cm**4

Required Stress in Ring plus Shell      Breq        3.10 N./mm²
Required Strain in Ring plus Shell      Areq   0.0000323
```

Required Moment of Inertia, Ring plus Shell:

```
  = ( OD² * Slen(Tca + Aring/Slen)Areq )/10.9
  = (1306.0²*2973.0002(3.0+4.7/2973.0002)0.000032)/10.9
  = 5 cm**4
```

Results for Stiffening Ring Weld Calculations per UG-30:

```
Given Stiffening Ring Fillet Weld Size         Wleg     3.000  mm.
Stiffening Ring Attachment Style                   CONTINUOUS
Location of Stiffening Ring                          EXTERNAL
Radial Pressure Load                      Pext*Slen      3.03  Kgf/mm.
The Radial Shear Load                             V     39.59  Kgf
The First Moment of the Area ( Ring + Shell )     Q   3587.38  mm.³
Weld Shear Flow due to Rad. Shear Load         VQ/I      0.81  Kgf/mm.
The Weld Allowable Stress                    0.55*S     73.59  N./mm²
Minimum Weld Leg Size Min( 6mm, t, tw )      Wldmin      3.00  mm.
The Weld Allowable Load            2*   WLeg*0.55*S     45.03  Kgf/mm.
The Combined Weld Load   SRSS of VQ/I and Pext*Slen      3.14  Kgf/mm.
```

Stiffening Ring Calcs for : Ring:[2 of 2] , SA-240 316 , Bar Ring: 47 x 10 mm.

```
Effective Length of Shell:                            69 mm.

                Area (cm²)   Distance (mm.)    Area*Dist
--------------------------------------------------------
Shell:              2.066         1.5000           3.098
Ring :              4.700        26.5000         124.550
Total:              6.766                        127.648
--------------------------------------------------------
Centroid of Ring plus Shell:                          19 mm.

                 Inertia        Distance         A*Dist²
--------------------------------------------------------
Shell:              0.015        17.3673         623.030
Ring :              8.652        -7.6327         273.815
Total:              8.667                        896.845
--------------------------------------------------------
Available Moment of Inertia, Ring plus Shell:         18 cm**4

Required Stress in Ring plus Shell      Breq        3.03 N./mm²
Required Strain in Ring plus Shell      Areq   0.0000315
```

Required Moment of Inertia, Ring plus Shell:

```
  = ( OD² * Slen(Tca + Aring/Slen)Areq )/10.9
  = (1306.0²*1990.5(3.0+4.7/1990.5)0.000032)/10.9
  = 3 cm**4
```

Results for Stiffening Ring Weld Calculations per UG-30:

```
Given Stiffening Ring Fillet Weld Size         Wleg     3.000  mm.
```

```
 Stiffening Ring Attachment Style                     CONTINUOUS
 Location of Stiffening Ring                            EXTERNAL
 Radial Pressure Load                      Pext*Slen      2.03  Kgf/mm.
 The Radial Shear Load                             V     26.51  Kgf
 The First Moment of the Area ( Ring + Shell )     Q   3587.38  mm.³
 Weld Shear Flow due to Rad. Shear Load         VQ/I      0.54  Kgf/mm.
 The Weld Allowable Stress                    0.55*S     73.59  N./mm²
 Minimum Weld Leg Size Min( 6mm, t, tw )      Wldmin      3.00  mm.
 The Weld Allowable Load            2*   WLeg*0.55*S     45.03  Kgf/mm.
 The Combined Weld Load   SRSS of VQ/I and Pext*Slen      2.10  Kgf/mm.
```

Stiffening Ring Calcs for : Ring:[3 of 3] , SA-240 316 , Bar Ring: 47 x 10 mm.

```
 Effective Length of Shell:                                69 mm.

                Area (cm²)   Distance (mm.)    Area*Dist
 --------------------------------------------------------
 Shell:             2.066         1.5000          3.098
 Ring :             4.700        26.5000        124.550
 Total:             6.766                       127.648
 --------------------------------------------------------
 Centroid of Ring plus Shell:                              19 mm.

                 Inertia        Distance         A*Dist²
 --------------------------------------------------------
 Shell:             0.015        17.3673        623.030
 Ring :             8.652        -7.6327        273.815
 Total:             8.667                       896.845
 --------------------------------------------------------
 Available Moment of Inertia, Ring plus Shell:         18 cm**4

 Required Stress in Ring plus Shell      Breq        2.82 N./mm²
 Required Strain in Ring plus Shell      Areq   0.0000294
```

Required Moment of Inertia, Ring plus Shell:

```
  = ( OD² * Slen(Tca + Aring/Slen)Areq )/10.9
  = (1306.0²*1003.0(3.0+4.7/1003.0)0.000029)/10.9
  = 2 cm**4
```

Results for Stiffening Ring Weld Calculations per UG-30:

```
 Given Stiffening Ring Fillet Weld Size         Wleg     3.000  mm.
 Stiffening Ring Attachment Style                     CONTINUOUS
 Location of Stiffening Ring                            EXTERNAL
 Radial Pressure Load                      Pext*Slen      1.02  Kgf/mm.
 The Radial Shear Load                             V     13.36  Kgf
 The First Moment of the Area ( Ring + Shell )     Q   3587.38  mm.³
 Weld Shear Flow due to Rad. Shear Load         VQ/I      0.27  Kgf/mm.
 The Weld Allowable Stress                    0.55*S     73.59  N./mm²
 Minimum Weld Leg Size Min( 6mm, t, tw )      Wldmin      3.00  mm.
 The Weld Allowable Load            2*   WLeg*0.55*S     45.03  Kgf/mm.
 The Combined Weld Load   SRSS of VQ/I and Pext*Slen      1.06  Kgf/mm.
```

Stiffening Ring Calcs for : Ring:[4 of 4] , SA-240 316 , Bar Ring: 47 x 10 mm.

```
 Effective Length of Shell:                                69 mm.

                Area (cm²)   Distance (mm.)    Area*Dist
 --------------------------------------------------------
 Shell:             2.066         1.5000          3.098
 Ring :             4.700        26.5000        124.550
 Total:             6.766                       127.648
 --------------------------------------------------------
 Centroid of Ring plus Shell:                              19 mm.

                 Inertia        Distance         A*Dist²
```

Shell:	0.015	17.3673	623.030
Ring :	8.652	-7.6327	273.815
Total:	8.667		896.845

Available Moment of Inertia, Ring plus Shell: 18 cm**4

Required Stress in Ring plus Shell Breq 0.87 N./mm²
Required Strain in Ring plus Shell Areq 0.0000090

Required Moment of Inertia, Ring plus Shell:
= (OD² * Slen(Tca + Aring/Slen)Areq)/10.9
= (1306.0²*56.5(3.0+4.7/56.5)0.000009)/10.9
= 0 cm**4

Results for Stiffening Ring Weld Calculations per UG-30:

Given Stiffening Ring Fillet Weld Size	Wleg	3.000	mm.
Stiffening Ring Attachment Style		CONTINUOUS	
Location of Stiffening Ring		EXTERNAL	
Radial Pressure Load	Pext*Slen	0.06	Kgf/mm.
The Radial Shear Load	V	0.75	Kgf
The First Moment of the Area (Ring + Shell)	Q	3587.38	mm.³
Weld Shear Flow due to Rad. Shear Load	VQ/I	0.02	Kgf/mm.
The Weld Allowable Stress	0.55*S	73.59	N./mm²
Minimum Weld Leg Size Min(6mm, t, tw)	Wldmin	3.00	mm.
The Weld Allowable Load	2* WLeg*0.55*S	45.03	Kgf/mm.
The Combined Weld Load	SRSS of VQ/I and Pext*Slen	0.06	Kgf/mm.

<u>Stiffening Ring Calcs for : Ring 16 , SA-240 304 , Bar Ring: 97 x 10 mm.</u>

Effective Length of Shell: 69 mm.

	Area (cm²)	Distance (mm.)	Area*Dist
Shell:	2.066	1.5000	3.098
Ring :	9.700	51.5000	499.550
Total:	11.766		502.648

Centroid of Ring plus Shell: 43 mm.

	Inertia	Distance	A*Dist²
Shell:	0.015	41.2219	3509.954
Ring :	76.056	-8.7781	747.439
Total:	76.071		4257.393

Available Moment of Inertia, Ring plus Shell: 119 cm**4

Required Stress in Ring plus Shell Breq 2.75 N./mm²
Required Strain in Ring plus Shell Areq 0.0000286

Required Moment of Inertia, Ring plus Shell:
= (OD² * Slen(Tca + Aring/Slen)Areq)/10.9
= (1306.0²*1716.1235(3.0+9.7/1716.1235)0.000029)/10.9
= 3 cm**4

<u>Stiffening Ring Calcs for : Ring5 , SA-240 304 , Bar Ring: 47 x 10 mm.</u>

Effective Length of Shell: 79 mm.

	Area (cm²)	Distance (mm.)	Area*Dist
Shell:	2.381	1.5000	3.572
Ring :	4.700	26.5000	124.550
Total:	7.081		128.122

```
 --------------------------------------------------------
 Centroid of Ring plus Shell:                         18 mm.

                  Inertia       Distance        A*Dist²
 --------------------------------------------------------
 Shell:             0.018        16.5926        655.656
 Ring :             8.652        -8.4075        332.221
 Total:             8.670                       987.878
 --------------------------------------------------------
 Available Moment of Inertia, Ring plus Shell:        19 cm**4

 Required Stress in Ring plus Shell      Breq       3.12 N./mm²
 Required Strain in Ring plus Shell      Areq  0.0000325
```

Required Moment of Inertia, Ring plus Shell:

```
  = ( OD² * Slen(Tca + Aring/Slen)Areq )/10.9
  = (1736.0²*400.0(3.0+4.7/400.0)0.000032)/10.9
  = 2 cm**4
```

Results for Stiffening Ring Weld Calculations per UG-30:

```
 Given Stiffening Ring Fillet Weld Size        Wleg     3.000  mm.
 Stiffening Ring Attachment Style                  CONTINUOUS
 Location of Stiffening Ring                         EXTERNAL
 Radial Pressure Load                     Pext*Slen      0.41  Kgf/mm.
 The Radial Shear Load                            V      7.08  Kgf
 The First Moment of the Area ( Ring + Shell )    Q   3951.51  mm.³
 Weld Shear Flow due to Rad. Shear Load        VQ/I      0.15  Kgf/mm.
 The Weld Allowable Stress                   0.55*S     73.09  N./mm²
 Minimum Weld Leg Size Min( 6mm, t, tw )     Wldmin      3.00  mm.
 The Weld Allowable Load            2*   WLeg*0.55*S     44.72  Kgf/mm.
 The Combined Weld Load   SRSS of VQ/I and Pext*Slen      0.43  Kgf/mm.
```

<u>Stiffening Ring Calcs for : Ring 21 , SA-240 304 , Bar Ring: 50 x 10 mm.</u>

```
 Effective Length of Shell:                           79 mm.

                Area (cm²)   Distance (mm.)    Area*Dist
 --------------------------------------------------------
 Shell:             2.381         1.5000          3.572
 Ring :             5.000        28.0000        140.000
 Total:             7.381                       143.572
 --------------------------------------------------------
 Centroid of Ring plus Shell:                         19 mm.

                  Inertia       Distance        A*Dist²
 --------------------------------------------------------
 Shell:             0.018        17.9503        767.347
 Ring :            10.417        -8.5497        365.487
 Total:            10.434                      1132.833
 --------------------------------------------------------
 Available Moment of Inertia, Ring plus Shell:        22 cm**4

 Required Stress in Ring plus Shell      Breq       3.88 N./mm²
 Required Strain in Ring plus Shell      Areq  0.0000405
```

Required Moment of Inertia, Ring plus Shell:

```
  = ( OD² * Slen(Tca + Aring/Slen)Areq )/10.9
  = (1736.0²*1418.7195(3.0+5.0/1418.7195)0.00004)/10.9
  = 5 cm**4
```

Results for Stiffening Ring Weld Calculations per UG-30:

```
 Given Stiffening Ring Fillet Weld Size        Wleg     3.000  mm.
 Stiffening Ring Attachment Style                  CONTINUOUS
 Location of Stiffening Ring                         EXTERNAL
 Radial Pressure Load                     Pext*Slen      1.45  Kgf/mm.
```

```
 The Radial Shear Load                             V     25.12  Kgf
 The First Moment of the Area ( Ring + Shell )     Q   4274.85  mm.³
 Weld Shear Flow due to Rad. Shear Load         VQ/I      0.49  Kgf/mm.
 The Weld Allowable Stress                    0.55*S     73.09  N./mm²
 Minimum Weld Leg Size Min( 6mm, t, tw )      Wldmin      3.00  mm.
 The Weld Allowable Load            2*   WLeg*0.55*S     44.72  Kgf/mm.
 The Combined Weld Load   SRSS of VQ/I and Pext*Slen      1.53  Kgf/mm.
```

Stiffening Ring Calcs for : Ring:17 , SA-240 304 , Bar Ring: 47 x 10 mm.

```
 Effective Length of Shell:                               71 mm.

                Area (cm²)   Distance (mm.)    Area*Dist
 --------------------------------------------------------
 Shell:            2.143          1.5000           3.215
 Ring :            4.686         26.4300         123.851
 Total:            6.829                         127.066
 --------------------------------------------------------
 Centroid of Ring plus Shell:                             19 mm.

                 Inertia        Distance         A*Dist²
 --------------------------------------------------------
 Shell:            0.016         17.1057         627.176
 Ring :            8.575         -7.8243         286.878
 Total:            8.591                         914.053
 --------------------------------------------------------
 Available Moment of Inertia, Ring plus Shell:         18 cm**4

 Required Stress in Ring plus Shell      Breq        2.73 N./mm²
 Required Strain in Ring plus Shell      Areq   0.0000284
```

Required Moment of Inertia, Ring plus Shell:

```
   = ( OD² * Slen(Tca + Aring/Slen)Areq )/10.9
   = (1406.275²*543.0673(3.0+4.686/543.0673)0.000028)/10.9
   = 1 cm**4
```

Results for Stiffening Ring Weld Calculations per UG-30:

```
 Given Stiffening Ring Fillet Weld Size         Wleg     3.000  mm.
 Stiffening Ring Attachment Style                   CONTINUOUS
 Location of Stiffening Ring                          EXTERNAL
 Radial Pressure Load                      Pext*Slen      0.55  Kgf/mm.
 The Radial Shear Load                             V      7.79  Kgf
 The First Moment of the Area ( Ring + Shell )     Q   3666.48  mm.³
 Weld Shear Flow due to Rad. Shear Load         VQ/I      0.16  Kgf/mm.
 The Weld Allowable Stress                    0.55*S     73.09  N./mm²
 Minimum Weld Leg Size Min( 6mm, t, tw )      Wldmin      3.00  mm.
 The Weld Allowable Load            2*   WLeg*0.55*S     44.72  Kgf/mm.
 The Combined Weld Load   SRSS of VQ/I and Pext*Slen      0.58  Kgf/mm.
```

Stiffening Ring Calcs for : Ring 6 , SA-240 304 , Bar Ring: 47 x 10 mm.

```
 Effective Length of Shell:                               71 mm.

                Area (cm²)   Distance (mm.)    Area*Dist
 --------------------------------------------------------
 Shell:            2.143          1.5000           3.215
 Ring :            4.700         26.5000         124.550
 Total:            6.843                         127.765
 --------------------------------------------------------
 Centroid of Ring plus Shell:                             19 mm.

                 Inertia        Distance         A*Dist²
 --------------------------------------------------------
 Shell:            0.016         17.1703         631.861
 Ring :            8.652         -7.8297         288.132
```

```
Total:            8.668                         919.992
---------------------------------------------------------
Available Moment of Inertia, Ring plus Shell:        18 cm**4

Required Stress in Ring plus Shell      Breq        0.87 N./mm²
Required Strain in Ring plus Shell      Areq   0.0000091
```

Required Moment of Inertia, Ring plus Shell:

```
  = ( OD² * Slen(Tca + Aring/Slen)Areq )/10.9
  = (1406.0²*51.5(3.0+4.7/51.5)0.000009)/10.9
  = 0 cm**4
```

Results for Stiffening Ring Weld Calculations per UG-30:

```
Given Stiffening Ring Fillet Weld Size         Wleg     3.000  mm.
Stiffening Ring Attachment Style                   CONTINUOUS
Location of Stiffening Ring                          EXTERNAL
Radial Pressure Load                        Pext*Slen      0.05  Kgf/mm.
The Radial Shear Load                               V      0.74  Kgf
The First Moment of the Area ( Ring + Shell )       Q   3679.97  mm.³
Weld Shear Flow due to Rad. Shear Load           VQ/I      0.02  Kgf/mm.
The Weld Allowable Stress                      0.55*S     73.09  N./mm²
Minimum Weld Leg Size Min( 6mm, t, tw )        Wldmin      3.00  mm.
The Weld Allowable Load            2*   WLeg*0.55*S     44.72  Kgf/mm.
The Combined Weld Load   SRSS of VQ/I and Pext*Slen      0.05  Kgf/mm.
```

Stiffening Ring Calcs for : Ring 7 , SA-240 304 , Bar Ring: 47 x 10 mm.

```
Effective Length of Shell:                            71 mm.

                Area (cm²)   Distance (mm.)    Area*Dist
---------------------------------------------------------
Shell:            2.143         1.5000           3.215
Ring :            4.700        26.5000         124.550
Total:            6.843                        127.765
---------------------------------------------------------
Centroid of Ring plus Shell:                          19 mm.

                 Inertia        Distance         A*Dist²
---------------------------------------------------------
Shell:            0.016        17.1703         631.861
Ring :            8.652        -7.8297         288.132
Total:            8.668                        919.992
---------------------------------------------------------
Available Moment of Inertia, Ring plus Shell:        18 cm**4

Required Stress in Ring plus Shell      Breq        2.88 N./mm²
Required Strain in Ring plus Shell      Areq   0.0000300
```

Required Moment of Inertia, Ring plus Shell:

```
  = ( OD² * Slen(Tca + Aring/Slen)Areq )/10.9
  = (1406.0²*711.5(3.0+4.7/711.5)0.00003)/10.9
  = 1 cm**4
```

Results for Stiffening Ring Weld Calculations per UG-30:

```
Given Stiffening Ring Fillet Weld Size         Wleg     3.000  mm.
Stiffening Ring Attachment Style                   CONTINUOUS
Location of Stiffening Ring                          EXTERNAL
Radial Pressure Load                        Pext*Slen      0.73  Kgf/mm.
The Radial Shear Load                               V     10.20  Kgf
The First Moment of the Area ( Ring + Shell )       Q   3679.97  mm.³
Weld Shear Flow due to Rad. Shear Load           VQ/I      0.21  Kgf/mm.
The Weld Allowable Stress                      0.55*S     73.09  N./mm²
Minimum Weld Leg Size Min( 6mm, t, tw )        Wldmin      3.00  mm.
The Weld Allowable Load            2*   WLeg*0.55*S     44.72  Kgf/mm.
The Combined Weld Load   SRSS of VQ/I and Pext*Slen      0.76  Kgf/mm.
```

Stiffening Ring Calcs for : Ring 8 , SA-240 304 , Bar Ring: 47 x 10 mm.

Effective Length of Shell: 71 mm.

	Area (cm²)	Distance (mm.)	Area*Dist
Shell:	2.143	1.5000	3.215
Ring :	4.700	26.5000	124.550
Total:	6.843		127.765

Centroid of Ring plus Shell: 19 mm.

	Inertia	Distance	A*Dist²
Shell:	0.016	17.1703	631.861
Ring :	8.652	-7.8297	288.132
Total:	8.668		919.992

Available Moment of Inertia, Ring plus Shell: 18 cm**4

Required Stress in Ring plus Shell Breq 3.16 N./mm²
Required Strain in Ring plus Shell Areq 0.0000330

Required Moment of Inertia, Ring plus Shell:
= (OD² * Slen(Tca + Aring/Slen)Areq)/10.9
= (1406.0²*1405.0(3.0+4.7/1405.0)0.000033)/10.9
= 3 cm**4

Results for Stiffening Ring Weld Calculations per UG-30:

Given Stiffening Ring Fillet Weld Size	Wleg	3.000	mm.
Stiffening Ring Attachment Style		CONTINUOUS	
Location of Stiffening Ring		EXTERNAL	
Radial Pressure Load	Pext*Slen	1.43	Kgf/mm.
The Radial Shear Load	V	20.14	Kgf
The First Moment of the Area (Ring + Shell)	Q	3679.97	mm.³
Weld Shear Flow due to Rad. Shear Load	VQ/I	0.41	Kgf/mm.
The Weld Allowable Stress	0.55*S	73.09	N./mm²
Minimum Weld Leg Size Min(6mm, t, tw)	Wldmin	3.00	mm.
The Weld Allowable Load	2* WLeg*0.55*S	44.72	Kgf/mm.
The Combined Weld Load	SRSS of VQ/I and Pext*Slen	1.49	Kgf/mm.

Stiffening Ring Calcs for : Ring 9 , SA-240 304 , Bar Ring: 47 x 10 mm.

Effective Length of Shell: 71 mm.

	Area (cm²)	Distance (mm.)	Area*Dist
Shell:	2.143	1.5000	3.215
Ring :	4.700	26.5000	124.550
Total:	6.843		127.765

Centroid of Ring plus Shell: 19 mm.

	Inertia	Distance	A*Dist²
Shell:	0.016	17.1703	631.861
Ring :	8.652	-7.8297	288.132
Total:	8.668		919.992

Available Moment of Inertia, Ring plus Shell: 18 cm**4

Required Stress in Ring plus Shell Breq 3.18 N./mm²
Required Strain in Ring plus Shell Areq 0.0000330

Required Moment of Inertia, Ring plus Shell:

```
= ( OD² * Slen(Tca + Aring/Slen)Areq )/10.9
= (1406.0²*1493.5001(3.0+4.7/1493.5001)0.000033)/10.9
= 3 cm**4
```

Results for Stiffening Ring Weld Calculations per UG-30:

```
Given Stiffening Ring Fillet Weld Size          Wleg     3.000  mm.
Stiffening Ring Attachment Style                    CONTINUOUS
Location of Stiffening Ring                           EXTERNAL
Radial Pressure Load                       Pext*Slen      1.52  Kgf/mm.
The Radial Shear Load                              V     21.41  Kgf
The First Moment of the Area ( Ring + Shell )      Q   3679.97  mm.³
Weld Shear Flow due to Rad. Shear Load          VQ/I      0.44  Kgf/mm.
The Weld Allowable Stress                     0.55*S     73.09  N./mm²
Minimum Weld Leg Size Min( 6mm, t, tw )       Wldmin      3.00  mm.
The Weld Allowable Load             2*   WLeg*0.55*S     44.72  Kgf/mm.
The Combined Weld Load   SRSS of VQ/I and Pext*Slen      1.59  Kgf/mm.
```

<u>Stiffening Ring Calcs for : Ring 18 , SA-240 304 , Bar Ring: 47 x 10 mm.</u>

```
Effective Length of Shell:                              71 mm.

                Area (cm²)   Distance (mm.)    Area*Dist
--------------------------------------------------------
Shell:             2.143         1.5000          3.215
Ring :             4.700        26.5000        124.550
Total:             6.843                       127.765
--------------------------------------------------------
Centroid of Ring plus Shell:                            19 mm.

                 Inertia        Distance         A*Dist²
--------------------------------------------------------
Shell:             0.016        17.1703        631.861
Ring :             8.652        -7.8297        288.132
Total:             8.668                       919.992
--------------------------------------------------------
Available Moment of Inertia, Ring plus Shell:         18 cm**4

Required Stress in Ring plus Shell      Breq        3.00 N./mm²
Required Strain in Ring plus Shell      Areq   0.0000312
```

Required Moment of Inertia, Ring plus Shell:

```
= ( OD² * Slen(Tca + Aring/Slen)Areq )/10.9
= (1406.0²*905.0399(3.0+4.7/905.0399)0.000031)/10.9
= 2 cm**4
```

Results for Stiffening Ring Weld Calculations per UG-30:

```
Given Stiffening Ring Fillet Weld Size          Wleg     3.000  mm.
Stiffening Ring Attachment Style                    CONTINUOUS
Location of Stiffening Ring                           EXTERNAL
Radial Pressure Load                       Pext*Slen      0.92  Kgf/mm.
The Radial Shear Load                              V     12.98  Kgf
The First Moment of the Area ( Ring + Shell )      Q   3679.97  mm.³
Weld Shear Flow due to Rad. Shear Load          VQ/I      0.27  Kgf/mm.
The Weld Allowable Stress                     0.55*S     73.09  N./mm²
Minimum Weld Leg Size Min( 6mm, t, tw )       Wldmin      3.00  mm.
The Weld Allowable Load             2*   WLeg*0.55*S     44.72  Kgf/mm.
The Combined Weld Load   SRSS of VQ/I and Pext*Slen      0.96  Kgf/mm.
```

<u>Stiffening Ring Calcs for : Ring 23 , SA-240 304 , Bar Ring: 47 x 10 mm.</u>

```
Effective Length of Shell:                              79 mm.

                Area (cm²)   Distance (mm.)    Area*Dist
--------------------------------------------------------
```

```
 Shell:            2.381         1.5000          3.572
 Ring :            4.700        26.5000        124.550
 Total:            7.081                       128.122
 --------------------------------------------------------
 Centroid of Ring plus Shell:                       18 mm.

                   Inertia       Distance        A*Dist²
 --------------------------------------------------------
 Shell:            0.018        16.5928        655.646
 Ring :            8.652        -8.4072        332.200
 Total:            8.670                       987.847
 --------------------------------------------------------
 Available Moment of Inertia, Ring plus Shell:         19 cm**4

 Required Stress in Ring plus Shell      Breq        3.70 N./mm²
 Required Strain in Ring plus Shell      Areq   0.0000385
```

Required Moment of Inertia, Ring plus Shell:

```
  = ( OD² * Slen(Tca + Aring/Slen)Areq )/10.9
  = (1735.8351²*905.0399(3.0+4.7/905.0399)0.000039)/10.9
  = 3 cm**4
```

Results for Stiffening Ring Weld Calculations per UG-30:

```
 Given Stiffening Ring Fillet Weld Size         Wleg     3.000  mm.
 Stiffening Ring Attachment Style                   CONTINUOUS
 Location of Stiffening Ring                          EXTERNAL
 Radial Pressure Load                      Pext*Slen      0.92  Kgf/mm.
 The Radial Shear Load                             V     16.02  Kgf
 The First Moment of the Area ( Ring + Shell )     Q   3951.38  mm.³
 Weld Shear Flow due to Rad. Shear Load         VQ/I      0.34  Kgf/mm.
 The Weld Allowable Stress                    0.55*S     73.09  N./mm²
 Minimum Weld Leg Size Min( 6mm, t, tw )      Wldmin      3.00  mm.
 The Weld Allowable Load            2*   WLeg*0.55*S     44.72  Kgf/mm.
 The Combined Weld Load   SRSS of VQ/I and Pext*Slen      0.98  Kgf/mm.
```

<u>Stiffening Ring Calcs for : Ring 10 , SA-240 304 , Bar Ring: 47 x 10 mm.</u>

```
 Effective Length of Shell:                          79 mm.

                 Area (cm²)   Distance (mm.)    Area*Dist
 --------------------------------------------------------
 Shell:            2.381         1.5000          3.572
 Ring :            4.700        26.5000        124.550
 Total:            7.081                       128.122
 --------------------------------------------------------
 Centroid of Ring plus Shell:                       18 mm.

                   Inertia       Distance        A*Dist²
 --------------------------------------------------------
 Shell:            0.018        16.5926        655.656
 Ring :            8.652        -8.4075        332.221
 Total:            8.670                       987.878
 --------------------------------------------------------
 Available Moment of Inertia, Ring plus Shell:         19 cm**4

 Required Stress in Ring plus Shell      Breq        3.06 N./mm²
 Required Strain in Ring plus Shell      Areq   0.0000320
```

Required Moment of Inertia, Ring plus Shell:

```
  = ( OD² * Slen(Tca + Aring/Slen)Areq )/10.9
  = (1736.0²*375.0(3.0+4.7/375.0)0.000032)/10.9
  = 1 cm**4
```

Results for Stiffening Ring Weld Calculations per UG-30:

```
 Given Stiffening Ring Fillet Weld Size         Wleg     3.000  mm.
```

```
 Stiffening Ring Attachment Style                     CONTINUOUS
 Location of Stiffening Ring                            EXTERNAL
 Radial Pressure Load                      Pext*Slen      0.38  Kgf/mm.
 The Radial Shear Load                             V      6.64  Kgf
 The First Moment of the Area ( Ring + Shell )     Q   3951.51  mm.³
 Weld Shear Flow due to Rad. Shear Load         VQ/I      0.14  Kgf/mm.
 The Weld Allowable Stress                    0.55*S     73.09  N./mm²
 Minimum Weld Leg Size Min( 6mm, t, tw )      Wldmin      3.00  mm.
 The Weld Allowable Load            2*   WLeg*0.55*S     44.72  Kgf/mm.
 The Combined Weld Load   SRSS of VQ/I and Pext*Slen      0.41  Kgf/mm.
```

<u>Stiffening Ring Calcs for : Ring 11 , SA-240 304 , Bar Ring: 47 x 10 mm.</u>

Effective Length of Shell: 79 mm.

	Area (cm²)	Distance (mm.)	Area*Dist
Shell:	2.381	1.5000	3.572
Ring :	4.700	26.5000	124.550
Total:	7.081		128.122

Centroid of Ring plus Shell: 18 mm.

	Inertia	Distance	A*Dist²
Shell:	0.018	16.5926	655.656
Ring :	8.652	-8.4075	332.221
Total:	8.670		987.878

Available Moment of Inertia, Ring plus Shell: 19 cm**4

```
 Required Stress in Ring plus Shell      Breq        0.73 N./mm²
 Required Strain in Ring plus Shell      Areq   0.0000076
```

Required Moment of Inertia, Ring plus Shell:

```
  = ( OD² * Slen(Tca + Aring/Slen)Areq )/10.9
  = (1736.0²*31.5(3.0+4.7/31.5)0.000008)/10.9
  = 0 cm**4
```

Results for Stiffening Ring Weld Calculations per UG-30:

```
 Given Stiffening Ring Fillet Weld Size         Wleg     3.000  mm.
 Stiffening Ring Attachment Style                     CONTINUOUS
 Location of Stiffening Ring                            EXTERNAL
 Radial Pressure Load                      Pext*Slen      0.03  Kgf/mm.
 The Radial Shear Load                             V      0.56  Kgf
 The First Moment of the Area ( Ring + Shell )     Q   3951.51  mm.³
 Weld Shear Flow due to Rad. Shear Load         VQ/I      0.01  Kgf/mm.
 The Weld Allowable Stress                    0.55*S     73.09  N./mm²
 Minimum Weld Leg Size Min( 6mm, t, tw )      Wldmin      3.00  mm.
 The Weld Allowable Load            2*   WLeg*0.55*S     44.72  Kgf/mm.
 The Combined Weld Load   SRSS of VQ/I and Pext*Slen      0.03  Kgf/mm.
```

<u>Stiffening Ring Calcs for : Ring 24 , SA-240 304 , Bar Ring: 47 x 10 mm.</u>

Effective Length of Shell: 79 mm.

	Area (cm²)	Distance (mm.)	Area*Dist
Shell:	2.381	1.5000	3.572
Ring :	4.684	26.4175	123.727
Total:	7.065		127.299

Centroid of Ring plus Shell: 18 mm.

	Inertia	Distance	A*Dist²

Shell:	0.018	16.5182	649.795
Ring :	8.561	-8.3993	330.411
Total:	8.579		980.207

Available Moment of Inertia, Ring plus Shell: 18 cm**4

Required Stress in Ring plus Shell Breq 3.37 N./mm²
Required Strain in Ring plus Shell Areq 0.0000350

Required Moment of Inertia, Ring plus Shell:

= (OD² * Slen(Tca + Aring/Slen)Areq)/10.9
= (1736.0²*543.0673(3.0+4.6835/543.0673)0.000035)/10.9
= 2 cm**4

Results for Stiffening Ring Weld Calculations per UG-30:

Given Stiffening Ring Fillet Weld Size	Wleg	3.000	mm.
Stiffening Ring Attachment Style		CONTINUOUS	
Location of Stiffening Ring		EXTERNAL	
Radial Pressure Load	Pext*Slen	0.55	Kgf/mm.
The Radial Shear Load	V	9.61	Kgf
The First Moment of the Area (Ring + Shell)	Q	3933.81	mm.³
Weld Shear Flow due to Rad. Shear Load	VQ/I	0.21	Kgf/mm.
The Weld Allowable Stress	0.55*S	73.09	N./mm²
Minimum Weld Leg Size Min(6mm, t, tw)	Wldmin	3.00	mm.
The Weld Allowable Load 2*	WLeg*0.55*S	44.72	Kgf/mm.
The Combined Weld Load SRSS of VQ/I and Pext*Slen		0.59	Kgf/mm.

Stiffening Ring Calcs for : Ring 26 , SA-240 304 , Bar Ring: 47 x 10 mm.

Effective Length of Shell: 71 mm.

	Area (cm²)	Distance (mm.)	Area*Dist
Shell:	2.143	1.5000	3.215
Ring :	4.683	26.4150	123.701
Total:	6.826		126.916

Centroid of Ring plus Shell: 19 mm.

	Inertia	Distance	A*Dist²
Shell:	0.016	17.0919	626.168
Ring :	8.558	-7.8231	286.600
Total:	8.574		912.769

Available Moment of Inertia, Ring plus Shell: 18 cm**4

Required Stress in Ring plus Shell Breq 2.73 N./mm²
Required Strain in Ring plus Shell Areq 0.0000284

Required Moment of Inertia, Ring plus Shell:

= (OD² * Slen(Tca + Aring/Slen)Areq)/10.9
= (1406.275²*543.0673(3.0+4.683/543.0673)0.000028)/10.9
= 1 cm**4

Results for Stiffening Ring Weld Calculations per UG-30:

Given Stiffening Ring Fillet Weld Size	Wleg	3.000	mm.
Stiffening Ring Attachment Style		CONTINUOUS	
Location of Stiffening Ring		EXTERNAL	
Radial Pressure Load	Pext*Slen	0.55	Kgf/mm.
The Radial Shear Load	V	7.79	Kgf
The First Moment of the Area (Ring + Shell)	Q	3663.53	mm.³
Weld Shear Flow due to Rad. Shear Load	VQ/I	0.16	Kgf/mm.
The Weld Allowable Stress	0.55*S	73.09	N./mm²

```
Minimum Weld Leg Size Min( 6mm, t, tw )      Wldmin      3.00  mm.
The Weld Allowable Load            2*   WLeg*0.55*S     44.72  Kgf/mm.
The Combined Weld Load   SRSS of VQ/I and Pext*Slen      0.58  Kgf/mm.
```

Stiffening Ring Calcs for : Ring 12 , SA-240 304 , Bar Ring: 47 x 10 mm.

```
Effective Length of Shell:                            71 mm.

                Area (cm²)   Distance (mm.)    Area*Dist
--------------------------------------------------------
Shell:             2.143         1.5000           3.215
Ring :             4.700        26.5000         124.550
Total:             6.843                        127.765
--------------------------------------------------------
Centroid of Ring plus Shell:                          19 mm.

                 Inertia        Distance         A*Dist²
--------------------------------------------------------
Shell:             0.016        17.1703         631.861
Ring :             8.652        -7.8297         288.132
Total:             8.668                        919.992
--------------------------------------------------------
Available Moment of Inertia, Ring plus Shell:         18 cm**4

Required Stress in Ring plus Shell      Breq        2.98 N./mm²
Required Strain in Ring plus Shell      Areq   0.0000310
```

Required Moment of Inertia, Ring plus Shell:

```
  = ( OD² * Slen(Tca + Aring/Slen)Areq )/10.9
  = (1406.0²*872.5(3.0+4.7/872.5)0.000031)/10.9
  = 2 cm**4
```

Results for Stiffening Ring Weld Calculations per UG-30:

```
Given Stiffening Ring Fillet Weld Size        Wleg     3.000  mm.
Stiffening Ring Attachment Style                  CONTINUOUS
Location of Stiffening Ring                         EXTERNAL
Radial Pressure Load                      Pext*Slen      0.89  Kgf/mm.
The Radial Shear Load                             V     12.51  Kgf
The First Moment of the Area ( Ring + Shell )     Q   3679.97  mm.³
Weld Shear Flow due to Rad. Shear Load         VQ/I      0.26  Kgf/mm.
The Weld Allowable Stress                    0.55*S     73.09  N./mm²
Minimum Weld Leg Size Min( 6mm, t, tw )      Wldmin      3.00  mm.
The Weld Allowable Load            2*   WLeg*0.55*S     44.72  Kgf/mm.
The Combined Weld Load   SRSS of VQ/I and Pext*Slen      0.93  Kgf/mm.
```

Stiffening Ring Calcs for : Ring 13] , SA-240 304 , Bar Ring: 47 x 10 mm.

```
Effective Length of Shell:                            71 mm.

                Area (cm²)   Distance (mm.)    Area*Dist
--------------------------------------------------------
Shell:             2.143         1.5000           3.215
Ring :             4.700        26.5000         124.550
Total:             6.843                        127.765
--------------------------------------------------------
Centroid of Ring plus Shell:                          19 mm.

                 Inertia        Distance         A*Dist²
--------------------------------------------------------
Shell:             0.016        17.1703         631.861
Ring :             8.652        -7.8297         288.132
Total:             8.668                        919.992
--------------------------------------------------------
Available Moment of Inertia, Ring plus Shell:         18 cm**4
```

```
 Required Stress in Ring plus Shell      Breq        3.19 N./mm²
 Required Strain in Ring plus Shell      Areq   0.0000333
```

Required Moment of Inertia, Ring plus Shell:

```
  = ( OD² * Slen(Tca + Aring/Slen)Areq )/10.9
  = (1406.0²*1562.5(3.0+4.7/1562.5)0.000033)/10.9
  = 3 cm**4
```

Results for Stiffening Ring Weld Calculations per UG-30:

```
 Given Stiffening Ring Fillet Weld Size         Wleg     3.000  mm.
 Stiffening Ring Attachment Style                   CONTINUOUS
 Location of Stiffening Ring                          EXTERNAL
 Radial Pressure Load                     Pext*Slen      1.59  Kgf/mm.
 The Radial Shear Load                            V     22.40  Kgf
 The First Moment of the Area ( Ring + Shell )    Q   3679.97  mm.³
 Weld Shear Flow due to Rad. Shear Load        VQ/I      0.46  Kgf/mm.
 The Weld Allowable Stress                   0.55*S     73.09  N./mm²
 Minimum Weld Leg Size Min( 6mm, t, tw )     Wldmin      3.00  mm.
 The Weld Allowable Load            2*   WLeg*0.55*S     44.72  Kgf/mm.
 The Combined Weld Load   SRSS of VQ/I and Pext*Slen      1.66  Kgf/mm.
```

<u>Stiffening Ring Calcs for : Ring 28 , SA-240 304 , Bar Ring: 50 x 10 mm.</u>

```
 Effective Length of Shell:                              71 mm.

                Area (cm²)   Distance (mm.)    Area*Dist
 --------------------------------------------------------
 Shell:            2.143         1.5000          3.215
 Ring :            5.042        28.2100        142.235
 Total:            7.185                       145.450
 --------------------------------------------------------
 Centroid of Ring plus Shell:                            20 mm.

                 Inertia        Distance         A*Dist²
 --------------------------------------------------------
 Shell:            0.016        18.7429        752.904
 Ring :           10.681        -7.9671        320.040
 Total:           10.697                      1072.945
 --------------------------------------------------------
 Available Moment of Inertia, Ring plus Shell:          21 cm**4

 Required Stress in Ring plus Shell      Breq        2.93 N./mm²
 Required Strain in Ring plus Shell      Areq   0.0000305
```

Required Moment of Inertia, Ring plus Shell:

```
  = ( OD² * Slen(Tca + Aring/Slen)Areq )/10.9
  = (1406.0²*840.1315(3.0+5.042/840.1315)0.000031)/10.9
  = 2 cm**4
```

Results for Stiffening Ring Weld Calculations per UG-30:

```
 Given Stiffening Ring Fillet Weld Size         Wleg     3.000  mm.
 Stiffening Ring Attachment Style                   CONTINUOUS
 Location of Stiffening Ring                          EXTERNAL
 Radial Pressure Load                     Pext*Slen      0.86  Kgf/mm.
 The Radial Shear Load                            V     12.05  Kgf
 The First Moment of the Area ( Ring + Shell )    Q   4017.02  mm.³
 Weld Shear Flow due to Rad. Shear Load        VQ/I      0.23  Kgf/mm.
 The Weld Allowable Stress                   0.55*S     73.09  N./mm²
 Minimum Weld Leg Size Min( 6mm, t, tw )     Wldmin      3.00  mm.
 The Weld Allowable Load            2*   WLeg*0.55*S     44.72  Kgf/mm.
 The Combined Weld Load   SRSS of VQ/I and Pext*Slen      0.89  Kgf/mm.
```

<u>Stiffening Ring Calcs for : Ring 22 , SA-240 304 , Bar Ring: 50 x 10 mm.</u>

```
 Effective Length of Shell:                              59 mm.
```

	Area (cm²)	Distance (mm.)	Area*Dist
Shell:	1.767	1.5000	2.651
Ring :	5.042	28.2113	142.248
Total:	6.810		144.899

Centroid of Ring plus Shell: 21 mm.

	Inertia	Distance	A*Dist²
Shell:	0.013	19.7783	691.404
Ring :	10.683	-6.9330	242.361
Total:	10.696		933.765

Available Moment of Inertia, Ring plus Shell: 20 cm**4

Required Stress in Ring plus Shell	Breq	1.99	N./mm²
Required Strain in Ring plus Shell	Areq	0.0000208	

Required Moment of Inertia, Ring plus Shell:

= (OD² * Slen(Tca + Aring/Slen)Areq)/10.9
= (956.225²*840.1315(3.0+5.0423/840.1315)0.000021)/10.9
= 1 cm**4

Results for Stiffening Ring Weld Calculations per UG-30:

Given Stiffening Ring Fillet Weld Size	Wleg	3.000	mm.
Stiffening Ring Attachment Style		CONTINUOUS	
Location of Stiffening Ring		EXTERNAL	
Radial Pressure Load	Pext*Slen	0.86	Kgf/mm.
The Radial Shear Load	V	8.19	Kgf
The First Moment of the Area (Ring + Shell)	Q	3495.77	mm.³
Weld Shear Flow due to Rad. Shear Load	VQ/I	0.14	Kgf/mm.
The Weld Allowable Stress	0.55*S	73.09	N./mm²
Minimum Weld Leg Size Min(6mm, t, tw)	Wldmin	3.00	mm.
The Weld Allowable Load	2* WLeg*0.55*S	44.72	Kgf/mm.
The Combined Weld Load	SRSS of VQ/I and Pext*Slen	0.87	Kgf/mm.

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	793.769	10689519	793.769	10689519	...
20	30	231.016	3630184	231.016	3630184	...
30	40	104.889	1880831	104.889	1880831	...
40	50	143.693	2317308	143.693	2317308	...
50	60	477.657	6928454	477.657	6928454	...
60	70	238.06	3862180	238.06	3862180	...
70	80	104.889	1880831	104.889	1880831	...
80	90	143.693	2317308	143.693	2317308	...
90	100	371.509	5388796	371.509	5388796	...
100	110	179.371	2195581	179.371	2195581	...
Total		2788	41090996.00	2788	41090996.00	0

Weight of Details:

From	Type	Weight of Detail kg.	X Offset, Dtl. Cent. mm.	Y Offset, Dtl. Cent. mm.	Description
10	Ring	16.0367	...	3958	Ring:[1 of 1]
10	Ring	16.0367	...	5946	Ring:[2 of 2]
10	Ring	16.0367	...	7939	Ring:[3 of 3]
10	Ring	16.0367	...	7952	Ring:[4 of 4]
20	Ring	34.3201	...	...	Ring 16
30	Ring	21.1334	...	...	Ring5
40	Ring	17.1723	...	1199	Ring:17
40	Ring	22.5201	...	...	Ring 21
50	Ring	17.222	...	90	Ring 6
50	Ring	17.222	...	103	Ring 7
50	Ring	17.222	...	1513	Ring 8
50	Ring	17.222	...	2913	Ring 9
60	Ring	17.222	...	...	Ring 18
60	Ring	21.1315	...	1999	Ring 23
70	Ring	21.1334	...	737	Ring 10
70	Ring	21.1334	...	750	Ring 11
80	Ring	21.0573	...	...	Ring 24
80	Ring	17.161	...	1199	Ring 26
90	Ring	17.222	...	375	Ring 12
90	Ring	17.222	...	1745	Ring 13]
100	Ring	12.8003	...	1999	Ring 22
100	Ring	18.5186	...	...	Ring 28

Total Weight of Each Detail Type:

Stiffeners	412.8
Sum of the Detail Weights	412.8 kg.

Weight Summation Results: (kg.)

	Fabricated	Shop Test	Shipping	Erected	Empty	Operating
Main Elements	2788.5	2788.5	2788.5	2788.5	2788.5	2788.5
Stif. Rings	412.8	412.8	412.8	412.8	412.8	412.8
Test Liquid	...	41065.9	...	...	...	...
Totals	3201.3	44267.2	3201.3	3201.3	3201.3	3201.3

Weight Summary:

Fabricated Wt.	- Bare Weight without Removable Internals	3201.3 kg.
Shop Test Wt.	- Fabricated Weight + Water (Full)	44267.2 kg.
Shipping Wt.	- Fab. Weight + removable Intls.+ Shipping App.	3201.3 kg.
Erected Wt.	- Fab. Wt + or - loose items (trays,platforms etc.)	3201.3 kg.
Ope. Wt. no Liq	- Fab. Weight + Internals. + Details + Weights	3201.3 kg.
Operating Wt.	- Empty Weight + Operating Liq. Uncorroded	3201.3 kg.
Field Test Wt.	- Empty Weight + Water (Full)	44267.2 kg.
Mass of the Upper 1/3 of the Vertical Vessel		1107.8 kg.

Outside Surface Areas of Elements:

From	To	Surface Area cm²
10	20	330367
20	30	96120.1
30	40	43630.4
40	50	59784.7
50	60	198769
60	70	99045.5
70	80	43630.4
80	90	59784.7
90	100	154598
100	110	74674.9

Total 1160404.250 cm²

Element and Detail Weights:

From	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	857.916	857.916	857.916	...	857.916
20	30	265.336	265.336	265.336	...	265.336
30	40	126.022	126.022	126.022	...	126.022
40	50	183.386	183.386	183.386	...	183.386
50	60	546.545	546.545	546.545	...	546.545
60	70	276.413	276.413	276.413	...	276.413
70	80	147.156	147.156	147.156	...	147.156
80	90	181.912	181.912	181.912	...	181.912
90	100	405.953	405.953	405.953	...	405.953
100	110	210.689	210.689	210.689	...	210.689

Cumulative Vessel Weight

From	To	Cumulative Ope Wgt. No Liquid kg.	Cumulative Oper. Wgt. kg.	Cumulative Hydro. Wgt. kg.
10	20	3201.33	3201.33	3201.33
20	30	2343.41	2343.41	2343.41
30	40	2078.08	2078.08	2078.08
40	50	1952.05	1952.05	1952.05
50	60	1768.67	1768.67	1768.67
60	70	1222.12	1222.12	1222.12
70	80	945.71	945.71	945.71
80	90	798.554	798.554	798.554
90	100	616.643	616.643	616.643
100	110	210.689	210.689	210.689

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	30	...	...	...
30	40	...	...	...
40	50	...	...	...
50	60	...	...	...
60	70	...	...	...
70	80	...	...	...
80	90	...	...	...
90	100	...	...	...
100	110	...	...	...

Conical Reinforcement Calculations, ASME VIII Div. 1, App. 1

Conical Section From 20 To 30 SA-240 316

Elastic Modulus Data from ASME Section II Part D at 50 °C

```
Elastic Modulus of Cone Material             0.193E+09 KPa. at 50 °C
Elastic Modulus of Small Cylinder Material   0.193E+09 KPa. at 50 °C
Elastic Modulus of Large Cylinder Material   0.193E+09 KPa. at 50 °C
Elastic Modulus of Large End Reinforcement   0.193E+09 KPa. at 50 °C
Elastic Modulus of Small End Reinforcement   0.193E+09 KPa. at 50 °C
```

Elastic Modulus Data from ASME Section II Part D at 170 °C

```
Elastic Modulus of Cone Material             0.185E+09 KPa. at 170 °C
Elastic Modulus of Small Cylinder Material   0.185E+09 KPa. at 170 °C
Elastic Modulus of Large Cylinder Material   0.185E+09 KPa. at 170 °C
Elastic Modulus of Large End Reinforcement   0.185E+09 KPa. at 170 °C
Elastic Modulus of Small End Reinforcement   0.185E+09 KPa. at 170 °C
```

```
Axial Force on Small End of Cone                     0.00  Kgf
Axial Force on Large End of Cone                     0.00  Kgf
Moment on Small End of Cone                          0.00  Kg-m.
Moment on Large End of Cone                          0.00  Kg-m.
```

Note: Since there are no supports, the forces and moments could
not be resolved to the large and small ends of the cone.

Note: Both ends of the Cone are Lines of Support

```
Maximum Centroid Reinforcement Distance Large End    12.7573  mm.
Maximum Centroid Reinforcement Distance Small End    11.0651  mm.
```

Reinforcement Calculations for Cone / Large Cylinder:

Required Area of Reinforcement for Large End Under Internal Pressure

```
Large end ratio of pressure to allowable stress      0.00048
Large end max. half apex angle w/o reinforcement      11.000  degrees
Large end actual half apex angle                       6.136  degrees
```

Required Area of Reinforcement for Large End Under External Pressure

```
Large end ratio of pressure to allowable stress      0.00007
Large end max. half apex angle w/o reinforcement       0.187  degrees
Large end actual half apex angle                       6.136  degrees
```

Intermediate Value [k]:

```
= max( Y / ( Srl * Erl ), 1 )
= max( 0.25813E+11/( 132.9 * 0.19291E+09 ), 1 )
= 1.0068
```

where [Y] is:

```
= Large End All. Stress * Large End Elastic Modulus (Ext. temp.)
= 133.8 * 0.19291E+09
= 25812725760.0 N./mm²^2
```

```
Allowable Stress of Large End Material (Ext. Temp)   133.8  N./mm²
Allowable Stress of Cone Material (Ext. Temp)        133.8  N./mm²
```

Required Area of Reinforcement, Large End, External [Arl]:

```
= (k*QL*Rl*tan(angle)/(Ss*E1))*(1-1/4((P*Rl-QL)/QL)*(delta/alpha)
= (1.0068*0.4426*868.0*0.107/(134*1.0))*
  (1-1/4((0.1*868.0-0.443)/0.443)*(0.187/6.136)
= 0.0302 cm²
```

Force per Length, Cone Large End External Pressure [QL]:

```
  = Pext( Rl/2 ) + Faxial/(pi(Dl - Tl)) + Moment/(pi(Rl - Tl/2)(Rl - Tl/2))
  = 0.1( 868.0/2 ) + 0.0/(pi(1736.0 - 3.0)) +
    0.0/(pi(868.0 - 3.0/2)(868.0 - 3.0/2))
  = 0.443 Kgf/mm.
```

Available Area of Reinforcement, Large End, External [Ael]:

```
  = 0.55*( Dl*ts )½ * ( ts + tc/cos(alpha) )
  = 0.55 * ( 1736.0 * 3.0 )½ * ( 3.0 + 3.0/0.994 )
  = 2.3884 cm²
```

Summary of Reinforcement Area, Large End, External Pressure:

Area of reinforcement required per App. 1-8(1)	0.0302	cm²
Area of reinforcement in shell per App. 1-8(2)	2.3884	cm²
Area of reinforcement in stiffening ring	4.7000	cm²

Intermediate Results, Large End, External Pressure:

Area Available in Cone, Shell, and Reinforcement	46.87	cm²
Force per Unit Length on Shell / Cone Junction	1.55	Kgf/mm.
Actual Buckling Stress associated with this Force	4.23	N./mm²
Material Strain associated with this stress	0.000044	

Required Moment of Inertia, Large End, External Pressure [I's]:

```
  = A * Dl² * Atl / 10.9
  = 0.438E-04 * 1736.0 * 1736.0 * 46.87/10.9
  = 56786.08 mm.⁴
```

Available Moment of Inertia, Large End, External Pressure:

	Area	Centroid	Ar*Ce	Dist	I	Ar*Di²
Shl	1.191	0.0000	0.000	16.2161	0.009	313.119
Con	1.198	-2.1334	-2.555	18.3495	0.027	403.238
Sec	4.700	25.0000	117.500	-8.7840	8.652	362.643
TOT	7.088		114.945		8.688	1079.001
Centroid of Section			16.2161	Moment of Inertia		19.48

Summary of Large End Inertia Calculations

Available Moment of Inertia (Large End)	19.478	cm**4
Required Moment of Inertia (Large End)	5.679	cm**4

Reinforcement Calculations for Cone / Small Cylinder:

Required Area of Reinforcement for Small End under Internal Pressure

Small end ratio of pressure to allowable stress	0.00048	
Small end max. half apex angle w/o reinforcement	4.000	degrees
Small end actual half apex angle	6.136	degrees

Intermediate Value [k]:

```
  = max( Y / ( Sr * Ers ), 1 )
  = max( 0.19226E+11/( 100.3 * 0.18458E+09 ), 1 )
  = 1.0386
```

where [Y] is:

```
  = Cone Allowable Stress * Cone Elastic Modulus (Int. temp.)
  = 104.2 * 0.18458E+09
  = 19225886720.0 N./mm²^2
```

Decay Length, Cone Small End:

```
  = 1.4 * sqrt( Rs( ts - ca ) )
  = 1.4 * sqrt( 650.0( 3.0 - 0.0 ) )
  = 61.822 mm.
```

Required Area of Reinforcement, Small End, Internal [Ars]:

```
  = k*QS*Rs/(Ss*E1)*(1-delta/alpha)*tan(alpha)
  = 1.04 * 1.6571 * 650.0/( 104 * 1.0 ) *
```

```
    ( 1 - 4.0/6.14 ) 0.1075
  = 0.0394 cm²
```

Force per Length, Cone Small End [QS]:

```
  = P( Rs/2 ) - Faxial/(pi(Ds + Ts)) + Moment/(pi(Rs + Ts/2)(Rs + Ts/2))
  = 0.5( 650.0/2 ) - 0.0/(pi(1300.0 + 3.0)) +
    0.0/(pi(650.0 + 3.0/2)(650.0 + 3.0/2))
  = 1.657 Kgf/mm.
```

Area of Reinforcement Available in Small End Shell [Aes]:

```
  = 0.78(Rs*Ts)½*((Ts-t)+(Tc-Tr)/cos(alpha) ))
  = 0.78(650.0*3.0)½*(( 3.0- 0.312 )+( 3.0- 0.314 )/0.99)
  = 1.8563 cm²
```

Summary of Reinforcement Area, Small End, Internal Pressure:

Area of reinforcement required per App. 1-5(3)	0.0394	cm²
Area of reinforcement in shell per App. 1-5(4)	1.8563	cm²
Area of reinforcement in stiffening ring	9.7000	cm²

Required Area of Reinforcement for Small End Under External Pressure

Allowable Stress of Small End Material (Ext. Temp)	133.8	N./mm²
Allowable Stress of Cone Material (Ext. Temp)	133.8	N./mm²

Intermediate Value [k]:

```
  = max( Y / ( Srs * Ers ), 1 )
  = max( 0.25813E+11/( 132.9 * 0.19291E+09 ), 1 )
  = 1.0068
```

where [Y] is:

```
   = Cone Allowable Stress * Cone Elastic Modulus (Ext. temp.)
   = 133.8 * 0.19291E+09
   = 25812725760.0 N./mm²^2
```

Area of Reinforcement Required in Small End Shell [Ars]:

```
  = k * QS * Rs * tan(alpha) / ( Ss * E1 )
  = (1.0068*0.333*653.0*0.1075/(134*1.0))
  = 0.0172 cm²
```

Force per Length, Cone Small End [QS]:

```
  = Pext( Rs/2 ) + Faxial/(pi(Ds - Ts)) + Moment/(pi(Rs - Ts/2)(Rs - Ts/2))
  = 0.1( 653.0/2 ) + 0.0/(pi(1306.0 - 3.0)) +
    0.0/(pi(653.0 - 3.0/2)(653.0 - 3.0/2))
  = 0.333 Kgf/mm.
```

Area of Reinforcement Available in Small End Shell [Aes]:

```
  = 0.55*(Ds*ts)½*[(ts-t)+(tc-tr)/cos(alpha))]
  = 0.55*(1306.0*3.0)½*[(3.0-0.573)+(3.0-1.893)/0.994]
  = 1.2188 cm²
```

Summary of Reinforcement Area, Small End, External Pressure:

Area of reinforcement required per App. 1-8(3)	0.0172	cm²
Area of reinforcement in shell per App. 1-8(4)	1.2188	cm²
Area of reinforcement in stiffening ring	9.7000	cm²

Intermediate Results, Small End, External Pressure:

Area Available in Cone, Shell, and Reinforcement	41.37	cm²
Force per Unit Length on Shell / Cone Junction	0.88	Kgf/mm.
Actual Buckling Stress associated with this Force	2.04	N./mm²
Material Strain associated with this stress	0.000021	

Required Moment of Inertia, Small End, External Pressure [I's]:

```
  = A * Ds² * Ats / 10.9
  = 0.211E-04 * 1306.0 * 1306.0 * 41.37/10.9
  = 13689.88 mm.⁴
```

Available Moment of Inertia, Small End, External Pressure:

	Area	Centroid	Ar*Ce	Dist	I	Ar*Di²
Shl	1.033	0.0000	0.000	41.3643	0.008	1767.127
Con	1.039	1.8504	1.922	39.5139	0.020	1621.850
Sec	9.700	50.0000	485.000	-8.6357	76.056	723.377
TOT	11.772		486.922		76.083	4112.354
Centroid of Section			41.3643	Moment of Inertia		117.21

Summary of Small End Inertia Calculations

Available Moment of Inertia (Small End)	0.1172E+03	cm**4
Required Moment of Inertia (Small End)	0.1369E+01	cm**4

Note: The following calculations are only required per 1-5(g)(1) and do include external loads due to wind or seismic. These discontinuity stresses are computed at the shell/cone junction and do not include effects of local stiffening from a junction ring.

Results for Discontinuity Stresses per Bednar p. 236 2nd Edition

Stress Type	Stress	Allowable	Location
Tensile Stress	15.45	312.47	Small Cyl. Long.
Compres. Stress	-4.60	-312.47	Small Cyl. Long.
Membrane Stress	16.38	-156.24	Small End Tang.
Tensile Stress	15.49	312.47	Cone Longitudinal
Compres. Stress	-4.56	-312.47	Cone Longitudinal
Compres Stress	16.44	-156.24	Cone Tangential
Tensile Stress	22.60	312.47	Large Cyl. Long.
Compres. Stress	-8.16	-312.47	Large Cyl. Long.
Membrane Stress	5.98	-156.24	Large End Tang.
Tensile Stress	22.64	312.47	Cone Longitudinal
Compres. Stress	-8.11	-312.47	Cone Longitudinal
Compres Stress	6.06	-156.24	Cone Tangential

Note: An asterisk (*) denotes that this stress was not applicable for this combination of loads.

Maximum Allowable Pressure Calculations for Cone to Shell Junction:

Pressure Case	Pressure bars	Reason for Failure at this Pressure
MAWP	3.584	Thickness due to internal pressure, Cone Large End
MAPnc	4.745	Thickness due to internal pressure, Cone Large End

These pressures were determined by iteration.

Conical Reinforcement Calculations, ASME VIII Div. 1, App. 1

Conical Section From 40 To 50 SA-240 316

Elastic Modulus Data from ASME Section II Part D at 50 °C

Elastic Modulus of Cone Material	0.193E+09 KPa. at 50 °C
Elastic Modulus of Small Cylinder Material	0.193E+09 KPa. at 50 °C
Elastic Modulus of Large Cylinder Material	0.193E+09 KPa. at 50 °C
Elastic Modulus of Large End Reinforcement	0.193E+09 KPa. at 50 °C
Elastic Modulus of Small End Reinforcement	0.193E+09 KPa. at 50 °C

Elastic Modulus Data from ASME Section II Part D at 170 °C

Elastic Modulus of Cone Material	0.185E+09 KPa. at 170 °C
Elastic Modulus of Small Cylinder Material	0.185E+09 KPa. at 170 °C
Elastic Modulus of Large Cylinder Material	0.185E+09 KPa. at 170 °C
Elastic Modulus of Large End Reinforcement	0.185E+09 KPa. at 170 °C
Elastic Modulus of Small End Reinforcement	0.185E+09 KPa. at 170 °C

Axial Force on Small End of Cone	0.00	Kgf
Axial Force on Large End of Cone	0.00	Kgf
Moment on Small End of Cone	0.00	Kg-m.
Moment on Large End of Cone	0.00	Kg-m.

Note: Since there are no supports, the forces and moments could not be resolved to the large and small ends of the cone.

Note: Both ends of the Cone are Lines of Support

Maximum Centroid Reinforcement Distance Large End	12.7573	mm.
Maximum Centroid Reinforcement Distance Small End	11.4810	mm.

Reinforcement Calculations for Cone / Large Cylinder:

Required Area of Reinforcement for Large End Under Internal Pressure

Large end ratio of pressure to allowable stress	0.00048	
Large end max. half apex angle w/o reinforcement	11.000	degrees
Large end actual half apex angle	7.829	degrees

Required Area of Reinforcement for Large End Under External Pressure

Large end ratio of pressure to allowable stress	0.00007	
Large end max. half apex angle w/o reinforcement	0.187	degrees
Large end actual half apex angle	7.829	degrees

Intermediate Value [k]:

```
= max( Y / ( Srl * Erl ), 1 )
= max( 0.25813E+11/( 132.9 * 0.19291E+09 ), 1 )
= 1.0068
```

where [Y] is:

```
= Cone Allowable Stress * Cone Elastic Modulus (Ext. temp.)
= 133.8 * 0.19291E+09
= 25812725760.0 N./mm²^2
```

Allowable Stress of Large End Material (Ext. Temp)	133.8	N./mm²
Allowable Stress of Cone Material (Ext. Temp)	133.8	N./mm²

Required Area of Reinforcement, Large End, External [Arl]:

```
= (k*QL*Rl*tan(angle)/(Ss*E1))*(1-1/4((P*Rl-QL)/QL)*(delta/alpha)
= (1.0068*0.4426*868.0*0.138/(134*1.0))*
  (1-1/4((0.1*868.0-0.443)/0.443)*(0.187/7.829)
= 0.0387 cm²
```

Force per Length, Cone Large End External Pressure [QL]:

```
= Pext( Rl/2 ) + Faxial/(pi(Dl - Tl)) + Moment/(pi(Rl - Tl/2)(Rl - Tl/2))
= 0.1( 868.0/2 ) + 0.0/(pi(1736.0 - 3.0)) +
  0.0/(pi(868.0 - 3.0/2)(868.0 - 3.0/2))
= 0.443 Kgf/mm.
```

Available Area of Reinforcement, Large End, External [Ael]:

```
= 0.55*( Dl*ts )½ * ( ts + tc/cos(alpha) )
= 0.55 * ( 1736.0 * 3.0 )½ * ( 3.0 + 3.0/0.991 )
= 2.3927 cm²
```

Summary of Reinforcement Area, Large End, External Pressure:

Area of reinforcement required per App. 1-8(1)	0.0387	cm²
Area of reinforcement in shell per App. 1-8(2)	2.3927	cm²
Area of reinforcement in stiffening ring	5.0000	cm²

Intermediate Results, Large End, External Pressure:

Area Available in Cone, Shell, and Reinforcement	35.17	cm²
Force per Unit Length on Shell / Cone Junction	1.09	Kgf/mm.
Actual Buckling Stress associated with this Force	3.94	N./mm²
Material Strain associated with this stress	0.000041	

Required Moment of Inertia, Large End, External Pressure [I's]:

```
= A * Dl² * Atl / 10.9
= 0.408E-04 * 1736.0 * 1736.0 * 35.17/10.9
= 39720.57 mm.⁴
```

Available Moment of Inertia, Large End, External Pressure:

	Area	Centroid	Ar*Ce	Dist	I	Ar*Di²
Shl	1.191	0.0000	0.000	17.4794	0.009	363.808
Con	1.202	-2.7288	-3.280	20.2082	0.039	490.842
Sec	5.000	26.5000	132.500	-9.0206	10.417	406.853
TOT	7.393		129.220		10.465	1261.504
Centroid of Section			17.4794	Moment of Inertia		23.08

Summary of Large End Inertia Calculations

Available Moment of Inertia (Large End)	23.080	cm**4
Required Moment of Inertia (Large End)	3.972	cm**4

Reinforcement Calculations for Cone / Small Cylinder:

Required Area of Reinforcement for Small End under Internal Pressure

Small end ratio of pressure to allowable stress	0.00048	
Small end max. half apex angle w/o reinforcement	4.000	degrees
Small end actual half apex angle	7.829	degrees

Intermediate Value [k]:

```
= max( Y / ( Sr * Ers ), 1 )
= max( 0.19226E+11/( 100.3 * 0.18458E+09 ), 1 )
= 1.0386
```

where [Y] is:

```
= Cone Allowable Stress * Cone Elastic Modulus (Int. temp.)
= 104.2 * 0.18458E+09
= 19225886720.0 N./mm²^2
```

Decay Length, Cone Small End:

```
= 1.4 * sqrt( Rs( ts - ca ) )
= 1.4 * sqrt( 700.0( 3.0 - 0.0 ) )
= 64.156 mm.
```

Required Area of Reinforcement, Small End, Internal [Ars]:

```
= k*QS*Rs/(Ss*E1)*(1-delta/alpha)*tan(alpha)
= 1.04 * 1.7846 * 700.0/( 104 * 1.0 ) *
```

```
    ( 1 - 4.0/7.83 ) 0.1375
  = 0.0822 cm²
```

Force per Length, Cone Small End [QS]:

```
  = P( Rs/2 ) - Faxial/(pi(Ds + Ts)) + Moment/(pi(Rs + Ts/2)(Rs + Ts/2))
  = 0.5( 700.0/2 ) - 0.0/(pi(1400.0 + 3.0)) +
    0.0/(pi(700.0 + 3.0/2)(700.0 + 3.0/2))
  = 1.785 Kgf/mm.
```

Area of Reinforcement Available in Small End Shell [Aes]:

```
  = 0.78(Rs*Ts)½*((Ts-t)+(Tc-Tr)/cos(alpha) ))
  = 0.78(700.0*3.0)½*(( 3.0- 0.336 )+( 3.0- 0.339 )/0.99)
  = 1.9122 cm²
```

Summary of Reinforcement Area, Small End, Internal Pressure:

```
 Area of reinforcement required per App. 1-5(3)         0.0822  cm²
 Area of reinforcement in shell per App. 1-5(4)         1.9122  cm²
 Area of reinforcement in stiffening ring               4.6860  cm²
```

Required Area of Reinforcement for Small End Under External Pressure

```
 Allowable Stress of Small End Material (Ext. Temp)    133.8  N./mm²
 Allowable Stress of Cone Material (Ext. Temp)         133.8  N./mm²
```

Intermediate Value [k]:

```
  = max( Y / ( Srs * Ers ), 1 )
  = max( 0.25813E+11/( 132.9 * 0.19291E+09 ), 1 )
  = 1.0068
```

where [Y] is:

```
   = Cone Allowable Stress * Cone Elastic Modulus (Ext. temp.)
   = 133.8 * 0.19291E+09
   = 25812725760.0 N./mm²^2
```

Area of Reinforcement Required in Small End Shell [Ars]:

```
  = k * QS * Rs * tan(alpha) / ( Ss * E1 )
  = (1.0068*0.3584*703.0*0.1375/(134*1.0))
  = 0.0256 cm²
```

Force per Length, Cone Small End [QS]:

```
  = Pext( Rs/2 ) + Faxial/(pi(Ds - Ts)) + Moment/(pi(Rs - Ts/2)(Rs - Ts/2))
  = 0.1( 703.0/2 ) + 0.0/(pi(1406.0 - 3.0)) +
    0.0/(pi(703.0 - 3.0/2)(703.0 - 3.0/2))
  = 0.358 Kgf/mm.
```

Area of Reinforcement Available in Small End Shell [Aes]:

```
  = 0.55*(Ds*ts)½*[(ts-t)+(tc-tr)/cos(alpha))]
  = 0.55*(1406.0*3.0)½*[(3.0-0.57)+(3.0-0.514)/0.991]
  = 1.7647 cm²
```

Summary of Reinforcement Area, Small End, External Pressure:

```
 Area of reinforcement required per App. 1-8(3)         0.0256  cm²
 Area of reinforcement in shell per App. 1-8(4)         1.7647  cm²
 Area of reinforcement in stiffening ring               4.6860  cm²
```

Intermediate Results, Small End, External Pressure:

```
 Area Available in Cone, Shell, and Reinforcement        24.21  cm²
 Force per Unit Length on Shell / Cone Junction           0.55  Kgf/mm.
 Actual Buckling Stress associated with this Force        2.35  N./mm²
 Material Strain associated with this stress          0.000024
```

Required Moment of Inertia, Small End, External Pressure [I's]:

```
  = A * Ds² * Ats / 10.9
  = 0.244E-04 * 1406.0 * 1406.0 * 24.21/10.9
  = 10712.14 mm.⁴
```

Available Moment of Inertia, Small End, External Pressure:

	Area	Centroid	Ar*Ce	Dist	I	Ar*Di²
Shl	1.072	0.0000	0.000	17.4694	0.008	327.033
Con	1.082	2.4558	2.656	15.0136	0.030	243.822
Sec	4.686	24.9300	116.822	-7.4606	8.575	260.827
TOT	6.839		119.478		8.613	831.682
Centroid of Section			17.4694	Moment of Inertia		16.93

Summary of Small End Inertia Calculations

Available Moment of Inertia (Small End)	0.1693E+02	cm**4
Required Moment of Inertia (Small End)	0.1071E+01	cm**4

Note: The following calculations are only required per 1-5(g)(1) and
do include external loads due to wind or seismic. These
discontinuity stresses are computed at the shell/cone junction
and do not include effects of local stiffening from a junction ring.

Results for Discontinuity Stresses per Bednar p. 236 2nd Edition

Stress Type	Stress	Allowable	Location
Tensile Stress	20.16	312.47	Small Cyl. Long.
Compres. Stress	-8.47	-312.47	Small Cyl. Long.
Membrane Stress	19.57	-156.24	Small End Tang.
Tensile Stress	20.22	312.47	Cone Longitudinal
Compres. Stress	-8.41	-312.47	Cone Longitudinal
Compres Stress	19.68	-156.24	Cone Tangential
Tensile Stress	26.87	312.47	Large Cyl. Long.
Compres. Stress	-12.43	-312.47	Large Cyl. Long.
Membrane Stress	3.63	-156.24	Large End Tang.
Tensile Stress	26.94	312.47	Cone Longitudinal
Compres. Stress	-12.36	-312.47	Cone Longitudinal
Compres Stress	3.76	-156.24	Cone Tangential

Note: An asterisk (*) denotes that this stress was not applicable
for this combination of loads.

Maximum Allowable Pressure Calculations for Cone to Shell Junction:

Pressure Case	Pressure bars	Reason for Failure at this Pressure
MAWP	3.571	Thickness due to internal pressure, Cone Large End
MAPnc	4.728	Thickness due to internal pressure, Cone Large End

These pressures were determined by iteration.

Conical Reinforcement Calculations, ASME VIII Div. 1, App. 1

Conical Section From 60 To 70 SA-240 316

Elastic Modulus Data from ASME Section II Part D at 50 °C

Elastic Modulus of Cone Material	0.193E+09 KPa.	at 50 °C
Elastic Modulus of Small Cylinder Material	0.193E+09 KPa.	at 50 °C
Elastic Modulus of Large Cylinder Material	0.193E+09 KPa.	at 50 °C
Elastic Modulus of Large End Reinforcement	0.193E+09 KPa.	at 50 °C
Elastic Modulus of Small End Reinforcement	0.193E+09 KPa.	at 50 °C

Elastic Modulus Data from ASME Section II Part D at 170 °C

Elastic Modulus of Cone Material	0.185E+09 KPa.	at 170 °C
Elastic Modulus of Small Cylinder Material	0.185E+09 KPa.	at 170 °C
Elastic Modulus of Large Cylinder Material	0.185E+09 KPa.	at 170 °C
Elastic Modulus of Large End Reinforcement	0.185E+09 KPa.	at 170 °C
Elastic Modulus of Small End Reinforcement	0.185E+09 KPa.	at 170 °C

Axial Force on Small End of Cone	0.00	Kgf
Axial Force on Large End of Cone	0.00	Kgf
Moment on Small End of Cone	0.00	Kg-m.
Moment on Large End of Cone	0.00	Kg-m.

Note: Since there are no supports, the forces and moments could not be resolved to the large and small ends of the cone.

Note: Both ends of the Cone are Lines of Support

Maximum Centroid Reinforcement Distance Large End	12.7573	mm.
Maximum Centroid Reinforcement Distance Small End	11.4810	mm.

Reinforcement Calculations for Cone / Large Cylinder:

Required Area of Reinforcement for Large End Under Internal Pressure

Large end ratio of pressure to allowable stress	0.00048	
Large end max. half apex angle w/o reinforcement	11.000	degrees
Large end actual half apex angle	4.716	degrees

Required Area of Reinforcement for Large End Under External Pressure

Large end ratio of pressure to allowable stress	0.00007	
Large end max. half apex angle w/o reinforcement	0.187	degrees
Large end actual half apex angle	4.716	degrees

Intermediate Value [k]:
```
= max( Y / ( Srl * Erl ), 1 )
= max( 0.25813E+11/( 132.9 * 0.19291E+09 ), 1 )
= 1.0068
```

where [Y] is:
```
= Cone Allowable Stress * Cone Elastic Modulus (Ext. temp.)
= 133.8 * 0.19291E+09
= 25812725760.0 N./mm²^2
```

Allowable Stress of Large End Material (Ext. Temp)	133.8	N./mm²
Allowable Stress of Cone Material (Ext. Temp)	133.8	N./mm²

Required Area of Reinforcement, Large End, External [Arl]:
```
= (k*QL*Rl*tan(angle)/(Ss*E1))*(1-1/4((P*Rl-QL)/QL)*(delta/alpha)
= (1.0068*0.4426*868.0*0.082/(134*1.0))*
  (1-1/4((0.1*868.0-0.443)/0.443)*(0.187/4.716)
= 0.0232 cm²
```

Force per Length, Cone Large End External Pressure [QL]:

```
  = Pext( Rl/2 ) + Faxial/(pi(Dl - Tl)) + Moment/(pi(Rl - Tl/2)(Rl - Tl/2))
  = 0.1( 868.0/2 ) + 0.0/(pi(1736.0 - 3.0)) +
    0.0/(pi(868.0 - 3.0/2)(868.0 - 3.0/2))
  = 0.443 Kgf/mm.
```

Available Area of Reinforcement, Large End, External [Ael]:

```
  = 0.55*( Dl*ts )½ * ( ts + tc/cos(alpha) )
  = 0.55 * ( 1736.0 * 3.0 )½ * ( 3.0 + 3.0/0.997 )
  = 2.3855 cm²
```

Summary of Reinforcement Area, Large End, External Pressure:

Area of reinforcement required per App. 1-8(1)	0.0232	cm²
Area of reinforcement in shell per App. 1-8(2)	2.3855	cm²
Area of reinforcement in stiffening ring	4.7000	cm²

Intermediate Results, Large End, External Pressure:

Area Available in Cone, Shell, and Reinforcement	45.86	cm²
Force per Unit Length on Shell / Cone Junction	1.57	Kgf/mm.
Actual Buckling Stress associated with this Force	4.37	N./mm²
Material Strain associated with this stress	0.000045	

Required Moment of Inertia, Large End, External Pressure [I's]:

```
  = A * Dl² * Atl / 10.9
  = 0.453E-04 * 1736.0 * 1736.0 * 45.86/10.9
  = 57448.63 mm.⁴
```

Available Moment of Inertia, Large End, External Pressure:

	Area	Centroid	Ar*Ce	Dist	I	Ar*Di²
Shl	1.191	0.0000	0.000	16.3070	0.009	316.641
Con	1.195	-1.6373	-1.956	17.9443	0.020	384.720
Sec	4.700	25.0000	117.500	-8.6930	8.652	355.172
TOT	7.086		115.544		8.681	1056.534
Centroid of Section			16.3070	Moment of Inertia		19.25

Summary of Large End Inertia Calculations

Available Moment of Inertia (Large End)	19.246	cm**4
Required Moment of Inertia (Large End)	5.745	cm**4

Reinforcement Calculations for Cone / Small Cylinder:

Required Area of Reinforcement for Small End under Internal Pressure

Small end ratio of pressure to allowable stress	0.00048	
Small end max. half apex angle w/o reinforcement	4.000	degrees
Small end actual half apex angle	4.716	degrees

Intermediate Value [k]:

```
  = max( Y / ( Sr * Ers ), 1 )
  = max( 0.19226E+11/( 100.3 * 0.18458E+09 ), 1 )
  = 1.0386
```

where [Y] is:

```
  = Cone Allowable Stress * Cone Elastic Modulus (Int. temp.)
  = 104.2 * 0.18458E+09
  = 19225886720.0 N./mm²^2
```

Decay Length, Cone Small End:

```
  = 1.4 * sqrt( Rs( ts - ca ) )
  = 1.4 * sqrt( 700.0( 3.0 - 0.0 ) )
  = 64.156 mm.
```

Required Area of Reinforcement, Small End, Internal [Ars]:

```
  = k*QS*Rs/(Ss*E1)*(1-delta/alpha)*tan(alpha)
  = 1.04 * 1.7846 * 700.0/( 104 * 1.0 ) *
```

```
    ( 1 - 4.0/4.72 ) 0.0825
  = 0.0153 cm²
```

Force per Length, Cone Small End [QS]:

```
  = P( Rs/2 ) - Faxial/(pi(Ds + Ts)) + Moment/(pi(Rs + Ts/2)(Rs + Ts/2))
  = 0.5( 700.0/2 ) - 0.0/(pi(1400.0 + 3.0)) +
    0.0/(pi(700.0 + 3.0/2)(700.0 + 3.0/2))
  = 1.785 Kgf/mm.
```

Area of Reinforcement Available in Small End Shell [Aes]:

```
  = 0.78(Rs*Ts)½*((Ts-t)+(Tc-Tr)/cos(alpha) ))
  = 0.78(700.0*3.0)½*(( 3.0- 0.336 )+( 3.0- 0.337 )/1.)
  = 1.9072 cm²
```

Summary of Reinforcement Area, Small End, Internal Pressure:

Area of reinforcement required per App. 1-5(3)	0.0153	cm²
Area of reinforcement in shell per App. 1-5(4)	1.9072	cm²
Area of reinforcement in stiffening ring	4.7000	cm²

Required Area of Reinforcement for Small End Under External Pressure

Allowable Stress of Small End Material (Ext. Temp)	133.8	N./mm²
Allowable Stress of Cone Material (Ext. Temp)	133.8	N./mm²

Intermediate Value [k]:

```
  = max( Y / ( Srs * Ers ), 1 )
  = max( 0.25813E+11/( 132.9 * 0.19291E+09 ), 1 )
  = 1.0068
```

where [Y] is:

```
   = Cone Allowable Stress * Cone Elastic Modulus (Ext. temp.)
   = 133.8 * 0.19291E+09
   = 25812725760.0 N./mm²^2
```

Area of Reinforcement Required in Small End Shell [Ars]:

```
  = k * QS * Rs * tan(alpha) / ( Ss * E1 )
  = (1.0068*0.3584*703.0*0.0825/(134*1.0))
  = 0.0153 cm²
```

Force per Length, Cone Small End [QS]:

```
  = Pext( Rs/2 ) + Faxial/(pi(Ds - Ts)) + Moment/(pi(Rs - Ts/2)(Rs - Ts/2))
  = 0.1( 703.0/2 ) + 0.0/(pi(1406.0 - 3.0)) +
    0.0/(pi(703.0 - 3.0/2)(703.0 - 3.0/2))
  = 0.358 Kgf/mm.
```

Area of Reinforcement Available in Small End Shell [Aes]:

```
  = 0.55*(Ds*ts)½*[(ts-t)+(tc-tr)/cos(alpha))]
  = 0.55*(1406.0*3.0)½*[(3.0-1.89)+(3.0-2.0)/0.997]
  = 0.7552 cm²
```

Summary of Reinforcement Area, Small End, External Pressure:

Area of reinforcement required per App. 1-8(3)	0.0153	cm²
Area of reinforcement in shell per App. 1-8(4)	0.7552	cm²
Area of reinforcement in stiffening ring	4.7000	cm²

Intermediate Results, Small End, External Pressure:

Area Available in Cone, Shell, and Reinforcement	58.61	cm²
Force per Unit Length on Shell / Cone Junction	1.60	Kgf/mm.
Actual Buckling Stress associated with this Force	2.82	N./mm²
Material Strain associated with this stress	0.000029	

Required Moment of Inertia, Small End, External Pressure [I's]:

```
  = A * Ds² * Ats / 10.9
  = 0.292E-04 * 1406.0 * 1406.0 * 58.61/10.9
  = 31077.31 mm.⁴
```

Available Moment of Inertia, Small End, External Pressure:

	Area	Centroid	Ar*Ce	Dist	I	Ar*Di²
Shl	1.072	0.0000	0.000	17.3925	0.008	324.163
Con	1.075	1.4735	1.584	15.9191	0.016	272.487
Sec	4.700	25.0000	117.500	-7.6075	8.652	272.005
TOT	6.847		119.084		8.676	868.655
Centroid of Section			17.3925	Moment of Inertia		17.36

Summary of Small End Inertia Calculations

Available Moment of Inertia (Small End)	0.1736E+02	cm**4
Required Moment of Inertia (Small End)	0.3108E+01	cm**4

Note: The following calculations are only required per 1-5(g)(1) and do include external loads due to wind or seismic. These discontinuity stresses are computed at the shell/cone junction and do not include effects of local stiffening from a junction ring.

Results for Discontinuity Stresses per Bednar p. 236 2nd Edition

Stress Type	Stress	Allowable	Location
Tensile Stress	14.45	312.47	Small Cyl. Long.
Compres. Stress	-2.76	-312.47	Small Cyl. Long.
Membrane Stress	16.43	-156.24	Small End Tang.
Tensile Stress	14.47	312.47	Cone Longitudinal
Compres. Stress	-2.74	-312.47	Cone Longitudinal
Compres Stress	16.47	-156.24	Cone Tangential
Tensile Stress	19.03	312.47	Large Cyl. Long.
Compres. Stress	-4.59	-312.47	Large Cyl. Long.
Membrane Stress	7.94	-156.24	Large End Tang.
Tensile Stress	19.05	312.47	Cone Longitudinal
Compres. Stress	-4.56	-312.47	Cone Longitudinal
Compres Stress	7.99	-156.24	Cone Tangential

Note: An asterisk (*) denotes that this stress was not applicable for this combination of loads.

Maximum Allowable Pressure Calculations for Cone to Shell Junction:

Pressure Case	Pressure bars	Reason for Failure at this Pressure
MAWP	3.592	Thickness due to internal pressure, Cone Large End
MAPnc	4.756	Thickness due to internal pressure, Cone Large End

These pressures were determined by iteration.

Conical Reinforcement Calculations, ASME VIII Div. 1, App. 1

Conical Section From 80 To 90 SA-240 316

Elastic Modulus Data from ASME Section II Part D at 50 °C

Elastic Modulus of Cone Material	0.193E+09 KPa. at 50 °C
Elastic Modulus of Small Cylinder Material	0.193E+09 KPa. at 50 °C
Elastic Modulus of Large Cylinder Material	0.193E+09 KPa. at 50 °C
Elastic Modulus of Large End Reinforcement	0.193E+09 KPa. at 50 °C
Elastic Modulus of Small End Reinforcement	0.193E+09 KPa. at 50 °C

Elastic Modulus Data from ASME Section II Part D at 170 °C

Elastic Modulus of Cone Material	0.185E+09 KPa. at 170 °C
Elastic Modulus of Small Cylinder Material	0.185E+09 KPa. at 170 °C
Elastic Modulus of Large Cylinder Material	0.185E+09 KPa. at 170 °C
Elastic Modulus of Large End Reinforcement	0.185E+09 KPa. at 170 °C
Elastic Modulus of Small End Reinforcement	0.185E+09 KPa. at 170 °C

Axial Force on Small End of Cone	0.00	Kgf
Axial Force on Large End of Cone	0.00	Kgf
Moment on Small End of Cone	0.00	Kg-m.
Moment on Large End of Cone	0.00	Kg-m.

Note: Since there are no supports, the forces and moments could
not be resolved to the large and small ends of the cone.

Note: Both ends of the Cone are Lines of Support

Maximum Centroid Reinforcement Distance Large End	12.7573	mm.
Maximum Centroid Reinforcement Distance Small End	11.4810	mm.

Reinforcement Calculations for Cone / Large Cylinder:

Required Area of Reinforcement for Large End Under Internal Pressure

Large end ratio of pressure to allowable stress	0.00048	
Large end max. half apex angle w/o reinforcement	11.000	degrees
Large end actual half apex angle	7.829	degrees

Required Area of Reinforcement for Large End Under External Pressure

Large end ratio of pressure to allowable stress	0.00007	
Large end max. half apex angle w/o reinforcement	0.187	degrees
Large end actual half apex angle	7.829	degrees

Intermediate Value [k]:
= max(Y / (Srl * Erl), 1)
= max(0.25813E+11/(132.9 * 0.19291E+09), 1)
= 1.0068

where [Y] is:
= Cone Allowable Stress * Cone Elastic Modulus (Ext. temp.)
= 133.8 * 0.19291E+09
= 25812725760.0 N./mm²^2

Allowable Stress of Large End Material (Ext. Temp)	133.8	N./mm²
Allowable Stress of Cone Material (Ext. Temp)	133.8	N./mm²

Required Area of Reinforcement, Large End, External [Arl]:
= (k*QL*Rl*tan(angle)/(Ss*E1))*(1-1/4((P*Rl-QL)/QL)*(delta/alpha)
= (1.0068*0.4426*868.0*0.138/(134*1.0))*
(1-1/4((0.1*868.0-0.443)/0.443)*(0.187/7.829)
= 0.0387 cm²

Force per Length, Cone Large End External Pressure [QL]:

```
  = Pext( Rl/2 ) + Faxial/(pi(Dl - Tl)) + Moment/(pi(Rl - Tl/2)(Rl - Tl/2))
  = 0.1( 868.0/2 ) + 0.0/(pi(1736.0 - 3.0)) +
    0.0/(pi(868.0 - 3.0/2)(868.0 - 3.0/2))
  = 0.443 Kgf/mm.
```

Available Area of Reinforcement, Large End, External [Ael]:

```
  = 0.55*( Dl*ts )½ * ( ts + tc/cos(alpha) )
  = 0.55 * ( 1736.0 * 3.0 )½ * ( 3.0 + 3.0/0.991 )
  = 2.3927 cm²
```

Summary of Reinforcement Area, Large End, External Pressure:

Area of reinforcement required per App. 1-8(1)	0.0387	cm²
Area of reinforcement in shell per App. 1-8(2)	2.3927	cm²
Area of reinforcement in stiffening ring	4.6835	cm²

Intermediate Results, Large End, External Pressure:

Calculate Cylinder Decay Length:

```
  = 2 * sqrt( RL * ts )
  = 2*sqrt(868.0*3.0)
  = 102.0588 mm.
```

Note: LL is zero since large cylinder length is less than the decay length

Area Available in Cone, Shell, and Reinforcement	22.85	cm²
Force per Unit Length on Shell / Cone Junction	0.68	Kgf/mm.
Actual Buckling Stress associated with this Force	3.78	N./mm²
Material Strain associated with this stress	0.000039	

Required Moment of Inertia, Large End, External Pressure [I's]:

```
  = A * Dl² * Atl / 10.9
  = 0.392E-04 * 1736.0 * 1736.0 * 22.85/10.9
  = 24792.07 mm.⁴
```

Available Moment of Inertia, Large End, External Pressure:

	Area	Centroid	Ar*Ce	Dist	I	Ar*Di²
Shl	1.191	0.0000	0.000	16.0286	0.009	305.921
Con	1.202	-2.7288	-3.280	18.7574	0.039	422.893
Sec	4.684	24.9175	116.701	-8.8889	8.561	370.059
TOT	7.076		113.421		8.609	1098.873
Centroid of Section			16.0286	Moment of Inertia		19.60

Summary of Large End Inertia Calculations

Available Moment of Inertia (Large End)	19.598	cm**4
Required Moment of Inertia (Large End)	2.479	cm**4

Reinforcement Calculations for Cone / Small Cylinder:

Required Area of Reinforcement for Small End under Internal Pressure

Small end ratio of pressure to allowable stress	0.00048	
Small end max. half apex angle w/o reinforcement	4.000	degrees
Small end actual half apex angle	7.829	degrees

Intermediate Value [k]:

```
  = max( Y / ( Sr * Ers ), 1 )
  = max( 0.19226E+11/( 100.3 * 0.18458E+09 ), 1 )
  = 1.0386
```

where [Y] is:

```
  = Cone Allowable Stress * Cone Elastic Modulus (Int. temp.)
  = 104.2 * 0.18458E+09
  = 19225886720.0 N./mm²^2
```

Decay Length, Cone Small End:
```
  = 1.4 * sqrt( Rs( ts - ca ) )
  = 1.4 * sqrt( 700.0( 3.0 - 0.0 ) )
  = 64.156 mm.
```

Required Area of Reinforcement, Small End, Internal [Ars]:
```
  = k*QS*Rs/(Ss*E1)*(1-delta/alpha)*tan(alpha)
  = 1.04 * 1.7846 * 700.0/( 104 * 1.0 ) *
    ( 1 - 4.0/7.83 ) 0.1375
  = 0.0822 cm²
```

Force per Length, Cone Small End [QS]:
```
  = P( Rs/2 ) - Faxial/(pi(Ds + Ts)) + Moment/(pi(Rs + Ts/2)(Rs + Ts/2))
  = 0.5( 700.0/2 ) - 0.0/(pi(1400.0 + 3.0)) +
    0.0/(pi(700.0 + 3.0/2)(700.0 + 3.0/2))
  = 1.785 Kgf/mm.
```

Area of Reinforcement Available in Small End Shell [Aes]:
```
  = 0.78(Rs*Ts)½*((Ts-t)+(Tc-Tr)/cos(alpha) ))
  = 0.78(700.0*3.0)½*(( 3.0- 0.336 )+( 3.0- 0.339 )/0.99)
  = 1.9122 cm²
```

Summary of Reinforcement Area, Small End, Internal Pressure:

Area of reinforcement required per App. 1-5(3)	0.0822	cm²
Area of reinforcement in shell per App. 1-5(4)	1.9122	cm²
Area of reinforcement in stiffening ring	4.6830	cm²

Required Area of Reinforcement for Small End Under External Pressure

Allowable Stress of Small End Material (Ext. Temp)	133.8	N./mm²
Allowable Stress of Cone Material (Ext. Temp)	133.8	N./mm²

Intermediate Value [k]:
```
  = max( Y / ( Srs * Ers ), 1 )
  = max( 0.25813E+11/( 132.9 * 0.19291E+09 ), 1 )
  = 1.0068
```

where [Y] is:
```
  = Cone Allowable Stress * Cone Elastic Modulus (Ext. temp.)
  = 133.8 * 0.19291E+09
  = 25812725760.0 N./mm²^2
```

Area of Reinforcement Required in Small End Shell [Ars]:
```
  = k * QS * Rs * tan(alpha) / ( Ss * E1 )
  = (1.0068*0.3584*703.0*0.1375/(134*1.0))
  = 0.0256 cm²
```

Force per Length, Cone Small End [QS]:
```
  = Pext( Rs/2 ) + Faxial/(pi(Ds - Ts)) + Moment/(pi(Rs - Ts/2)(Rs - Ts/2))
  = 0.1( 703.0/2 ) + 0.0/(pi(1406.0 - 3.0)) +
    0.0/(pi(703.0 - 3.0/2)(703.0 - 3.0/2))
  = 0.358 Kgf/mm.
```

Area of Reinforcement Available in Small End Shell [Aes]:
```
  = 0.55*(Ds*ts)½*[(ts-t)+(tc-tr)/cos(alpha))]
  = 0.55*(1406.0*3.0)½*[(3.0-1.043)+(3.0-0.514)/0.991]
  = 1.5954 cm²
```

Summary of Reinforcement Area, Small End, External Pressure:

Area of reinforcement required per App. 1-8(3)	0.0256	cm²
Area of reinforcement in shell per App. 1-8(4)	1.5954	cm²
Area of reinforcement in stiffening ring	4.6830	cm²

Intermediate Results, Small End, External Pressure:

Area Available in Cone, Shell, and Reinforcement	28.48	cm²

Force per Unit Length on Shell / Cone Junction	0.70	Kgf/mm.
Actual Buckling Stress associated with this Force	2.53	N./mm²
Material Strain associated with this stress	0.000026	

Required Moment of Inertia, Small End, External Pressure [I's]:

= A * Ds² * Ats / 10.9
= 0.262E-04 * 1406.0 * 1406.0 * 28.48/10.9
= 13537.53 mm.^{4}

Available Moment of Inertia, Small End, External Pressure:

	Area	Centroid	Ar*Ce	Dist	I	Ar*Di²
Shl	1.072	0.0000	0.000	17.4558	0.008	326.525
Con	1.082	2.4558	2.656	15.0000	0.030	243.382
Sec	4.683	24.9150	116.677	-7.4592	8.558	260.558
TOT	6.836		119.333		8.596	830.465
Centroid of Section			17.4558	Moment of Inertia		16.90

Summary of Small End Inertia Calculations

Available Moment of Inertia (Small End)	0.1690E+02	cm**4
Required Moment of Inertia (Small End)	0.1354E+01	cm**4

Note: The following calculations are only required per 1-5(g)(1) and do include external loads due to wind or seismic. These discontinuity stresses are computed at the shell/cone junction and do not include effects of local stiffening from a junction ring.

Results for Discontinuity Stresses per Bednar p. 236 2nd Edition

Stress Type	Stress	Allowable	Location
Tensile Stress	20.16	312.47	Small Cyl. Long.
Compres. Stress	-8.47	-312.47	Small Cyl. Long.
Membrane Stress	19.57	-156.24	Small End Tang.
Tensile Stress	20.22	312.47	Cone Longitudinal
Compres. Stress	-8.41	-312.47	Cone Longitudinal
Compres Stress	19.68	-156.24	Cone Tangential
Tensile Stress	26.87	312.47	Large Cyl. Long.
Compres. Stress	-12.43	-312.47	Large Cyl. Long.
Membrane Stress	3.63	-156.24	Large End Tang.
Tensile Stress	26.94	312.47	Cone Longitudinal
Compres. Stress	-12.36	-312.47	Cone Longitudinal
Compres Stress	3.76	-156.24	Cone Tangential

Note: An asterisk (*) denotes that this stress was not applicable for this combination of loads.

Maximum Allowable Pressure Calculations for Cone to Shell Junction:

Pressure Case	Pressure bars	Reason for Failure at this Pressure
MAWP	3.571	Thickness due to internal pressure, Cone Large End
MAPnc	4.728	Thickness due to internal pressure, Cone Large End

These pressures were determined by iteration.

Conical Reinforcement Calculations, ASME VIII Div. 1, App. 1

Conical Section From 100 To 110 SA-240 316

Elastic Modulus Data from ASME Section II Part D at 50 °C

Elastic Modulus of Cone Material	0.193E+09 KPa. at 50 °C
Elastic Modulus of Small Cylinder Material	0.193E+09 KPa. at 50 °C
Elastic Modulus of Large Cylinder Material	0.193E+09 KPa. at 50 °C
Elastic Modulus of Large End Reinforcement	0.193E+09 KPa. at 50 °C
Elastic Modulus of Small End Reinforcement	0.193E+09 KPa. at 50 °C

Elastic Modulus Data from ASME Section II Part D at 170 °C

Elastic Modulus of Cone Material	0.185E+09 KPa. at 170 °C
Elastic Modulus of Small Cylinder Material	0.185E+09 KPa. at 170 °C
Elastic Modulus of Large Cylinder Material	0.185E+09 KPa. at 170 °C
Elastic Modulus of Large End Reinforcement	0.185E+09 KPa. at 170 °C
Elastic Modulus of Small End Reinforcement	0.185E+09 KPa. at 170 °C

Axial Force on Small End of Cone	0.00	Kgf
Axial Force on Large End of Cone	0.00	Kgf
Moment on Small End of Cone	0.00	Kg-m.
Moment on Large End of Cone	0.00	Kg-m.

Note: Since there are no supports, the forces and moments could not be resolved to the large and small ends of the cone.

Note: Both ends of the Cone are Lines of Support

Maximum Centroid Reinforcement Distance Large End	11.4810	mm.
Maximum Centroid Reinforcement Distance Small End	9.4670	mm.

Reinforcement Calculations for Cone / Large Cylinder:

Required Area of Reinforcement for Large End Under Internal Pressure

Large end ratio of pressure to allowable stress	0.00048	
Large end max. half apex angle w/o reinforcement	11.000	degrees
Large end actual half apex angle	6.419	degrees

Required Area of Reinforcement for Large End Under External Pressure

Large end ratio of pressure to allowable stress	0.00007	
Large end max. half apex angle w/o reinforcement	0.187	degrees
Large end actual half apex angle	6.419	degrees

Intermediate Value [k]:
= max(Y / (Srl * Erl), 1)
= max(0.25813E+11/(132.9 * 0.19291E+09), 1)
= 1.0068

where [Y] is:
= Cone Allowable Stress * Cone Elastic Modulus (Ext. temp.)
= 133.8 * 0.19291E+09
= 25812725760.0 N./mm²^2

Allowable Stress of Large End Material (Ext. Temp)	133.8	N./mm²
Allowable Stress of Cone Material (Ext. Temp)	133.8	N./mm²

Required Area of Reinforcement, Large End, External [Arl]:
= (k*QL*Rl*tan(angle)/(Ss*E1))*(1-1/4((P*Rl-QL)/QL)*(delta/alpha)
= (1.0068*0.3584*703.0*0.112/(134*1.0))*
(1-1/4((0.1*703.0-0.358)/0.358)*(0.187/6.419)
= 0.0208 cm²

Force per Length, Cone Large End External Pressure [QL]:

```
= Pext( Rl/2 ) + Faxial/(pi(Dl - Tl)) + Moment/(pi(Rl - Tl/2)(Rl - Tl/2))
= 0.1( 703.0/2 ) + 0.0/(pi(1406.0 - 3.0)) +
  0.0/(pi(703.0 - 3.0/2)(703.0 - 3.0/2))
= 0.358 Kgf/mm.
```

Available Area of Reinforcement, Large End, External [Ael]:

```
= 0.55*( Dl*ts )½ * ( ts + tc/cos(alpha) )
= 0.55 * ( 1406.0 * 3.0 )½ * ( 3.0 + 3.0/0.994 )
= 2.1500 cm²
```

Summary of Reinforcement Area, Large End, External Pressure:

Area of reinforcement required per App. 1-8(1)	0.0208	cm²
Area of reinforcement in shell per App. 1-8(2)	2.1500	cm²
Area of reinforcement in stiffening ring	5.0420	cm²

Intermediate Results, Large End, External Pressure:

Area Available in Cone, Shell, and Reinforcement	61.56	cm²
Force per Unit Length on Shell / Cone Junction	2.00	Kgf/mm.
Actual Buckling Stress associated with this Force	3.35	N./mm²
Material Strain associated with this stress	0.000035	

Required Moment of Inertia, Large End, External Pressure [I's]:

```
= A * Dl² * Atl / 10.9
= 0.348E-04 * 1406.0 * 1406.0 * 61.56/10.9
= 38820.20 mm.⁴
```

Available Moment of Inertia, Large End, External Pressure:

	Area	Centroid	Ar*Ce	Dist	I	Ar*Di²
Shl	1.072	0.0000	0.000	18.4240	0.008	363.751
Con	1.078	-2.0093	-2.167	20.4333	0.023	450.240
Sec	5.042	26.7100	134.672	-8.2860	10.681	346.172
TOT	7.192		132.505		10.712	1160.163
Centroid of Section			18.4240	Moment of Inertia		22.31

Summary of Large End Inertia Calculations

Available Moment of Inertia (Large End)	22.314	cm**4
Required Moment of Inertia (Large End)	3.882	cm**4

Note: The following calculations are only required per 1-5(g)(1) and do include external loads due to wind or seismic. These discontinuity stresses are computed at the shell/cone junction and do not include effects of local stiffening from a junction ring.

Results for Discontinuity Stresses per Bednar p. 236 2nd Edition

Stress Type	Stress	Allowable	Location
Tensile Stress	17.57	312.47	Large Cyl. Long.
Compres. Stress	-5.87	-312.47	Large Cyl. Long.
Membrane Stress	5.24	-156.24	Large End Tang.
Tensile Stress	17.60	312.47	Cone Longitudinal
Compres. Stress	-5.84	-312.47	Cone Longitudinal
Compres Stress	5.31	-156.24	Cone Tangential

Note: An asterisk (*) denotes that this stress was not applicable for this combination of loads.

Maximum Allowable Pressure Calculations for Cone to Shell Junction:

Pressure Case	Pressure bars	Reason for Failure at this Pressure
MAWP	4.424	Thickness due to internal pressure, Cone Large End

```
MAPnc         5.857     Thickness due to internal pressure, Cone Large End
```

These pressures were determined by iteration.

Shop/Field Installation Options :

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

Center of Gravity of Stiffening Rings	14631.545 mm.
Center of Gravity of Bare Shell New and Cold	13151.735 mm.
Center of Gravity of Bare Shell Corroded	13151.735 mm.
Vessel CG in the Operating Condition	13342.544 mm.
Vessel CG in the Fabricated (Shop/Empty) Condition	13342.544 mm.

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
[16]		-196						
[16]		-196						
[16]		-196						
[16]		-196						
[16]		-196						
[16]		-196						
[16]		-196						
[16]		-196						
[16]		-196						
[16]		-196						
Warmest MDMT:		-196						

```
Required Minimum Design Metal Temperature            -28.9   °C
Warmest Computed Minimum Design Metal Temperature   -196.0   °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)
[19] - Select a valid hydrotest type to get the UG-20(f) exemption
[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 : 1300.000 x 1730.000 x 1400.000 x 1730.000 x 1400.000 mm. ID
Vessel Design Length, Tangent to Tangent          26052.00  mm.

Distance of Bottom Tangent above Grade             8052.00  mm.
Distance of Base above Grade                          0.00  mm.
Specified Datum Line Distance                         0.00  mm.

Internal Design Temperature                            170  °C
Internal Design Pressure                             0.500  bars

External Design Temperature                             50  °C
External Design Pressure                             0.100  bars

Maximum Allowable Working Pressure                   3.571  bars
External Max. Allowable Working Pressure             0.137  bars
Hydrostatic Test Pressure                            0.000  bars

Required Minimum Design Metal Temperature            -28.9  °C
Warmest Computed Minimum Design Metal Temperature   -196.0  °C

Wind Design Code                                  ASCE-93
Earthquake Design Code                             UBC-94
```

Materials of Construction:

Component Type	Material	Class	Thickness	UNS #	Normalized	Impact Tested
Shell	SA-240 316	...	...	S31600	No	No
Cone	SA-240 316	...	...	S31600	No	No
Rings	SA-240 316	...	...	S31600	No	No
Rings	SA-240 304	...	...	S30400	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
Cylinder	0.500	0.10	4.794	0.0000	N/A	No
Conical	0.500	0.10	3.584	0.0000	N/A	No
Cylinder	0.500	0.10	3.605	0.0000	N/A	No
Conical	0.500	0.10	3.571	0.0000	N/A	No
Cylinder	0.500	0.10	4.452	0.0000	N/A	No
Conical	0.500	0.10	3.593	0.0000	N/A	No
Cylinder	0.500	0.10	3.605	0.0000	N/A	No
Conical	0.500	0.10	3.571	0.0000	N/A	No
Cylinder	0.500	0.10	4.452	0.0000	N/A	No
Conical	0.500	0.10	4.424	0.0000	N/A	No

Stiffener Ring Specifications:

Elevation mm.	Selected Type	User Description
3958.00	Bar 47.0 x 10.	Ring:[1 of 1]
5946.00	Bar 47.0 x 10.	Ring:[2 of 2]
7939.00	Bar 47.0 x 10.	Ring:[3 of 3]
7952.00	Bar 47.0 x 10.	Ring:[4 of 4]
8052.00	Bar 97.0 x 10.	Ring 16
10052.00	Bar 47.0 x 10.	Ring5
12051.00	Bar 46.9 x 10.	Ring:17

10852.00	Bar	50.0 x	10.	Ring 21
12142.00	Bar	47.0 x	10.	Ring 6
12155.00	Bar	47.0 x	10.	Ring 7
13565.00	Bar	47.0 x	10.	Ring 8
14965.00	Bar	47.0 x	10.	Ring 9
16552.00	Bar	47.0 x	10.	Ring 18
18551.00	Bar	47.0 x	10.	Ring 23
19289.00	Bar	47.0 x	10.	Ring 10
19302.00	Bar	47.0 x	10.	Ring 11
19352.00	Bar	46.8 x	10.	Ring 24
20551.00	Bar	46.8 x	10.	Ring 26
20927.00	Bar	47.0 x	10.	Ring 12
22297.00	Bar	47.0 x	10.	Ring 13]
26051.00	Bar	50.4 x	10.	Ring 22
24052.00	Bar	50.4 x	10.	Ring 28

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
Cylinder	8052.0	8052.0	3.0	3.0	1.5	...	1.00	1.00
Conical	10052.0	2000.0	3.0	3.0	1.5	...	1.00	1.00
Cylinder	10852.0	800.0	3.0	3.0	1.5	...	1.00	1.00
Conical	12052.0	1200.0	3.0	3.0	1.5	...	1.00	1.00
Cylinder	16552.0	4500.0	3.0	3.0	1.5	...	1.00	1.00
Conical	18552.0	2000.0	3.0	3.0	1.5	...	1.00	1.00
Cylinder	19352.0	800.0	3.0	3.0	1.5	...	1.00	1.00
Conical	20552.0	1200.0	3.0	3.0	1.5	...	1.00	1.00
Cylinder	24052.0	3500.0	3.0	3.0	1.5	...	1.00	1.00
Conical	26052.0	2000.0	3.0	3.0	1.5	...	1.00	1.00

External Pressure Calculations:

From	To	External Actual T. mm.	External Required T. mm.	External Design Pressure bars	External M.A.W.P. bars
10	Ring	3	2.64879	0.1	0.13736
Ring	Ring	3	1.98494	0.1	0.28018
Ring	Ring	3	1.98708	0.1	0.27946
Ring	Ring	3	0.47257	0.1	2.80031
Ring	20	3	0.57319	0.1	2.56958
20	Ring	3	1.86049	0.1	0.32853
Ring	30	3	2.24961	0.1	0.20495
30	Ring	3	No Calc	0.1	No Calc
Ring	40	3	1.62103	0.1	0.46793
40	Ring	3	2.25778	0.1	0.20299
Ring	Ring	3	1.85593	0.1	0.33169
Ring	50	3	0.51366	0.1	2.52828
50	Ring	3	0.56956	0.1	2.4333
Ring	Ring	3	0.50876	0.1	2.55869
Ring	Ring	3	1.80715	0.1	0.35777
Ring	Ring	3	1.80239	0.1	0.36038
Ring	60	3	1.89031	0.1	0.31681
60	Ring	3	0.51049	0.1	2.54788
Ring	Ring	3	2.27117	0.1	0.19962
Ring	70	3	0.6303	0.1	1.95727
70	Ring	3	1.56614	0.1	0.51
Ring	Ring	3	0.62816	0.1	1.96585
Ring	80	3	0.62816	0.1	1.96585
80	Ring	3	0.63409	0.1	1.9422
Ring	Ring	3	1.85593	0.1	0.33169
Ring	90	3	0.51366	0.1	2.52828
90	Ring	3	1.04348	0.1	1.44208

Ring	Ring	3	1.78809	0.1	0.3684
Ring	100	3	1.96728	0.1	0.28568
100	Ring	3	0.51198	0.1	2.53866
Ring	Ring	3	1.94504	0.1	0.2941
Ring	110	3	0.34821	0.1	4.03247

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	Ring	3958	5366.66	No Calc	No Calc
Ring	Ring	1988	5367.77	4.74696	17.6358
Ring	Ring	1993	5367.78	3.17821	17.6358
Ring	Ring	12.9998	362.283	1.60148	17.6358
Ring	20	100	3105.85	0.090213	17.6358
20	Ring	1679.94	1679.94	No Calc	No Calc
Ring	30	1752.3	1752.3	2.74012	118.645
30	Ring	No Calc	No Calc	No Calc	No Calc
Ring	40	800	3576.41	1.50003	18.5486
40	Ring	1752.3	1752.3	No Calc	No Calc
Ring	Ring	1085.13	1085.13	5.32031	21.7628
Ring	50	0.99994	0.99994	1.08257	17.7314
50	Ring	90	2782.45	No Calc	No Calc
Ring	Ring	13	332.63	0.1026	17.8679
Ring	Ring	1410	4840.94	1.41706	17.8679
Ring	Ring	1400	4840.92	2.80393	17.8679
Ring	60	1587	4841.33	2.96283	17.8679
60	Ring	0.99994	0.99994	No Calc	No Calc
Ring	Ring	1809.08	1809.08	1.80308	17.8679
Ring	70	0.99989	0.99989	3.39301	18.5482
70	Ring	737	3576.31	No Calc	No Calc
Ring	Ring	13	979.513	1.41118	18.5486
Ring	80	50	1799.98	0.11813	18.5486
80	Ring	0.99989	0.99989	No Calc	No Calc
Ring	Ring	1085.13	1085.13	2.0298	18.381
Ring	90	0.99994	0.99994	1.08257	17.7021
90	Ring	375	4840.98	No Calc	No Calc
Ring	Ring	1370	4840.85	1.73585	17.8679
Ring	100	1755	4841.66	3.11292	17.8679
100	Ring	0.99994	0.99994	No Calc	No Calc
Ring	Ring	1679.26	1679.26	1.67377	21.4269
Ring	110	0.99982	0.99982	0.52653	20.0339

Factored Loads:

Un-Factored Loads:

Weights:

Fabricated - Bare W/O Removable Internals	3201.3	kg.
Shop Test - Fabricated + Water (Full)	44267.2	kg.
Shipping - Fab. + Rem. Intls.+ Shipping App.	3201.3	kg.
Erected - Fab. + Rem. Intls.+ Insul. (etc)	3201.3	kg.
Empty - Fab. + Intls. + Details + Wghts.	3201.3	kg.
Operating - Empty + Operating Liquid (No CA)	3201.3	kg.
Field Test - Empty Weight + Water (Full)	44267.2	kg.