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DESIGN CALCULATION

In Accordance with ASME Section VIII Division 1

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ASME Code Version     : 2023

Analysis Performed by : Kedkep Consulting Inc

Job File              : D:\Jobs 2008 to today\Business\web\Horizontal Tank.pvdb

Date of Analysis      : Jun 10,2025   9:45pm
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PV Elite 27, January 2025

Vessel Design Summary:

ASME Code, Section VIII Division 1, 2023

Diameter Spec : 60.000 in. ID		
Vessel Design Length, Tangent to Tangent	10.33	ft.
Specified Datum Line Distance	0.00	ft.
Internal Design Temperature	200	F
Internal Design Pressure	100.000	psig
External Design Temperature	200	F
External Design Pressure	15.000	psig
Maximum Allowable Working Pressure	195.5	psig
External Max. Allowable Working Pressure	70.48	psig
Shop Test Pressure	130.000	psig
Required Minimum Design Metal Temperature	-20.0	F
Warmest Computed Minimum Design Metal Temperature	-55.0	F
Wind Design Code	IBC 2006	
Earthquake Design Code	IBC 2006	

Materials of Construction:

Component Type	Material	Class	Thickness	UNS #	Normal ized	Impact Tested
Shell	SA-516 70	...	...	K02700	No	No
Head	SA-516 70	...	...	K02700	No	No
Nozzle	SA-106 B	...	...	K03006	No	No
Nozzle	SA-516 70	...	...	K02700	No	No
Nozzle Flg	SA-105	...	...	K03504	Yes	No
Hrz Bolting		...	...		No	No
Saddles	SA-516 70	...	...	K02700	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 (psig & in.):

Element Description or Type	Design Pressure + Stat. head	Ext. Press.	Element M.A.W.P	Total Corrosion Allowance	Str. Flg. Gov.	In Creep Range
LF Head	100.000	15.00	328.700	0.1250	Yes	No
Shell	100.000	15.00	279.400	0.1250	N/A	No
RT Head	100.000	15.00	328.700	0.1250	Yes	No

Element Types and Properties:

Element Type	"To" Elev ft.	Element Length ft.	Nominal Thickness in.	Finished Thickness in.	Reqd Thk Internal in.	Reqd Thk External in.	Long Eff	Circ Eff
Ellipse	0.17	0.167	...	0.625	0.276	0.284	1.00	1.00
Cylinder	10.17	10.000	...	0.625	0.303	0.395	0.85	0.85

Ellipse	10.33	0.167	...	0.625	0.276	0.284	1.00	0.85

Foundation/Support Summary

Saddle Parameters:

Saddle Width	8.000	in.
Saddle Bearing Angle	120.000	deg.
Centerline Dimension	45.000	in.
Wear Pad Width	12.000	in.
Wear Pad Thickness	0.375	in.
Wear Pad Bearing Angle	132.000	deg.
Distance from Saddle to Tangent	17.000	in.

Summary of Maximum Saddle Loads, Operating Case:

Maximum Vertical Saddle Load	3473.54	lb.
Maximum Transverse Saddle Shear Load	338.47	lb.
Maximum Longitudinal Saddle Shear Load	676.94	lb.

Summary of Maximum Saddle Loads, Operating Case, Un-Factored:

Maximum Vertical Saddle Load	3838.26	lb.
Maximum Transverse Saddle Shear Load	483.53	lb.
Maximum Longitudinal Saddle Shear Load	967.06	lb.

Summary of Maximum Saddle Loads, Pressure Test Case:

Maximum Vertical Saddle Load	10930.51	lb.
Maximum Transverse Saddle Shear Load	54.63	lb.
Maximum Longitudinal Saddle Shear Load	98.36	lb.

Weights:

Fabricated	- Bare w/o removable internals	6143.2	lbm
Shop Test	- Fabricated + water (full)	20845.9	lbm
Shipping	- Fab. + rem. intls.+ shipping app.	6143.2	lbm
Erected	- Fab. + rem. intls.+ insul. (etc)	6143.2	lbm
Empty	- Fab. + intls. + details + wghts.	6143.2	lbm
Operating	- Empty + operating liquid (no ca)	6143.2	lbm

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Nozzle Calculation Summary (psig & in.):

Description	MAWP	Ext	MAPNC	UG-45	[tr]	Weld Path	Areas or Stresses
Inspection	210.6	OK	...	OK	0.276	OK	Passed
Outlet	210.6	OK	...	OK	0.276	OK	Passed
Manhole	195.5	OK	...	OK	0.276	OK	Passed
Drain	279.4	...	...	OK	0.260	OK	No Calc[*]
Inlet	227.8	OK	...	OK	0.276	OK	Passed

Nozzle MAWP Summary:

Minimum MAWP Nozzles :	195.5	Nozzle : Manhole
Minimum MAWP Shells/Flanges :	195.5	Element : Shell
Minimum MAPnc Shells/Flanges :	349.8	Element : Shell
Computed Vessel M.A.W.P. :	195.5 psig	

[*] - This was a small opening and the areas were not computed.

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

Multiple output lines for the same nozzle indicates required Code calculations in both the longitudinal and circumferential planes of reinforcement where applicable.

Check the spatial relationship between the nozzles:

From Node	Nozzle Description	X Coordinate in.	Layout Angle deg	Dia. Limit in.
10	Inspection	0.000	0.000	12.022
10	Outlet	0.000	0.000	12.022
20	Manhole	62.000	0.000	32.500
20	Drain	62.000	180.000	3.874
30	Inlet	0.000	0.000	7.748

The nozzle spacing is computed by the following:

= sqrt(ll^2 + lc^2) where

ll - Arc length along the inside vessel surface in the long. direction.
lc - Arc length along the inside vessel surface in the circ. direction

If any interferences/violations are found, they will be noted below.

No interference violations have been detected!

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Nozzle Schedule:

Description	Nominal or Actual Size	Schd or FVC Type	Flg Type	Nozzle O/Dia in	Wall Thk in	Reinforcing Pad Diameter	Pad Thk in	Cut Length in	Flg Class
Drain	2.000 in	160	WNF	2.375	0.344	...	...	2.65	150
Inlet	4.000 in	120	WNF	4.500	0.438	...	...	2.67	150
Inspection	6.000 in	80	WNF	6.625	0.432	...	...	2.73	150
Outlet	6.000 in	80	WNF	6.625	0.432	...	...	2.73	150
Manhole	16.000 in	Actual	WNF	17.500	0.750	...	...	5.93	150

General Notes for the above table:

The cut length is the outside projection + inside projection + drop + in-plane shell thickness. This value does not include weld gaps, nor does it account for shrinkage.

In the case of oblique nozzles, the outside diameter must be increased. The re-pad width around the nozzle is calculated as follows:
Width of Pad = (Pad Outside Dia. (per above) - Nozzle Outside Dia.)/2

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

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

Description	Material	Shl Grve Weld	Noz Shl/Pad Weld	Pad OD Weld	Pad Grve Weld	Inside Weld
Drain	SA-106 B	0.625	0.375	...	...	...
Inlet	SA-106 B	0.625	0.375	...	...	...
Inspection	SA-106 B	0.625	0.375	...	...	...
Outlet	SA-106 B	0.625	0.375	...	...	...
Manhole	SA-516 70	0.625	0.375	...	...	...

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

Nozzle Miscellaneous Data:

Description	Elev/Distance From Datum ft.	Layout Angle deg	Proj Outside in.	Proj Inside in.	Installed in Component
Drain	5.167	180.0	2.00	0.00	Shell
Inlet	...	0.0	2.00	0.00	RT Head
Inspection	...	0.0	2.00	0.00	LF Head
Outlet	...	0.0	2.00	0.00	LF Head
Manhole	5.167	0.0	4.00	0.00	Shell

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Bill of Materials:

QTY	DESCRIPTION	MATERIAL
2	ELLIPTICAL HEAD: 2.0 X 1, 0.625" THK X 60.000" ID X 2.00"	SA-516 70
1	CYLINDER: 0.625" THK X 60.000" ID X 10'	SA-516 70
2	SADDLE: 8.000" X 120 DEG	SA-516 70
1	NAMEPLATE	...

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Minimum Design Metal Temperature Results Summary (F):

Description	Notes	Curve	Basic MDMT	Reduced MDMT	UG-20(f) MDMT	Thickness ratio	Gov Thk in.	E*	PWHT reqd
LF Head	[10]	B	6	-155	-20	0.301	0.625	1.00	No
LF Head	[7]	B	6	-155	-20	0.302	0.625	1.00	No
Shell	[8]	B	6	-155	-20	0.302	0.625	0.85	No
RT Head	[10]	B	6	-155	-20	0.301	0.625	1.00	No
RT Head	[7]	B	6	-155	-20	0.302	0.625	1.00	No
Lft Sdl	[24]	B	-20	-155	-20	0.302	0.375	0.85	No
Sdl 2 Fr20	[24]	B	-20	-155	-20	0.302	0.375	0.85	No
Inspection	[1]	B	-20	-155		0.070	0.378	1.00	No
Nozzle Flg	[5]	B	0	-55					
Outlet	[1]	B	-20	-155		0.070	0.378	1.00	No
Nozzle Flg	[5]	B	0	-55					
Manhole	[1]	B	16	-155	-20	0.065	0.750	1.00	No
Nozzle Flg	[5]	B	0	-55					
Drain	[1]	B	-20	-155		0.032	0.301	1.00	No
Nozzle Flg	[5]	B	0	-55					
Inlet	[1]	B	-20	-155		0.044	0.383	1.00	No
Nozzle Flg	[5]	B	0	-55					
Warmest MDMT:			16	-55					

Required Minimum Design Metal Temperature -20.0 F
Warmest Computed Minimum Design Metal Temperature -55.0 F

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

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.

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Class From To : Basic Element Checks.

Class From To: Check of Additional Element Data

There were no geometry errors or warnings.

One or more nozzles in this model was specified using the actual thickness basis and a standard flange is also specified. In many cases a matching nominal diameter cannot be determined and the weight of the flange and optional blind flange cannot be determined. When actual thickness basis is specified, you must calculate the weight of the assembly (by hand) and enter it into the 'Overriding Weight' field in the nozzle dialog when there is a standard flange specified. However, for FVC nozzles that have their nominal diameter specified in the FVC dialog, entering the overriding weight for that nozzle is not required.

The ASME Code Section VIII Division 1 does not explicitly require stresses on elements to be computed under test conditions. Please see interpretation VIII-1-10-12 for more information. PV Elite also computes weight due to test fluid and uses the weight in various calculations such as saddle and leg loads. PV Elite also computes static pressure due to operating and test liquids. The static pressure is used in conjunction with the design and test pressures to determine a total pressure in the determination of required thickness, MAWP etc. This ensures compliance with UG-22 requirements.

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Units used in this Analysis (ENGLISH):

Name	System Unit	Constant	User Unit
Length	Feet	1.0000	ft.
Force	Pounds	1.0000	lb.
Mass	Pounds	1.0000	lbm
Area	sq. inches	1.0000	sq.in.
Moment	ft. lbs.	1.0000	ft.lb.
Stress	lbs./sq.in.	1.0000	psi
Temperature	Degrees F	1.0000	F
Pressure	psig	1.0000	psig
Elast. Modulus	lbs./sq.in.	1.0000	psi
Pipe Density	lbs./cu.in.	1.0000	lb./cu.in.
Ins. Density	lbs./cu.ft.	1.0000	lb./cu.ft.
Fluid Density	lbs./cu.ft.	1.0000	lb./cu.ft.
Wind Speed	miles/hr	1.0000	mile/hr
Tray Weight	lbs./sq.ft.	1.0000	lb./sq.ft.
Inertia	in.^4	1.0000	in**4
G Load	G's	1.0000	g's
Wind Load	lbs./sq.ft.	1.0000	psf
Elevation	Feet	1.0000	ft.
Volume	in.^3	1.0000	in3
Diameter	inches	1.0000	in.
Thickness	inches	1.0000	in.

PV Elite Vessel Analysis Program: Input Data

Design Internal Pressure (for Hydrotest)	100	psig
Design Internal Temperature	200.0	F
Projection of Nozzle from Vessel Top	0	in.
Projection of Nozzle from Vessel Bottom	0	in.
Minimum Design Metal Temperature	-20.0	F
Type of Construction	Welded	
Special Service	Air/Water/Steam	
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	

Shop Pressure Test:

Type of Pressure Test	UG-99(b) Note [35]
Pressure Test Position	Horizontal
Test Performed in Corroded Condition	No

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


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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                               IBC 2006
Wind Load Reduction Scale Factor                  1.000
Basic Wind Speed                    [V]              70  mile/hr
Surface Roughness Category              C: Open Terrain
Importance Factor                                   1.0
Type of Surface                       Moderately Smooth
Base Elevation                                        0  ft.
Percent Wind for Hydrotest                         33.0
Using User defined Wind Press. Vs Elev.               N
Height of Hill or Escarpment     H or Hh              0  ft.
Distance Upwind of Crest              Lh              0  ft.
Distance from Crest to the Vessel      x              0  ft.
Type of Terrain ( Hill, Escarpment )               Flat
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                            IBC 2006
Seismic Load Reduction Scale Factor               0.700
Importance Factor                                 1.000
Table Value Fa                                    1.000
Table Value Fv                                    1.400
Short Period Acceleration value Ss                1.000
Long Period Acceleration Value Sl                 0.400
Moment Reduction Factor Tau                       1.000
Force Modification Factor R                       3.000
Site Class                                            C
Component Elevation Ratio           z/h           0.000
Amplification Factor                 Ap           0.000
Force Factor                                      0.000
Consider Vertical Acceleration                       No
Minimum Acceleration Multiplier                   0.000
User Value of Sds (used if > 0 )                  0.000
User Value of Sd1 (used if > 0 )                  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

Perform Blast Load Analysis                          No
Material Database Year       Current w/Addenda or Code Year
```

Configuration Directives:

```
 g0 is taken as min( g0, attached shell thk )            Yes


 Do not use Nozzle MDMT Interpretation VIII-1 01-37        No
 Use Table G instead of exact equation for "A"             No
 Shell Head Joints are Tapered                             No
 Compute "K" in corroded condition                         No
 Use Code Case 2286                                        No
 Use the MAWP to compute the MDMT                          No
```

```
 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 Calculations        Yes
```

Complete Listing of Vessel Elements and Details:

```
Element#                                                  1/3
Element From Node                                          10
Element To Node                                            20
Element Type                                       Elliptical
Description                                           LF Head
Distance "FROM" to "TO"                                0.1667  ft.
Inside Diameter                                            60  in.
Element Thickness                                       0.625  in.
Internal Corrosion Allowance                            0.125  in.
Nominal Thickness                                           0  in.
External Corrosion Allowance                                0  in.
Design Internal Pressure                                  100  psig
Design Temperature Internal Pressure                      200  F
Design External Pressure                                   15  psig
Design Temperature External Pressure                      200  F
Effective Diameter Multiplier                             1.2
Material Name                                       SA-516 70
    Allowable Stress, Ambient                           20000  psi
    Allowable Stress, Operating                         20000  psi
    Allowable Stress, Hydrotest                         34200  psi
    Material Density                                     0.28  lb./cu.in.
    P Number Thickness                                   1.25  in.
    Yield Stress, Operating                             34800  psi
    UCS-66 Chart Curve Designation                          B
    External Pressure Chart Name                         CS-2
    UNS Number                                         K02700
    Product Form                                        Plate
Efficiency, Longitudinal Seam                             1.0
Efficiency, Circumferential Seam                          1.0
Elliptical Head Factor                                    2.0
Weld is pre-Heated                                         No

    Element From Node                                      10
    Detail Type                                        Nozzle
    Detail ID                                      Inspection
    Dist. from "FROM" Node / Offset dist                    0  in.
    Nozzle Diameter                                         6  in.
    Nozzle Schedule                                        80
    Nozzle Class                                          150
    Layout Angle                                          0.0
    Blind Flange (Y/N)                                      N
    Weight of Nozzle ( Used if > 0 )                        0  lb.
    Grade of Attached Flange                           GR 1.1
    Nozzle Matl                                      SA-106 B

    Element From Node                                      10
    Detail Type                                        Nozzle
    Detail ID                                          Outlet
    Dist. from "FROM" Node / Offset dist                   15  in.
    Nozzle Diameter                                         6  in.
    Nozzle Schedule                                        80
    Nozzle Class                                          150
```

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

--------------------------------------------------------------------

Element#                                             2/3
Element From Node                                     20
Element To Node                                       30
Element Type                                    Cylinder
Description                                        Shell
Distance "FROM" to "TO"                               10  ft.
Inside Diameter                                       60  in.
Element Thickness                                  0.625  in.
Internal Corrosion Allowance                       0.125  in.
Nominal Thickness                                      0  in.
External Corrosion Allowance                           0  in.
Design Internal Pressure                             100  psig
Design Temperature Internal Pressure                 200  F
Design External Pressure                              15  psig
Design Temperature External Pressure                 200  F
Effective Diameter Multiplier                        1.2
Material Name                                  SA-516 70
Efficiency, Longitudinal Seam                       0.85
Efficiency, Circumferential Seam                    0.85
Weld is pre-Heated                                    No

    Element From Node                                 20
    Detail Type                                   Saddle
    Detail ID                                    Lft Sdl
    Dist. from "FROM" Node / Offset dist            1.25  ft.
    Width of Saddle                                    8  in.
    Height of Saddle at Bottom                        45  in.
    Saddle Contact Angle                           120.0
    Height of Composite Ring Stiffener                 0  in.
    Width of Wear Plate                               12  in.
    Thickness of Wear Plate                        0.375  in.
    Contact Angle, Wear Plate (degrees)            132.0
    Friction coefficient                             0.0
    Moment Factor                                    3.0
    Dimension E at base (optional)                     0  in.
    Circumferential Eff. over Saddle                 1.0
    Circumferential Eff. at Midspan                  1.0
    Tangent to Tangent dist. (optional)                0  ft.

    Element From Node                                 20
    Detail Type                                   Saddle
    Detail ID                                Sdl 2 Fr20
    Dist. from "FROM" Node / Offset dist               9  ft.
    Width of Saddle                                    8  in.
    Height of Saddle at Bottom                        45  in.
    Saddle Contact Angle                           120.0
    Height of Composite Ring Stiffener                 0  in.
    Width of Wear Plate                               12  in.
    Thickness of Wear Plate                        0.375  in.
    Contact Angle, Wear Plate (degrees)            132.0
    Friction coefficient                             0.0
    Moment Factor                                    3.0
    Dimension E at base (optional)                     0  in.
    Circumferential Eff. over Saddle                 1.0
```

```
    Circumferential Eff. at Midspan                        1.0
    Tangent to Tangent dist. (optional)                      0  ft.

    Element From Node                                       20
    Detail Type                                         Nozzle
    Detail ID                                          Manhole
    Dist. from "FROM" Node / Offset dist                     5  ft.
    Nozzle Diameter                                         16  in.
    Nozzle Schedule                                       None
    Nozzle Class                                           150
    Layout Angle                                           0.0
    Blind Flange (Y/N)                                       N
    Weight of Nozzle ( Used if > 0 )                         0  lb.
    Grade of Attached Flange                            GR 1.1
    Nozzle Matl                                      SA-516 70

    Element From Node                                       20
    Detail Type                                         Nozzle
    Detail ID                                            Drain
    Dist. from "FROM" Node / Offset dist                     5  ft.
    Nozzle Diameter                                          2  in.
    Nozzle Schedule                                        160
    Nozzle Class                                           150
    Layout Angle                                         180.0
    Blind Flange (Y/N)                                       N
    Weight of Nozzle ( Used if > 0 )                         0  lb.
    Grade of Attached Flange                            GR 1.1
    Nozzle Matl                                       SA-106 B

--------------------------------------------------------------------

Element#                                                   3/3
Element From Node                                           30
Element To Node                                             40
Element Type                                        Elliptical
Description                                            RT Head
Distance "FROM" to "TO"                                 0.1667  ft.
Inside Diameter                                             60  in.
Element Thickness                                        0.625  in.
Internal Corrosion Allowance                             0.125  in.
Nominal Thickness                                            0  in.
External Corrosion Allowance                                 0  in.
Design Internal Pressure                                   100  psig
Design Temperature Internal Pressure                       200  F
Design External Pressure                                    15  psig
Design Temperature External Pressure                       200  F
Effective Diameter Multiplier                              1.2
Material Name                                        SA-516 70
Efficiency, Longitudinal Seam                              1.0
Efficiency, Circumferential Seam                          0.85
Elliptical Head Factor                                     2.0
Weld is pre-Heated                                          No

    Element From Node                                       30
    Detail Type                                         Nozzle
    Detail ID                                            Inlet
    Dist. from "FROM" Node / Offset dist                     0  in.
    Nozzle Diameter                                          4  in.
    Nozzle Schedule                                        120
    Nozzle Class                                           150
    Layout Angle                                           0.0
    Blind Flange (Y/N)                                       N
```

```
Weight of Nozzle ( Used if > 0 )                   0  lb.
Grade of Attached Flange                      GR 1.1
Nozzle Matl                                 SA-106 B
```

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XY Coordinate Calculations:

From	To	X (Horiz.) ft.	Y (Vert.) ft.	DX (Horiz.) ft.	DY (Vert.) ft.
LF Head		0.16667	...	0.16667	...
Shell		10.1667	...	10	...
RT Head		10.3333	...	0.16667	...

PV Elite includes an 1/8 inch (3.175mm) raised face and gasket thicknesses for girth flanges and tubesheet thicknesses where applicable in the Tangent to Tangent length calculation. The calculated dimensions are based on the given element lengths. Due to variability in manufacturing (weld gaps etc.), the Tangent to Tangent length may not be exact.

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Internal Pressure Results Summary:

Element Thickness, Pressure, Diameter and Allowable Stress :

From	To	Int. Press + Liq. Hd psig	Nominal Thickness in.	Total Corr Allowance in.	Element Diameter in.	Allowable Stress(SE) psi	Element#
LF Head		100	...	0.125	60	20000	1
Shell		100	...	0.125	60	17000	2
RT Head		100	...	0.125	60	20000	3

Element Required Thickness and MAWP :

From	To	Design Pressure psig	M.A.W.P. Corroded psig	M.A.P. New & Cold psig	Minimum Thickness in.	Required Thickness in.	Element#
LF Head		100	328.7	415.8	0.625	0.2757	1
Shell		100	279.4	349.8	0.625	0.30283	2
RT Head		100	328.7	415.8	0.625	0.2757	3
Minimum			195.5	285			

Warning: A standard flange is governing the MAP(NC)!

MAWP: 195.5 psig, limited by: Nozzle Reinforcement.

Elements Suitable for Design Internal Pressure.

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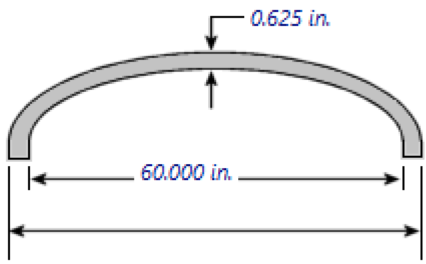
Internal Pressure Calculation Results:

ASME Code, Section VIII Division 1, 2023



Internal Pressure Results for: LF Head

Elliptical Head Design Information:			
Design Pressure P	100.000 psig	Int. Design Temperature	200 F
Material	SA-516 70	Ext. Design Temperature	200 F
Length	0.167 ft.	External Pressure Chart	CS-2
		UNS Number	K02700
Int. Corr. All. c	0.1250 in.	Allowable Stress (ope) S	20000.0 psi
Ext. Corr. All. ce	0.0000 in.	Allowable Stress (amb) Sa	20000.0 psi
Inside Diameter Di	60.000 in.	Actual Stress	6035.0 psi
Spec. Min. Thk t,e, or sa	0.6250 in.	Spec. Nominal Thk.	... in.
Surface Area	4451.5 sq.in.	SG of Contents	0.000
Element Volume	33929.2 in3	Weight of Contents	0.0 lb.
Empty Weight	836.5 lb.	Operating Weight	836.5 lb.
		Comp. All. Ope. Stress	18136.4 psi
		Aspect Ratio	2.00

Radiography Information:			
User Defined Circ. Joint Efficiency	100 %	User Defined Long. Joint Efficiency E	100 %

Tolerance for Formed Heads per UG-81(a):

```
Head inner surface maximum deviation outside the specified shape,  1.25% of D: 0.750 in.
Head inner surface maximum deviation inside the specified shape,  0.625% of D: 0.375 in.
```

Required Thickness due to Internal Pressure [tr]:

```
= (P*D*K)/(2*S*E-0.2*P) Appendix 1-4(c)
= (100*60.25*1)/(2*20000*1-0.2*100)
= 0.1507 + 0.1250 = 0.2757 in.
```

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

```
= (2*S*E*t)/(K*D+0.2*t) per Appendix 1-4 (c)
= (2*20000*1*0.5)/(1*60.25+0.2*0.5)
= 331.4 psig
```

Maximum Allowable Pressure, New and Cold [MAPNC]:

```
= (2*S*E*t)/(K*D+0.2*t) per Appendix 1-4 (c)
= (2*20000*1*0.625)/(1*60+0.2*0.625)
= 415.8 psig
```

Actual stress at given pressure and thickness, corroded [Sact]:
```
  = (P*(K*D+0.2*t))/(2*E*t)
  = (100*(1*60.25+0.2*0.5))/(2*1*0.5)
  = 6035.000 psi
```

Straight Flange Required Thickness:
```
  = (P*R)/(S*E-0.6*P) + c    per UG-27 (c)(1)
  = (100*30.12)/(20000*1-0.6*100)+0.125
  = 0.276 in.
```

Straight Flange Maximum Allowable Working Pressure:
```
  = (S*E*t)/(R+0.6*t) per UG-27 (c)(1)
  = (20000 * 1 * 0.5 )/(30.12 + 0.6 * 0.5 )
  = 328.7 psig
```

Percent Elong. per UCS-79, VIII-1-01-57 (75*tnom/Rf)*(1-Rf/Ro) 4.459 %

MDMT Calculations in the Knuckle Portion:

Govrn. thk, tg = 0.625, tr = 0.151, c = 0.125 in., E∗ = 1
Thickness Ratio = tr * E∗/(tg - c) = 0.301, Temp. Reduction = 140 F

```
 Min Metal Temp. w/o impact per UCS-66, Curve B              6 F
 Min Metal Temp. at Required thickness (UCS 66.1)         -155 F
 Min Metal Temp. w/o impact per UG-20(f)                   -20 F
```

MDMT Calculations in the Head Straight Flange:

Govrn. thk, tg = 0.625, tr = 0.151, c = 0.125 in., E∗ = 1
Thickness Ratio = tr * E∗/(tg - c) = 0.302, Temp. Reduction = 140 F

```
 Min Metal Temp. w/o impact per UCS-66, Curve B              6 F
 Min Metal Temp. at Required thickness (UCS 66.1)         -155 F
 Min Metal Temp. w/o impact per UG-20(f)                   -20 F
```

MDMT Design Information:

MDMT Curve	B	Press. at MDMT	100.000 psig
UCS-66(b) red.	Yes	Min. Des. Mtl. Temp.	-20 F
Governing Thk.	0.625 in.	Basic MDMT	6 F
Stress/Thk. Ratio	0.302	Temperature Difference	161 F
UCS-66(c) red.	No	Computed Min. Temp.	-155 F
		MDMT per UG-20(f)	-20 F
		Joint Efficiency E*	100 %

Note: Temperature values displayed above are for the location with the highest basic MDMT

Tolerance for Formed Heads per UG-81(a):
```
 Head inner surface maximum deviation outside the specified shape,  1.25% of D: 0.750 in.
 Head inner surface maximum deviation inside the specified shape,  0.625% of D: 0.375 in.
```

EXTERNAL PRESSURE RESULTS for: LF Head

Elliptical Head From 10 to 20 Ext. Chart: CS-2 at 200 F

Elastic Modulus from Chart: CS-2 at 200 F: 29000000 psi

Results for Maximum Allowable Ext. Pressure | MAEP |

Tca	Outer Dia	Do/t	Factor A	Factor B
0.500	61.25	122.50	0.0011338	12917.58

MAEP = B/(K0*Do/t) = 12918/(0.9 *122.5) = 117.2 psig

Results for Required Thickness | Tca |

Tca	Outer Dia	Do/t	Factor A	Factor B
0.159	61.25	386.22	0.0003596	5214.34

MAEP = B/(K0*Do/t) = 5214/(0.9 *386.2) = 15 psig

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Internal Pressure Calculation Results:

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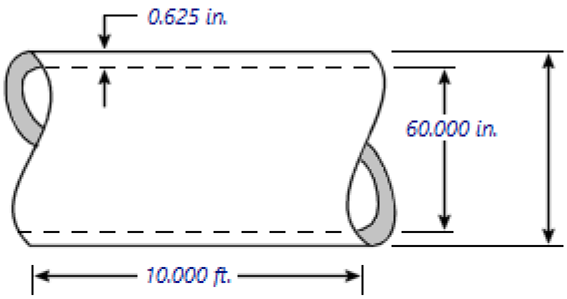

Internal Pressure Results for: Shell

```
                                                 |                                                |
 Cylindrical Shell Design Information:           |                                                |
--------------------------------------------------------------------------------------------------
   Design Pressure   P            100.000 psig   | Int. Design Temperature          200 F         |
          Material               SA-516 70       | Ext. Design Temperature          200 F         |
            Length                10.000 ft.     | External Pressure Chart         CS-2           |
                                                 |              UNS Number        K02700          |
   Int. Corr. All.   c            0.1250 in.     |  Allowable Stress (ope)  S    20000.0 psi      |
   Ext. Corr. All.   ce           0.0000 in.     |  Allowable Stress (amb) Sa    20000.0 psi      |
   Inside Diameter  Di            60.000 in.     |           Actual Stress        7158.8 psi      |
 Spec. Min. Thk t,e, or sa        0.6250 in.     |       Spec. Nominal Thk.          ... in.      |
      Surface Area               23090.7 sq.in.  |         SG of Contents          0.000          |
    Element Volume              339292.0 in3     |      Weight of Contents           0.0 lb.      |
      Empty Weight                3999.7 lb.     |        Operating Weight        3999.7 lb.      |
                                                 |  Comp. All. Ope. Stress       18136.4 psi      |

                                                 |                                                |
  Radiography Information:                       |                                                |
--------------------------------------------------------------------------------------------------
  User Defined                                   | User Defined                                   |
  Circ. Joint Efficiency              85 %       | Long. Joint Efficiency    E          85 %      |
--------------------------------------------------------------------------------------------------
```

Required Thickness due to Internal Pressure [tr]:

```
  = (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
  = (100*30.12)/(20000*0.85-0.6*100)
  = 0.1778 + 0.1250 = 0.3028 in.
```

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

```
  = (S*E*t)/(R+0.6*t) per UG-27 (c)(1)
  = (20000*0.85*0.5)/(30.12+0.6*0.5)
  = 279.4 psig
```

Maximum Allowable Pressure, New and Cold [MAPNC]:

```
  = (S*E*t)/(R+0.6*t) per UG-27 (c)(1)
  = (20000*0.85*0.625)/(30+0.6*0.625)
  = 349.8 psig
```

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

```
  = (P*(R+0.6*t))/(E*t)
  = (100*(30.12+0.6*0.5))/(0.85*0.5)
  = 7158.823 psi
```

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 1.031 %

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 0.625, tr = 0.178, c = 0.125 in., E∗ = 0.85
Thickness Ratio = tr * E∗/(tg - c) = 0.302, Temp. Reduction = 140 F

```
Min Metal Temp. w/o impact per UCS-66, Curve B           6 F
Min Metal Temp. at Required thickness (UCS 66.1)      -155 F
Min Metal Temp. w/o impact per UG-20(f)                -20 F
```

MDMT Design Information:

MDMT Curve	B	Press. at MDMT	100.000 psig
UCS-66(b) red.	Yes	Min. Des. Mtl. Temp.	-20 F
Governing Thk.	0.625 in.	Basic MDMT	6 F
Stress/Thk. Ratio	0.302	Temperature Difference	161 F
UCS-66(c) red.	No	Computed Min. Temp.	-155 F
		MDMT per UG-20(f)	-20 F
		Joint Efficiency E*	85 %

EXTERNAL PRESSURE RESULTS for: Shell

<u>Cylindrical Shell From 20 to 30 Ext. Chart: CS-2 at 200 F</u>

Elastic Modulus from Chart: CS-2 at 200 F: 29000000 psi

Results for Maximum Allowable Ext. Pressure | MAEP

Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B
0.500	61.25	134.00	122.50	2.1878	0.0004466	6475.23

MAEP = (4*B)/(3*(Do/t)) = (4*6475)/(3*122.5) = 70.48 psig

Results for Required Thickness | Tca

Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B
0.270	61.25	134.00	227.01	2.1878	0.0001761	2554.01

MAEP = (4*B)/(3*(Do/t)) = (4*2554)/(3*227) = 15 psig

Results for Maximum Stiffened Length | Slen

Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B
0.500	61.25	619.96	122.50	10.1218	0.0000951	1379.11

MAEP = (4*B)/(3*(Do/t)) = (4*1379)/(3*122.5) = 15.01 psig

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Internal Pressure Calculation Results:

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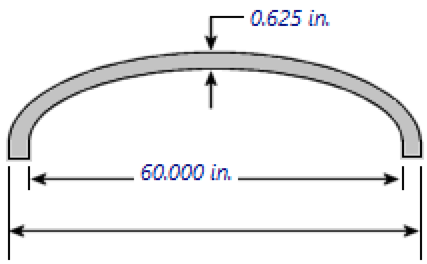

Internal Pressure Results for: RT Head

Elliptical Head Design Information:

Design Pressure	P	100.000 psig	Int. Design Temperature		200 F
Material		SA-516 70	Ext. Design Temperature		200 F
Length		0.167 ft.	External Pressure Chart		CS-2
			UNS Number		K02700
Int. Corr. All.	c	0.1250 in.	Allowable Stress (ope)	S	20000.0 psi
Ext. Corr. All.	ce	0.0000 in.	Allowable Stress (amb)	Sa	20000.0 psi
Inside Diameter	Di	60.000 in.	Actual Stress		6035.0 psi
Spec. Min. Thk t,e, or sa		0.6250 in.	Spec. Nominal Thk.		... in.
Surface Area		4451.5 sq.in.	SG of Contents		0.000
Element Volume		33929.2 in3	Weight of Contents		0.0 lb.
Empty Weight		836.5 lb.	Operating Weight		836.5 lb.
			Comp. All. Ope. Stress		18136.4 psi
			Aspect Ratio		2.00

Radiography Information:

User Defined Circ. Joint Efficiency	85 %	User Defined Long. Joint Efficiency E	100 %

Tolerance for Formed Heads per UG-81(a):

Head inner surface maximum deviation outside the specified shape, 1.25% of D: 0.750 in.
Head inner surface maximum deviation inside the specified shape, 0.625% of D: 0.375 in.

Required Thickness due to Internal Pressure [tr]:

```
= (P*D*K)/(2*S*E-0.2*P) Appendix 1-4(c)
= (100*60.25*1)/(2*20000*1-0.2*100)
= 0.1507 + 0.1250 = 0.2757 in.
```

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

```
= (2*S*E*t)/(K*D+0.2*t) per Appendix 1-4 (c)
= (2*20000*1*0.5)/(1*60.25+0.2*0.5)
= 331.4 psig
```

Maximum Allowable Pressure, New and Cold [MAPNC]:

```
= (2*S*E*t)/(K*D+0.2*t) per Appendix 1-4 (c)
= (2*20000*1*0.625)/(1*60+0.2*0.625)
= 415.8 psig
```

Actual stress at given pressure and thickness, corroded [Sact]:
```
= (P*(K*D+0.2*t))/(2*E*t)
= (100*(1*60.25+0.2*0.5))/(2*1*0.5)
= 6035.000 psi
```

Straight Flange Required Thickness:
```
= (P*R)/(S*E-0.6*P) + c    per UG-27 (c)(1)
= (100*30.12)/(20000*1-0.6*100)+0.125
= 0.276 in.
```

Straight Flange Maximum Allowable Working Pressure:
```
= (S*E*t)/(R+0.6*t) per UG-27 (c)(1)
= (20000 * 1 * 0.5 )/(30.12 + 0.6 * 0.5 )
= 328.7 psig
```

Percent Elong. per UCS-79, VIII-1-01-57 (75*tnom/Rf)*(1-Rf/Ro) 4.459 %

MDMT Calculations in the Knuckle Portion:

Govrn. thk, tg = 0.625, tr = 0.151, c = 0.125 in., E∗ = 1
Thickness Ratio = tr * E∗/(tg - c) = 0.301, Temp. Reduction = 140 F

```
Min Metal Temp. w/o impact per UCS-66, Curve B              6 F
Min Metal Temp. at Required thickness (UCS 66.1)         -155 F
Min Metal Temp. w/o impact per UG-20(f)                   -20 F
```

MDMT Calculations in the Head Straight Flange:

Govrn. thk, tg = 0.625, tr = 0.151, c = 0.125 in., E∗ = 1
Thickness Ratio = tr * E∗/(tg - c) = 0.302, Temp. Reduction = 140 F

```
Min Metal Temp. w/o impact per UCS-66, Curve B              6 F
Min Metal Temp. at Required thickness (UCS 66.1)         -155 F
Min Metal Temp. w/o impact per UG-20(f)                   -20 F
```

MDMT Design Information:

MDMT Curve	B	Press. at MDMT	100.000 psig
UCS-66(b) red.	Yes	Min. Des. Mtl. Temp.	-20 F
Governing Thk.	0.625 in.	Basic MDMT	6 F
Stress/Thk. Ratio	0.302	Temperature Difference	161 F
UCS-66(c) red.	No	Computed Min. Temp.	-155 F
		MDMT per UG-20(f)	-20 F
		Joint Efficiency E*	100 %

Note: Temperature values displayed above are for the location with the highest basic MDMT

Tolerance for Formed Heads per UG-81(a):
```
Head inner surface maximum deviation outside the specified shape,  1.25% of D: 0.750 in.
Head inner surface maximum deviation inside the specified shape,  0.625% of D: 0.375 in.
```

EXTERNAL PRESSURE RESULTS for: RT Head

Elliptical Head From 30 to 40 Ext. Chart: CS-2 at 200 F

Elastic Modulus from Chart: CS-2 at 200 F: 29000000 psi

Results for Maximum Allowable Ext. Pressure | MAEP |

Tca	Outer Dia	Do/t	Factor A	Factor B
0.500	61.25	122.50	0.0011338	12917.58

MAEP = B/(K0*Do/t) = 12918/(0.9 *122.5) = 117.2 psig

Results for Required Thickness | Tca |

Tca	Outer Dia	Do/t	Factor A	Factor B
0.159	61.25	386.22	0.0003596	5214.34

MAEP = B/(K0*Do/t) = 5214/(0.9 *386.2) = 15 psig

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Hydrostatic Test Pressure Results:

UG99(b)	= 1.30 * M.A.W.P. * Sa/S	254.190 psig
UG99b(b)(35)	= 1.30 * Design Pres * Sa/S	130.000 psig
UG99(c)	= 1.30 * M.A.P. - Head(Hyd)	370.500 psig
UG100	= 1.10 * M.A.W.P. * Sa/S	215.084 psig
PED	= max(1.43*DP, 1.25*DP*ratio)	143.000 psig
PED&UG99(b)(35)	= max(1.43*DP, 1.3*DP*ratio)	143.000 psig
App 27-4	= M.A.W.P.	195.531 psig

UG-99(b) Note 35, Test Pressure Calculation:
= Test Factor * Design Pressure * Stress Ratio
= 1.3 * 100 * 1
= 130.000 psig

Horizontal Test performed per: UG-99b (Note 35)

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

Stresses on Elements due to Test Pressure (psi & psig):

From To	Stress	Allowable	Ratio	Pressure
LF Head	6357.2	34200.0	0.186	132.17
Shell	7556.8	34200.0	0.221	132.17
RT Head	6357.2	34200.0	0.186	132.17

Stress ratios for Nozzle and Pad Materials (psi):

Description	Pad/Nozzle	Ambient	Operating	Ratio
Inspection	Nozzle	17100.00	17100.00	1.000
Outlet	Nozzle	17100.00	17100.00	1.000
Manhole	Nozzle	20000.00	20000.00	1.000
Drain	Nozzle	17100.00	17100.00	1.000
Inlet	Nozzle	17100.00	17100.00	1.000
Minimum				1.000

Stress ratios for Pressurized Vessel Elements (psi):

Description	Ambient	Operating	Ratio
LF Head	20000.00	20000.00	1.000
Shell	20000.00	20000.00	1.000
RT Head	20000.00	20000.00	1.000
Minimum			1.000

Hoop Stress in Nozzle Wall during Pressure Test (psi):

Description	Ambient	Operating	Ratio
Inspection	960.56	22230.00	0.043
Outlet	960.56	22230.00	0.043
Manhole	1489.08	26000.00	0.057
Drain	403.38	22230.00	0.018
Inlet	626.07	22230.00	0.028

Elements Suitable for Test Pressure.

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External Pressure Calculation Results Summary:

ASME Code, Section VIII Division 1, 2023

External Pressure Calculations:

From	To	Section Length ft.	Outside Diameter in.	Corroded Thickness in.	Factor A	Factor B psi
10	20	No Calc	61.25	0.5	0.0011338	12917.6
20	30	11.1667	61.25	0.5	0.00044657	6475.23
30	40	No Calc	61.25	0.5	0.0011338	12917.6

External Pressure Calculations:

From	To	External Actual T. in.	External Required T. in.	External Design Pressure psig	External M.A.W.P. psig
10	20	0.625	0.28359	15	117.2
20	30	0.625	0.39481	15	70.48
30	40	0.625	0.28359	15	117.2
Minimum					70.48

External Pressure Calculations:

From	To	Actual Length Bet. Stiffeners ft.	Allowable Length Bet. Stiffeners ft.	Ring Inertia Required in**4	Ring Inertia Available in**4
10	20	No Calc	No Calc	No Calc	No Calc
20	30	11.1667	51.6633	No Calc	No Calc
30	40	No Calc	No Calc	No Calc	No Calc

Elements Suitable for External Pressure.

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Element and Detail Weights:

From	To	Element Metal Wgt. lb.	ID Element Volume in3	Corroded Metal Wgt. lb.	Corroded ID Volume in3	Extra due Misc % lb.
10	20	836.468	33929.2	669.175	34331.3	...
20	30	3999.65	339292	3206.31	342125	...
30	40	836.468	33929.2	669.175	34331.3	...
Total		5672	407150	4544	410787	0

Weight of Details:

From	Type	Weight of Detail lb.	X Offset, Dtl. Cent. ft.	Y Offset, Dtl. Cent. ft.	Z Offset Dtl. Cent. ft.	Description
10	Nozl	33.9963	-1.25	...	...	Inspection
10	Nozl	33.9963	-1.08253	1.25	...	Outlet
20	Sadl	89.9878	1.25	3.08333	...	Lft Sdl
20	Sadl	89.9878	9	3.08333	...	Sdl 2 Fr20
20	Nozl	191.162	5	3.16667	...	Manhole
20	Nozl	8.95404	5	-2.57029	...	Drain
30	Nozl	22.5341	1.41667	...	...	Inlet

Total Weight of Each Detail Type:

Saddles	180.0
Nozzles	290.6
Sum of the Detail Weights	470.6 lb.

Weight Summation Results: (lb.)

	Fabricated	Shop Test	Shipping	Erected	Empty	Operating
Main Elements	5672.6	5672.6	5672.6	5672.6	5672.6	5672.6
Saddles	180.0	180.0	180.0	180.0	180.0	180.0
Nozzles	290.6	290.6	290.6	290.6	290.6	290.6
Test Liquid	...	14702.6	...	...	...	...
Totals	6143.2	20845.9	6143.2	6143.2	6143.2	6143.2

Weight Summary:

Fabricated Wt.	- Bare weight without removable internals	6143.2 lb.
Shop Test Wt.	- Fabricated weight + water (full)	20845.9 lb.
Shipping Wt.	- Fab. weight + removable intls.+ shipping app.	6143.2 lb.
Erected Wt.	- Fab. wt + or - loose items (trays,platforms etc.)	6143.2 lb.
Ope. Wt. no Liq	- Fab. weight + internals. + details + weights	6143.2 lb.
Operating Wt.	- Empty weight + operating liq. uncorroded	6143.2 lb.
Oper. Wt. + CA	- Corr wt. + operating liquid	5015.3 lb.

The Corroded Weight and thickness are used in the Horizontal
Vessel Analysis (Ope Case) and Earthquake Load Calculations.

Surface Areas of Elements:

		Outside Surface	Inside Surface

From	To	Area sq.in.	Area sq.in.
10	20	4451.48	4279.34
20	30	23090.7	22619.5
30	40	4451.48	4279.34
Total		31993.7	31178.1 sq.in.
Total		222.2	216.5 ft^2

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Nozzle Flange MAWP Results: (psig & F)

Nozzle Description	Flange Rating Ope.	Flange Rating Ambient	Des. Temp	Class	Grade/Group	Equiv. Press	Max Pressure UG-44	Max Pressure 50%	Max Pressure DNV
Inspection	260.0	285.0	200	150	GR 1.1	...	...	...	...
Outlet	260.0	285.0	200	150	GR 1.1	...	...	...	...
Manhole	260.0	285.0	200	150	GR 1.1	...	...	...	...
Drain	260.0	285.0	200	150	GR 1.1	...	...	...	...
Inlet	260.0	285.0	200	150	GR 1.1	...	...	...	...
Min Rating	260.0	285.0, [for Core Elements]					...	...	...

Flange Pressure Ratings are per ASME B16.5 2020 Edition

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Wind Load Calculation Results:

Input Values:

```
Wind Design Code                                        IBC 2006
Wind Load Reduction Scale Factor                           1.000
Basic Wind Speed                        [V]                   70  mile/hr
Surface Roughness Category                       C: Open Terrain
Importance Factor                                            1.0
Type of Surface                                Moderately Smooth
Base Elevation                                                 0  ft.
Percent Wind for Hydrotest                                  33.0
Using User defined Wind Press. Vs Elev.                        N
Height of Hill or Escarpment      H or Hh                      0  ft.
Distance Upwind of Crest               Lh                      0  ft.
Distance from Crest to the Vessel       x                      0  ft.
Type of Terrain ( Hill, Escarpment )                        Flat
Damping Factor (Beta) for Wind (Ope)                      0.0100
Damping Factor (Beta) for Wind (Empty)                    0.0000
Damping Factor (Beta) for Wind (Filled)                   0.0000
```

Wind Analysis Results

Static Gust-Effect Factor, Operating Case [G]:

```
  = min(0.85, 0.925((1 + 1.7 * gQ * Izbar * Q )/( 1 + 1.7 * gV * Izbar)))
  = min(0.85,0.925((1+1.7*3.4*0.228*0.981)/(1+1.7*3.4*0.228)))
  = min(0.85, 0.915 )
  = 0.850

 Natural Frequency of Vessel (Operating)              33.000 Hz
 Natural Frequency of Vessel (Empty)                  33.000 Hz
 Natural Frequency of Vessel (Test)                   33.000 Hz
```

Per Section 1609 of IBC 2003/06/09/12/15/18/21/24 these results are also applicable for the determination of Wind Loads on structures (1609.1.1).

```
 User Entered Importance Factor is                    1.000
 Force Coefficient                               [Cf] 0.522
 Structure Height to Diameter ratio                   2.336
```

This is classified as a rigid structure. Static analysis performed.

Sample Calculation for the First Element:

The ASCE code performs calculations in Imperial Units. The wind pressure is therefore computed in these units.

Value of [Alpha] and [Zg]:
Exposure Category: C from Table C6-2
Alpha = 9.5 : Zg = 900 ft.

Effective Height [z]:
= Centroid Height + Vessel Base Elevation
= 3.75 + 0 = 3.75 ft.

Velocity Pressure coefficient evaluated at height z [Kz]:
Because z (3.75 ft.) < 15 ft.
= $2.01(15 / Zg)^{2/Alpha}$
= $2.01(15/900)^{2/9.5}$
= 0.849

Type of Hill: No Hill

Wind Directionality Factor [Kd]:
= 0.95, per [6-6 ASCE-7 98][6-4 ASCE-7 02/05]

As there is No Hill Present: [Kzt]:
K1 = 0, K2 = 0, K3 = 0

Topographical Factor [Kzt]:
$= (1 + K1 * K2 * K3)^2$
$= (1 + 0 * 0 * 0)^2$
$= 1$

Velocity Pressure evaluated at height z, Imperial Units [qz]:
$= 0.00256 * Kz * Kzt * Kd * I * Vr(mph)^2$
$= 0.00256 * 0.849 * 1 * 0.95 * 1 * 70^2$
= 10.1 psf

Force on the first element [F]:
= qz * G * Cf * WindArea
= 10.12 * 0.85 * 0.522 * 6.241
= 28.0 lb.

Element	Hgt (z) ft.	K1	K2	K3	Kz	Kzt	qz psf
LF Head	3.8	0.000	0.000	0.000	0.849	1.000	10.116
Shell	3.8	0.000	0.000	0.000	0.849	1.000	10.116
RT Head	3.8	0.000	0.000	0.000	0.849	1.000	10.116

Wind Load Calculation:

From	To	Wind Height ft.	Wind Diameter ft.	Wind Area sq.in.	Wind Pressure psf	Element Wind Load lb.
10	20	3.75	6.125	898.651	10.116	28.0249
20	30	3.75	6.125	8820	10.116	275.056
30	40	3.75	6.125	898.651	10.116	28.0249

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Earthquake Load Calculation Results:

Earthquake Load Calculation:

Input Values:

```
Seismic Design Code                                    IBC 2006
Seismic Load Reduction Scale Factor                       0.700
Importance Factor                                         1.000
Table Value Fa                                            1.000
Table Value Fv                                            1.400
Short Period Acceleration value Ss                        1.000
Long Period Acceleration Value Sl                         0.400
Moment Reduction Factor Tau                               1.000
Force Modification Factor R                               3.000
Site Class                                                    C
Component Elevation Ratio            z/h                  0.000
Amplification Factor                  Ap                  0.000
Force Factor                                              0.000
Consider Vertical Acceleration                               No
Minimum Acceleration Multiplier                           0.000
User Value of Sds (used if > 0 )                          0.000
User Value of Sd1 (used if > 0 )                          0.000
```

Seismic Analysis Results:

```
SMS = Fa * Ss = 1 * 1 = 1
SM1 = Fv * S1 = 1.4 * 0.4 = 0.56
SDS = 2/3 * Sms = 2/3 * 1 = 0.667
SD1 = 2/3 * Sm1 = 2/3 * 0.56 = 0.373
```

Check Approximate Fundamental Period from 12.8-7 [Ta]:
= Ct * hn^x where Ct = 0.020, x = 0.75 and hn = Structural Height (ft.)
= 0.020($6.25^{0.75}$)
= 0.079 seconds

The Coefficient Cu from Table 12.8-1 is : 1.400

Fundamental Period (1/Frequency) [T]:
= (1/Natural Frequency) = (1/33)
= 0.030

Check the Value of T which is the smaller of Cu*Ta and T:
= Minimum Value of (1.4 * 0.0791, 0.0303) per 12.8.2
= 0.030
As the time period is < 0.06 second, use section 15.4.2.

Base Shear per equation 15.4-5, [V]:
= 0.3 * Sds * W * I
= 0.3 * 0.667 * 4835 * 1
= 967.062 lb.

Final Base Shear, V = 676.94 lb.

Earthquake Load Calculation:

From	To	Earthquake Height ft.	Earthquake Weight lb.	Ope Element Load lb.
10	20	2.5	967.061	135.389
20	Sadl	2.5	967.061	135.389

Sadl	30	2.5	967.061	135.389
20	30	2.5	967.061	135.389
30	40	2.5	967.061	135.389

The Earthquake Weight does not include the weight of the saddles.

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

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Shop/Field Installation Options :

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

```
Center of Gravity of the Saddles                           5.292 ft.
Center of Gravity of the Nozzles                           4.183 ft.

Center of Gravity of Bare Shell New and Cold               5.167 ft.
Center of Gravity of Bare Shell Corroded                   5.167 ft.

Vessel CG in the Operating Condition                       5.114 ft.
Vessel CG in the Fabricated (Shop/Empty) Condition         5.124 ft.
Vessel CG in the Test Condition                            5.154 ft.
```

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ASME VIII Division 2 Horizontal Vessel Analysis, Left Saddle:

Horizontal Vessel Stress Calculations : Operating Case

Note:
Wear Pad Width (12.00) is less than 1.56*sqrt(rm*t)
and less than 2a. The wear plate will be ignored.

Minimum Wear Plate Width to be considered in analysis [b1]:
```
  = min( b + 1.56*sqrt( Rm * t ), 2a )
  = min( 8 + 1.56*sqrt( 30.38 * 0.5 ), 2 * 17 )
  = 14.0795 in.
```

Input and Calculated Values:

Vessel Mean Radius	Rm	30.38	in.
Shell Thickness used in this Case	t	0.625	in.
Stiffened Vessel Length per 4.15.6	L	10.33	ft.
Distance from Saddle to Vessel tangent	a1 or a	17.00	in.
Saddle Width	b1 or b	8.00	in.
Saddle Bearing Angle	delta or theta	120.00	degrees
Inside or Mean Depth of Head	Hi or hm	1.28	ft.
Shell Allowable Stress used in Calculation		20000.00	psi
Head Allowable Stress used in Calculation		20000.00	psi
Circumferential Efficiency in Plane of Saddle		1.00	
Circumferential Efficiency at Mid-Span		1.00	
Distance from Saddle Base to Centerline	B	45.00	in.
Coefficient of Friction	mu	0.00	

<u>Results for Horizontal Vessel Analysis:</u>

Saddle Force Q, Operating Case		3383.55	lb.
Pressure used in Analysis	P	100.000	psig

Horizontal Vessel Analysis Results:	Actual psi	Allowable psi
Long. Stress at Top of Midspan	3009.54	20000.00
Long. Stress at Bottom of Midspan	3065.46	20000.00
Long. Stress at Top of Saddles	3082.11	20000.00
Long. Stress at Bottom of Saddles	3012.77	20000.00
Tangential Shear in Shell	162.44	16000.00
Circ. Stress at Horn of Saddle	834.02	25000.00
Circ. Compressive Stress in Shell	36.54	20000.00

Intermediate Results: Saddle Reaction Q due to Wind or Seismic:

Transverse Saddle Reaction Force [Fwt]:
```
  = Ftr( Ft/Num of Saddles + Z Force Load ) * B / E
  = 3 ( 331.1/2 + 0 ) * 45/53.69
  = 416.2 lb.
```

Longitudinal Saddle Reaction Force [Fwl]:
```
  = max( Fl,wind; Sum of X Forces) * B / Ls
  = max( 298.1, 0 ) * 45/93
  = 144.2 lb.
```

Saddle Reaction Force due to Earthquake Fl [Fsl]:
```
  = max( Fl,eq; Sum of X Forces ) * B / Ls
  = max( 676.9, 0 ) * 45/93
  = 327.6 lb.
```

Saddle Reaction Force due to Earthquake Ft [Fst]:
```
  = Ftr( Ft/Num of Saddles + Z Force Load ) * B / E
  = 3 ( 676.9/2 + 0 ) * 45/53.69
  = 851.0 lb.
```

Load Combination Results for Q + Wind or Seismic [Q]:
```
  = Saddle Load + max( Fwl, Fwt, Fsl, Fst )
  = 2533 + max( 144.2, 416.2, 327.6, 851 )
  = 3383.6 lb.
```

Longitudinal Wind Force [Fl]:
```
  = WindScalar * WindPress( Platform Area + ( pi/4( OD * WindDiaMult )² ) )
  = 1 * 10.12 ( 0 + pi/4( 5.104 * 1.2 )² )
  = 298.064 lbf
```

Summary of Loads at the Base of this Saddle:
```
 Vertical Load (including saddle weight)            3473.54  lb.
 Transverse Shear Load                               338.47  lb.
 Longitudinal Shear Load                             676.94  lb.
```

Note: Wear Plate is Welded to the Shell, k = 0.1

Saddle Dimension [E]:
```
  = min( 2( ShellID/2 + t + WearPadThickness )sin(θ/2 ), 2*Rm )
  = min( 2( 60/2 + 0.625 + 0.375 )sin( 120/2 ), 2*30.38 )
  = 53.694 in.
```

The Computed K values from Table 4.15.1:
```
 K1  = 0.1066     K2  = 1.1707     K3  = 0.8799     K4  = 0.4011
 K5  = 0.7603     K6  = 0.0529     K7  = 0.0179     K8  = 0.3405
 K9  = 0.2711     K10 = 0.0581     K1* = 0.1923
```

Note: Dimension a is greater than or equal to Rm/2.

Moment per Equation 4.15.1 [M1]:
```
  = -Q*a [1 - (1- a/L + (Rm²-hm²)/(2a*L))/(1+(4hm²)/3L)]
  = -3384*1.417[1-(1-1.417/10.33+(2.531²-1.281²)/
    (2*1.417*10.33))/(1+(4*1.281)/(3*10.33))]
  = -574.4 ft.lb.
```

Moment per Equation 4.15.2 [M2]:
```
  = Q*L/4(1+2(Rm²-hi²)/(L²))/(1+(4hi)/( 3L))-4a/L
  = 3384*10.33/4(1+2(2.531²-1.281²)/(10.33²))/(1+(4*1.281)/
    (3*10.33))-4*1.417/10.33
  = 3377.0 ft.lb.
```

Longitudinal Stress at Top of Shell (4.15.4) [sigma1]:
```
  = P * Rm/(2t) - M2/(pi*Rm²t)
  = 100 * 30.38/(2*0.5 ) - 40524/(pi*30.38²*0.5 )
  = 3009.54 psi
```

Longitudinal Stress at Bottom of Shell (4.15.5) [sigma2]:
```
  = P * Rm/(2t) + M2/(pi * Rm² * t)
  = 100 * 30.38/(2 * 0.5 ) + 40524/(pi * 30.38² * 0.5 )
  = 3065.46 psi
```

Longitudinal Stress at Top of Shell at Support (4.15.8) [sigma*3]:

```
  = P * Rm/(2t) - M1/(K1*pi*Rm²t)
  = 100*30.38/(2*0.5)--6893/(0.107*pi*30.38²*0.5)
  = 3082.11 psi
```

Longitudinal Stress at Bottom of Shell at Support (4.15.9) [sigma*4]:

```
  = P * Rm/(2t) + M1/(K1* * pi * Rm² * t)
  = 100*30.38/(2*0.5)+-6893/(0.192*pi*30.38²*0.5)
  = 3012.77 psi
```

Maximum Shear Force in the Saddle (4.15.3) [T]:

```
  = Q(L-2a)/(L+(4*hm/3))
  = 3384 ( 10.33 - 2 * 1.417 )/(10.33 + ( 4 * 1.281/3))
  = 2107.4 lb.
```

Shear Stress in the shell no rings, not stiffened (4.15.12) [tau2]:

```
  = K2 * T / ( Rm * t )
  = 1.171 * 2107/( 30.38 * 0.5 )
  = 162.44 psi
```

Decay Length (4.15.20) [x1,x2]:

```
  = 0.78 * sqrt( Rm * t )
  = 0.78 * sqrt( 30.38 * 0.5 )
  = 3.040 in.
```

Circumferential Stress in shell, no rings (4.15.21) [sigma6]:

```
  = -K5 * Q * k / ( t( b + X1 + X2 ) )
  = -0.76 * 3384 * 0.1/( 0.5 ( 8 + 3.04 + 3.04 ) )
  = -36.54 psi
```

Circ. Comp. Stress at Horn of Saddle, L<8Rm (4.15.23) [sigma7*]:

```
  = -Q/(4*t(b+X1+X2)) - 12*K7*Q*Rm/(L*t²)
  = -3384/(4*0.5 (8 +3.04 +3.04 )) -
     12 * 0.0179 * 3384 * 30.38/(10.33 * 0.5²)
  = -834.02 psi
```

Effective reinforcing plate width (4.15.24) [B1]:

```
  = min( b + 1.56 * sqrt( Rm * t ), 2a  )
  = min( 8 + 1.56 * sqrt( 30.38 * 0.5 ), 2 * 17 )
  = 14.08 in.
```

Distance between Saddle Supports [Ls]:

```
  = 93.0 in.
```

Free Un-Restrained Thermal Expansion between the Saddles [Exp]:

```
  = Alpha * Ls( Design Temperature - Ambient Temperature )
  = 0.67000E-05 * 93 ( 200 - 70 )
  = 0.081 in.
```

Input Data for Base Plate Bolting Calculations:

Total Number of Bolts per BasePlate	Nbolts	8	
Total Number of Bolts in Tension/Baseplate	Nbt	4	
Bolt Material Specification		SA-193 B7	
Bolt Allowable Stress	Stba	25000.00	psi
Bolt Corrosion Allowance	Bca	0.0000	in.
Distance from Bolts to Edge	Edgedis	2.0000	in.
Nominal Bolt Diameter	Bnd	1.3750	in.
Thread Series	Series	TEMA	
BasePlate Allowable Stress	S	13800.00	psi
Area Available in a Single Bolt	BltArea	1.1550	sq.in.
Saddle Load QO (Weight)	QO	2622.5	lb.
Saddle Load QL (Wind/Seismic contribution)	QL	327.6	lb.

```
Maximum Transverse Force                        Ft       338.5  lb.
Maximum Longitudinal Force                      Fl       676.9  lb.
Saddle Bolted to Steel Foundation                          No
```

Bolt Area Calculation per Dennis R. Moss

Bolt Area Requirement Due to Longitudinal Load [Bltarearl]:
```
= 0.0 (QO > QL --> No Uplift in Longitudinal direction)
```

Bolt Area due to Shear Load [Bltarears]:
```
= Fl / ( BoltShearAllowable * Nbolts )
= 676.9/(25000 * 8 )
= 0.0034 sq.in.
```

Bolt Area due to Transverse Load:

Moment on Baseplate Due to Transverse Load [Rmom]:
```
= B * Ft + Sum of X Moments
= 3.75 * 338.5 + 0
= 1269.27 ft.lb.
```

Eccentricity (e):
```
= Rmom / QO
= 15231/2623
= 5.81 in. < Bplen/6 --> No Uplift in Transverse direction
```

Bolt Area due to Transverse Load [Bltareart]:
```
= 0 (No Uplift)
```

Required Area of a Single Bolt [Bltarear]:
```
= max[Bltarearl, Bltarears, Bltareart]
= max[0, 0.00338, 0 ]
= 0.0034 sq.in.
```

MDMT Calculations for: Lft Sdl, Saddle to Wearplate Junction, Curve: B

Govrn. thk, tg = 0.375, c = 0.125 in., E✱ = 0.85
Thickness Ratio = tr * E✱/(tg - c) = 0.302, Temp. Reduction = 140 F
Attachment governing, Attachment stress = Shell stress per Code

```
Min Metal Temp. w/o impact per UCS-66, Curve B            -20 F
Min Metal Temp. at Required thickness (UCS 66.1)         -155 F
```

ASME VIII Division 2 Horizontal Vessel Analysis, Right Saddle:

Note:
Wear Pad Width (12.00) is less than 1.56*sqrt(rm*t)
and less than 2a. The wear plate will be ignored.

Minimum Wear Plate Width to be considered in analysis [b1]:
```
= min( b + 1.56*sqrt( Rm * t ), 2a )
= min( 8 + 1.56*sqrt( 30.38 * 0.5 ), 2 * 17 )
= 14.0795 in.
```

Input and Calculated Values:

```
Vessel Mean Radius                         Rm       30.38  in.
Shell Thickness used in this Case           t       0.625  in.
Stiffened Vessel Length per 4.15.6          L       10.33  ft.
Distance from Saddle to Vessel tangent   a1 or a    17.00  in.
```

```
Saddle Width                            b1 or b       8.00  in.
Saddle Bearing Angle               delta or theta    120.00  degrees

Inside or Mean Depth of Head            Hi or hm      1.28  ft.

Shell Allowable Stress used in Calculation        20000.00  psi
Head Allowable Stress used in Calculation         20000.00  psi
Circumferential Efficiency in Plane of Saddle         1.00
Circumferential Efficiency at Mid-Span                1.00

Distance from Saddle Base to Centerline      B       45.00  in.
Coefficient of Friction                     mu        0.00
```

Results for Horizontal Vessel Analysis:

```
Saddle Force Q, Operating Case                      3153.77  lb.
Pressure used in Analysis                    P     100.000  psig
```

Horizontal Vessel Analysis Results:	Actual psi	Allowable psi
Long. Stress at Top of Midspan	3011.44	20000.00
Long. Stress at Bottom of Midspan	3063.56	20000.00
Long. Stress at Top of Saddles	3079.08	20000.00
Long. Stress at Bottom of Saddles	3014.45	20000.00
Tangential Shear in Shell	151.41	16000.00
Circ. Stress at Horn of Saddle	777.38	25000.00
Circ. Compressive Stress in Shell	34.06	20000.00

Intermediate Results: Saddle Reaction Q due to Wind or Seismic:

Transverse Saddle Reaction Force [Fwt]:

```
  = Ftr( Ft/Num of Saddles + Z Force Load ) * B / E
  = 3 ( 331.1/2 + 0 ) * 45/53.69
  = 416.2 lb.
```

Longitudinal Saddle Reaction Force [Fwl]:

```
  = max( Fl,wind; Sum of X Forces) * B / Ls
  = max( 298.1, 0 ) * 45/93
  = 144.2 lb.
```

Saddle Reaction Force due to Earthquake Fl [Fsl]:

```
  = max( Fl,eq; Sum of X Forces ) * B / Ls
  = max( 676.9, 0 ) * 45/93
  = 327.6 lb.
```

Saddle Reaction Force due to Earthquake Ft [Fst]:

```
  = Ftr( Ft/Num of Saddles + Z Force Load ) * B / E
  = 3 ( 676.9/2 + 0 ) * 45/53.69
  = 851.0 lb.
```

Load Combination Results for Q + Wind or Seismic [Q]:

```
  = Saddle Load + max( Fwl, Fwt, Fsl, Fst )
  = 2303 + max( 144.2, 416.2, 327.6, 851 )
  = 3153.8 lb.
```

Longitudinal Wind Force [Fl]:

```
  = WindScalar * WindPress( Platform Area + ( pi/4( OD * WindDiaMult )² ) )
  = 1 * 10.12 ( 0 + pi/4( 5.104 * 1.2 )² )
  = 298.064 lbf
```

Summary of Loads at the Base of this Saddle:

Vertical Load (including saddle weight)	3243.76	lb.
Transverse Shear Load	338.47	lb.
Longitudinal Shear Load	676.94	lb.

Note: Wear Plate is Welded to the Shell, k = 0.1

Saddle Dimension [E]:

```
  = min( 2( ShellID/2 + t + WearPadThickness )sin(θ/2 ), 2*Rm )
  = min( 2( 60/2 + 0.625 + 0.375 )sin( 120/2 ), 2*30.38 )
  = 53.694 in.
```

The Computed K values from Table 4.15.1:

```
 K1  = 0.1066     K2  = 1.1707     K3  = 0.8799     K4  = 0.4011
 K5  = 0.7603     K6  = 0.0529     K7  = 0.0179     K8  = 0.3405
 K9  = 0.2711     K10 = 0.0581     K1* = 0.1923
```

Note: Dimension a is greater than or equal to Rm/2.

Moment per Equation 4.15.1 [M1]:

```
  = -Q*a [1 - (1- a/L + (Rm²-hm²)/(2a*L))/(1+(4hm²)/3L)]
  = -3154*1.417[1-(1-1.417/10.33+(2.531²-1.281²)/
    (2*1.417*10.33))/(1+(4*1.281)/(3*10.33))]
  = -535.4 ft.lb.
```

Moment per Equation 4.15.2 [M2]:

```
  = Q*L/4(1+2(Rm²-hi²)/(L²))/(1+(4hi)/( 3L))-4a/L
  = 3154*10.33/4(1+2(2.531²-1.281²)/(10.33²))/(1+(4*1.281)/
    (3*10.33))-4*1.417/10.33
  = 3147.6 ft.lb.
```

Longitudinal Stress at Top of Shell (4.15.4) [sigma1]:

```
  = P * Rm/(2t) - M2/(pi*Rm²t)
  = 100 * 30.38/(2*0.5 ) - 37772/(pi*30.38²*0.5 )
  = 3011.44 psi
```

Longitudinal Stress at Bottom of Shell (4.15.5) [sigma2]:

```
  = P * Rm/(2t) + M2/(pi * Rm² * t)
  = 100 * 30.38/(2 * 0.5 ) + 37772/(pi * 30.38² * 0.5 )
  = 3063.56 psi
```

Longitudinal Stress at Top of Shell at Support (4.15.8) [sigma*3]:

```
  = P * Rm/(2t) - M1/(K1*pi*Rm²t)
  = 100*30.38/(2*0.5)--6425/(0.107*pi*30.38²*0.5)
  = 3079.08 psi
```

Longitudinal Stress at Bottom of Shell at Support (4.15.9) [sigma*4]:

```
  = P * Rm/(2t) + M1/(K1* * pi * Rm² * t)
  = 100*30.38/(2*0.5)+-6425/(0.192*pi*30.38²*0.5)
  = 3014.45 psi
```

Maximum Shear Force in the Saddle (4.15.3) [T]:

```
  = Q(L-2a)/(L+(4*hm/3))
  = 3154 ( 10.33 - 2 * 1.417 )/(10.33 + ( 4 * 1.281/3))
  = 1964.3 lb.
```

Shear Stress in the shell no rings, not stiffened (4.15.12) [tau2]:

```
  = K2 * T / ( Rm * t )
  = 1.171 * 1964/( 30.38 * 0.5 )
  = 151.41 psi
```

Decay Length (4.15.20) [x1,x2]:

```
  = 0.78 * sqrt( Rm * t )
  = 0.78 * sqrt( 30.38 * 0.5 )
  = 3.040 in.
```

Circumferential Stress in shell, no rings (4.15.21) [sigma6]:

```
  = -K5 * Q * k / ( t( b + X1 + X2 ) )
  = -0.76 * 3154 * 0.1/( 0.5 ( 8 + 3.04 + 3.04 ) )
  = -34.06 psi
```

Circ. Comp. Stress at Horn of Saddle, L<8Rm (4.15.23) [sigma7∗]:

```
  = -Q/(4*t(b+X1+X2)) - 12*K7*Q*Rm/(L*t²)
  = -3154/(4*0.5 (8 +3.04 +3.04 )) -
     12 * 0.0179 * 3154 * 30.38/(10.33 * 0.5²)
  = -777.38 psi
```

Effective reinforcing plate width (4.15.24) [B1]:

```
  = min( b + 1.56 * sqrt( Rm * t ), 2a  )
  = min( 8 + 1.56 * sqrt( 30.38 * 0.5 ), 2 * 17 )
  = 14.08 in.
```

MDMT Calculations for: Sdl 2 Fr20, Saddle to Wearplate Junction, Curve: B

Govrn. thk, tg = 0.375, c = 0.125 in., E∗ = 0.85
Thickness Ratio = tr * E∗/(tg - c) = 0.302, Temp. Reduction = 140 F
Attachment governing, Attachment stress = Shell stress per Code

```
 Min Metal Temp. w/o impact per UCS-66, Curve B             -20 F
 Min Metal Temp. at Required thickness (UCS 66.1)          -155 F
```

Review notes about nozzle loadings and supports in the Warnings report.

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ASME VIII Division 2 Horizontal Vessel Analysis, Left Saddle:

Horizontal Vessel Stress Calculations : Test Case

Note:
Wear Pad Width (12.00) is less than 1.56*sqrt(rm*t)
and less than 2a. The wear plate will be ignored.

Minimum Wear Plate Width to be considered in analysis [b1]:

```
  = min( b + 1.56*sqrt( Rm * t ), 2a )
  = min( 8 + 1.56*sqrt( 30.31 * 0.625 ), 2 * 17 )
  = 14.7901 in.
```

Input and Calculated Values:

```
 Vessel Mean Radius                              Rm       30.31  in.
 Shell Thickness used in this Case                t       0.625  in.
 Stiffened Vessel Length per 4.15.6               L       10.33  ft.
 Distance from Saddle to Vessel tangent     a1 or a       17.00  in.

 Saddle Width                               b1 or b        8.00  in.
 Saddle Bearing Angle                delta or theta      120.00  degrees

 Inside or Mean Depth of Head              Hi or hm        1.28  ft.

 Shell Allowable Stress used in Calculation          34200.00  psi
 Head Allowable Stress used in Calculation           34200.00  psi
 Circumferential Efficiency in Plane of Saddle           1.00
 Circumferential Efficiency at Mid-Span                  1.00

 Distance from Saddle Base to Centerline          B       45.00  in.
 Coefficient of Friction                         mu        0.00
```

<u>Results for Horizontal Vessel Analysis:</u>

```
 Saddle Force Q, Test Case, no Ext. Forces           10840.53  lb.
 Pressure used in Analysis                        P   131.095  psig
```

Horizontal Vessel Analysis Results:	Actual psi	Allowable psi
Long. Stress at Top of Midspan	3107.02	34200.00
Long. Stress at Bottom of Midspan	3251.07	34200.00
Long. Stress at Top of Saddles	3293.74	34200.00
Long. Stress at Bottom of Saddles	3115.47	34200.00
Tangential Shear in Shell	417.46	20254.00
Circ. Stress at Horn of Saddle	1761.39	51300.00
Circ. Compressive Stress in Shell	89.16	34200.00

Intermediate Results: Saddle Reaction Q due to Wind or Seismic:

Transverse Saddle Reaction Force [Fwt]:

```
  = Ftr( Ft/Num of Saddles + Z Force Load ) * B / E
  = 3 ( 109.3/2 + 0 ) * 45/53.69
  = 137.4 lb.
```

Longitudinal Saddle Reaction Force [Fwl]:

```
  = max( Fl,wind; Sum of X Forces) * B / Ls
  = max( 98.36, 0 ) * 45/93
  = 47.6 lb.
```

Load Combination Results for Q + Wind or Seismic [Q]:
```
  = Saddle Load + max( Fwl, Fwt, Fsl, Fst )
  = 10703 + max( 47.59, 137.4, 0, 0 )
  = 10840.5 lb.
```

Longitudinal Wind Force [Fl]:
```
  = WindScalar * WindPress( Platform Area + ( pi/4( OD * WindDiaMult )² ) )
  = 1 * 10.12 ( 0 + pi/4( 5.104 * 1.2 )² )
  = 298.064 lbf
```

Summary of Loads at the Base of this Saddle:

Vertical Load (including saddle weight)	10930.51	lb.
Transverse Shear Load	54.63	lb.
Longitudinal Shear Load	98.36	lb.

Note: Wear Plate is Welded to the Shell, k = 0.1

Saddle Dimension [E]:
```
  = min( 2( ShellID/2 + t + WearPadThickness )sin(θ/2 ), 2*Rm )
  = min( 2( 60/2 + 0.625 + 0.375 )sin( 120/2 ), 2*30.31 )
  = 53.694 in.
```

The Computed K values from Table 4.15.1:

K1 = 0.1066	K2 = 1.1707	K3 = 0.8799	K4 = 0.4011
K5 = 0.7603	K6 = 0.0529	K7 = 0.0180	K8 = 0.3405
K9 = 0.2711	K10 = 0.0581	K1* = 0.1923	

Note: Dimension a is greater than or equal to Rm/2.

Moment per Equation 4.15.1 [M1]:
```
  = -Q*a [1 - (1- a/L + (Rm²-hm²)/(2a*L))/(1+(4hm²)/3L)]
  = -10841*1.417[1-(1-1.417/10.33+(2.526²-1.276²)/
    (2*1.417*10.33))/(1+(4*1.276)/(3*10.33))]
  = -1838.4 ft.lb.
```

Moment per Equation 4.15.2 [M2]:
```
  = Q*L/4(1+2(Rm²-hi²)/(L²))/(1+(4hi)/( 3L))-4a/L
  = 10841*10.33/4(1+2(2.526²-1.276²)/(10.33²))/(1+(4*1.276)/
    (3*10.33))-4*1.417/10.33
  = 10828.7 ft.lb.
```

Longitudinal Stress at Top of Shell (4.15.4) [sigma1]:
```
  = P * Rm/(2t) - M2/(pi*Rm²t)
  = 131.1 * 30.31/(2*0.625 ) - 129944/(pi*30.31²*0.625 )
  = 3107.02 psi
```

Longitudinal Stress at Bottom of Shell (4.15.5) [sigma2]:
```
  = P * Rm/(2t) + M2/(pi * Rm² * t)
  = 131.1 * 30.31/(2 * 0.625 ) + 129944/(pi * 30.31² * 0.625 )
  = 3251.07 psi
```

Longitudinal Stress at Top of Shell at Support (4.15.8) [sigma✱3]:
```
  = P * Rm/(2t) - M1/(K1*pi*Rm²t)
  = 131.1*30.31/(2*0.625)--22061/(0.107*pi*30.31²*0.625)
  = 3293.74 psi
```

Longitudinal Stress at Bottom of Shell at Support (4.15.9) [sigma✱4]:
```
  = P * Rm/(2t) + M1/(K1✱ * pi * Rm² * t)
  = 131.1*30.31/(2*0.625)+-22061/(0.192*pi*30.31²*0.625)
  = 3115.47 psi
```

Maximum Shear Force in the Saddle (4.15.3) [T]:
```
  = Q(L-2a)/(L+(4*hm/3))
  = 10841 ( 10.33 - 2 * 1.417 )/(10.33 + ( 4 * 1.276/3))
  = 6755.8 lb.
```

Shear Stress in the shell no rings, not stiffened (4.15.12) [tau2]:
```
  = K2 * T / ( Rm * t )
  = 1.171 * 6756/( 30.31 * 0.625 )
  = 417.46 psi
```

Decay Length (4.15.20) [x1,x2]:
```
  = 0.78 * sqrt( Rm * t )
  = 0.78 * sqrt( 30.31 * 0.625 )
  = 3.395 in.
```

Circumferential Stress in shell, no rings (4.15.21) [sigma6]:
```
  = -K5 * Q * k / ( t( b + X1 + X2 ) )
  = -0.76 * 10841 * 0.1/( 0.625 ( 8 + 3.395 + 3.395 ) )
  = -89.16 psi
```

Circ. Comp. Stress at Horn of Saddle, L<8Rm (4.15.23) [sigma7✱]:
```
  = -Q/(4*t(b+X1+X2)) - 12*K7*Q*Rm/(L*t²)
  = -10841/(4*0.625 (8 +3.395 +3.395 )) -
     12 * 0.018 * 10841 * 30.31/(10.33 * 0.625²)
  = -1761.39 psi
```

Effective reinforcing plate width (4.15.24) [B1]:
```
  = min( b + 1.56 * sqrt( Rm * t ), 2a  )
  = min( 8 + 1.56 * sqrt( 30.31 * 0.625 ), 2 * 17 )
  = 14.79 in.
```

Input Data for Base Plate Bolting Calculations:

Total Number of Bolts per BasePlate	Nbolts	8	
Total Number of Bolts in Tension/Baseplate	Nbt	4	
Bolt Material Specification		SA-193 B7	
Bolt Allowable Stress	Stba	25000.00	psi
Bolt Corrosion Allowance	Bca	0.0000	in.
Distance from Bolts to Edge	Edgedis	2.0000	in.
Nominal Bolt Diameter	Bnd	1.3750	in.
Thread Series	Series	TEMA	
BasePlate Allowable Stress	S	13800.00	psi
Area Available in a Single Bolt	BltArea	1.1550	sq.in.
Saddle Load QO (Weight)	QO	10793.2	lb.
Saddle Load QL (Wind/Seismic contribution)	QL	47.6	lb.
Maximum Transverse Force	Ft	54.6	lb.
Maximum Longitudinal Force	Fl	98.4	lb.
Saddle Bolted to Steel Foundation		No	

Bolt Area Calculation per Dennis R. Moss

Bolt Area Requirement Due to Longitudinal Load [Bltarearl]:
```
  = 0.0 (QO > QL --> No Uplift in Longitudinal direction)
```

Bolt Area due to Shear Load [Bltarears]:
```
  = Fl / ( BoltShearAllowable * Nbolts )
  = 98.36/(25000 * 8 )
  = 0.0005 sq.in.
```

Bolt Area due to Transverse Load:

Moment on Baseplate Due to Transverse Load [Rmom]:

```
  = B * Ft + Sum of X Moments
  = 3.75 * 54.63 + 0
  = 204.87 ft.lb.
```

Eccentricity (e):

```
  = Rmom / QO
  = 2458/10793
  = 0.23 in. < Bplen/6 --> No Uplift in Transverse direction
```

Bolt Area due to Transverse Load [Bltareart]:

```
  = 0 (No Uplift)
```

Required Area of a Single Bolt [Bltarear]:

```
  = max[Bltarearl, Bltarears, Bltareart]
  = max[0, 0.000492, 0 ]
  = 0.0005 sq.in.
```

ASME VIII Division 2 Horizontal Vessel Analysis, Right Saddle:

Note:
Wear Pad Width (12.00) is less than 1.56*sqrt(rm*t)
and less than 2a. The wear plate will be ignored.

Minimum Wear Plate Width to be considered in analysis [b1]:

```
  = min( b + 1.56*sqrt( Rm * t ), 2a )
  = min( 8 + 1.56*sqrt( 30.31 * 0.625 ), 2 * 17 )
  = 14.7901 in.
```

Input and Calculated Values:

Vessel Mean Radius	Rm	30.31	in.
Shell Thickness used in this Case	t	0.625	in.
Stiffened Vessel Length per 4.15.6	L	10.33	ft.
Distance from Saddle to Vessel tangent	a1 or a	17.00	in.
Saddle Width	b1 or b	8.00	in.
Saddle Bearing Angle	delta or theta	120.00	degrees
Inside or Mean Depth of Head	Hi or hm	1.28	ft.
Shell Allowable Stress used in Calculation		34200.00	psi
Head Allowable Stress used in Calculation		34200.00	psi
Circumferential Efficiency in Plane of Saddle		1.00	
Circumferential Efficiency at Mid-Span		1.00	
Distance from Saddle Base to Centerline	B	45.00	in.
Coefficient of Friction	mu	0.00	

<u>Results for Horizontal Vessel Analysis:</u>

Saddle Force Q, Test Case, no Ext. Forces		10100.08	lb.
Pressure used in Analysis	P	131.095	psig

Horizontal Vessel Analysis Results:	Actual psi	Allowable psi
Long. Stress at Top of Midspan	3111.94	34200.00
Long. Stress at Bottom of Midspan	3246.15	34200.00
Long. Stress at Top of Saddles	3285.91	34200.00
Long. Stress at Bottom of Saddles	3119.81	34200.00

```
 Tangential Shear in Shell              388.95 |     20254.00 |
 Circ. Stress at Horn of Saddle        1641.08 |     51300.00 |
 Circ. Compressive Stress in Shell       83.07 |     34200.00 |
 ----------------------------------------------------------------
```

Intermediate Results: Saddle Reaction Q due to Wind or Seismic:

Transverse Saddle Reaction Force [Fwt]:
```
  = Ftr( Ft/Num of Saddles + Z Force Load ) * B / E
  = 3 ( 109.3/2 + 0 ) * 45/53.69
  = 137.4 lb.
```

Longitudinal Saddle Reaction Force [Fwl]:
```
  = max( Fl,wind; Sum of X Forces) * B / Ls
  = max( 98.36, 0 ) * 45/93
  = 47.6 lb.
```

Load Combination Results for Q + Wind or Seismic [Q]:
```
  = Saddle Load + max( Fwl, Fwt, Fsl, Fst )
  = 9963 + max( 47.59, 137.4, 0, 0 )
  = 10100.1 lb.
```

Longitudinal Wind Force [Fl]:
```
  = WindScalar * WindPress( Platform Area + ( pi/4( OD * WindDiaMult )² ) )
  = 1 * 10.12 ( 0 + pi/4( 5.104 * 1.2 )² )
  = 298.064 lbf
```

Summary of Loads at the Base of this Saddle:
```
 Vertical Load (including saddle weight)            10190.06  lb.
 Transverse Shear Load                                 54.63  lb.
 Longitudinal Shear Load                               98.36  lb.
```

Note: Wear Plate is Welded to the Shell, k = 0.1

Saddle Dimension [E]:
```
  = min( 2( ShellID/2 + t + WearPadThickness )sin(θ/2 ), 2*Rm )
  = min( 2( 60/2 + 0.625 + 0.375 )sin( 120/2 ), 2*30.31 )
  = 53.694 in.
```

The Computed K values from Table 4.15.1:
```
 K1   = 0.1066      K2   = 1.1707      K3   = 0.8799      K4   = 0.4011
 K5   = 0.7603      K6   = 0.0529      K7   = 0.0180      K8   = 0.3405
 K9   = 0.2711      K10  = 0.0581      K1*  = 0.1923
```

Note: Dimension a is greater than or equal to Rm/2.

Moment per Equation 4.15.1 [M1]:
```
  = -Q*a [1 - (1- a/L + (Rm²-hm²)/(2a*L))/(1+(4hm²)/3L)]
  = -10100*1.417[1-(1-1.417/10.33+(2.526²-1.276²)/
    (2*1.417*10.33))/(1+(4*1.276)/(3*10.33))]
  = -1712.8 ft.lb.
```

Moment per Equation 4.15.2 [M2]:
```
  = Q*L/4(1+2(Rm²-hi²)/(L²))/(1+(4hi)/( 3L))-4a/L
  = 10100*10.33/4(1+2(2.526²-1.276²)/(10.33²))/(1+(4*1.276)/
    (3*10.33))-4*1.417/10.33
  = 10089.0 ft.lb.
```

Longitudinal Stress at Top of Shell (4.15.4) [sigma1]:
```
  = P * Rm/(2t) - M2/(pi*Rm²t)
  = 131.1 * 30.31/(2*0.625 ) - 121068/(pi*30.31²*0.625 )
  = 3111.94 psi
```

Longitudinal Stress at Bottom of Shell (4.15.5) [sigma2]:

```
= P * Rm/(2t) + M2/(pi * Rm² * t)
= 131.1 * 30.31/(2 * 0.625 ) + 121068/(pi * 30.31² * 0.625 )
= 3246.15 psi
```

Longitudinal Stress at Top of Shell at Support (4.15.8) [sigma*3]:

```
= P * Rm/(2t) - M1/(K1*pi*Rm²t)
= 131.1*30.31/(2*0.625)--20554/(0.107*pi*30.31²*0.625)
= 3285.91 psi
```

Longitudinal Stress at Bottom of Shell at Support (4.15.9) [sigma*4]:

```
= P * Rm/(2t) + M1/(K1* * pi * Rm² * t)
= 131.1*30.31/(2*0.625)+-20554/(0.192*pi*30.31²*0.625)
= 3119.81 psi
```

Maximum Shear Force in the Saddle (4.15.3) [T]:

```
= Q(L-2a)/(L+(4*hm/3))
= 10100 ( 10.33 - 2 * 1.417 )/(10.33 + ( 4 * 1.276/3))
= 6294.3 lb.
```

Shear Stress in the shell no rings, not stiffened (4.15.12) [tau2]:

```
= K2 * T / ( Rm * t )
= 1.171 * 6294/( 30.31 * 0.625 )
= 388.95 psi
```

Decay Length (4.15.20) [x1,x2]:

```
= 0.78 * sqrt( Rm * t )
= 0.78 * sqrt( 30.31 * 0.625 )
= 3.395 in.
```

Circumferential Stress in shell, no rings (4.15.21) [sigma6]:

```
= -K5 * Q * k / ( t( b + X1 + X2 ) )
= -0.76 * 10100 * 0.1/( 0.625 ( 8 + 3.395 + 3.395 ) )
= -83.07 psi
```

Circ. Comp. Stress at Horn of Saddle, L<8Rm (4.15.23) [sigma7*]:

```
= -Q/(4*t(b+X1+X2)) - 12*K7*Q*Rm/(L*t²)
= -10100/(4*0.625 (8 +3.395 +3.395 )) -
   12 * 0.018 * 10100 * 30.31/(10.33 * 0.625²)
= -1641.08 psi
```

Effective reinforcing plate width (4.15.24) [B1]:

```
= min( b + 1.56 * sqrt( Rm * t ), 2a  )
= min( 8 + 1.56 * sqrt( 30.31 * 0.625 ), 2 * 17 )
= 14.79 in.
```

Review notes about nozzle loadings and supports in the Warnings report.

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ASME VIII Division 2 Horizontal Vessel Analysis, Left Saddle:

Horizontal Vessel Stress Calculations : External Pressure

Note:
Wear Pad Width (12.00) is less than 1.56*sqrt(rm*t)
and less than 2a. The wear plate will be ignored.

Minimum Wear Plate Width to be considered in analysis [b1]:

```
  = min( b + 1.56*sqrt( Rm * t ), 2a )
  = min( 8 + 1.56*sqrt( 30.38 * 0.5 ), 2 * 17 )
  = 14.0795 in.
```

Input and Calculated Values:

```
 Vessel Mean Radius                              Rm       30.38  in.
 Shell Thickness used in this Case                t       0.625  in.
 Stiffened Vessel Length per 4.15.6               L       10.33  ft.
 Distance from Saddle to Vessel tangent     a1 or a       17.00  in.

 Saddle Width                               b1 or b        8.00  in.
 Saddle Bearing Angle                delta or theta      120.00  degrees

 Inside or Mean Depth of Head              Hi or hm        1.28  ft.

 Shell Allowable Stress used in Calculation            20000.00  psi
 Head Allowable Stress used in Calculation             20000.00  psi
 Circumferential Efficiency in Plane of Saddle             1.00
 Circumferential Efficiency at Mid-Span                    1.00

 Distance from Saddle Base to Centerline          B       45.00  in.
 Coefficient of Friction                         mu        0.00
```

<u>Results for Horizontal Vessel Analysis:</u>

```
 Saddle Force Q, External Pressure Case                 3383.55  lb.
 Pressure used in Analysis                        P     -15.000  psig
```

Horizontal Vessel Analysis Results:	Actual psi	Allowable psi
Long. Stress at Top of Midspan	-483.59	-31320.00
Long. Stress at Top of Midspan	483.59	20000.00
Long. Stress at Bottom of Midspan	-427.66	-31320.00
Long. Stress at Bottom of Midspan	427.66	20000.00
Long. Stress at Top of Saddles	-411.01	-31320.00
Long. Stress at Top of Saddles	411.01	20000.00
Long. Stress at Bottom of Saddles	-480.35	-31320.00
Long. Stress at Bottom of Saddles	480.35	20000.00
Tangential Shear in Shell	162.44	16000.00
Circ. Stress at Horn of Saddle	834.02	25000.00
Circ. Compressive Stress in Shell	36.54	20000.00

Intermediate Results: Saddle Reaction Q due to Wind or Seismic:

Transverse Saddle Reaction Force [Fwt]:

```
  = Ftr( Ft/Num of Saddles + Z Force Load ) * B / E
  = 3 ( 331.1/2 + 0 ) * 45/53.69
  = 416.2 lb.
```

Longitudinal Saddle Reaction Force [Fwl]:
```
  = max( Fl,wind; Sum of X Forces) * B / Ls
  = max( 298.1, 0 ) * 45/93
  = 144.2 lb.
```

Saddle Reaction Force due to Earthquake Fl [Fsl]:
```
  = max( Fl,eq; Sum of X Forces ) * B / Ls
  = max( 676.9, 0 ) * 45/93
  = 327.6 lb.
```

Saddle Reaction Force due to Earthquake Ft [Fst]:
```
  = Ftr( Ft/Num of Saddles + Z Force Load ) * B / E
  = 3 ( 676.9/2 + 0 ) * 45/53.69
  = 851.0 lb.
```

Load Combination Results for Q + Wind or Seismic [Q]:
```
  = Saddle Load + max( Fwl, Fwt, Fsl, Fst )
  = 2533 + max( 144.2, 416.2, 327.6, 851 )
  = 3383.6 lb.
```

Longitudinal Wind Force [Fl]:
```
  = WindScalar * WindPress( Platform Area + ( pi/4( OD * WindDiaMult )² ) )
  = 1 * 10.12 ( 0 + pi/4( 5.104 * 1.2 )² )
  = 298.064 lbf
```

Summary of Loads at the Base of this Saddle:

Vertical Load (including saddle weight)	3473.54	lb.
Transverse Shear Load	338.47	lb.
Longitudinal Shear Load	676.94	lb.

Note: Wear Plate is Welded to the Shell, k = 0.1

Saddle Dimension [E]:
```
  = min( 2( ShellID/2 + t + WearPadThickness )sin(θ/2 ), 2*Rm )
  = min( 2( 60/2 + 0.625 + 0.375 )sin( 120/2 ), 2*30.38 )
  = 53.694 in.
```

The Computed K values from Table 4.15.1:

K1 = 0.1066	K2 = 1.1707	K3 = 0.8799	K4 = 0.4011
K5 = 0.7603	K6 = 0.0529	K7 = 0.0179	K8 = 0.3405
K9 = 0.2711	K10 = 0.0581	K1* = 0.1923	

Note: Dimension a is greater than or equal to Rm/2.

Moment per Equation 4.15.1 [M1]:
```
  = -Q*a [1 - (1- a/L + (Rm²-hm²)/(2a*L))/(1+(4hm²)/3L)]
  = -3384*1.417[1-(1-1.417/10.33+(2.531²-1.281²)/
    (2*1.417*10.33))/(1+(4*1.281)/(3*10.33))]
  = -574.4 ft.lb.
```

Moment per Equation 4.15.2 [M2]:
```
  = Q*L/4(1+2(Rm²-hi²)/(L²))/(1+(4hi)/( 3L))-4a/L
  = 3384*10.33/4(1+2(2.531²-1.281²)/(10.33²))/(1+(4*1.281)/
    (3*10.33))-4*1.417/10.33
  = 3377.0 ft.lb.
```

Longitudinal Stress at Top of Shell (4.15.4) [sigma1]:
```
  = P * Rm/(2t) - M2/(pi*Rm²t)
  = -15 * 30.38/(2*0.5 ) - 40524/(pi*30.38²*0.5 )
  = -483.59 psi
```

Longitudinal Stress at Bottom of Shell (4.15.5) [sigma2]:
```
  = P * Rm/(2t) + M2/(pi * Rm² * t)
```

```
  = -15 * 30.38/(2 * 0.5 ) + 40524/(pi * 30.38² * 0.5 )
  = -427.66 psi
```

Longitudinal Stress at Top of Shell at Support (4.15.8) [sigma*3]:

```
  = P * Rm/(2t) - M1/(K1*pi*Rm²t)
  = -15*30.38/(2*0.5)--6893/(0.107*pi*30.38²*0.5)
  = -411.01 psi
```

Longitudinal Stress at Bottom of Shell at Support (4.15.9) [sigma*4]:

```
  = P * Rm/(2t) + M1/(K1* * pi * Rm² * t)
  = -15*30.38/(2*0.5)+-6893/(0.192*pi*30.38²*0.5)
  = -480.35 psi
```

Maximum Shear Force in the Saddle (4.15.3) [T]:

```
  = Q(L-2a)/(L+(4*hm/3))
  = 3384 ( 10.33 - 2 * 1.417 )/(10.33 + ( 4 * 1.281/3))
  = 2107.4 lb.
```

Shear Stress in the shell no rings, not stiffened (4.15.12) [tau2]:

```
  = K2 * T / ( Rm * t )
  = 1.171 * 2107/( 30.38 * 0.5 )
  = 162.44 psi
```

Decay Length (4.15.20) [x1,x2]:

```
  = 0.78 * sqrt( Rm * t )
  = 0.78 * sqrt( 30.38 * 0.5 )
  = 3.040 in.
```

Circumferential Stress in shell, no rings (4.15.21) [sigma6]:

```
  = -K5 * Q * k / ( t( b + X1 + X2 ) )
  = -0.76 * 3384 * 0.1/( 0.5 ( 8 + 3.04 + 3.04 ) )
  = -36.54 psi
```

Circ. Comp. Stress at Horn of Saddle, L<8Rm (4.15.23) [sigma7*]:

```
  = -Q/(4*t(b+X1+X2)) - 12*K7*Q*Rm/(L*t²)
  = -3384/(4*0.5 (8 +3.04 +3.04 )) -
     12 * 0.0179 * 3384 * 30.38/(10.33 * 0.5²)
  = -834.02 psi
```

Effective reinforcing plate width (4.15.24) [B1]:

```
  = min( b + 1.56 * sqrt( Rm * t ), 2a  )
  = min( 8 + 1.56 * sqrt( 30.38 * 0.5 ), 2 * 17 )
  = 14.08 in.
```

ASME VIII Division 2 Horizontal Vessel Analysis, Right Saddle:

Note:
Wear Pad Width (12.00) is less than 1.56*sqrt(rm*t)
and less than 2a. The wear plate will be ignored.

Minimum Wear Plate Width to be considered in analysis [b1]:

```
  = min( b + 1.56*sqrt( Rm * t ), 2a )
  = min( 8 + 1.56*sqrt( 30.38 * 0.5 ), 2 * 17 )
  = 14.0795 in.
```

Input and Calculated Values:

Vessel Mean Radius	Rm	30.38	in.
Shell Thickness used in this Case	t	0.625	in.
Stiffened Vessel Length per 4.15.6	L	10.33	ft.
Distance from Saddle to Vessel tangent	a1 or a	17.00	in.

Saddle Width	b1 or b	8.00	in.
Saddle Bearing Angle	delta or theta	120.00	degrees
Inside or Mean Depth of Head	Hi or hm	1.28	ft.
Shell Allowable Stress used in Calculation		20000.00	psi
Head Allowable Stress used in Calculation		20000.00	psi
Circumferential Efficiency in Plane of Saddle		1.00	
Circumferential Efficiency at Mid-Span		1.00	
Distance from Saddle Base to Centerline	B	45.00	in.
Coefficient of Friction	mu	0.00	

Results for Horizontal Vessel Analysis:

Saddle Force Q, External Pressure Case		3153.77	lb.
Pressure used in Analysis	P	-15.000	psig

Horizontal Vessel Analysis Results:	Actual psi	Allowable psi
Long. Stress at Top of Midspan	-481.69	-31320.00
Long. Stress at Top of Midspan	481.69	20000.00
Long. Stress at Bottom of Midspan	-429.56	-31320.00
Long. Stress at Bottom of Midspan	429.56	20000.00
Long. Stress at Top of Saddles	-414.04	-31320.00
Long. Stress at Top of Saddles	414.04	20000.00
Long. Stress at Bottom of Saddles	-478.67	-31320.00
Long. Stress at Bottom of Saddles	478.67	20000.00
Tangential Shear in Shell	151.41	16000.00
Circ. Stress at Horn of Saddle	777.38	25000.00
Circ. Compressive Stress in Shell	34.06	20000.00

Intermediate Results: Saddle Reaction Q due to Wind or Seismic:

Transverse Saddle Reaction Force [Fwt]:
```
  = Ftr( Ft/Num of Saddles + Z Force Load ) * B / E
  = 3 ( 331.1/2 + 0 ) * 45/53.69
  = 416.2 lb.
```

Longitudinal Saddle Reaction Force [Fwl]:
```
  = max( Fl,wind; Sum of X Forces) * B / Ls
  = max( 298.1, 0 ) * 45/93
  = 144.2 lb.
```

Saddle Reaction Force due to Earthquake Fl [Fsl]:
```
  = max( Fl,eq; Sum of X Forces ) * B / Ls
  = max( 676.9, 0 ) * 45/93
  = 327.6 lb.
```

Saddle Reaction Force due to Earthquake Ft [Fst]:
```
  = Ftr( Ft/Num of Saddles + Z Force Load ) * B / E
  = 3 ( 676.9/2 + 0 ) * 45/53.69
  = 851.0 lb.
```

Load Combination Results for Q + Wind or Seismic [Q]:
```
  = Saddle Load + max( Fwl, Fwt, Fsl, Fst )
  = 2303 + max( 144.2, 416.2, 327.6, 851 )
  = 3153.8 lb.
```

Longitudinal Wind Force [Fl]:

```
  = WindScalar * WindPress( Platform Area + ( pi/4( OD * WindDiaMult )^2 ) )
  = 1 * 10.12 ( 0 + pi/4( 5.104 * 1.2 )^2 )
  = 298.064 lbf
```

Summary of Loads at the Base of this Saddle:

Vertical Load (including saddle weight)	3243.76	lb.
Transverse Shear Load	338.47	lb.
Longitudinal Shear Load	676.94	lb.

Note: Wear Plate is Welded to the Shell, k = 0.1

Saddle Dimension [E]:

```
  = min( 2( ShellID/2 + t + WearPadThickness )sin(θ/2 ), 2*Rm )
  = min( 2( 60/2 + 0.625 + 0.375 )sin( 120/2 ), 2*30.38 )
  = 53.694 in.
```

The Computed K values from Table 4.15.1:

K1 = 0.1066	K2 = 1.1707	K3 = 0.8799	K4 = 0.4011
K5 = 0.7603	K6 = 0.0529	K7 = 0.0179	K8 = 0.3405
K9 = 0.2711	K10 = 0.0581	K1* = 0.1923	

Note: Dimension a is greater than or equal to Rm/2.

Moment per Equation 4.15.1 [M1]:

```
  = -Q*a [1 - (1- a/L + (Rm^2-hm^2)/(2a*L))/(1+(4hm^2)/3L)]
  = -3154*1.417[1-(1-1.417/10.33+(2.531^2-1.281^2)/
    (2*1.417*10.33))/(1+(4*1.281)/(3*10.33))]
  = -535.4 ft.lb.
```

Moment per Equation 4.15.2 [M2]:

```
  = Q*L/4(1+2(Rm^2-hi^2)/(L^2))/(1+(4hi)/( 3L))-4a/L
  = 3154*10.33/4(1+2(2.531^2-1.281^2)/(10.33^2))/(1+(4*1.281)/
    (3*10.33))-4*1.417/10.33
  = 3147.6 ft.lb.
```

Longitudinal Stress at Top of Shell (4.15.4) [sigma1]:

```
  = P * Rm/(2t) - M2/(pi*Rm^2t)
  = -15 * 30.38/(2*0.5 ) - 37772/(pi*30.38^2*0.5 )
  = -481.69 psi
```

Longitudinal Stress at Bottom of Shell (4.15.5) [sigma2]:

```
  = P * Rm/(2t) + M2/(pi * Rm^2 * t)
  = -15 * 30.38/(2 * 0.5 ) + 37772/(pi * 30.38^2 * 0.5 )
  = -429.56 psi
```

Longitudinal Stress at Top of Shell at Support (4.15.8) [sigma*3]:

```
  = P * Rm/(2t) - M1/(K1*pi*Rm^2t)
  = -15*30.38/(2*0.5)--6425/(0.107*pi*30.38^2*0.5)
  = -414.04 psi
```

Longitudinal Stress at Bottom of Shell at Support (4.15.9) [sigma*4]:

```
  = P * Rm/(2t) + M1/(K1* * pi * Rm^2 * t)
  = -15*30.38/(2*0.5)+-6425/(0.192*pi*30.38^2*0.5)
  = -478.67 psi
```

Maximum Shear Force in the Saddle (4.15.3) [T]:

```
  = Q(L-2a)/(L+(4*hm/3))
  = 3154 ( 10.33 - 2 * 1.417 )/(10.33 + ( 4 * 1.281/3))
  = 1964.3 lb.
```

Shear Stress in the shell no rings, not stiffened (4.15.12) [tau2]:

```
  = K2 * T / ( Rm * t )
```

```
  = 1.171 * 1964/( 30.38 * 0.5 )
  = 151.41 psi
```

Decay Length (4.15.20) [x1,x2]:

```
  = 0.78 * sqrt( Rm * t )
  = 0.78 * sqrt( 30.38 * 0.5 )
  = 3.040 in.
```

Circumferential Stress in shell, no rings (4.15.21) [sigma6]:

```
  = -K5 * Q * k / ( t( b + X1 + X2 ) )
  = -0.76 * 3154 * 0.1/( 0.5 ( 8 + 3.04 + 3.04 ) )
  = -34.06 psi
```

Circ. Comp. Stress at Horn of Saddle, L<8Rm (4.15.23) [sigma7*]:

```
  = -Q/(4*t(b+X1+X2)) - 12*K7*Q*Rm/(L*t²)
  = -3154/(4*0.5 (8 +3.04 +3.04 )) -
     12 * 0.0179 * 3154 * 30.38/(10.33 * 0.5²)
  = -777.38 psi
```

Effective reinforcing plate width (4.15.24) [B1]:

```
  = min( b + 1.56 * sqrt( Rm * t ), 2a   )
  = min( 8 + 1.56 * sqrt( 30.38 * 0.5 ), 2 * 17 )
  = 14.08 in.
```

Review notes about nozzle loadings and supports in the Warnings report.

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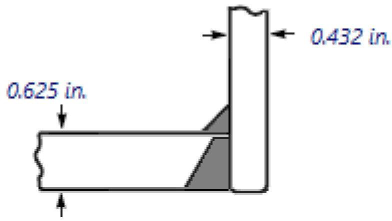
Input, Nozzle Desc: Inspection From: 10

Pressure for Reinforcement Calculations	P	100.000	psig
Temperature for Internal Pressure	Temp	200	F
Design External Pressure	Pext	15.00	psig
Temperature for External Pressure	Tempex	200	F
Parent Material		SA-516 70	
Parent Allowable Stress at Temperature	Sv	20000.00	psi
Parent Allowable Stress At Ambient	Sva	20000.00	psi
Inside Diameter of Elliptical Head	D	60.0000	in.
Aspect Ratio of Elliptical Head	Ar	2.00	
Head Finished (Minimum) Thickness	t	0.6250	in.
Head Internal Corrosion Allowance	c	0.1250	in.
Head External Corrosion Allowance	co	0.0000	in.
Distance from Head Centerline	L1	0.0000	in.
User Entered Minimum Design Metal Temperature		-20.00	F

Type of Element Connected to the Parent : Nozzle

Material		SA-106 B	
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	17100.00	psi
Allowable Stress At Ambient	Sna	17100.00	psi
Diameter Basis (for tr calc only)		Inside	
Layout Angle		0.00	deg
Diameter		6.0000	in.
Size and Thickness Basis		Nominal	
Nominal Thickness		80	
Flange Material		SA-105	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	0.1250	in.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	2.0000	in.
Weld leg size between Nozzle and Pad/Shell	Wo	0.3750	in.
Groove weld depth between Nozzle and Vessel	Wgnv	0.6250	in.
Inside Projection	h	0.0000	in.
Weld leg size, Inside Element to Shell	Wi	0.0000	in.
Flange Class		150	
Flange Grade		GR 1.1	

The Pressure Design option was Design Pressure + static head.



Reinforcement CALCULATION, Description: Inspection

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

```
 Actual Inside Diameter Used in Calculation            5.761  in.
 Actual Thickness Used in Calculation                  0.432  in.
```

Nozzle input data check completed without errors.

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

```
  = P*D*K1/(2*Sv*E-0.2*P) per Appendix 1-4(c)
  = 100*60.25*0.9/(2*20000*1-0.2*100)
  = 0.1356 in.
```

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

```
  = P*R/(Sn*E-0.6*P) per UG-27 (c)(1)
  = 100*3.006/(17100*1-0.6*100)
  = 0.0176 in.
```

Required Nozzle thickness under External Pressure per UG-28 : 0.0129 in.

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

```
 Parallel to Vessel Wall (Diameter Limit)            Dl    12.0220  in.
 Parallel to Vessel Wall, opening length              d     6.0110  in.
 Normal to Vessel Wall (Thickness Limit), no pad   Tlnp     0.7675  in.
```

Weld Strength Reduction Factor [fr1]:

```
  = min( 1, Sn/Sv )
  = min( 1, 17100/20000 )
  = 0.855
```

Weld Strength Reduction Factor [fr2]:

```
  = min( 1, Sn/Sv )
  = min( 1, 17100/20000 )
  = 0.855
```

Weld Strength Reduction Factor [fr3]:

```
  = min( fr2, fr4 )
  = min( 0.855, 1 )
  = 0.855
```

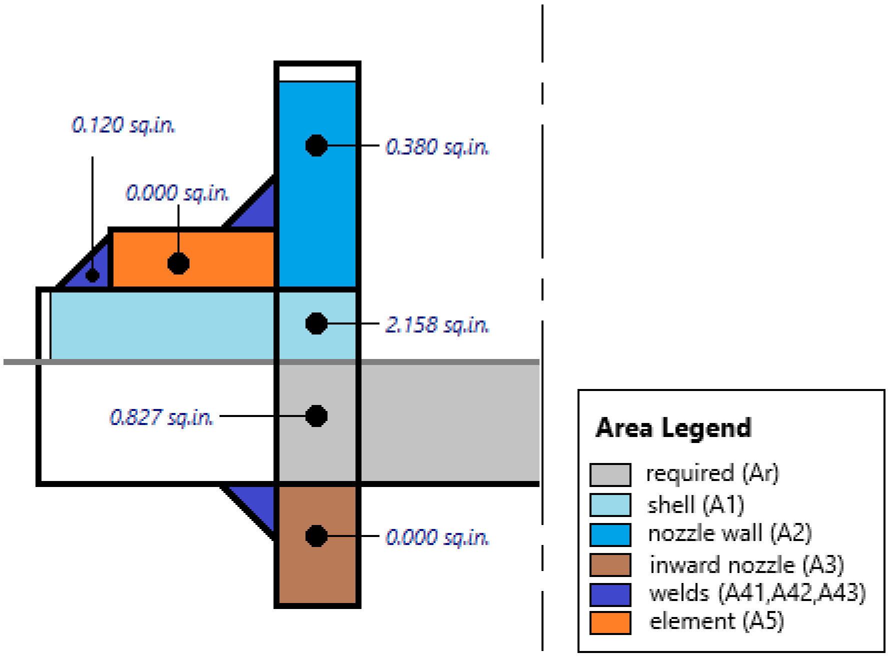


Figure UG 37.1 Nozzle Areas

Results of Nozzle Reinforcement Area Calculations: (sq.in.)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	0.827	0.484	NA
Area in Shell	A1	2.158	2.022	NA
Area in Nozzle Wall	A2	0.380	0.386	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	0.120	0.120	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	2.658	2.528	NA

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 degs.

The area available without a pad is Sufficient.

Area Required [A]:
```
  = ( d * tr*F + 2 * tn * tr*F * (1-fr1) ) UG-37(c)
  = (6.011*0.136*1+2*0.307*0.136*1*(1-0.855))
  = 0.827 sq.in.
```

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:
```
  = d( E1*t - F*tr ) - 2 * tn( E1*t - F*tr ) * ( 1 - fr1 )
  = 6.011 ( 1 * 0.5 - 1 * 0.136 ) - 2 * 0.307
    ( 1 * 0.5 - 1 * 0.136 ) * ( 1 - 0.855 )
  = 2.158 sq.in.
```

Area Available in Nozzle Projecting Outward [A2]:
```
  = ( 2 * tlnp )( tn - trn )fr2
  = ( 2 * 0.768 )( 0.307 - 0.0176 )0.855
```

= 0.380 sq.in.

Area Available in Inward Weld + Outward Weld [A41 + A43]:
= Wo² * fr2 + (Wi-can/0.707)² * fr2
= 0.375² * 0.855 + (0)² * 0.855
= 0.120 sq.in.

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

```
Wall Thickness for Internal/External pressures      ta = 0.1426 in.
Wall Thickness per UG16(b),                       tr16b = 0.2188 in.
Wall Thickness, shell/head, internal pressure     trb1 = 0.2757 in.
Wall Thickness                 tb1 = max(trb1, tr16b) = 0.2757 in.
Wall Thickness, shell/head, external pressure     trb2 = 0.1476 in.
Wall Thickness                 tb2 = max(trb2, tr16b) = 0.2188 in.
Wall Thickness per table UG-45                      tb3 = 0.3699 in.
```

Determine Nozzle Thickness candidate [tb]:
= min[tb3, max(tb1,tb2)]
= min[0.37, max(0.276, 0.219)]
= 0.2757 in.

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
= max(ta, tb)
= max(0.143, 0.276)
= 0.2757 in.

Available Nozzle Neck Thickness = 0.875 * 0.432 = 0.378 in. -> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld, Curve: B

Govrn. thk, tg = 0.378, tr = 0.0176, c = 0.125 in., E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.0697, Temp. Reduction = 140 F

```
Min Metal Temp. w/o impact per UCS-66, Curve B             -20 F
Min Metal Temp. at Required thickness (UCS 66.1)          -155 F
```

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

Govrn. thk, tg = 0.378, tr = 0.0176, c = 0.125 in., E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.0697, Temp. Reduction = 140 F

```
Min Metal Temp. w/o impact per UCS-66, Curve B             -20 F
Min Metal Temp. at Required thickness (UCS 66.1)          -155 F

Gov. MDMT of the nozzle to shell joint welded assembly :  -155 F
```

Flange MDMT including Temperature reduction per UCS-66.1:

```
Unadjusted MDMT of ASME B16.5/47 flanges per UCS-66(c)       0 F
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b)       -55 F
```

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :
Design Pressure/Ambient Rating = 100.00/285.00 = 0.351

<u>Weld Size Calculations, Description: Inspection</u>

```
Intermediate Calc. for nozzle/shell Welds   Tmin      0.3070  in.
```

Results Per UW-16.1:

```
                         Required Thickness    Actual Thickness
```

```
 Nozzle Weld          0.2149 = 0.7 * tmin.  0.2651 = 0.7 * Wo in.
```

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

Weld Load [W]:
```
  = max( 0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)
  = max( 0, (0.827 - 2.158 + 2 * 0.307 * 0.855 *
    (1 * 0.5 - 0.136 ) )20000 )
  = max( 0, -22783.08) lb.
```

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

Weld Load [W1]:
```
  = (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
  = ( 0.38 + 0 + 0.12 - 0 * 0.855 ) * 20000
  = 10000.01 lb.
```

Weld Load [W2]:
```
  = (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
  = ( 0.38 + 0 + 0.12 + ( 0.262 ) ) * 20000
  = 15249.71 lb.
```

Weld Load [W3]:
```
  = (A2+A3+A4+A5+(2*tn*t*fr1))*S
  = ( 0.38 + 0 + 0.12 + 0 + ( 0.262 ) ) * 20000
  = 15249.71 lb.
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:
```
  = (pi/2) * Dlo * Wo * 0.49 * Snw
  = ( 3.142/2.0 ) * 6.625 * 0.375 * 0.49 * 17100
  = 32699. lb.
```

Shear, Nozzle Wall [Snw]:
```
  = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
  = (3.142 * 3.159 ) * ( 0.432 - 0.125 ) * 0.7 * 17100
  = 36470. lb.
```

Tension, Shell Groove Weld [Tngw]:
```
  = (pi/2) * Dlo * ( T - cas ) * 0.74 * Sng
  = ( 3.142/2.0 ) * 6.625 * ( 0.625 - 0.125 ) * 0.74 * 20000
  = 77008. lb.
```

See UG-41 and UW-15 for clarification of allowable stresses.

Strength of Failure Paths:

Failure Path [Path 1-1]:
```
  = ( SONW + SNW ) = ( 32699 + 36470 ) = 69168 lb.
```

Failure Path [Path 2-2]:
```
  = ( Sonw + Tpgw + Tngw + Sinw )
  = ( 32699 + 0 + 77008 + 0 ) = 109707 lb.
```

Failure Path [Path 3-3]:
```
  = ( Sonw + Tngw + Sinw )
  = ( 32699 + 77008 + 0 ) = 109707 lb.
```

Summary of Failure Path Calculations:
```
 Path 1-1 = 69168   lb., must exceed W = 0 lb.        or W1 = 10000 lb.
 Path 2-2 = 109706  lb., must exceed W = 0 lb.        or W2 = 15249 lb.
```

```
Path 3-3 = 109706  lb., must exceed W = 0 lb.       or W3 = 15249 lb.
```

Maximum Allowable Pressure for this Nozzle at this Location:

```
Converged Maximum Allowable Pressure in the Operating case: 210.6 psig

Nozzle is O.K. for the External Pressure: 15 psig
```

The Drop for this Nozzle is : 0.1008 in.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 2.7258 in.

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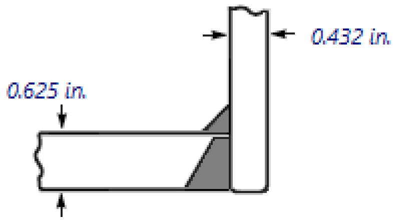
Input, Nozzle Desc: Outlet From: 10

Pressure for Reinforcement Calculations	P	100.000	psig
Temperature for Internal Pressure	Temp	200	F
Design External Pressure	Pext	15.00	psig
Temperature for External Pressure	Tempex	200	F
Parent Material		SA-516 70	
Parent Allowable Stress at Temperature	Sv	20000.00	psi
Parent Allowable Stress At Ambient	Sva	20000.00	psi
Inside Diameter of Elliptical Head	D	60.0000	in.
Aspect Ratio of Elliptical Head	Ar	2.00	
Head Finished (Minimum) Thickness	t	0.6250	in.
Head Internal Corrosion Allowance	c	0.1250	in.
Head External Corrosion Allowance	co	0.0000	in.
Distance from Head Centerline	L1	15.0000	in.
User Entered Minimum Design Metal Temperature		-20.00	F

Type of Element Connected to the Parent : Nozzle

Material		SA-106 B	
Material UNS Number		K03006	
Material Specification/Type		Smls. pipe	
Allowable Stress at Temperature	Sn	17100.00	psi
Allowable Stress At Ambient	Sna	17100.00	psi
Diameter Basis (for tr calc only)		Inside	
Layout Angle		0.00	deg
Diameter		6.0000	in.
Size and Thickness Basis		Nominal	
Nominal Thickness		80	
Flange Material		SA-105	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	0.1250	in.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	2.0000	in.
Weld leg size between Nozzle and Pad/Shell	Wo	0.3750	in.
Groove weld depth between Nozzle and Vessel	Wgnv	0.6250	in.
Inside Projection	h	0.0000	in.
Weld leg size, Inside Element to Shell	Wi	0.0000	in.
Flange Class		150	
Flange Grade		GR 1.1	

The Pressure Design option was Design Pressure + static head.



Reinforcement CALCULATION, Description: Outlet

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

```
 Actual Inside Diameter Used in Calculation            5.761  in.
 Actual Thickness Used in Calculation                  0.432  in.
```

Nozzle input data check completed without errors.

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

```
  = P*D*K1/(2*Sv*E-0.2*P) per Appendix 1-4(c)
  = 100*60.25*0.9/(2*20000*1-0.2*100)
  = 0.1356 in.
```

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

```
  = P*R/(Sn*E-0.6*P) per UG-27 (c)(1)
  = 100*3.006/(17100*1-0.6*100)
  = 0.0176 in.
```

Required Nozzle thickness under External Pressure per UG-28 : 0.0129 in.

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

```
 Parallel to Vessel Wall (Diameter Limit)            Dl    12.0220  in.
 Parallel to Vessel Wall, opening length              d     6.0110  in.
 Normal to Vessel Wall (Thickness Limit), no pad   Tlnp     0.7675  in.
```

Weld Strength Reduction Factor [fr1]:

```
  = min( 1, Sn/Sv )
  = min( 1, 17100/20000 )
  = 0.855
```

Weld Strength Reduction Factor [fr2]:

```
  = min( 1, Sn/Sv )
  = min( 1, 17100/20000 )
  = 0.855
```

Weld Strength Reduction Factor [fr3]:

```
  = min( fr2, fr4 )
  = min( 0.855, 1 )
  = 0.855
```

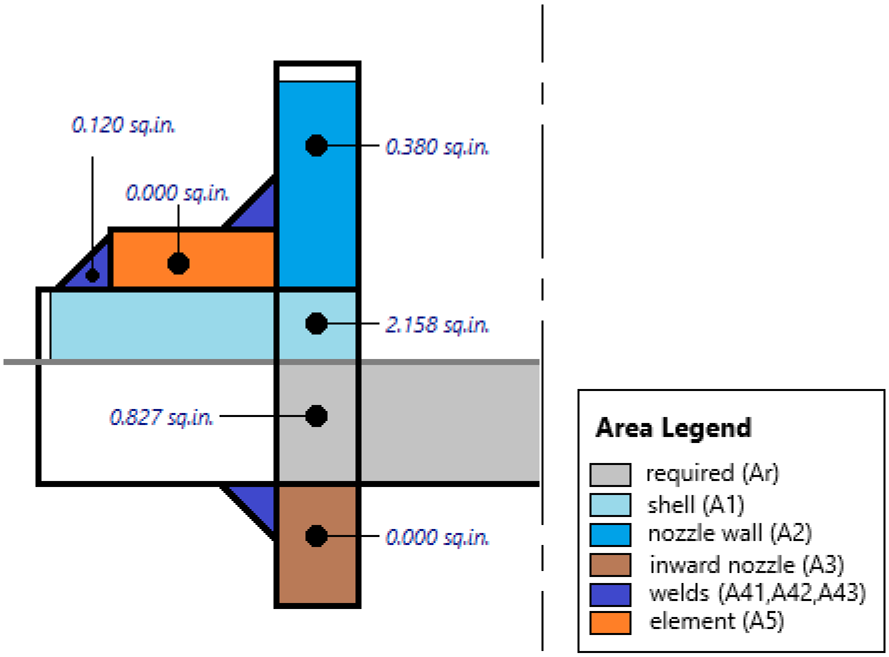



Figure UG 37.1   Nozzle Areas

Results of Nozzle Reinforcement Area Calculations: (sq.in.)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	0.827	0.484	NA
Area in Shell	A1	2.158	2.022	NA
Area in Nozzle Wall	A2	0.380	0.386	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	0.120	0.120	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	2.658	2.528	NA

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations   90.00   degs.

The area available without a pad is Sufficient.

Area Required [A]:
```
  = ( d * tr*F + 2 * tn * tr*F * (1-fr1) ) UG-37(c)
  = (6.011*0.136*1+2*0.307*0.136*1*(1-0.855))
  = 0.827 sq.in.
```

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:
```
  = d( E1*t - F*tr ) - 2 * tn( E1*t - F*tr ) * ( 1 - fr1 )
  = 6.011 ( 1 * 0.5 - 1 * 0.136 ) - 2 * 0.307
    ( 1 * 0.5 - 1 * 0.136 ) * ( 1 - 0.855 )
  = 2.158 sq.in.
```

Area Available in Nozzle Projecting Outward [A2]:
```
  = ( 2 * tlnp )( tn - trn )fr2
  = ( 2 * 0.768 )( 0.307 - 0.0176 )0.855
```

```
  = 0.380 sq.in.
```

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

```
  = Wo² * fr2 + ( Wi-can/0.707 )² * fr2
  = 0.375² * 0.855 + ( 0 )² * 0.855
  = 0.120 sq.in.
```

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

```
 Wall Thickness for Internal/External pressures      ta = 0.1426 in.
 Wall Thickness per UG16(b),                       tr16b = 0.2188 in.
 Wall Thickness, shell/head, internal pressure     trb1 = 0.2757 in.
 Wall Thickness                 tb1 = max(trb1, tr16b) = 0.2757 in.
 Wall Thickness, shell/head, external pressure     trb2 = 0.1476 in.
 Wall Thickness                 tb2 = max(trb2, tr16b) = 0.2188 in.
 Wall Thickness per table UG-45                     tb3 = 0.3699 in.
```

Determine Nozzle Thickness candidate [tb]:

```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 0.37, max( 0.276, 0.219 ) ]
  = 0.2757 in.
```

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

```
  = max( ta, tb )
  = max( 0.143, 0.276 )
  = 0.2757 in.
```

Available Nozzle Neck Thickness = 0.875 * 0.432 = 0.378 in. -> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld, Curve: B

Govrn. thk, tg = 0.378, tr = 0.0176, c = 0.125 in., E∗ = 1
Thickness Ratio = tr * E∗/(tg - c) = 0.0697, Temp. Reduction = 140 F

```
 Min Metal Temp. w/o impact per UCS-66, Curve B             -20 F
 Min Metal Temp. at Required thickness (UCS 66.1)          -155 F
```

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

Govrn. thk, tg = 0.378, tr = 0.0176, c = 0.125 in., E∗ = 1
Thickness Ratio = tr * E∗/(tg - c) = 0.0697, Temp. Reduction = 140 F

```
 Min Metal Temp. w/o impact per UCS-66, Curve B             -20 F
 Min Metal Temp. at Required thickness (UCS 66.1)          -155 F

 Gov. MDMT of the nozzle to shell joint welded assembly :  -155 F
```

Flange MDMT including Temperature reduction per UCS-66.1:

```
 Unadjusted MDMT of ASME B16.5/47 flanges per UCS-66(c)       0 F
 Flange MDMT with Temp reduction per UCS-66(b)(1)(-b)       -55 F
```

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

```
 Design Pressure/Ambient Rating = 100.00/285.00 = 0.351
```

Weld Size Calculations, Description: Outlet

```
 Intermediate Calc. for nozzle/shell Welds   Tmin      0.3070  in.
```

Results Per UW-16.1:

```
                       Required Thickness    Actual Thickness
```

```
 Nozzle Weld          0.2149 = 0.7 * tmin.  0.2651 = 0.7 * Wo in.
```

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

Weld Load [W]:
```
  = max( 0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)
  = max( 0, (0.827 - 2.158 + 2 * 0.307 * 0.855 *
    (1 * 0.5 - 0.136 ) )20000 )
  = max( 0, -22783.08) lb.
```

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

Weld Load [W1]:
```
  = (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
  = ( 0.38 + 0 + 0.12 - 0 * 0.855 ) * 20000
  = 10000.01 lb.
```

Weld Load [W2]:
```
  = (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
  = ( 0.38 + 0 + 0.12 + ( 0.262 ) ) * 20000
  = 15249.71 lb.
```

Weld Load [W3]:
```
  = (A2+A3+A4+A5+(2*tn*t*fr1))*S
  = ( 0.38 + 0 + 0.12 + 0 + ( 0.262 ) ) * 20000
  = 15249.71 lb.
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:
```
  = (pi/2) * Dlo * Wo * 0.49 * Snw
  = ( 3.142/2.0 ) * 6.625 * 0.375 * 0.49 * 17100
  = 32699. lb.
```

Shear, Nozzle Wall [Snw]:
```
  = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
  = (3.142 * 3.159 ) * ( 0.432 - 0.125 ) * 0.7 * 17100
  = 36470. lb.
```

Tension, Shell Groove Weld [Tngw]:
```
  = (pi/2) * Dlo * ( T - cas ) * 0.74 * Sng
  = ( 3.142/2.0 ) * 6.625 * ( 0.625 - 0.125 ) * 0.74 * 20000
  = 77008. lb.
```

See UG-41 and UW-15 for clarification of allowable stresses.

Strength of Failure Paths:

Failure Path [Path 1-1]:
```
  = ( SONW + SNW ) = ( 32699 + 36470 ) = 69168 lb.
```

Failure Path [Path 2-2]:
```
  = ( Sonw + Tpgw + Tngw + Sinw )
  = ( 32699 + 0 + 77008 + 0 ) = 109707 lb.
```

Failure Path [Path 3-3]:
```
  = ( Sonw + Tngw + Sinw )
  = ( 32699 + 77008 + 0 ) = 109707 lb.
```

Summary of Failure Path Calculations:
```
 Path 1-1 = 69168   lb., must exceed W = 0 lb.        or W1 = 10000 lb.
 Path 2-2 = 109706  lb., must exceed W = 0 lb.        or W2 = 15249 lb.
```

Path 3-3 = 109706 lb., must exceed W = 0 lb. or W3 = 15249 lb.

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Maximum Allowable Pressure in the Operating case: 210.6 psig

Nozzle is O.K. for the External Pressure: 15 psig

The Drop for this Nozzle is : 0.1008 in.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 2.7258 in.

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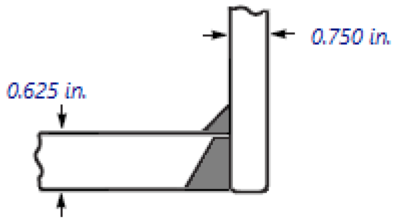
Input, Nozzle Desc: Manhole From: 20

Pressure for Reinforcement Calculations	P	100.000	psig
Temperature for Internal Pressure	Temp	200	F
Design External Pressure	Pext	15.00	psig
Temperature for External Pressure	Tempex	200	F
Parent Material		SA-516 70	
Parent Allowable Stress at Temperature	Sv	20000.00	psi
Parent Allowable Stress At Ambient	Sva	20000.00	psi
Inside Diameter of Cylindrical Shell	D	60.0000	in.
Design Length of Section	L	134.0000	in.
Shell Finished (Minimum) Thickness	t	0.6250	in.
Shell Internal Corrosion Allowance	c	0.1250	in.
Shell External Corrosion Allowance	co	0.0000	in.
Distance from Bottom/Left Tangent		5.17	ft.
User Entered Minimum Design Metal Temperature		-20.00	F

Type of Element Connected to the Parent : Nozzle

Material		SA-516 70	
Material UNS Number		K02700	
Material Specification/Type		Plate	
Allowable Stress at Temperature	Sn	20000.00	psi
Allowable Stress At Ambient	Sna	20000.00	psi
Diameter Basis (for tr calc only)		Inside	
Layout Angle		0.00	deg
Diameter		16.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	0.7500	in.
Flange Material		SA-105	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	0.1250	in.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	4.0000	in.
Weld leg size between Nozzle and Pad/Shell	Wo	0.3750	in.
Groove weld depth between Nozzle and Vessel	Wgnv	0.6250	in.
Inside Projection	h	0.0000	in.
Weld leg size, Inside Element to Shell	Wi	0.0000	in.
Flange Class		150	
Flange Grade		GR 1.1	

The Pressure Design option was Design Pressure + static head.



Reinforcement CALCULATION, Description: Manhole

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

```
 Actual Inside Diameter Used in Calculation            16.000  in.
 Actual Thickness Used in Calculation                   0.750  in.
```

Messages regarding the Nozzle Input Data:

For this nozzle, the actual wall thickness was specified. In these cases, the weight of the attached nozzle flange cannot be determined. It is required to manually compute the weight of the assembly and enter it into the nozzle dialog's overriding weight field.

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Cylindrical Shell, tr [Int. Press]
```
  = P*R/(Sv*E-0.6*P) per UG-27 (c)(1)
  = 100*30.12/(20000*1-0.6*100)
  = 0.1511 in.
```

Reqd thk per UG-37(a) of Nozzle Wall, trn [Int. Press]
```
  = P*R/(Sn*E-0.6*P) per UG-27 (c)(1)
  = 100*8.125/(20000*1-0.6*100)
  = 0.0407 in.
```

Required Nozzle thickness under External Pressure per UG-28 : 0.0303 in.

UG-40, Limits of Reinforcement: [Internal Pressure]
```
 Parallel to Vessel Wall (Diameter Limit)            Dl    32.5000  in.
 Parallel to Vessel Wall, opening length              d    16.2500  in.
 Normal to Vessel Wall (Thickness Limit), no pad   Tlnp     1.2500  in.
```

Weld Strength Reduction Factor [fr1]:
```
  = min( 1, Sn/Sv )
  = min( 1, 20000/20000 )
  = 1.000
```

Weld Strength Reduction Factor [fr2]:
```
  = min( 1, Sn/Sv )
  = min( 1, 20000/20000 )
  = 1.000
```

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

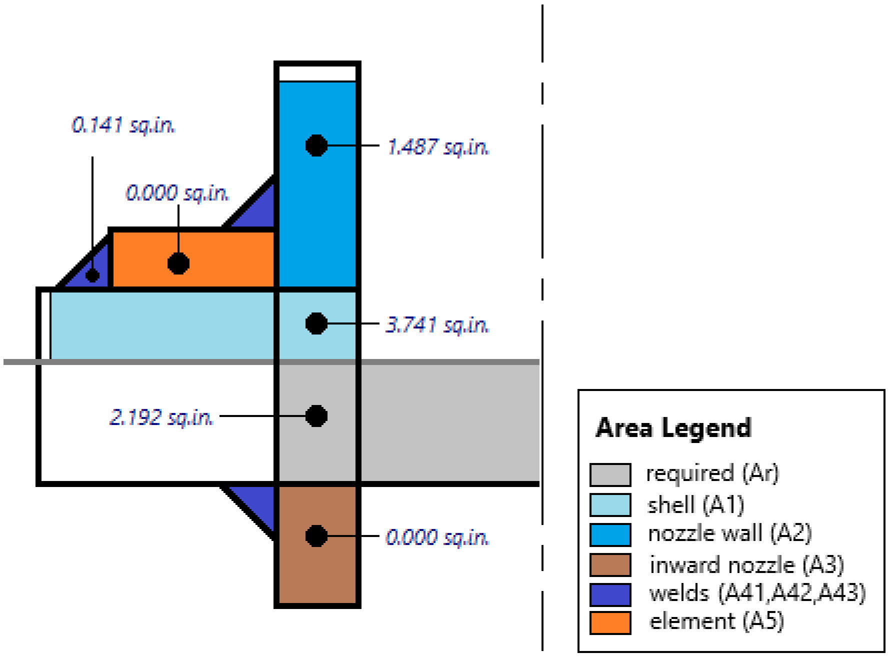


Figure UG 37.1 Nozzle Areas

Results of Nozzle Reinforcement Area Calculations: (sq.in.)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	2.455	2.192	NA
Area in Shell	A1	5.670	3.741	NA
Area in Nozzle Wall	A2	1.461	1.487	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	0.141	0.141	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	7.271	5.368	NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 degs.

The area available without a pad is Sufficient.

Area Required [A]:
```
  = 0.5( d * tr*F + 2 * tn * tr*F(1-fr1) ) per UG-37(d)
  = 0.5(16.25*0.27*1+2*0.625*0.27*1(1-1))
  = 2.192 sq.in.
```

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:
```
  = d( E1*t - F*tr ) - 2 * tn( E1*t - F*tr ) * ( 1 - fr1 )
  = 16.25 ( 1 * 0.5 - 1 * 0.27 ) - 2 * 0.625
    ( 1 * 0.5 - 1 * 0.27 ) * ( 1 - 1 )
  = 3.741 sq.in.
```

Area Available in Nozzle Projecting Outward [A2]:
```
  = ( 2 * tlnp )( tn - trn )fr2
  = ( 2 * 1.25 )( 0.625 - 0.0303 )1
```

```
  = 1.487 sq.in.
```

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

```
  = Wo² * fr2 + ( Wi-can/0.707 )² * fr2
  = 0.375² * 1 + ( 0 )² * 1
  = 0.141 sq.in.
```

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

```
 Wall Thickness for Internal/External pressures      ta = 0.1657 in.
 Wall Thickness per UG16(b),                       tr16b = 0.2188 in.
 Wall Thickness, shell/head, internal pressure      trb1 = 0.2761 in.
 Wall Thickness                 tb1 = max(trb1, tr16b) = 0.2761 in.
 Wall Thickness, shell/head, external pressure      trb2 = 0.1476 in.
 Wall Thickness                 tb2 = max(trb2, tr16b) = 0.2188 in.
 Wall Thickness per table UG-45                      tb3 = 0.4530 in.
```

Determine Nozzle Thickness candidate [tb]:

```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 0.453, max( 0.276, 0.219 ) ]
  = 0.2761 in.
```

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

```
  = max( ta, tb )
  = max( 0.166, 0.276 )
  = 0.2761 in.
```

Available Nozzle Neck Thickness = 0.7500 in. -> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld, Curve: B

Govrn. thk, tg = 0.75, tr = 0.0407, c = 0.125 in., E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.0652, Temp. Reduction = 140 F

```
 Min Metal Temp. w/o impact per UCS-66, Curve B              16 F
 Min Metal Temp. at Required thickness (UCS 66.1)          -155 F
 Min Metal Temp. w/o impact per UG-20(f)                    -20 F
```

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

Govrn. thk, tg = 0.625, tr = 0.151, c = 0.125 in., E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.302, Temp. Reduction = 140 F

```
 Min Metal Temp. w/o impact per UCS-66, Curve B               6 F
 Min Metal Temp. at Required thickness (UCS 66.1)          -155 F
 Min Metal Temp. w/o impact per UG-20(f)                    -20 F

 Gov. MDMT of the nozzle to shell joint welded assembly :  -155 F
```

Flange MDMT including Temperature reduction per UCS-66.1:

```
 Unadjusted MDMT of ASME B16.5/47 flanges per UCS-66(c)       0 F
 Flange MDMT with Temp reduction per UCS-66(b)(1)(-b)       -55 F
```

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

```
 Design Pressure/Ambient Rating = 100.00/285.00 = 0.351
```

<u>Weld Size Calculations, Description: Manhole</u>

```
 Intermediate Calc. for nozzle/shell Welds   Tmin      0.5000  in.
```

Results Per UW-16.1:

```
                      Required Thickness    Actual Thickness
 Nozzle Weld         0.2500 = Min per Code 0.2651 = 0.7 * Wo in.
```

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

Weld Load [W]:

```
  = max( 0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)
  = max( 0, (2.192 - 3.741 + 2 * 0.625 * 1 *
    (1 * 0.5 - 0.27 ) )20000 )
  = max( 0, -25210.57) lb.
```

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

Weld Load [W1]:

```
  = (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
  = ( 1.487 + 0 + 0.141 - 0 * 1 ) * 20000
  = 32545.11 lb.
```

Weld Load [W2]:

```
  = (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
  = ( 1.487 + 0 + 0.141 + ( 0.625 ) ) * 20000
  = 45045.11 lb.
```

Weld Load [W3]:

```
  = (A2+A3+A4+A5+(2*tn*t*fr1))*S
  = ( 1.487 + 0 + 0.141 + 0 + ( 0.625 ) ) * 20000
  = 45045.11 lb.
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

```
  = (pi/2) * Dlo * Wo * 0.49 * Snw
  = ( 3.142/2.0 ) * 17.5 * 0.375 * 0.49 * 20000
  = 101022. lb.
```

Shear, Nozzle Wall [Snw]:

```
  = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
  = (3.142 * 8.438 ) * ( 0.75 - 0.125 ) * 0.7 * 20000
  = 231938. lb.
```

Tension, Shell Groove Weld [Tngw]:

```
  = (pi/2) * Dlo * ( T - cas ) * 0.74 * Sng
  = ( 3.142/2.0 ) * 17.5 * ( 0.625 - 0.125 ) * 0.74 * 20000
  = 203418. lb.
```

See UG-41 and UW-15 for clarification of allowable stresses.

Strength of Failure Paths:

Failure Path [Path 1-1]:

```
  = ( SONW + SNW ) = ( 101022 + 231938 ) = 332960 lb.
```

Failure Path [Path 2-2]:

```
  = ( Sonw + Tpgw + Tngw + Sinw )
  = ( 101022 + 0 + 203418 + 0 ) = 304440 lb.
```

Failure Path [Path 3-3]:

```
  = ( Sonw + Tngw + Sinw )
  = ( 101022 + 203418 + 0 ) = 304440 lb.
```

Summary of Failure Path Calculations:

```
 Path 1-1 = 332959  lb., must exceed W = 0 lb.        or W1 = 32545 lb.
```

```
 Path 2-2 = 304440  lb., must exceed W = 0 lb.        or W2 = 45045 lb.
 Path 3-3 = 304440  lb., must exceed W = 0 lb.        or W3 = 45045 lb.
```

Maximum Allowable Pressure for this Nozzle at this Location:

```
 Converged Maximum Allowable Pressure in the Operating case: 195.5 psig

 Nozzle is O.K. for the External Pressure: 15 psig
```

The Drop for this Nozzle is : 1.3044 in.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 5.9294 in.

Percent Elongation Calculations:

```
 % Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro))  4.478 %
```

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Input, Nozzle Desc: Drain From: 20

```
Pressure for Reinforcement Calculations        P      100.000  psig
Temperature for Internal Pressure           Temp         200  F
Design External Pressure                    Pext       15.00  psig
Temperature for External Pressure         Tempex         200  F

Parent Material                                   SA-516 70
Parent Allowable Stress at Temperature        Sv    20000.00  psi
Parent Allowable Stress At Ambient           Sva    20000.00  psi

Inside Diameter of Cylindrical Shell           D     60.0000  in.
Design Length of Section                       L    134.0000  in.
Shell Finished (Minimum) Thickness             t      0.6250  in.
Shell Internal Corrosion Allowance             c      0.1250  in.
Shell External Corrosion Allowance            co      0.0000  in.

Distance from Bottom/Left Tangent                       5.17  ft.

User Entered Minimum Design Metal Temperature         -20.00  F
```

Type of Element Connected to the Parent : Nozzle

```
Material                                            SA-106 B
Material UNS Number                                   K03006
Material Specification/Type                       Smls. pipe
Allowable Stress at Temperature               Sn    17100.00  psi
Allowable Stress At Ambient                  Sna    17100.00  psi

Diameter Basis (for tr calc only)                     Inside
Layout Angle                                          180.00  deg
Diameter                                              2.0000  in.

Size and Thickness Basis                             Nominal
Nominal Thickness                                        160

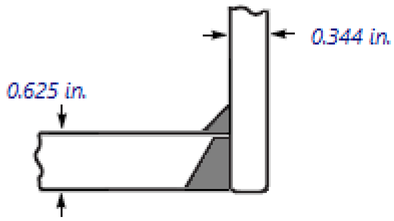
Flange Material                                       SA-105
Flange Type                                Weld Neck Flange

Corrosion Allowance                          can      0.1250  in.
Joint Efficiency of Shell Seam at Nozzle      E1        1.00
Joint Efficiency of Nozzle Neck               En        1.00

Outside Projection                            ho      2.0000  in.
Weld leg size between Nozzle and Pad/Shell    Wo      0.3750  in.
Groove weld depth between Nozzle and Vessel Wgnv      0.6250  in.
Inside Projection                              h      0.0000  in.
Weld leg size, Inside Element to Shell        Wi      0.0000  in.

Flange Class                                             150
Flange Grade                                          GR 1.1
```

The Pressure Design option was Design Pressure + static head.



Reinforcement CALCULATION, Description: Drain

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

```
Actual Inside Diameter Used in Calculation           1.687  in.
Actual Thickness Used in Calculation                 0.344  in.
```

Nozzle input data check completed without errors.

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

```
= P*R/(Sv*E-0.6*P) per UG-27 (c)(1)
= 100*30.12/(20000*1-0.6*100)
= 0.1511 in.
```

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

```
= P*R/(Sn*E-0.6*P) per UG-27 (c)(1)
= 100*0.969/(17100*1-0.6*100)
= 0.0057 in.
```

Required Nozzle thickness under External Pressure per UG-28 : 0.0071 in.

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

```
Parallel to Vessel Wall (Diameter Limit)            Dl     3.8740  in.
Parallel to Vessel Wall, opening length              d     1.9370  in.
Normal to Vessel Wall (Thickness Limit), no pad   Tlnp     0.5475  in.
```

Taking a UG-36(c)(3)(a) exemption for nozzle: Drain.
This calculation is valid for nozzles that meet all the requirements of paragraph UG-36. Please check the Code carefully, especially for nozzles that are not isolated or do not meet Code spacing requirements. To force the computation of areas for small nozzles go to Tools->Configuration and check the box to force the UG-37 small nozzle area calculation.

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

```
Wall Thickness for Internal/External pressures      ta = 0.1321 in.
Wall Thickness per UG16(b),                      tr16b = 0.2188 in.
Wall Thickness, shell/head, internal pressure     trb1 = 0.2761 in.
Wall Thickness             tb1 = max(trb1, tr16b) = 0.2761 in.
Wall Thickness, shell/head, external pressure     trb2 = 0.1476 in.
Wall Thickness             tb2 = max(trb2, tr16b) = 0.2188 in.
Wall Thickness per table UG-45                     tb3 = 0.2596 in.
```

Determine Nozzle Thickness candidate [tb]:

```
= min[ tb3, max( tb1,tb2) ]
= min[ 0.26, max( 0.276, 0.219 ) ]
= 0.2596 in.
```

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

```
= max( ta, tb )
= max( 0.132, 0.26 )
= 0.2596 in.
```

Available Nozzle Neck Thickness = 0.875 * 0.344 = 0.301 in. -> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld, Curve: B

Govrn. thk, tg = 0.301, tr = 0.00568, c = 0.125 in., E∗ = 1
Thickness Ratio = tr * E∗/(tg - c) = 0.0323, Temp. Reduction = 140 F

```
Min Metal Temp. w/o impact per UCS-66, Curve B           -20 F
Min Metal Temp. at Required thickness (UCS 66.1)         -155 F
```

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

Govrn. thk, tg = 0.301, tr = 0.00568, c = 0.125 in., E∗ = 1
Thickness Ratio = tr * E∗/(tg - c) = 0.0323, Temp. Reduction = 140 F

```
Min Metal Temp. w/o impact per UCS-66, Curve B           -20 F
Min Metal Temp. at Required thickness (UCS 66.1)         -155 F

Gov. MDMT of the nozzle to shell joint welded assembly :  -155 F
```

Flange MDMT including Temperature reduction per UCS-66.1:

```
Unadjusted MDMT of ASME B16.5/47 flanges per UCS-66(c)     0 F
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b)     -55 F
```

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :
Design Pressure/Ambient Rating = 100.00/285.00 = 0.351

Weld Size Calculations, Description: Drain

```
Intermediate Calc. for nozzle/shell Welds   Tmin     0.2190  in.
```

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	0.1533 = 0.7 * tmin.	0.2651 = 0.7 * Wo in.

Skipping the nozzle attachment weld strength calculations. Per UW-15(b)(2) the nozzles exempted by UG-36(c)(3)(a) (small nozzles) do not require a weld strength check.

The Drop for this Nozzle is : 0.0235 in.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 2.6485 in.

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Input, Nozzle Desc: Inlet From: 30

```
Pressure for Reinforcement Calculations        P      100.000  psig
Temperature for Internal Pressure           Temp          200  F
Design External Pressure                    Pext        15.00  psig
Temperature for External Pressure         Tempex          200  F

Parent Material                                    SA-516 70
Parent Allowable Stress at Temperature        Sv     20000.00  psi
Parent Allowable Stress At Ambient           Sva     20000.00  psi

Inside Diameter of Elliptical Head             D      60.0000  in.
Aspect Ratio of Elliptical Head               Ar         2.00
Head Finished (Minimum) Thickness              t       0.6250  in.
Head Internal Corrosion Allowance              c       0.1250  in.
Head External Corrosion Allowance             co       0.0000  in.

Distance from Head Centerline                 L1       0.0000  in.

User Entered Minimum Design Metal Temperature          -20.00  F
```

Type of Element Connected to the Parent : Nozzle

```
Material                                             SA-106 B
Material UNS Number                                    K03006
Material Specification/Type                        Smls. pipe
Allowable Stress at Temperature               Sn     17100.00  psi
Allowable Stress At Ambient                  Sna     17100.00  psi

Diameter Basis (for tr calc only)                      Inside
Layout Angle                                             0.00  deg
Diameter                                               4.0000  in.

Size and Thickness Basis                              Nominal
Nominal Thickness                                         120

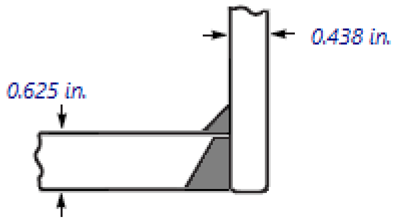
Flange Material                                        SA-105
Flange Type                                 Weld Neck Flange

Corrosion Allowance                          can       0.1250  in.
Joint Efficiency of Shell Seam at Nozzle      E1         1.00
Joint Efficiency of Nozzle Neck               En         1.00

Outside Projection                            ho       2.0000  in.
Weld leg size between Nozzle and Pad/Shell    Wo       0.3750  in.
Groove weld depth between Nozzle and Vessel Wgnv       0.6250  in.
Inside Projection                              h       0.0000  in.
Weld leg size, Inside Element to Shell        Wi       0.0000  in.

Flange Class                                              150
Flange Grade                                           GR 1.1
```

The Pressure Design option was Design Pressure + static head.



Reinforcement CALCULATION, Description: Inlet

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

```
 Actual Inside Diameter Used in Calculation              3.624  in.
 Actual Thickness Used in Calculation                    0.438  in.
```

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Elliptical Head, tr [Int. Press]
```
  = P*D*K1/(2*Sv*E-0.2*P) per Appendix 1-4(c)
  = 100*60.25*0.9/(2*20000*1-0.2*100)
  = 0.1356 in.
```

Reqd thk per UG-37(a) of Nozzle Wall, trn [Int. Press]
```
  = P*R/(Sn*E-0.6*P) per UG-27 (c)(1)
  = 100*1.937/(17100*1-0.6*100)
  = 0.0114 in.
```

Required Nozzle thickness under External Pressure per UG-28 : 0.0103 in.

UG-40, Limits of Reinforcement: [Internal Pressure]
```
 Parallel to Vessel Wall (Diameter Limit)            Dl     7.7480  in.
 Parallel to Vessel Wall, opening length              d     3.8740  in.
 Normal to Vessel Wall (Thickness Limit), no pad   Tlnp     0.7825  in.
```

Weld Strength Reduction Factor [fr1]:
```
  = min( 1, Sn/Sv )
  = min( 1, 17100/20000 )
  = 0.855
```

Weld Strength Reduction Factor [fr2]:
```
  = min( 1, Sn/Sv )
  = min( 1, 17100/20000 )
  = 0.855
```

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

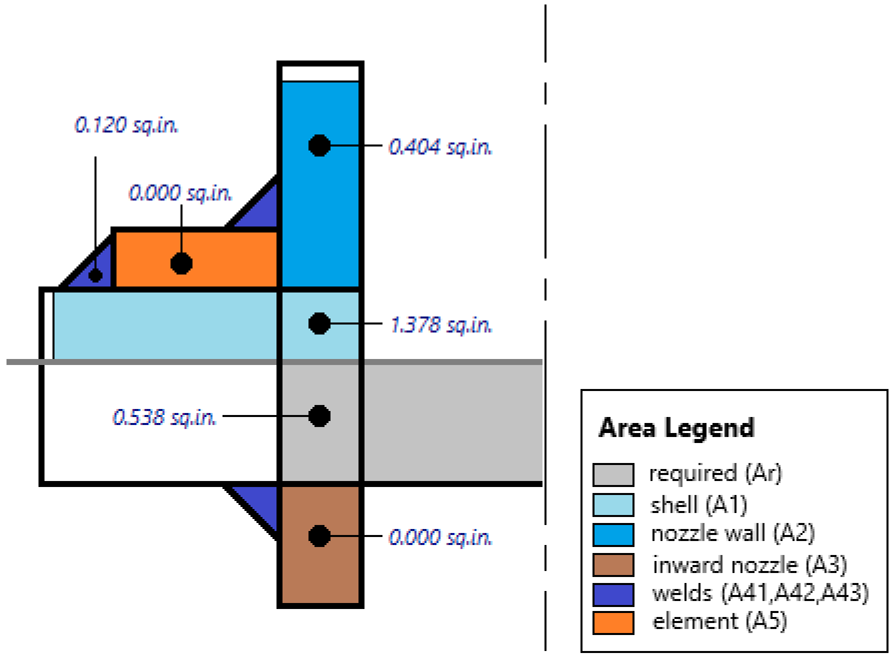


Figure UG 37.1 Nozzle Areas

Results of Nozzle Reinforcement Area Calculations: (sq.in.)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	0.538	0.314	NA
Area in Shell	A1	1.378	1.292	NA
Area in Nozzle Wall	A2	0.404	0.405	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	0.120	0.120	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	1.902	1.817	NA

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 degs.

The area available without a pad is Sufficient.

Area Required [A]:
```
  = ( d * tr*F + 2 * tn * tr*F * (1-fr1) ) UG-37(c)
  = (3.874*0.136*1+2*0.313*0.136*1*(1-0.855))
  = 0.538 sq.in.
```

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:
```
  = d( E1*t - F*tr ) - 2 * tn( E1*t - F*tr ) * ( 1 - fr1 )
  = 3.874 ( 1 * 0.5 - 1 * 0.136 ) - 2 * 0.313
    ( 1 * 0.5 - 1 * 0.136 ) * ( 1 - 0.855 )
  = 1.378 sq.in.
```

Area Available in Nozzle Projecting Outward [A2]:
```
  = ( 2 * tlnp )( tn - trn )fr2
  = ( 2 * 0.782 )( 0.313 - 0.0114 )0.855
```

```
  = 0.404 sq.in.
```

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

```
  = Wo² * fr2 + ( Wi-can/0.707 )² * fr2
  = 0.375² * 0.855 + ( 0 )² * 0.855
  = 0.120 sq.in.
```

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

```
 Wall Thickness for Internal/External pressures      ta = 0.1364 in.
 Wall Thickness per UG16(b),                       tr16b = 0.2188 in.
 Wall Thickness, shell/head, internal pressure     trb1 = 0.2757 in.
 Wall Thickness                 tb1 = max(trb1, tr16b) = 0.2757 in.
 Wall Thickness, shell/head, external pressure     trb2 = 0.1476 in.
 Wall Thickness                 tb2 = max(trb2, tr16b) = 0.2188 in.
 Wall Thickness per table UG-45                     tb3 = 0.3320 in.
```

Determine Nozzle Thickness candidate [tb]:

```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 0.332, max( 0.276, 0.219 ) ]
  = 0.2757 in.
```

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

```
  = max( ta, tb )
  = max( 0.136, 0.276 )
  = 0.2757 in.
```

Available Nozzle Neck Thickness = 0.875 * 0.438 = 0.383 in. -> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld, Curve: B

Govrn. thk, tg = 0.383, tr = 0.0114, c = 0.125 in., E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.044, Temp. Reduction = 140 F

```
 Min Metal Temp. w/o impact per UCS-66, Curve B             -20 F
 Min Metal Temp. at Required thickness (UCS 66.1)          -155 F
```

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

Govrn. thk, tg = 0.383, tr = 0.0114, c = 0.125 in., E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.044, Temp. Reduction = 140 F

```
 Min Metal Temp. w/o impact per UCS-66, Curve B             -20 F
 Min Metal Temp. at Required thickness (UCS 66.1)          -155 F

 Gov. MDMT of the nozzle to shell joint welded assembly :  -155 F
```

Flange MDMT including Temperature reduction per UCS-66.1:

```
 Unadjusted MDMT of ASME B16.5/47 flanges per UCS-66(c)       0 F
 Flange MDMT with Temp reduction per UCS-66(b)(1)(-b)       -55 F
```

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

```
 Design Pressure/Ambient Rating = 100.00/285.00 = 0.351
```

<u>Weld Size Calculations, Description: Inlet</u>

```
 Intermediate Calc. for nozzle/shell Welds   Tmin      0.3130  in.
```

Results Per UW-16.1:

```
                       Required Thickness    Actual Thickness
```

```
 Nozzle Weld          0.2191 = 0.7 * tmin.  0.2651 = 0.7 * Wo in.
```

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

Weld Load [W]:
```
  = max( 0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)
  = max( 0, (0.538 - 1.378 + 2 * 0.313 * 0.855 *
    (1 * 0.5 - 0.136 ) )20000 )
  = max( 0, -12914.60) lb.
```

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

Weld Load [W1]:
```
  = (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
  = ( 0.404 + 0 + 0.12 - 0 * 0.855 ) * 20000
  = 10476.83 lb.
```

Weld Load [W2]:
```
  = (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
  = ( 0.404 + 0 + 0.12 + ( 0.268 ) ) * 20000
  = 15829.13 lb.
```

Weld Load [W3]:
```
  = (A2+A3+A4+A5+(2*tn*t*fr1))*S
  = ( 0.404 + 0 + 0.12 + 0 + ( 0.268 ) ) * 20000
  = 15829.13 lb.
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:
```
  = (pi/2) * Dlo * Wo * 0.49 * Snw
  = ( 3.142/2.0 ) * 4.5 * 0.375 * 0.49 * 17100
  = 22210. lb.
```

Shear, Nozzle Wall [Snw]:
```
  = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
  = (3.142 * 2.094 ) * ( 0.438 - 0.125 ) * 0.7 * 17100
  = 24641. lb.
```

Tension, Shell Groove Weld [Tngw]:
```
  = (pi/2) * Dlo * ( T - cas ) * 0.74 * Sng
  = ( 3.142/2.0 ) * 4.5 * ( 0.625 - 0.125 ) * 0.74 * 20000
  = 52308. lb.
```

See UG-41 and UW-15 for clarification of allowable stresses.

Strength of Failure Paths:

Failure Path [Path 1-1]:
```
  = ( SONW + SNW ) = ( 22210 + 24641 ) = 46852 lb.
```

Failure Path [Path 2-2]:
```
  = ( Sonw + Tpgw + Tngw + Sinw )
  = ( 22210 + 0 + 52308 + 0 ) = 74518 lb.
```

Failure Path [Path 3-3]:
```
  = ( Sonw + Tngw + Sinw )
  = ( 22210 + 52308 + 0 ) = 74518 lb.
```

Summary of Failure Path Calculations:
```
 Path 1-1 = 46851   lb., must exceed W = 0 lb.        or W1 = 10476 lb.
 Path 2-2 = 74517   lb., must exceed W = 0 lb.        or W2 = 15829 lb.
```

Path 3-3 = 74517 lb., must exceed W = 0 lb. or W3 = 15829 lb.

Maximum Allowable Pressure for this Nozzle at this Location:

Converged Maximum Allowable Pressure in the Operating case: 227.8 psig

Nozzle is O.K. for the External Pressure: 15 psig

The Drop for this Nozzle is : 0.0465 in.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 2.6715 in.

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