Table of Contents

DESIGN CALCULATION

In Accordance with ASME Section VIII Division 1

ASME Code Version : 2017

Analysis Performed by : SPLM Licensed User

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

Date of Analysis : Feb 20,2026 5:10pm

PV Elite 2019 SP1, March 2019

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

```
 Class From To : Basic Element Checks.
 ======================================================================

 Class From To: Check of Additional Element Data
 ======================================================================

 There were no geometry errors or warnings.
```

PV Elite Vessel Analysis Program: Input Data

Design Internal Pressure (for Hydrotest)		0.5	bars
Design Internal Temperature		170.0	°C
Type of Hydrotest		not Specified	
Hydrotest Position		Horizontal	
Projection of Nozzle from Vessel Top		0	mm.
Projection of Nozzle from Vessel Bottom		0	mm.
Minimum Design Metal Temperature		-28.9	°C
Type of Construction		Welded	
Special Service		None	
Degree of Radiography		RT-1	
Use Higher Longitudinal Stresses (Flag)		Y	
Select t for Internal Pressure (Flag)		N	
Select t for External Pressure (Flag)		N	
Select t for Axial Stress (Flag)		N	
Select Location for Stiff. Rings (Flag)		N	
Consider Vortex Shedding		N	
Perform a Corroded Hydrotest		N	
Load Case 1		NP+EW+WI+FW+BW	
Load Case 2		NP+EW+EE+FS+BS	
Load Case 3		NP+OW+WI+FW+BW	
Load Case 4		NP+OW+EQ+FS+BS	
Load Case 5		NP+HW+HI	
Load Case 6		NP+HW+HE	
Load Case 7		IP+OW+WI+FW+BW	
Load Case 8		IP+OW+EQ+FS+BS	
Load Case 9		EP+OW+WI+FW+BW	
Load Case 10		EP+OW+EQ+FS+BS	
Load Case 11		HP+HW+HI	
Load Case 12		HP+HW+HE	
Load Case 13		IP+WE+EW	
Load Case 14		IP+WF+CW	
Load Case 15		IP+VO+OW	
Load Case 16		IP+VE+EW	
Load Case 17		NP+VO+OW	
Load Case 18		FS+BS+IP+OW	
Load Case 19		FS+BS+EP+OW	
Wind Design Code		ASCE-7 93	
Basic Wind Speed	[V]	112.65	Km/hr
Surface Roughness Category		C: Open Terrain	
Importance Factor		1.0	
Type of Surface		Moderately Smooth	
Base Elevation		0	mm.
Percent Wind for Hydrotest		33.0	
Using User defined Wind Press. Vs Elev.		N	
Damping Factor (Beta) for Wind (Ope)		0.0100	
Damping Factor (Beta) for Wind (Empty)		0.0000	
Damping Factor (Beta) for Wind (Filled)		0.0000	
Seismic Design Code		UBC 94	
UBC Seismic Zone (1=1,2=2a,3=2b,4=3,5=4)		0.000	
UBC Importance Factor		1.000	
UBC Soil Type		S1	
UBC Horizontal Force Factor		3.000	
UBC Percent Seismic for Hydrotest		0.000	
Design Pressure + Static Head		Y	
Consider MAP New and Cold in Noz. Design		N	
Consider External Loads for Nozzle Des.		Y	
Use ASME VIII-1 Appendix 1-9		N	

Material Database Year Current w/Addenda or Code Year

Configuration Directives:

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

Complete Listing of Vessel Elements and Details:

Element From Node	10	
Element To Node	20	
Element Type	Cylinder	
Description		
Distance "FROM" to "TO"	50	mm.
Inside Diameter	300	mm.
Element Thickness	3	mm.
Internal Corrosion Allowance	0	mm.
Nominal Thickness	3	mm.
External Corrosion Allowance	0	mm.
Design Internal Pressure	0.5	bars
Design Temperature Internal Pressure	170	°C
Design External Pressure	0.1	bars
Design Temperature External Pressure	50	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-240 316	
Allowable Stress, Ambient	137.9	N./mm²
Allowable Stress, Operating	136.07	N./mm²
Allowable Stress, Hydrotest	179.27	N./mm²
Material Density	0.008027	kg./cm³
P Number Thickness	0	mm.
Yield Stress, Operating	156.11	N./mm²
External Pressure Chart Name	HA-2	
UNS Number	S31600	
Product Form	Plate	
Efficiency, Longitudinal Seam	1.0	
Efficiency, Circumferential Seam	1.0	
Weld is pre-Heated	No	
Element From Node	10	
Detail Type	Ring	
Detail ID	Ring:[1 of 1]	
Dist. from "FROM" Node / Offset dist	0	mm.
Inside Diameter of Ring	306	mm.
Thickness of Ring	14	mm.
Outside Diameter of Ring	370	mm.
Material Name	SA-240 304	
Height of Section Ring	0	mm.
Using Custom Stiffener Section	No	

Element From Node	20	
Element To Node	40	
Element Type	Conical	
Description		

Distance "FROM" to "TO"	2000	mm.
Inside Diameter	300	mm.
Element Thickness	3	mm.
Internal Corrosion Allowance	0	mm.
Nominal Thickness	3	mm.
External Corrosion Allowance	0	mm.
Design Internal Pressure	0.5	bars
Design Temperature Internal Pressure	170	°C
Design External Pressure	0.1	bars
Design Temperature External Pressure	50	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-240 316	
Efficiency, Longitudinal Seam	1.0	
Efficiency, Circumferential Seam	1.0	
Cone Diameter at "To" End	1920	mm.
Design Length of Cone	2000	mm.
Half Apex Angle of Cone	22.047947	degrees
Toriconical (Y/N)	N	
Weld is pre-Heated	No	

Element From Node	20	
Detail Type	Ring	
Detail ID	Flange -1	
Dist. from "FROM" Node / Offset dist	1983	mm.
Inside Diameter of Ring	1912.2	mm.
Thickness of Ring	12	mm.
Outside Diameter of Ring	2020.9	mm.
Material Name	SA-240 304	
Height of Section Ring	0	mm.
Using Custom Stiffener Section	No	

XY Coordinate Calculations:

From	To	X (Horiz.) mm.	Y (Vert.) mm.	DX (Horiz.) mm.	DY (Vert.) mm.
10	20	...	50	...	50
20	40	...	2050	...	2000

Element Thickness, Pressure, Diameter and Allowable Stress :

From	To	Int. Press + Liq. Hd bars	Nominal Thickness mm.	Total Corr Allowance mm.	Element Diameter mm.	Allowable Stress(SE) N./mm²
10	20	0.5	3	...	300	136.07
20	40	0.5	3	...	1920	136.07

Element Required Thickness and MAWP :

From	To	Design Pressure bars	M.A.W.P. Corroded bars	M.A.P. New & Cold bars	Minimum Thickness mm.	Required Thickness mm.
10	20	0.5	26.8892	27.2514	3	1.5
20	40	0.5	3.93408	3.98707	3	1.5
Minimum			3.934	3.987		

MAWP: 3.934 bars, limited by: Cone.

Internal Pressure Calculation Results :

ASME Code, Section VIII Division 1, 2017

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

Material UNS Number: S31600

Required Thickness due to Internal Pressure [tr]:
= (P*R)/(S*E-0.6*P) per UG-27 (c)(1)
= (0.5*150.0)/(136.07*1.0-0.6*0.5)
= 0.0551 + 0.0000 = 0.0551 mm.

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

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
= (S*E*t)/(R+0.6*t) per UG-27 (c)(1)
= (136.07*1.0*3.0)/(150.0+0.6*3.0)
= 26.889 bars

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (S*E*t)/(R+0.6*t) per UG-27 (c)(1)
= (137.9*1.0*3.0)/(150.0+0.6*3.0)
= 27.251 bars

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(R+0.6*t))/(E*t)
= (0.5*(150.0+0.6*3.0))/(1.0*3.0)
= 2.530 N./mm²

% Elongation per Table UG-79-1 (50*tnom/Rf)*(1-Rf/Ro) 0.990 %
Note: Please Check Requirements of Table UHA-44 for Elongation limits.

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

Conical Section From 20 To 40 SA-240 316 at 170 °C

Material UNS Number: S31600

Required Thickness due to Internal Pressure [tr]:
= (P*D)/(2*cos(a)*(S*E-0.6*P)) per Appendix 1-4 (e)
= (0.5*1920.0)/(2*0.9269*(136.07*1.0-0.6*0.5))
= 0.3807 + 0.0000 = 0.3807 mm.

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

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
= (2*S*E*t*cos(a))/(D+1.2*t*cos(a)) per App 1-4(e)
= (2*136.07*1.0*3.0*0.927)/(1920.0+1.2*3.0*0.927)
= 3.934 bars

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (2*S*E*t*cos(a))/(D+1.2*t*cos(a)) per App 1-4(e)
= (2*137.9*1.0*3.0*0.9269)/(1920.0+1.2*3.0*0.9269)
= 3.987 bars

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(D+1.2*t*cos(a)))/(2*E*t*cos(a))
= (0.5*(1920.0+1.2*3.0*0.9269))/(2*1.0*3.0*0.9269)
= 17.293 N./mm²

% Elongation per Table UG-79-1 (50*tnom/Rf)*(1-Rf/Ro) 0.989 %
Note: Please Check Requirements of Table UHA-44 for Elongation limits.

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

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

Elements Suitable for Internal Pressure.

External Pressure Calculation Results :

External Pressure Calculations:

From	To	Section Length mm.	Outside Diameter mm.	Corroded Thickness mm.	Factor A	Factor B N./mm²
10	Ring	No Calc	...	3	No Calc	No Calc
Ring	20	50	306	3	0.01054	99.0623
20	Ring	1150.16	1912.7	3	0.00012505	12.0049
Ring	40	16.9392	1926.47	3	0.0021617	81.3491

External Pressure Calculations:

From	To	External Actual T. mm.	External Required T. mm.	External Design Pressure bars	External M.A.W.P. bars
10	Ring	3	No Calc	0.1	No Calc
Ring	20	3	0.18486	0.1	12.9486
20	Ring	3	2.15271	0.1	0.23268
Ring	40	3	0.75209	0.1	1.56547
Minimum					0.233

External Pressure Calculations:

From	To	Actual Length Bet. Stiffeners mm.	Allowable Length Bet. Stiffeners mm.	Ring Inertia Required cm**4	Ring Inertia Available cm**4
10	Ring	No Calc	No Calc	No Calc	No Calc
Ring	20	50	5133.63	0.00051345	6.33378
20	Ring	1150.16	1150.16	No Calc	No Calc
Ring	40	16.9392	16.9392	2.92476	30.9459

Elements Suitable for External Pressure.

ASME Code, Section VIII Division 1, 2017

Cone From 20 to Flange -1 Ext. Chart: HA-2 at 50 °C

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

Results for Maximum Allowable External Pressure (MAEP):

Tca	OD	SLEN	D/t	L/D	Factor A	B
2.781	1912.70	1150.16	687.87	0.6013	0.0001251	12.00

EMAP = (4*B)/(3*(D/t)) = (4*12.0049)/(3*687.8719) = 0.2327 bars

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

Results for Required Thickness (Tca):

Tca	OD	SLEN	D/t	L/D	Factor A	B
1.995	1912.70	1150.16	958.61	0.6013	0.0000749	7.19

EMAP = (4*B)/(3*(D/t)) = (4*7.1904)/(3*958.6123) = 0.1 bars

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

Cone From Flange -1 to the end: Ext. Chart: HA-2 at 50 °C

Stiffening Ring Calcs for : Ring:[1 of 1] , SA-240 304 , Bar Ring: 32 x 14 mm.

Effective Length of Shell: 33 mm.

	Area (cm²)	Distance (mm.)	Area*Dist
Shell:	1.000	1.5000	1.500
Ring :	4.480	19.0000	85.120
Total:	5.480		86.620

Centroid of Ring plus Shell: 16 mm.

	Inertia	Distance	A*Dist²
Shell:	0.007	14.3070	204.659
Ring :	3.823	-3.1930	45.676
Total:	3.830		250.335

Available Moment of Inertia, Ring plus Shell: 6 cm**4

Required Stress in Ring plus Shell Breq 0.11 N./mm²
Required Strain in Ring plus Shell Areq 0.0000011

Required Moment of Inertia, Ring plus Shell:
= (OD² * Slen(Tca + Aring/Slen)Areq)/10.9
= (306.0²*25.0(3.0+4.48/25.0)0.000001)/10.9
= 0 cm**4

Stiffening Ring Calcs for : Flange -1 , SA-240 304 , Bar Ring: 54 x 12 mm.

Effective Length of Shell: 83 mm.

	Area (cm²)	Distance (mm.)	Area*Dist
Shell:	2.499	1.5000	3.749
Ring :	6.523	30.1800	196.870
Total:	9.023		200.619

Centroid of Ring plus Shell: 22 mm.

	Inertia	Distance	A*Dist²
Shell:	0.019	20.7351	1074.620
Ring :	16.063	-7.9449	411.755
Total:	16.082		1486.376

Available Moment of Inertia, Ring plus Shell: 31 cm**4

Required Stress in Ring plus Shell Breq 3.48 N./mm²
Required Strain in Ring plus Shell Areq 0.0000363

Required Moment of Inertia, Ring plus Shell:
= (OD² * Slen(Tca + Aring/Slen)Areq)/10.9
= (1912.2301²*583.5508(3.0+6.5232/583.5508)0.000036)/10.9
= 3 cm**4

Element and Detail Weights:

From	To	Element Metal Wgt. kg.	Element ID Volume Cm.	Corroded Metal Wgt. kg.	Corroded ID Volume Cm.	Extra due Misc % kg.
10	20	1.14618	3534.92	1.14618	3534.92	...
20	40	181.738	2279319	181.738	2279319	...
Total		182	2282854.50	182	2282854.50	0

Weight of Details:

From	Type	Weight of Detail kg.	X Offset, Dtl. Cent. mm.	Y Offset, Dtl. Cent. mm.	Description
10	Ring	3.81869	...	...	Ring:[1 of 1]
20	Ring	32.3515	...	1983	Flange -1

Total Weight of Each Detail Type:

Stiffeners	36.2
Sum of the Detail Weights	36.2 kg.

Weight Summation Results: (kg.)

	Fabricated	Shop Test	Shipping	Erected	Empty	Operating
Main Elements	182.9	182.9	182.9	182.9	182.9	182.9
Stif. Rings	36.2	36.2	36.2	36.2	36.2	36.2
Test Liquid	...	2281.5	...	...	...	...
Totals	219.1	2500.5	219.1	219.1	219.1	219.1

Weight Summary:

Fabricated Wt.	- Bare Weight without Removable Internals	219.1 kg.
Shop Test Wt.	- Fabricated Weight + Water (Full)	2500.5 kg.
Shipping Wt.	- Fab. Weight + removable Intls.+ Shipping App.	219.1 kg.
Erected Wt.	- Fab. Wt + or - loose items (trays,platforms etc.)	219.1 kg.
Ope. Wt. no Liq	- Fab. Weight + Internals. + Details + Weights	219.1 kg.
Operating Wt.	- Empty Weight + Operating Liq. Uncorroded	219.1 kg.
Field Test Wt.	- Empty Weight + Water (Full)	2500.5 kg.
Mass of the Upper 1/3 of the Vertical Vessel		94.4 kg.

Outside Surface Areas of Elements:

From	To	Surface Area cm²
10	20	480.664
20	40	75684.9
Total		76165.602 cm²

Element and Detail Weights:

From	To	Total Ele. Empty Wgt. kg.	Total. Ele. Oper. Wgt. kg.	Total. Ele. Hydro. Wgt. kg.	Total Dtl. Offset Mom. Kg-m.	Oper. Wgt. No Liquid kg.

10	20	4.96487	4.96487	4.96487	...	4.96487
20	40	214.09	214.09	214.09	...	214.09

Cumulative Vessel Weight

From	To	Cumulative Ope Wgt. No Liquid kg.	Cumulative Oper. Wgt. kg.	Cumulative Hydro. Wgt. kg.
10	20	219.055	219.055	219.055
20	40	214.09	214.09	214.09

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

Cumulative Vessel Moment

From	To	Cumulative Empty Mom. Kg-m.	Cumulative Oper. Mom. Kg-m.	Cumulative Hydro. Mom. Kg-m.
10	20	...	...	...
20	40	...	...	...

Shop/Field Installation Options :

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

Center of Gravity of Stiffening Rings	1818.365 mm.
Center of Gravity of Bare Shell New and Cold	1285.295 mm.
Center of Gravity of Bare Shell Corroded	1285.295 mm.
Vessel CG in the Operating Condition	1373.315 mm.
Vessel CG in the Fabricated (Shop/Empty) Condition	1373.315 mm.

Minimum Design Metal Temperature Results Summary :

Description	Curve Notes	Basic MDMT °C	Reduced MDMT °C	UG-20(f) MDMT °C	Thickness ratio	Gov Thk mm.	E*	PWHT reqd
	[16]	-196						
	[16]	-196						
Warmest MDMT:		-196						

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

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

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

Notes:
Impact test temps were not entered in and not considered in the analysis.
UCS-66(i) applies to impact tested materials not by specification and
UCS-66(g) applies to materials impact tested per UG-84.1 General Note (c).
The Basic MDMT includes the (30F) PWHT credit if applicable.

ASME Code, Section VIII Division 1, 2017

Diameter Spec : 300.000 mm. ID		
Vessel Design Length, Tangent to Tangent	2050.00	mm.
Distance of Bottom Tangent above Grade	50.00	mm.
Distance of Base above Grade	0.00	mm.
Specified Datum Line Distance	0.00	mm.
Internal Design Temperature	170	°C
Internal Design Pressure	0.500	bars
External Design Temperature	50	°C
External Design Pressure	0.100	bars
Maximum Allowable Working Pressure	3.934	bars
External Max. Allowable Working Pressure	0.233	bars
Hydrostatic Test Pressure	0.000	bars
Required Minimum Design Metal Temperature	-28.9	°C
Warmest Computed Minimum Design Metal Temperature	-196.0	°C
Wind Design Code	ASCE-93	
Earthquake Design Code	UBC-94	

Materials of Construction:

Component Type	Material	Class	Thickness	UNS #	Normalized	Impact Tested
Shell	SA-240 316	...	...	S31600	No	No
Cone	SA-240 316	...	...	S31600	No	No
Rings	SA-240 304	...	...	S30400	No	No

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

Element Pressures and MAWP (bars & mm.):

Element Description or Type	Design Pressure + Stat. head	Ext. Press.	Element M.A.W.P	Corrosion Allowance	Str. Flg. Gov.	In Creep Range
Cylinder	0.500	0.10	26.889	0.0000	N/A	No
Conical	0.500	0.10	3.934	0.0000	N/A	No

Stiffener Ring Specifications:

Elevation mm.	Selected Type	User Description
0.00	Bar 32.0 x 14.	Ring:[1 of 1]
2033.00	Bar 54.4 x 12.	Flange -1

Element Types and Properties:

Element Type	"To" Elev mm.	Element Length mm.	Nominal Thickness mm.	Finished Thickness mm.	Reqd Thk Internal mm.	Reqd Thk External mm.	Long Eff	Circ Eff
Cylinder	50.0	50.0	3.0	3.0	1.5	...	1.00	1.00
Conical	2050.0	2000.0	3.0	3.0	1.5	...	1.00	1.00

External Pressure Calculations:

From	To	External Actual T.	External Required T.	External Design Pressure	External M.A.W.P.

		mm.	mm.	bars	bars
10	Ring	3	No Calc	0.1	No Calc
Ring	20	3	0.18486	0.1	12.9486
20	Ring	3	2.15271	0.1	0.23268
Ring	40	3	0.75209	0.1	1.56547

External Pressure Calculations:

From	To	Actual Length Bet. Stiffeners mm.	Allowable Length Bet. Stiffeners mm.	Ring Inertia Required cm**4	Ring Inertia Available cm**4
10	Ring	No Calc	No Calc	No Calc	No Calc
Ring	20	50	5133.63	0.00051345	6.33378
20	Ring	1150.16	1150.16	No Calc	No Calc
Ring	40	16.9392	16.9392	2.92476	30.9459

Factored Loads:

Un-Factored Loads:

Weights:

Fabricated	- Bare W/O Removable Internals	219.1	kg.
Shop Test	- Fabricated + Water (Full)	2500.5	kg.
Shipping	- Fab. + Rem. Intls.+ Shipping App.	219.1	kg.
Erected	- Fab. + Rem. Intls.+ Insul. (etc)	219.1	kg.
Empty	- Fab. + Intls. + Details + Wghts.	219.1	kg.
Operating	- Empty + Operating Liquid (No CA)	219.1	kg.
Field Test	- Empty Weight + Water (Full)	2500.5	kg.