Base Load Power Hub (BLPH)

INSTRUMENT AIR PACKAGE
AIR RECEIVER CALCULATION

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COES

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DESIGN CALCULATION

In Accordance with ASME Section VIII Division 1

ASME Code Version : 2023

Analysis Performed by : Coes S.r.l.

Job File : ...\Air Receiver R2.pvdb

Date of Analysis : Apr 2,2025 4:53pm

PV Elite 26 SP1, March 2024

Vessel Design Summary:

ASME Code, Section VIII Division 1, 2023

Diameter Spec : 2500.000 mm OD		
Vessel Design Length, Tangent to Tangent	4020.00	mm
Distance of Bottom Tangent above Grade	0.00	mm
Specified Datum Line Distance	60.00	mm
Internal Design Temperature	90	°C
Internal Design Pressure	12.000	barg
External Design Temperature	0	°C
Maximum Allowable Working Pressure	14.14	barg
Shop Test Pressure	17.160	barg
Required Minimum Design Metal Temperature	-29.0	°C
Warmest Computed Minimum Design Metal Temperature	-29.0	°C
Wind Design Code	Euro Code	
Earthquake Design Code	G-Loading	

Materials of Construction:

Component Type	Material	Class	Thickness	UNS #	Normalized	Impact Tested
Shell	SA-516 70	...	...	K02700	No	Yes
Head	SA-516 70	...	...	K02700	No	Yes
Nozzle	SA-333 6	...	...	K03006	No	Yes
Nozzle	SA-350 LF2	1	...	K03011	No	Yes
Nozzle	SA-516 70	...	...	K02700	No	No
Re-Pad	SA-516 70	...	...	K02700	No	No
Nozzle Flg	SA-350 LF2	1	...	K03011	No	Yes
Leg Baseplate	SA-516 70	...	...	K02700	No	No
Leg Bolting	SA-307 B	...	...		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 (barg & mm):

Element Description or Type	Design Pressure + Stat. head	Ext. Press.	Element M.A.W.P	Total Corrosion Allowance	Str. Flg. Gov.	In Creep Range
Ellipse	12.600	0.00	14.800	1.5000	No	No
Cylinder	12.600	0.00	14.810	1.5000	N/A	No
Cylinder	12.600	0.00	14.810	1.5000	N/A	No
Ellipse	12.600	0.00	14.800	1.5000	No	No

Element Types and Properties:

Element Type	"To" Elev mm	Element Length mm	Nominal Thickness mm	Finished Thickness mm	Reqd Thk Internal mm	Reqd Thk External mm	Long Eff	Circ Eff
Ellipse	0.0	60.0	18.0	15.3	12.8	...	1.00	0.85

Cylinder	1950.0	1950.0	18.0	17.9	14.9	...	0.85	0.85
Cylinder	3900.0	1950.0	18.0	17.9	14.9	...	0.85	0.85
Ellipse	3960.0	60.0	18.0	15.3	12.8	...	1.00	0.85

Loads for Foundation/Support Design:

Total Wind Shear on top of all Legs	2319.	kgf
Total Earthquake Shear on top of all Legs	4809.	kgf
Total Wind Moment at top of all Legs	3977.	kgm
Total Earthquake Moment at top of all Legs	7473.	kgm
Wind Load Case Test Moment on Support	1313.	kgm
Test Case Wind Shear on Support	765.	kgf
Max. Wind Shear on one Leg (top & bottom)	858.	kgf
Max. Earthq. Shear on one Leg (top & bottom)	1778.	kgf
Max. Wind Moment at base of one Leg	1235.	kgm
Max. Earthquake Moment at base of one Leg	2560.	kgm
Max. Vertical Load (Wt. + Wind) on one Leg	3179.	kgf
Max. Vertical Load (Wt. + Eq.) on one Leg	4463.	kgf

For the Pressure Test Case:

Max. Wind Shear on one Leg (top & bottom)	283.	kgf
Max. Wind Moment at base of one Leg	407.	kgm
Max. Vertical Load (Wt. + Wind) on one Leg	8114.	kgf
Max. Vertical Load (Wt. + Eq.) on one Leg	7632.	kgf

The Wind and Seismic loads were not load factored in this analysis.

Wind and Earthquake moments include the effects of user defined forces and moments if any exist in the job and were specified to act (compute loads and stresses) during these cases. Also included are moment effects due to eccentric weights if any are present in the input.

Local Stress Analysis Results:

Description	Analysis Type	Max Stress Ratio	High Stress Location	Pass Fail
Trunnion	WRC-107/537	0.053	n/a	Passed
LEGS	WRC-107/537	0.661	n/a	Passed
LEGS	WRC-107/537	0.568	n/a	Passed

Weights:

Fabricated	- Bare W/O Removable Internals	7419.1	kg
Shop Test	- Fabricated + Water (Full)	30527.4	kg
Shipping	- Fab. + Rem. Intls.+ Shipping App.	7419.1	kg
Erected	- Fab. + Rem. Intls.+ Insul. (etc)	7419.1	kg
Empty	- Fab. + Intls. + Details + Wghts.	7419.1	kg
Operating	- Empty + Operating Liquid (No CA)	7419.1	kg
Field Test	- Empty Weight + Water (Full)	30527.4	kg

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Nozzle Calculation Summary (barg & mm):

Description	MAWP	Ext	MAPNC	UG-45	[tr]	Weld Path	Areas or Stresses
Drain	14.8	...	...	OK	4.45	OK	No Calc[*]
PG	14.81	...	...	OK	4.62	OK	No Calc[*]
PT	14.81	...	...	OK	4.62	OK	No Calc[*]
TG	14.81	...	...	OK	4.72	OK	No Calc[*]
TT	14.81	...	...	OK	4.72	OK	No Calc[*]
IN/OUT	14.81	...	...	OK	4.92	OK	No Calc[*]
MAN HOLE	14.14	...	...	...		OK	Passed
Vent	14.8	...	...	OK	4.45	OK	No Calc[*]
PSV	14.8	...	...	OK	6.30	OK	Passed

Nozzle MAWP Summary:

Minimum MAWP Nozzles	:	14.14 Nozzle	: MAN HOLE
Minimum MAWP Shells/Flanges	:	14.14 Element	:
Minimum MAPnc Shells/Flanges	:	16.83 Element	:
Computed Vessel M.A.W.P.	:	14.14 barg	

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

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

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	Y Coordinate mm	Layout Angle deg	Dia. Limit mm
10	Drain	0.000	0.000	61.001
20	PG	360.000	-15.000	70.800
20	PT	1060.000	15.000	70.800
20	TG	360.000	15.000	80.960
20	TT	1060.000	-15.000	80.960
20	IN/OUT	360.000	180.000	93.025
20	MAN HOLE	560.000	270.000	1153.200
50	Vent	0.000	0.000	61.001
50	PSV	0.000	0.000	122.840

The nozzle spacing is computed by the following:

= sqrt(ll² + lc²) 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 mm	Reinforcing Pad Diameter	Reinforcing Pad Thk mm	Cut Length mm	Flg Class
Drain	1.000 in	XXS	WNF	1.315	9.093	...	...	115.36	150
Vent	1.000 in	XXS	WNF	1.315	9.093	...	...	115.36	150
PG	1.500 in	Actual	None	1.500	8.382	...	...	50.77	...
PT	1.500 in	Actual	None	1.500	8.382	...	...	50.77	...
TG	1.500 in	160	WNF	1.900	7.137	...	...	93.09	150
TT	1.500 in	160	WNF	1.900	7.137	...	...	93.09	150
IN/OUT	2.000 in	160	WNF	2.375	8.738	...	...	50.99	150
PSV	3.000 in	XXS	WNF	3.500	15.240	...	...	126.38	150
MAN HOLE	24.000 in	Actual	WNF	24.000	18.000	810.00	18.00	131.15	150

General Notes for the above table:

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

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

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

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

Description	Material	Shl Grve Weld	Noz Shl/Pad Weld	Pad OD Weld	Pad Grve Weld	Inside Weld
Drain	SA-333 6	12.750	10.000	...	...	...
Vent	SA-333 6	12.750	10.000	...	...	...
PG	SA-350 LF2	14.850	10.000	...	...	...
PT	SA-350 LF2	14.850	10.000	...	...	...
TG	SA-333 6	14.850	10.000	...	...	...
TT	SA-333 6	14.850	10.000	...	...	...
IN/OUT	SA-333 6	14.850	10.000	...	...	...
PSV	SA-333 6	12.750	9.000	...	...	...
MAN HOLE	SA-516 70	14.850	15.000	18.000	18.000	...

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

Nozzle Miscellaneous Data:

Description	Elev/Distance From Datum mm	Layout Angle deg	Proj Outside mm	Proj Inside mm	Installed in Component
Drain	...	0.0	100.00	0.00	Node: 10
Vent	...	0.0	100.00	0.00	Node: 50
PG	300.000	-15.0	32.78	0.00	Node: 20
PT	1000.000	15.0	32.78	0.00	Node: 20
TG	300.000	15.0	75.00	0.00	Node: 20
TT	1000.000	-15.0	75.00	0.00	Node: 20
IN/OUT	300.000	180.0	32.78	0.00	Node: 20
PSV	...	0.0	100.00	0.00	Node: 50
MAN HOLE	500.000	270.0	75.00	0.00	Node: 20

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Bill of Materials:

QTY	DESCRIPTION	MATERIAL
2	ELLIPTICAL HEAD: 2.0 X 1, 18.0mm THK X 2469.4mm ID X 60.0mm	SA-516 70
4	LEGS, SHAPE: HE200B 1440.0mm	...
4	BASEPLATES: 400.0mm X 400.0mm X 40.0mm	SA-516 70
24	BASEPLATE BOLTS: 33.0mm	SA-307 B
4	LEG RE-PADS: 300.000mm X 350.000mm X 18.000mm	SA-516 70
2	TRUNNIONS:	SA-516 70
2	TRUNNION PADS: 320.0mm OD X 219.1mm ID X 18.0mm THK	
1	CLASS 150 GR 1.1, 24.0" BLIND FLANGE(S)	SA-350 LF2
1	CYLINDRICAL SEGMENT 18.0mm THK X 3763.3mm X 1950.0mm	SA-516 70
1	CYLINDRICAL SEGMENT 18.0mm THK X 3741.8mm X 1950.0mm	SA-516 70
1	CYLINDRICAL SEGMENT 18.0mm THK X 236.6mm X 1950.0mm	SA-516 70
1	CYLINDRICAL SEGMENT 18.0mm THK X 3755.5mm X 1950.0mm	SA-516 70
1	CYLINDRICAL SEGMENT 18.0mm THK X 3986.2mm X 1950.0mm	SA-516 70
1	CYLINDRICAL SEGMENT 18.0mm THK X 0.0mm X 1950.0mm	SA-516 70
1	NAMEPLATE	...

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Minimum Design Metal Temperature Results Summary (°C):

Description	Notes	Curve	Basic MDMT	Reduced MDMT	UG-20(f) MDMT	Thickness ratio	Gov Thk mm	E*	PWHT reqd
	[10]	!	-29	-31	-29	0.958	15.300	1.00	No
	[7]	!	-29	-40	-29	0.806	18.000	1.00	No
	[8]	!	-29	-39	-29	0.813	17.850	0.85	No
	[8]	!	-29	-39	-29	0.813	17.850	0.85	No
	[10]	!	-29	-31	-29	0.958	15.300	1.00	No
	[7]	!	-29	-40	-29	0.806	18.000	1.00	No
Drain	[1]	!	-46	-104		0.015	7.957	1.00	No
Nozzle Flg	[5]	!	-46	-65					
PG	[1]	!	-46	-104		0.025	8.382	1.00	No
PT	[1]	!	-46	-104		0.025	8.382	1.00	No
TG	[1]	!	-46	-104		0.054	6.245	1.00	No
Nozzle Flg	[5]	!	-46	-65					
TT	[1]	!	-46	-104		0.054	6.245	1.00	No
Nozzle Flg	[5]	!	-46	-65					
IN/OUT	[1]	!	-46	-104		0.052	7.645	1.00	No
Nozzle Flg	[5]	!	-46	-65					
MAN HOLE	[1]	B	-11	-29	-29	0.693	17.850	1.00	No
Nozzle Flg	[5]	B	-46	-48					
Vent	[1]	!	-46	-104		0.014	7.957	1.00	No
Nozzle Flg	[5]	!	-46	-67					
PSV	[1]	!	-46	-104		0.028	13.335	1.00	No
Nozzle Flg	[5]	!	-46	-65					
Nozl. Bolting	[22]		-48			1.000	63.500	1.00	No
Warmest MDMT:			-11	-29					

Required Minimum Design Metal Temperature -29.0 °C
Warmest Computed Minimum Design Metal Temperature -29.0 °C

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.

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 set of selected units for this analysis.



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.

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Units used in this Analysis (barg_UniCode):

Name	System Unit	Constant	User Unit
Length	Feet	304.8000	mm
Force	Pounds	0.4536	kgf
Mass	Pounds	0.4536	kg
Area	sq. inches	6.4516	cm^2
Moment	ft. lbs.	0.1383	kgm
Stress	lbs./sq.iN	0.0069	N/mm^2
Temperature	Degrees F	0.5556	°C
Pressure	psig	0.0689	barg
Elast. Modulus	lbs./sq.iN	6.8946	kPa
Pipe Density	lbs./cu.iN	0.0277	kg/cm^3
Ins. Density	lbs./cu.ft.	0.1600E-04	kg/cm^3
Fluid Density	lbs./cu.ft.	0.1600E-04	kg/cm^3
Wind Speed	miles/hr	1.6093	km/hr
Tray Weight	lbs./sq.ft.	0.0005	kg/cm^2
Inertia	iN^4	41.6231	cm^4
G Load	G's	1.0000	g's
Wind Load	lbs./sq.ft.	4.8825	kg/m^2
Elevation	Feet	304.8000	mm
Volume	iN^3	16.3900	cm³
Diameter	inches	25.4000	mm
Thickness	inches	25.4000	mm

PV Elite Vessel Analysis Program: Input Data

Design Internal Pressure (for Hydrotest)	12	barg
Design Internal Temperature	90.0	°C
Projection of Nozzle from Vessel Top	0	mm
Projection of Nozzle from Vessel Bottom	0	mm
Minimum Design Metal Temperature	-29.0	°C
Type of Construction	Welded	
Special Service	Air/Water/Steam	
Degree of Radiography	RT-3	
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	1.43 * MAWP (PED)
Pressure Test Position	Vertical
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
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	
Load Case 20	BL+IP+OW	
Wind Design Code	European Code	
Design Wind Speed	144	Km/hr
Seismic Design Code	G Loading	
Seismic Importance Factor	1.000	
G Loading Coefficient Gx	0.000	
G Loading Coefficient Gz	0.700	
G Loading Coefficient Gy	0.000	
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	
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)	No
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 Calculations	Yes

Complete Listing of Vessel Elements and Details:

Element#	1/4	
Element From Node	10	
Element To Node	20	
Element Type	Elliptical	
Description		
Distance "FROM" to "TO"	60	mm
Element Outside Diameter	2500	mm
Element Thickness	15.3	mm
Internal Corrosion Allowance	1.5	mm
Nominal Thickness	18	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	12	barg
Design Temperature Internal Pressure	90	°C
Design External Pressure	0	barg
Design Temperature External Pressure	0	°C
Effective Diameter Multiplier	1.2	

Material Name	SA-516 70 [Impact Tested]	
Allowable Stress, Ambient	137.9	N/mm^2
Allowable Stress, Operating	137.9	N/mm^2
Allowable Stress, Hydrotest	179.3	N/mm^2
Material Density	0.00775	kg/cm^3
P Number Thickness	30.988	mm
Yield Stress, Operating	240.7	N/mm^2
UCS-66 Chart Curve Designation	Impact Tested	
External Pressure Chart Name	CS-2	
UNS Number	K02700	
Product Form	Plate	
Efficiency, Longitudinal Seam	1.0	
Efficiency, Circumferential Seam	0.85	
Elliptical Head Factor	2.0	
Weld is pre-Heated	No	
Element From Node	10	
Detail Type	Nozzle	
Detail ID	Drain	
Dist. from "FROM" Node / Offset dist	0	mm
Nozzle Diameter	1	iN
Nozzle Schedule	XXS	
Nozzle Class	150	
Layout Angle	0.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	1.8274	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-333 6 [Impact Tested]	

Element#	2/4	
Element From Node	20	
Element To Node	40	
Element Type	Cylinder	
Description		
Distance "FROM" to "TO"	1950	mm
Element Outside Diameter	2500	mm
Element Thickness	17.85	mm
Internal Corrosion Allowance	1.5	mm
Nominal Thickness	18	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	12	barg
Design Temperature Internal Pressure	90	°C
Design External Pressure	0	barg
Design Temperature External Pressure	0	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-516 70 [Impact Tested]	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Weld is pre-Heated	No	
Element From Node	20	
Detail Type	Nozzle	
Detail ID	PG	
Dist. from "FROM" Node / Offset dist	300	mm
Nozzle Diameter	1.5	iN
Nozzle Schedule	None	
Nozzle Class	None	
Layout Angle	-15.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0.2889	kgf
Grade of Attached Flange	None	
Nozzle Matl	SA-350 LF2 [Impact Tested]	

Element From Node	20	
Detail Type	Nozzle	
Detail ID	PT	
Dist. from "FROM" Node / Offset dist	1000	mm
Nozzle Diameter	1.5	iN
Nozzle Schedule	None	
Nozzle Class	None	
Layout Angle	15.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0.2889	kgf
Grade of Attached Flange	None	
Nozzle Matl	SA-350 LF2 [Impact Tested]	

Element From Node	20	
Detail Type	Nozzle	
Detail ID	TG	
Dist. from "FROM" Node / Offset dist	300	mm
Nozzle Diameter	1.5	iN
Nozzle Schedule	160	
Nozzle Class	150	
Layout Angle	15.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	2.9477	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-333 6 [Impact Tested]	

Element From Node	20	
Detail Type	Nozzle	
Detail ID	TT	
Dist. from "FROM" Node / Offset dist	1000	mm
Nozzle Diameter	1.5	iN
Nozzle Schedule	160	
Nozzle Class	150	
Layout Angle	-15.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0.6421	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-333 6 [Impact Tested]	

Element From Node	20	
Detail Type	Nozzle	
Detail ID	IN/OUT	
Dist. from "FROM" Node / Offset dist	300	mm
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	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-333 6 [Impact Tested]	

Element From Node	20	
Detail Type	Nozzle	
Detail ID	MAN HOLE	
Dist. from "FROM" Node / Offset dist	500	mm
Nozzle Diameter	24	iN
Nozzle Schedule	None	
Nozzle Class	150	
Layout Angle	270.0	
Blind Flange (Y/N)	Y	
Weight of Nozzle (Used if > 0)	373.42	kgf
Grade of Attached Flange	GR 1.1	

Nozzle Matl	SA-516 70	
Element From Node	20	
Detail Type	Leg	
Detail ID	LEGS	
Dist. from "FROM" Node / Offset dist	350	mm
Diameter at Leg Centerline	2722	mm
Leg Orientation	2	
Number of Legs	4	
Section Identifier	HE200B	
Length of Legs	1440	mm

Element#	3/4	
Element From Node	40	
Element To Node	50	
Element Type	Cylinder	
Description		
Distance "FROM" to "TO"	1950	mm
Element Outside Diameter	2500	mm
Element Thickness	17.85	mm
Internal Corrosion Allowance	1.5	mm
Nominal Thickness	18	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	12	barg
Design Temperature Internal Pressure	90	°C
Design External Pressure	0	barg
Design Temperature External Pressure	0	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-516 70 [Impact Tested]	
Efficiency, Longitudinal Seam	0.85	
Efficiency, Circumferential Seam	0.85	
Weld is pre-Heated	No	

Element#	4/4	
Element From Node	50	
Element To Node	60	
Element Type	Elliptical	
Description		
Distance "FROM" to "TO"	60	mm
Element Outside Diameter	2500	mm
Element Thickness	15.3	mm
Internal Corrosion Allowance	1.5	mm
Nominal Thickness	18	mm
External Corrosion Allowance	0	mm
Design Internal Pressure	12	barg
Design Temperature Internal Pressure	90	°C
Design External Pressure	0	barg
Design Temperature External Pressure	0	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-516 70 [Impact Tested]	
Efficiency, Longitudinal Seam	1.0	
Efficiency, Circumferential Seam	0.85	
Elliptical Head Factor	2.0	
Weld is pre-Heated	No	

Element From Node	50	
Detail Type	Nozzle	
Detail ID	Vent	
Dist. from "FROM" Node / Offset dist	0	mm
Nozzle Diameter	1	iN

Nozzle Schedule	XXS	
Nozzle Class	150	
Layout Angle	0.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	1.8274	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-333 6 [Impact Tested]	
Element From Node	50	
Detail Type	Nozzle	
Detail ID	PSV	
Dist. from "FROM" Node / Offset dist	500	mm
Nozzle Diameter	3	iN
Nozzle Schedule	XXS	
Nozzle Class	150	
Layout Angle	0.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	9.0928	kgf
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-333 6 [Impact Tested]	

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XY Coordinate Calculations:

From	To	X (Horiz.) mm	Y (Vert.) mm	DX (Horiz.) mm	DY (Vert.) mm
10	20	...	60	...	60
20	40	...	2010	...	1950
40	50	...	3960	...	1950
50	60	...	4020	...	60

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 barg	Nominal Thickness mm	Total Corr Allowance mm	Element Diameter mm	Allowable Stress(SE) N/mm^2	Element#
10	20	12.6	18	1.5	2500	137.9	1
20	40	12.6	18	1.5	2500	117.21	2
40	50	12.6	18	1.5	2500	117.21	3
50	60	12.6	18	1.5	2500	137.9	4

Element Required Thickness and MAWP :

From	To	Design Pressure barg	M.A.W.P. Corroded barg	M.A.P. New & Cold barg	Minimum Thickness mm	Required Thickness mm	Element#
10	20	12	14.8	17.07	15.3	12.8107	1
20	40	12	14.81	16.83	17.85	14.8801	2
40	50	12	14.81	16.83	17.85	14.8801	3
50	60	12	14.8	17.07	15.3	12.8107	4
Minimum			14.14	16.83			

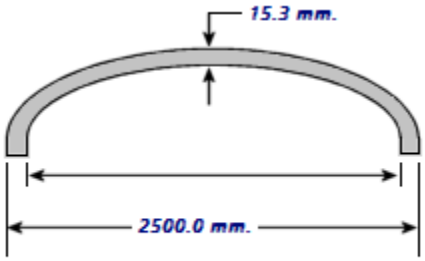
MAWP: 14.14 barg, limited by: Nozzle Reinforcement.

Elements Suitable for Design Internal Pressure.

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Internal Pressure Calculation Results:

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Internal Pressure Results for: Element # 1

Elliptical Head Design Information:			
Design Pressure P	12.600 barg	Int. Design Temperature	90 °C
Material	SA-516 70	Ext. Design Temperature	0 °C
Length	60.000 mm	External Pressure Chart	CS-2
		UNS Number	K02700
Int. Corr. All. c	1.5000 mm	Allowable Stress (ope) S	137.9 N/mm^2
Ext. Corr. All. ce	0.0000 mm	Allowable Stress (amb) Sa	137.9 N/mm^2
Outside Diameter Do	2500.000 mm	Actual Stress	112.8 N/mm^2
Spec. MiN Thk t or e	15.3000 mm	Spec. Nominal Thk.	18.000 mm
Surface Area	72764.6 cm^2	SG of Contents	0.000
Element Volume	2258882.5 cm³	Weight of Contents	0.0 kgf
Empty Weight	1098.5 kgf	Operating Weight	1098.5 kgf
		Comp. All. Ope. Stress	113.5 N/mm^2
		Aspect Ratio	2.00

Radiography Information:			
Spot Radiography per UW-11(a,5,b) Type 1		Seamless	
Circ. Joint Efficiency	85 %	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: 31.025 mm
Head inner surface maximum deviation inside the specified shape, 0.625% of D: 15.513 mm

Required Thickness due to Internal Pressure [tr]:
= (P*Do*Kcor)/(2*S*E+2*P*(Kcor-0.1)) per Appendix 1-4 (c)
= (12.6*2500*0.998)/(2*137.9*1+2*12.6*(0.998-0.1))
= 11.3107 + 1.5000 = 12.8107 mm

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
Less Operating Hydrostatic Head Pressure of 0.600 barg
= (2*S*E*t)/(Kcor*Do-2*t*(Kcor-0.1)) per Appendix 1-4 (c)
= (2*137.9*1*13.8)/(0.998*2500-2*13.8*(0.998-0.1))
= 15.4 - 0.6 = 14.8 barg

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (2*S*E*t)/(K*Do-2*t*(K-0.1)) per Appendix 1-4 (c)
= (2*137.9*1*15.3)/(1*2500-2*15.3*(1-0.1))

= 17.07 barg

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(Kcor*Do-2*t*(Kcor-0.1)))/(2*E*t)
= (12.6*(0.998*2500-2*13.8*(0.998-0.1)))/(2*1*13.8)
= 112.821 N/mm^2

Straight Flange Required Thickness:
= (P*Ro)/(S*E+0.4*P) + ca per Appendix 1-1 (a)(1)
= (12.6*1250)/(137.9*1+0.4*12.6)+1.5
= 12.880 mm

Straight Flange Maximum Allowable Working Pressure:
Less Operating Hydrostatic Head Pressure of 0.600 barg
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (137.9 * 1 * 16.5)/(1250 - 0.4 * 16.5)
= 18.3 - 0.6 = 17.7 barg

Factor K, corroded condition [Kcor]:
= (2 + (Inside Diameter/(2 * Inside Head Depth))^2)/6
= (2 + (2472/(2 * 618.9))^2)/6
= 0.998385

Percent Elong. per UCS-79, VIII-1-01-57 (75*tnom/Rf)*(1-Rf/Ro) 3.155 %

MDMT Calculations in the Knuckle Portion:

Note: This Element/Detail was specified as being Impact Tested.

MDMT Calculations in the Head Straight Flange:

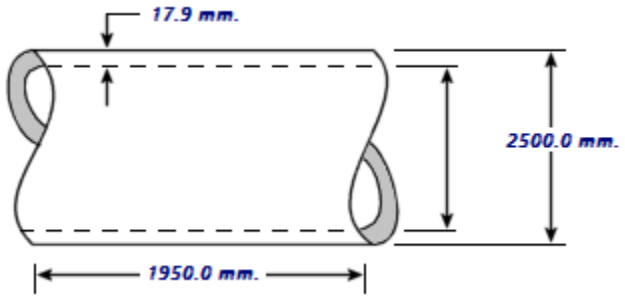
Note: This Element/Detail was specified as being Impact Tested.

Tolerance for Formed Heads per UG-81(a):
Head inner surface maximum deviation outside the specified shape, 1.25% of D: 31.025 mm
Head inner surface maximum deviation inside the specified shape, 0.625% of D: 15.513 mm

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Internal Pressure Calculation Results:

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Internal Pressure Results for: Element # 2

Cylindrical Shell Design Information:			
Design Pressure P	12.600 barg	Int. Design Temperature	90 °C
Material	SA-516 70	Ext. Design Temperature	0 °C
Length	1950.000 mm	External Pressure Chart	CS-2
		UNS Number	K02700
Int. Corr. All. c	1.5000 mm	Allowable Stress (ope) S	137.9 N/mm^2
Ext. Corr. All. ce	0.0000 mm	Allowable Stress (amb) Sa	137.9 N/mm^2
Outside Diameter Do	2500.000 mm	Actual Stress	112.7 N/mm^2
Spec. MiN Thk t or e	17.8500 mm	Spec. Nominal Thk.	18.000 mm
Surface Area	153171.0 cm^2	SG of Contents	0.000
Element Volume	9302281.0 cm³	Weight of Contents	0.0 kgf
Empty Weight	2121.5 kgf	Operating Weight	2121.5 kgf
		Comp. All. Ope. Stress	118.8 N/mm^2

Radiography Information:			
Spot Radiography per UW-11(a,5,b) Type 1		Spot Radiography per UW-11(b) Type 1	
Circ. Joint Efficiency	85 %	Long. Joint Efficiency E	85 %

Required Thickness due to Internal Pressure [tr]:
= (P*Ro) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
= (12.6*1250)/(137.9*0.85+0.4*12.6)
= 13.3801 + 1.5000 = 14.8801 mm

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
Less Operating Hydrostatic Head Pressure of 0.600 barg
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (137.9*0.85*16.35)/(1250-0.4*16.35)
= 15.41 - 0.6 = 14.81 barg

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (137.9*0.85*17.85)/(1250-0.4*17.85)
= 16.83 barg

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(Ro-0.4*t))/(E*t)
= (12.6*((1250-0.4*16.35))/(0.85*16.35)

= 112.743 N/mm^2

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 0.725 %

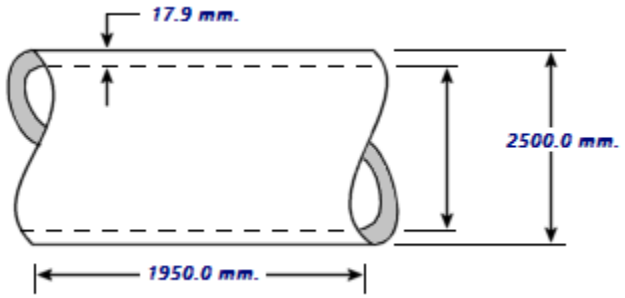
Minimum Design Metal Temperature Results:

Note: This Element/Detail was specified as being Impact Tested.

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Internal Pressure Calculation Results:

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Internal Pressure Results for: Element # 3

Cylindrical Shell Design Information:			
Design Pressure P	12.600 barg	Int. Design Temperature	90 °C
Material	SA-516 70	Ext. Design Temperature	0 °C
Length	1950.000 mm	External Pressure Chart	CS-2
		UNS Number	K02700
Int. Corr. All. c	1.5000 mm	Allowable Stress (ope) S	137.9 N/mm^2
Ext. Corr. All. ce	0.0000 mm	Allowable Stress (amb) Sa	137.9 N/mm^2
Outside Diameter Do	2500.000 mm	Actual Stress	112.7 N/mm^2
Spec. MiN Thk t or e	17.8500 mm	Spec. Nominal Thk.	18.000 mm
Surface Area	153171.0 cm^2	SG of Contents	0.000
Element Volume	9302281.0 cm³	Weight of Contents	0.0 kgf
Empty Weight	2121.5 kgf	Operating Weight	2121.5 kgf
		Comp. All. Ope. Stress	118.8 N/mm^2

Radiography Information:			
Spot Radiography per UW-11(a,5,b) Type 1		Spot Radiography per UW-11(b) Type 1	
Circ. Joint Efficiency	85 %	Long. Joint Efficiency E	85 %

Required Thickness due to Internal Pressure [tr]:
= (P*Ro) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
= (12.6*1250)/(137.9*0.85+0.4*12.6)
= 13.3801 + 1.5000 = 14.8801 mm

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
Less Operating Hydrostatic Head Pressure of 0.600 barg
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (137.9*0.85*16.35)/(1250-0.4*16.35)
= 15.41 - 0.6 = 14.81 barg

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (137.9*0.85*17.85)/(1250-0.4*17.85)
= 16.83 barg

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(Ro-0.4*t))/(E*t)
= (12.6*((1250-0.4*16.35))/(0.85*16.35)

= 112.743 N/mm^2

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 0.725 %

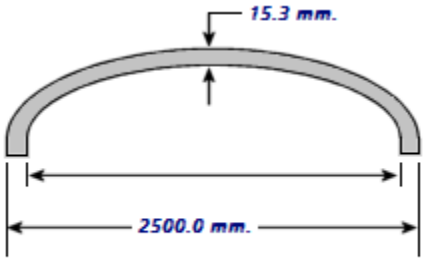
Minimum Design Metal Temperature Results:

Note: This Element/Detail was specified as being Impact Tested.

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Internal Pressure Calculation Results:

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Internal Pressure Results for: Element # 4

Elliptical Head Design Information:			
Design Pressure P	12.600 barg	Int. Design Temperature	90 °C
Material	SA-516 70	Ext. Design Temperature	0 °C
Length	60.000 mm	External Pressure Chart	CS-2
		UNS Number	K02700
Int. Corr. All. c	1.5000 mm	Allowable Stress (ope) S	137.9 N/mm^2
Ext. Corr. All. ce	0.0000 mm	Allowable Stress (amb) Sa	137.9 N/mm^2
Outside Diameter Do	2500.000 mm	Actual Stress	112.8 N/mm^2
Spec. MiN Thk t or e	15.3000 mm	Spec. Nominal Thk.	18.000 mm
Surface Area	72764.6 cm^2	SG of Contents	0.000
Element Volume	2258882.5 cm³	Weight of Contents	0.0 kgf
Empty Weight	1098.5 kgf	Operating Weight	1098.5 kgf
		Comp. All. Ope. Stress	113.5 N/mm^2
		Aspect Ratio	2.00

Radiography Information:			
Spot Radiography per UW-11(a,5,b) Type 1		Seamless	
Circ. Joint Efficiency	85 %	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: 31.025 mm
Head inner surface maximum deviation inside the specified shape, 0.625% of D: 15.513 mm

Required Thickness due to Internal Pressure [tr]:
= (P*Do*Kcor)/(2*S*E+2*P*(Kcor-0.1)) per Appendix 1-4 (c)
= (12.6*2500*0.998)/(2*137.9*1+2*12.6*(0.998-0.1))
= 11.3107 + 1.5000 = 12.8107 mm

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
Less Operating Hydrostatic Head Pressure of 0.600 barg
= (2*S*E*t)/(Kcor*Do-2*t*(Kcor-0.1)) per Appendix 1-4 (c)
= (2*137.9*1*13.8)/(0.998*2500-2*13.8*(0.998-0.1))
= 15.4 - 0.6 = 14.8 barg

Maximum Allowable Pressure, New and Cold [MAPNC]:
= (2*S*E*t)/(K*Do-2*t*(K-0.1)) per Appendix 1-4 (c)
= (2*137.9*1*15.3)/(1*2500-2*15.3*(1-0.1))

= 17.07 barg

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(Kcor*Do-2*t*(Kcor-0.1)))/(2*E*t)
= (12.6*(0.998*2500-2*13.8*(0.998-0.1)))/(2*1*13.8)
= 112.821 N/mm^2

Straight Flange Required Thickness:
= (P*Ro)/(S*E+0.4*P) + ca per Appendix 1-1 (a)(1)
= (12.6*1250)/(137.9*1+0.4*12.6)+1.5
= 12.880 mm

Straight Flange Maximum Allowable Working Pressure:
Less Operating Hydrostatic Head Pressure of 0.600 barg
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (137.9 * 1 * 16.5)/(1250 - 0.4 * 16.5)
= 18.3 - 0.6 = 17.7 barg

Factor K, corroded condition [Kcor]:
= (2 + (Inside Diameter/(2 * Inside Head Depth))^2)/6
= (2 + (2472/(2 * 618.9))^2)/6
= 0.998385

Percent Elong. per UCS-79, VIII-1-01-57 (75*tnom/Rf)*(1-Rf/Ro) 3.155 %

MDMT Calculations in the Knuckle Portion:

Note: This Element/Detail was specified as being Impact Tested.

MDMT Calculations in the Head Straight Flange:

Note: This Element/Detail was specified as being Impact Tested.

Tolerance for Formed Heads per UG-81(a):
Head inner surface maximum deviation outside the specified shape, 1.25% of D: 31.025 mm
Head inner surface maximum deviation inside the specified shape, 0.625% of D: 15.513 mm

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Hydrostatic Test Pressure Results:

UG99(b)	= 1.30 * M.A.W.P. * Sa/S	18.383 barg
UG99b(b)(35)	= 1.30 * Design Pres * Sa/S	15.600 barg
UG99(c)	= 1.30 * M.A.P. - Head(Hyd)	21.626 barg
UG100	= 1.10 * M.A.W.P. * Sa/S	15.555 barg
PED	= max(1.43*DP, 1.25*DP*ratio)	17.160 barg
PED&UG99(b)(35)	= max(1.43*DP, 1.3*DP*ratio)	17.160 barg
App 27-4	= M.A.W.P.	14.141 barg

Pressure per the PED:
= max(1.43 * Design Pressure, 1.25 * Design Pressure * Stress ratio)
= max(1.43 * 12, 1.25 * 12 * 1)
= max(17.16, 15)
= 17.160 barg

Vertical Test performed per: PED

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

Stresses on Elements due to Test Pressure (N/mm^2 & barg):

From	To	Stress	Allowable	Ratio	Pressure
10	20	142.8	179.3	0.797	17.68
20	40	144.3	179.3	0.805	17.61
40	50	142.7	179.3	0.796	17.42
50	60	139.2	179.3	0.776	17.23

Stress ratios for Nozzle and Pad Materials (N/mm^2):

Description	Pad/Nozzle	Ambient	Operating	Ratio
Drain	Nozzle	117.90	117.90	1.000
PG	Nozzle	137.90	137.90	1.000
PT	Nozzle	137.90	137.90	1.000
TG	Nozzle	117.90	117.90	1.000
TT	Nozzle	117.90	117.90	1.000
IN/OUT	Nozzle	117.90	117.90	1.000
MAN HOLE	Nozzle	137.90	137.90	1.000
MAN HOLE	Pad	137.90	137.90	1.000
Vent	Nozzle	117.90	117.90	1.000
PSV	Nozzle	117.90	117.90	1.000
Minimum				1.000

Stress ratios for Pressurized Vessel Elements (N/mm^2):

Description	Ambient	Operating	Ratio
	137.90	137.90	1.000
	137.90	137.90	1.000
	137.90	137.90	1.000
	137.90	137.90	1.000
Minimum			1.000

Hoop Stress in Nozzle Wall during Pressure Test (N/mm^2):

Description	Ambient	Operating	Ratio
Drain	2.54	153.30	0.017
PG	3.29	179.27	0.018
PT	3.28	179.27	0.018
TG	5.24	153.28	0.034
TT	5.22	153.28	0.034
IN/OUT	5.37	153.30	0.035
MAN HOLE	29.03	179.27	0.162
Vent	2.47	153.30	0.016
PSV	4.34	153.30	0.028

Elements Suitable for Test Pressure.

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External Pressure Results Summary:

External Pressure Calculation Results:

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External Pressure Calculations:

From	To	Section Length mm	Outside Diameter mm	Corroded Thickness mm	Factor A	Factor B N/mm^2
10	20	No Calc	2500	13.8	0.00076667	76.7114
20	40	4431.57	2500	16.35	0.00038682	38.6729
40	50	4431.57	2500	16.35	0.00038682	38.6729
50	60	No Calc	2500	13.8	0.00076667	76.7114

External Pressure Calculations:

From	To	External Actual T. mm	External Required T. mm	External Design Pressure barg	External M.A.W.P. barg
10	20	15.3	No Calc	...	4.705
20	40	17.85	No Calc	...	3.372
40	50	17.85	No Calc	...	3.372
50	60	15.3	No Calc	...	4.705
Minimum					3.372

External Pressure Calculations:

From	To	Actual Length Bet. Stiffeners mm	Allowable Length Bet. Stiffeners mm	Ring Inertia Required cm^4	Ring Inertia Available cm^4
10	20	No Calc	No Calc	No Calc	No Calc
20	40	4431.57	No Calc	No Calc	No Calc
40	50	4431.57	No Calc	No Calc	No Calc
50	60	No Calc	No Calc	No Calc	No Calc

Elements Suitable for External Pressure.

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Element and Detail Weights:

From	To	Element Metal Wgt. kg	Element ID Volume cm³	Corroded Metal Wgt. kg	Corroded ID Volume cm³	Extra due Misc % kg
10	20	1098.49	2258882	1006.95	2266775	...
20	40	2121.49	9302281	1945.87	9324945	...
40	50	2121.49	9302281	1945.87	9324945	...
50	60	1098.49	2258882	1006.95	2266775	...
Total		6439	23122326.00	5905	23183442.00	0

Weight of Details:

From	Type	Weight of Detail kg	X Offset, Dtl. Cent. mm	Y Offset, Dtl. Cent. mm	Z Offset Dtl. Cent. mm	Description
10	Nozl	1.82742	...	-719.7	...	Drain
20	Nozl	0.28886	1205.99	300	323.144	PG
20	Nozl	0.28886	1205.99	1000	-323.144	PT
20	Nozl	2.94774	1226.39	300	-328.61	TG
20	Nozl	0.64212	1226.39	1000	328.61	TT
20	Nozl	3.8853	-1248.53	300	...	IN/OUT
20	Nozl	373.425	...	500	1269.65	MAN HOLE
20	Legs	549.199	...	-370	...	LEGS
50	Nozl	1.82742	...	719.7	...	Vent
50	Nozl	9.09278	500	666.815	...	PSV
40	Trun	35.7523	...	1750	...	Trunnions

Total Weight of Each Detail Type:

Nozzles	394.2
Legs	549.2
Trunnions	35.8
Sum of the Detail Weights	979.2 kg

Weight Summation Results: (kg)

	Fabricated	Shop Test	Shipping	Erected	Empty	Operating
Main Elements	6440.0	6440.0	6440.0	6440.0	6440.0	6440.0
Nozzles	394.2	394.2	394.2	394.2	394.2	394.2
Legs	549.2	549.2	549.2	549.2	549.2	549.2
Trunnions	35.8	35.8	35.8	35.8	35.8	35.8
Test Liquid	...	23108.2	...	...	...	...
Totals	7419.1	30527.4	7419.1	7419.1	7419.1	7419.1

Weight Summary:

Fabricated Wt.	- Bare Weight without Removable Internals	7419.1 kg
Shop Test Wt.	- Fabricated Weight + Water (Full)	30527.4 kg
Shipping Wt.	- Fab. Weight + removable Intls.+ Shipping App.	7419.1 kg
Erected Wt.	- Fab. Wt + or - loose items (trays,platforms etc.)	7419.1 kg
Ope. Wt. no Liq	- Fab. Weight + Internals. + Details + Weights	7419.1 kg
Operating Wt.	- Empty Weight + Operating Liq. Uncorroded	7419.1 kg
Field Test Wt.	- Empty Weight + Water (Full)	30527.4 kg

Weights used in Vortex Shedding Calculations:

Mass of the Upper 1/3 of the Vertical Vessel (operating)	2295.2 kg
Mass of the Upper 1/3 of the Vertical Vessel (filled w/water)	9483.9 kg
Mass of the Upper 1/3 of the Vertical Vessel (empty)	2502.0 kg

Surface Areas of Elements:

From	To	Outside Surface Area cm^2	Inside Surface Area cm^2
10	20	72764.6	70755.4
20	40	153171	150966
40	50	153171	150966
50	60	72764.6	70755.4
Total		451871.4	443442.2 cm^2
Total		486.4	477.3 ft²

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. kgm	Oper. Wgt. No Liquid kg
10	20	1100.32	1100.32	3357.82	...	1100.32
20	Legs	449.251	449.251	2117.87	473.372	449.251
Legs	40	2053.72	2053.72	9681.7	...	2053.72
40	50	2157.25	2157.25	11453.8	...	2157.25
50	60	1109.41	1109.41	3366.92	...	1109.41

Cumulative Vessel Weight

From	To	Cumulative Ope Wgt. No Liquid kg	Cumulative Oper. Wgt. kg	Cumulative Hydro. Wgt. kg
10	20	...	...	...
20	Legs	-1100.32	-1100.32	-3357.82
Legs	40	5320.38	5320.38	24502.5
40	50	3266.66	3266.66	14820.8
50	60	1109.41	1109.41	3366.92

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. kgm	Cumulative Oper. Mom. kgm	Cumulative Hydro. Mom. kgm
10	20	...	...	...
20	Legs	473.372	473.372	473.372
Legs	40	...	...	...
40	50	...	...	...
50	60	...	...	...

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Nozzle Flange MAWP Results: (barg & °C)

Nozzle Description	Flange Rating Ope.	Flange Rating Ambient	Design Temp	Class	Grade/ Group	Equiv. Press	Max Pressure UG-44(b)	Max Pressure 50%	Max Pressure DNV
Drain	18.00	19.60	90	150	GR 1.1	...	...	...	...
TG	18.00	19.60	90	150	GR 1.1	...	...	...	...
TT	18.00	19.60	90	150	GR 1.1	...	...	...	...
IN/OUT	18.00	19.60	90	150	GR 1.1	...	...	...	...
MAN HOLE	18.00	19.60	90	150	GR 1.1	...	...	...	...
Vent	18.00	19.60	90	150	GR 1.1	...	...	...	...
PSV	18.00	19.60	90	150	GR 1.1	...	...	...	...
Min Rating	18.000	19.600, [for Core Elements]				...	...	...	...

Flange Pressure Ratings are per ASME B16.5 2020 Metric Edition

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Natural Frequency [fn]:

```
  = 1 / ( 2 * pi * sqrt( wyy /( 386 * |( wy )| )))
  = 1/( 2 * pi * sqrt( 150.5/( 386 * |( 1779 )| ))) Imperial units
  = 10.750 Hz.
```

where:

```
 wy = SumOf( weight * deflection )
 wyy = SumOf( weight * deflection^2 )
```

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

The Natural Frequency for the Vessel (Empty.) is 33.6429 Hz.

Natural Frequency [fn]:
```
  = 1 / ( 2 * pi * sqrt( wyy /( 386 * |( wy )| )))
  = 1/( 2 * pi * sqrt( 150.5/( 386 * |( 1779 )| ))) Imperial units
  = 10.750 Hz.
```

where:
```
 wy = SumOf( weight * deflection )
 wyy = SumOf( weight * deflection^2 )
```

The Natural Frequency for the Vessel (Ope...) is 33.6429 Hz.

Natural Frequency [fn]:
```
  = 1 / ( 2 * pi * sqrt( wyy /( 386 * |( wy )| )))
  = 1/( 2 * pi * sqrt( 13696/( 386 * |( 37124 )| ))) Imperial units
  = 5.148 Hz.
```

where:
```
 wy = SumOf( weight * deflection )
 wyy = SumOf( weight * deflection^2 )
```

The Natural Frequency for the Vessel (Filled) is 16.1681 Hz.

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Wind Load Calculation Results:

Wind Code: European Eurocode ENV 1991-2-4: 1995

Input Echo - User Input Values:

Terrain Category I Flat Unobstructed			
Terrain Factor	kt	0.170	
Effective Height - Table 8.1	Zmin	6.562	m
Effective Height - Table 8.1	Zo	0.033	m
Reference Wind Velocity	Vref	144.000	Km/hr
Air Density per Section 7.1	Rho	1.250	kg/m³
Wind Direction Factor	Cdir	1.000	
Temperature Factor	Ctmp	1.000	
Altitude Factor	Calt	1.000	
Peak Factor	g	3.500	
Topography Coefficient	Ct	1.000	
Wind Force Coefficient	Cf	0.700	
Vessel Base Height (site)	Hb	0.000	mm
Total Vessel Height	h	4873.693	mm

Sample Calculation for the First Element:

Reference Wind Velocity - paragraph 7.2 [Vref]
= Vref0 * Cd * Ctmp * Calt
= 144 * 1 * 1 * 1
= 144 Km/hr

Reference Wind Pressure - paragarph 7.1 [qref]
= 0.50 * Rho(kg/m^3) * Vref² - Metric Units
= 0.00261 * Vref² - Imperial Units
= 0.00261(based on mph units) * 144²
= 20.9 psf
In chosen units:
= 102 kg/m^2

Dynamic Coefficient - per Section 9 [Cd]
Average Diameter = 2500 mm
H/D = 4020/2500 = 1.608

From Section 9:
Cd = 1.05

Roughness Coefficient- paragraph 8.2 [cr(z)]
Wind Height for first element = 396.3 mm
Because Wind Height < 20 m
Cr(z) = Kt * Ln ((HgtMin + Base Height) / Zo)
= 0.17 * Ln ((2000 + 0)/10)
= 0.901

Exposure Coefficient - paragraph 8.5 [Ce]
Because Cd >= 1.0:
= Cr(z)² * (1 + 2 * gpeak * Kt / (Cr(z) * Ct))
= 0.901² * (1 + 2 * 3.5 * 0.17/(0.901 * 1))
= 1.883

Force on the First Element - paragraph 6.1 [Rf]
= qref * Ce * Cd * Cf * Area
= 102 * 1.883 * 1.05 * 0.7 * 1.671
= 235.9 kgf

Summary:

Element	Hgt z	qref	Ce(z)	Cr(z)	Area	Force

	mm	kg/m^2			cm^2	kgf
Node 10 - 20	396.307	102.031	1.883	0.901	16706.5	235.933
Node 20 - 40	1652.350	102.031	1.883	0.901	58500.0	826.151
Node 40 - 50	3602.350	102.031	2.192	1.001	58500.0	961.823
Node 50 - 60	4873.693	102.031	2.359	1.052	16706.5	295.555

Wind Vibration Calculations

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

Nomenclature

```
 Cf  - Correction factor for natural frequency
  D  - Average outer insulated diameter of vessel, mm
 Df  - Damping Factor < 0.75 Unstable,  > 0.95 Stable
 Dr  - Average outer insulated of top half of vessel, mm
  f  - Natural frequency of vibration (Hertz)
 f1  - Natural frequency of bare vessel based on a unit value of (D/L²)(10⁴)
  L  - Total height of structure mm
 Lc  - Total length of conical section(s) of vessel, mm
 tb  - Uncorroded plate thickness at bottom of vessel, mm
 V30 - Design Wind Speed provided by user, Km/hr
 Vc  - Critical wind velocity, Km/hr
 Vw  - Maximum wind speed at top of structure, Km/hr
 W   - Total corroded weight of structure, kgf
 Ws  - Cor. vessel weight excl. weight of parts which do not effect stiff. kgf
  Z  - Maximum amplitude of vibration at top of vessel, mm
 Dl  - Logarithmic decrement ( taken as 0.03 for Welded Structures )
 Vp  - Vib. Chance, <= 0.32037E-06 (High); 0.32037E-06 < 0.40047E-06 (Probable)
 P30 - wind pressure 30 feet above the base
```

Check other Conditions and Basic Assumptions:

```
 :: Total Cone Length / Total Length < 0.5
 :: 0/4020 = 0

 :: [ D / L² ] * 10⁴ < 8 (English Units, ft.)
 :: [ 8.202/13.19² ] * 10⁴ = 471.5 [Geometry Violation]
```

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

```
  = W / ( L * Dr²)
  = 6885/( 4020 * 2500² )
  = 0.27402E-06
```

Compute the damping factor Df which is a measure of instability [Df]:

```
  = W * Dl/ ( L * Dr² )
  = 6885 * 0.03/( 4020 * 2500² )
  = 0.513
```

Compute the critical wind velocity [Vc]:

```
  = 3.4 * f * Dr
  = 3.4 * 33.64 * 8.202
  = 938.203 mile/hr  [1509.851 Km/hr]
```

Compute the velocity at the top of the tower [Vw]:

```
  = V30 * ( L / ( 30 + BaseHeight ))^0.143
  = 144 * ( 4020/( 30 + 0 ))^0.143
  = 128.034 Km/hr
```

Compute the maximum gust velocity using the gust response factor Gh [Vg]:

```
  = Vw * Gh
  = 128 * 1
  = 128.034 Km/hr
```

Since Vc is greater than Vg the dynamic deflection Z, does not need to be computed.

The Natural Frequency for the Vessel (Ope...) is 33.6429 Hz.

Wind Load Calculation:

From	To	Wind Height mm	Wind Diameter mm	Wind Area cm^2	Wind Pressure kg/m^2	Element Wind Load kgf
10	20	396.307	3000	16706.5	141.222	235.933
20	40	1652.35	3000	58500	141.222	826.151
40	50	3602.35	3000	58500	164.414	961.823
50	60	4873.69	3000	16706.5	176.91	295.555

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Earthquake Load Calculation Results:

Input Values for G Loading:

Horizontal Acceleration factor	(GX)	0.000
Horizontal Acceleration factor	(GZ)	0.700
Vertical Acceleration factor	(GY)	0.000

Computed Results:

The Natural Frequency for the Vessel (Ope...) is 33.6429 Hz.

Earthquake Load Calculation:

From	To	Earthquake Height mm	Earthquake Weight kgf	Element Ope Load kgf	Element Emp Load kgf	Element Vertical Load kgf
10	20	30	1100.32	770.224	770.224	...
20	Legs	410	449.251	314.476	314.476	...
Legs	40	1210	2053.72	1437.6	1437.6	...
40	50	2985	2157.25	1510.07	1510.07	...
50	60	3990	1109.41	776.589	776.589	...

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The following table is for the Operating Case.

Wind/Earthquake Shear, Bending:

From	To	Distance to Support mm	Cumulative Wind Shear kgf	Earthquake Shear kgf	Wind Bending kgm	Earthquake Bending kgm
10	20	646.343	...	...	...	...
20	Legs	175	235.933	770.224	69.9184	228.255
Legs	40	800	2319.46	4808.96	3977.43	7472.83
40	50	2575	1257.38	2286.66	1601.73	3216.87
50	60	3846.34	295.555	776.589	87.5876	230.141

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

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

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Wind Deflection Calculations:

The following table is for Wind Deflection; Operating Case.

Wind Load Deflection:

From	To	Cumulative Shear kgf	Centroid Deflection mm	Elem. End Deflection mm	Elem. Ang. Rotation
10	20	...	0.72274	0.72274	0.00075225
20	Legs	235.933	0.72278	0.72288	0.000753
Legs	40	2319.46	0.7241	0.72623	0.00075531
40	50	1257.38	0.72952	0.73311	0.00075599
50	60	295.555	0.73323	0.73334	0.00075599

Critical Wind Velocity for Tower Vibration:

From	To	1st Crit. Wind Speed Km/hr	2nd Crit. Wind Speed Km/hr
10	20	1811.82	11323.9
20	40	1811.82	11323.9
40	50	1811.82	11323.9
50	60	1811.82	11323.9

Allowable deflection at the Tower Top (Ope)(6.000"/100ft. Criteria)
Allowable deflection : 20.100 Actual deflection : 0.733 mm

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Longitudinal Stress Constants:

From	To	Metal Area New cm^2	Metal Area Corroded cm^2	Section Modulus New mm³	Section Modulus Corroded mm³
10	20	1194.31	1077.87	73736184	66627120
20	40	1391.93	1275.73	85761792	78696800
40	50	1391.93	1275.73	85761792	78696800
50	60	1194.31	1077.87	73736184	66627120

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Longitudinal Allowable Stresses:

From	To	Tensile N/mm^2	Hydrotest Tensile N/mm^2	Compressive N/mm^2	Hydrotest Compressive N/mm^2
10	20	140.658	182.886	-113.503	-116.76
20	Legs	140.658	182.855	-118.775	-121.343
Legs	40	140.658	182.855	-118.775	-121.343
40	50	140.658	182.886	-118.775	-121.343
50	60	140.658	182.886	-113.503	-116.76

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Longitudinal Stress Report

Longitudinal Operating and Empty Stresses are computed in the corroded conditioN Stresses due to loads in the hydrostatic test cases have been computed in the new and cold conditioN

Longitudinal Pressure Stresses due to:

From	To	Longitudinal Stress Internal Pressure N/mm^2	Longitudinal Stress External Pressure N/mm^2	Longitudinal Stress Hydrotest Pressure N/mm^2
10	20	56.1865	...	68.9008
20	40	47.2859	...	58.8863
40	50	47.2859	...	58.8863
50	60	56.1865	...	68.9008

Longitudinal Stresses due to Weight Loads for these Conditions:

From	To	Wght. Str. Empty N/mm^2	Wght. Str. Operating N/mm^2	Wght. Str. Hydrotest N/mm^2	Wght. Str. Emp. Mom. N/mm^2	Wght. Str. Opr. Mom. N/mm^2
10	20	...	...	...	...	...
20	Legs	0.084584	0.084584	0.23658	0.058988	0.058988
Legs	40	-0.40899	-0.40899	-0.37485	...	...
40	50	-0.25112	-0.25112	-0.23015	...	...
50	60	-0.10094	-0.10094	-0.091097	...	...

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

From	To	Wght. Str. Hyd. Mom. N/mm^2	Bend. Str. Oper. Wind N/mm^2	Bend. Str. Oper. Equ. N/mm^2	Bend. Str. Hyd. Wind N/mm^2	Bend. Str. Hyd. Equ. N/mm^2
10	20	...	...	...	...	...
20	Legs	0.054129	0.0087127	0.028444	0.0026383	...
Legs	40	...	0.49564	0.93121	0.15009	...
40	50	...	0.1996	0.40086	0.060441	...
50	60	...	0.012892	0.033874	0.0038441	...

Longitudinal Stresses due to these Conditions:

From	To	Vortex Shedding Operating Case N/mm^2	Vortex Shedding Empty Case N/mm^2	Vortex Shedding Test Case N/mm^2	Earthquake Empty Case N/mm^2
10	20	...	...	...	...
20	Legs	...	...	...	0.028444
Legs	40	...	...	...	0.93121
40	50	...	...	...	0.40086
50	60	...	...	...	0.033874

Longitudinal Stresses due to Applied Axial Forces:

		Longitudinal Stress	Longitudinal Stress

From	To	Y Forces Wind N/mm^2	Y Forces Seismic N/mm^2
10	20	...	...
20	Legs	...	...
Legs	40	...	...
40	50	...	...
50	60	...	...

Longitudinal Stresses due to User Forces and Moments:

From	To	Wind For/Mom Corroded N/mm^2	Earthquake For/Mom Corroded N/mm^2	Wind For/Mom No Corrosion N/mm^2	Earthquake For/Mom No Corrosion N/mm^2
10	20	...	...	...	...
20	Legs	...	...	...	...
Legs	40	...	...	...	...
40	50	...	...	...	...
50	60	...	...	...	...

Bending Stresses due to Blast Load:

From	To	Bending Stress N/mm^2
10	20	...
20	Legs	...
Legs	40	...
40	50	...
50	60	...

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Stress Combination Load Cases for Vertical Vessels:

Load Case Definition Key

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

General Notes:

Case types HI and HE are in the Un-Corroded conditioN

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

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

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

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

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	0.00	140.66	0.00	113.50	0.0000	0.0000
20	0.15	140.66		118.78	0.0011	
20	0.09	140.66	-0.90	118.78	0.0006	0.0076
40		140.66	-0.45	118.78		0.0038
50		140.66	-0.11	113.50		0.0010

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

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	0.00	140.66	0.00	113.50	0.0000	0.0000
20	0.17	140.66	-0.00	118.78	0.0012	0.0000
20	0.52	140.66	-1.34	118.78	0.0037	0.0113
40	0.15	140.66	-0.65	118.78	0.0011	0.0055
50		140.66	-0.13	113.50		0.0012

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

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	0.00	140.66	0.00	113.50	0.0000	0.0000
20	0.15	140.66		118.78	0.0011	
20	0.09	140.66	-0.90	118.78	0.0006	0.0076
40		140.66	-0.45	118.78		0.0038
50		140.66	-0.11	113.50		0.0010

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

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	0.00	140.66	0.00	113.50	0.0000	0.0000
20	0.17	140.66	-0.00	118.78	0.0012	0.0000
20	0.52	140.66	-1.34	118.78	0.0037	0.0113
40	0.15	140.66	-0.65	118.78	0.0011	0.0055
50		140.66	-0.13	113.50		0.0012

Analysis of Load Case 5 : NP+HW+HI

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	0.00	182.89	0.00	116.76	0.0000	0.0000
20	0.29	182.86		121.34	0.0016	
20		182.86	-0.52	121.34		0.0043
40		182.89	-0.29	121.34		0.0024
50		182.89	-0.09	116.76		0.0008

Analysis of Load Case 6 : NP+HW+HE

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	0.00	182.89	0.00	116.76	0.0000	0.0000
20	0.29	182.86		121.34	0.0016	
20		182.86	-0.37	121.34		0.0031
40		182.89	-0.23	121.34		0.0019
50		182.89	-0.09	116.76		0.0008

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

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	56.19	140.66		113.50	0.3995	
20	47.44	140.66		118.78	0.3373	
20	47.37	140.66		118.78	0.3368	
40	47.23	140.66		118.78	0.3358	
50	56.10	140.66		113.50	0.3988	

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

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	56.19	140.66		113.50	0.3995	
20	47.46	140.66		118.78	0.3374	
20	47.81	140.66		118.78	0.3399	
40	47.44	140.66		118.78	0.3372	
50	56.12	140.66		113.50	0.3990	

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

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio

10	0.00	140.66	0.00	113.50	0.0000	0.0000
20	0.15	140.66		118.78	0.0011	
20	0.09	140.66	-0.90	118.78	0.0006	0.0076
40		140.66	-0.45	118.78		0.0038
50		140.66	-0.11	113.50		0.0010

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

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	0.00	140.66	0.00	113.50	0.0000	0.0000
20	0.17	140.66	-0.00	118.78	0.0012	0.0000
20	0.52	140.66	-1.34	118.78	0.0037	0.0113
40	0.15	140.66	-0.65	118.78	0.0011	0.0055
50		140.66	-0.13	113.50		0.0012

Analysis of Load Case 11 : HP+HW+HI

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	68.90	182.89		116.76	0.3767	
20	59.18	182.86		121.34	0.3236	
20	58.66	182.86		121.34	0.3208	
40	58.72	182.89		121.34	0.3211	
50	68.81	182.89		116.76	0.3763	

Analysis of Load Case 12 : HP+HW+HE

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	68.90	182.89		116.76	0.3767	
20	59.18	182.86		121.34	0.3236	
20	58.51	182.86		121.34	0.3200	
40	58.66	182.89		121.34	0.3207	
50	68.81	182.89		116.76	0.3762	

Analysis of Load Case 13 : IP+WE+EW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	56.19	140.66		113.50	0.3995	
20	47.43	140.66		118.78	0.3372	
20	46.88	140.66		118.78	0.3333	
40	47.03	140.66		118.78	0.3344	
50	56.09	140.66		113.50	0.3987	

Analysis of Load Case 14 : IP+WF+CW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	56.19	140.66		113.50	0.3995	
20	47.36	140.66		118.78	0.3367	
20	46.91	140.66		118.78	0.3335	
40	47.06	140.66		118.78	0.3345	
50	56.10	140.66		113.50	0.3988	

Analysis of Load Case 15 : IP+VO+OW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	56.19	140.66		113.50	0.3995	
20	47.43	140.66		118.78	0.3372	
20	46.88	140.66		118.78	0.3333	

40	47.03	140.66		118.78	0.3344
50	56.09	140.66		113.50	0.3987

Analysis of Load Case 16 : IP+VE+EW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	56.19	140.66		113.50	0.3995	
20	47.43	140.66		118.78	0.3372	
20	46.88	140.66		118.78	0.3333	
40	47.03	140.66		118.78	0.3344	
50	56.09	140.66		113.50	0.3987	

Analysis of Load Case 17 : NP+VO+OW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	0.00	140.66	0.00	113.50	0.0000	0.0000
20	0.14	140.66		118.78	0.0010	
20		140.66	-0.41	118.78		0.0034
40		140.66	-0.25	118.78		0.0021
50		140.66	-0.10	113.50		0.0009

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

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	56.19	140.66		113.50	0.3995	
20	47.43	140.66		118.78	0.3372	
20	46.88	140.66		118.78	0.3333	
40	47.03	140.66		118.78	0.3344	
50	56.09	140.66		113.50	0.3987	

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

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	0.00	140.66	0.00	113.50	0.0000	0.0000
20	0.14	140.66		118.78	0.0010	
20		140.66	-0.41	118.78		0.0034
40		140.66	-0.25	118.78		0.0021
50		140.66	-0.10	113.50		0.0009

Analysis of Load Case 20 : BL+IP+OW

From Node	Tensile Stress	All. Tens. Stress	Comp. Stress	All. Comp. Stress	Tens. Ratio	Comp. Ratio
10	56.19	140.66		113.50	0.3995	
20	47.43	140.66		118.78	0.3372	
20	46.88	140.66		118.78	0.3333	
40	47.03	140.66		118.78	0.3344	
50	56.09	140.66		113.50	0.3987	

Absolute Maximum of the all of the Stress Ratio's 0.3995

Element From : 10 to : 20
Governing Load Case 7 : IP+OW+WI+FW+BW

Element Description	Long Pressure Stress	Weight + Axial Load Stress	Eccentric Moment Stress	Wind or Earthquake Stress	Combined Stress	Which Side
Element # 1	56.2	...	...	...	56.2	+ Tens

Element # 1	56.2	...	...	...	...	- Comp
Element # 2	47.3	0.1	0.1	...	47.4	+ Tens
Element # 2	47.3	0.1	-0.1	-0.0	...	- Comp
Element # 2	47.3	-0.4	...	0.5	47.4	+ Tens
Element # 2	47.3	-0.4	...	-0.5	...	- Comp
Element # 3	47.3	-0.3	...	0.2	47.2	+ Tens
Element # 3	47.3	-0.3	...	-0.2	...	- Comp
Element # 4	56.2	-0.1	...	...	56.1	+ Tens
Element # 4	56.2	-0.1	...	-0.0	...	- Comp

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Shop/Field Installation Options :

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

Center of Gravity of the Nozzles	664.533 mm
Center of Gravity of the Legs	-310.000 mm
Center of Gravity of the Trunnions	3760.000 mm
Center of Gravity of Bare Shell New and Cold	2010.000 mm
Center of Gravity of Bare Shell Corroded	2010.000 mm
Vessel CG in the Operating Condition	1756.981 mm
Vessel CG in the Fabricated (Shop/Empty) Condition	1775.203 mm
Vessel CG in the Test Condition	1952.937 mm

Rigging Analysis Results:

- Lifting weight based on the user selected calculated empty weight

Total Effective Length of Vessel for this analysis		4020.00 mm
Total vessel weight (No Liquid)	Twt	7419.15 kgf
Impact weight multiplication factor	Imp	1.50
Design lifting weight, DWT = Imp * Twt		11128.72 kgf
Elevation of the Tailing Lug (bottom)		0.00 mm
Elevation of the Lifting Lug (top)		3760.00 mm
Design Reaction force at the tailing lug		5874.54 kgf
Design Reaction force at the Trunnions		5254.19 kgf
CG distance during field lifting operation		1775.20 mm
CG distance from tailing lug		1775.20 mm
CG distance from the nearer lifting lug/trunnion		1775.20 mm
Compressive Allowable Increase Factor		1.00

Critical Values: (N/mm^2, mm)

	Max Stress	Elevation	Allowables	
Bending	0.14	2010.00	101.12	(UG-23)
Shear	0.35	3570.00	96.53	(0.7*S)

The compressive bending allowable stress is the minimum of the tensile allowable and the compressive allowable times the specified compressive allowable increase factor.

Forces and Moments at selected elevations (not all analysis points shown):

Distance mm	Bending Moment kgm	Bending Stress N/mm^2	Shear Force kgf	Shear Stress N/mm^2
0.00	0.0	0.0	31.3	0.0
450.00	195.0	0.0	642.3	0.0
1620.00	1199.6	0.1	1698.9	0.1
2790.00	677.7	0.1	3500.0	0.2
3960.00	1078.4	0.1	507.3	0.0

Unity Check (Actual Stress / Allowable Stress):

Maximum Unity Check is 0.00147 at elevation 3960 mm - Must be <=1

Note: The rigging analysis is performed using a uniformly distributed load.

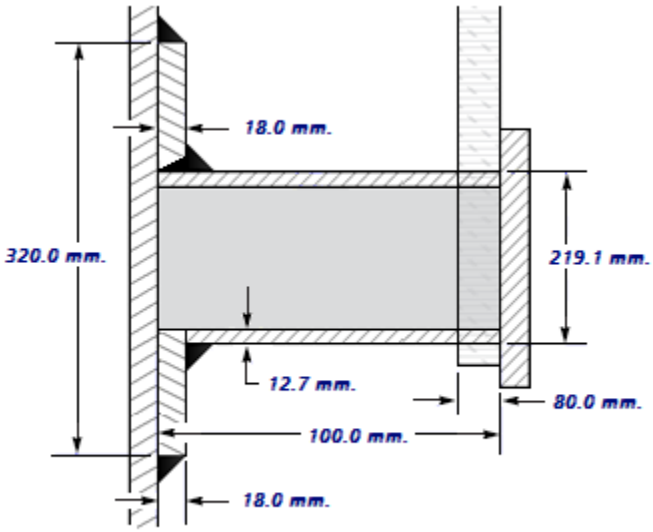
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Trunnion Analysis:

Input Data:

Trunnion Material		SA-516 70	
Trunnion Yield Stress	Sy	262.01	N/mm^2
Trunnion Outside Diameter	Tod	219.100	mm
Trunnion Thickness	Tthk	12.7000	mm
Trunnion Length	Tl	100.0000	mm
Reinforcing Pad Used		Yes	
Pad Outside Diameter	Dp	320.000	mm
Pad Thickness	Thkp	18.0000	mm
Pad Edge Fillet Weld Thk	Tfp	18.0000	mm
Bail/Sling Width	Tt	80.0000	mm
Sling Angle from Horizontal		0.0	deg
Occasional Load Factor	Occfac	1.0	
Number of Lugs in Group		2	



Trunnion may be inserted or abutting

Trunnion Force and Stress Results for different Lift Angles (kgf&N/mm^2):

Bending Stress Allowable:	172.9	N/mm^2
Shear Stress Allowable:	104.8	N/mm^2
Bearing Stress Allowable:	196.5	N/mm^2

Angle	Trunnion Lifting Load	Bending Stress	Shear Stress	Bearing Stress	Unity Check	Pass Fail
0	2627.1	3.8	3.1	1.5	0.052	Pass
5	2715.7	4.0	3.2	1.5	0.054	Pass
10	2800.3	4.1	3.3	1.6	0.056	Pass
15	2882.5	4.2	3.4	1.6	0.057	Pass
20	2963.5	4.3	3.5	1.7	0.059	Pass
25	3044.7	4.5	3.6	1.7	0.060	Pass
30	3127.2	4.6	3.7	1.7	0.062	Pass
35	3212.4	4.7	3.8	1.8	0.064	Pass
40	3301.8	4.8	3.9	1.8	0.065	Pass
45	3397.3	5.0	4.0	1.9	0.067	Pass
50	3501.0	5.1	4.2	2.0	0.069	Pass
55	3616.0	5.3	4.3	2.0	0.072	Pass

60	3746.3	5.5	4.5	2.1	0.074	Pass
65	3897.5	5.7	4.6	2.2	0.077	Pass
70	4078.2	6.0	4.9	2.3	0.081	Pass
75	4301.8	6.3	5.1	2.4	0.085	Pass
80	4590.3	6.7	5.5	2.6	0.091	Pass
85	4984.1	7.3	5.9	2.8	0.099	Pass
90	5564.4	8.1	6.6	3.1	0.110	Pass

Trunnion Calculation Results:

Trunnion Lifting Load [Tlf]:
= Resultant Load * Impact Factor
= 3710 * 1.5
= 5564.4 kgf

Trunnion Section Modulus [Z]:
= pi(Tod^4 - Tid^4) / (32 * Tod)
= pi(219.1^4 - 193.7^4)/(32 * 219.1)
= 401810.6 mm³

Trunnion Bending Moment [Tmom]:
= (Tl - 0.5 * Tt)/9.807 * Tlf
= (100 - 0.5 * 80)/9.807 * 5564
= 333.9 kgm

Trunnion Calculated Bending Stress [Sbc]:
= Tmom * 9.807/Z
= 333.9 * 9.807/401811
= 8.15 N/mm^ [Passed] Sbc < min(0.66 * SY * Occfac, 0.75 * Sy) (172.93)

Trunnion Cross Section Area [Txsa]:
= pi/4(Tod² - Tid²)
= pi/4(219.1² - 193.7²)
= 82.3 cm^2

Trunnion Calculated Shear Stress [Ssc]:
= Tlf/Txsa
= 5564/82.35
= 6.63 N/mm^ [Passed] Ssc < 0.4 * Sy * Occfac (104.80)

Trunnion Unity Check [Uchk]:
= Sbc/Sba + Ssc/Ssa
= 8.148/172.9 + 6.626/104.8
= 0.110 [Passed]

Weld Section Modulus at Edge of Trunnion [Sw]:
= pi(Tod/2)²
= pi(219.1/2)²
= 37702.9 mm²

Shear Stress in Weld due to Bending Moment [fs]:
= Tmom/Sw
= 333.9/37703
= 8.855 kgf/mm

Required Fillet Weld Leg Size at Edge of Trunnion [Wsr]:
= max(10mm, fs/(0.4 * Sy))
= max(10mm, 8.855/(0.4 * 262))
= 10.000 mm

Trunnion Bearing Contact Area [Tbca]:
= Tod * Tt
= 219.1 * 80

= 175.3 cm^2

Trunnion Bearing Stress [Sbec]:
= Tlf/Tbca
= 5564/175.3
= 3.11 N/mm^ [Passed] Sbec < min(0.75 * SY * Occfac, 0.9 * Sy) (196.51)

Summary of Results:

Trunnion Unity Check Value: 0.1103 Must be less than or equal to 1

Comparison of Stress Values versus Allowables: (N/mm^2)

Type of Stress	Actual	Allowable	Pass/Fail
Bending Stress	8.15	172.93	Pass
Shear Stress	6.63	104.80	Pass
Bearing Stress	3.11	196.51	Pass

Results of WRC-107/537 Analysis on the Trunnion:

This following Stress Analysis assumes that the Trunnion
passes through the pad and is welded to the shell via a groove weld.
Additionally the re-pad is welded to the shell at the outside
edge via a fillet weld.

In the local stress results below, the 'Nozzle' is the 'Trunnion'.

WRC 107/537 Stress Analysis for the Lifting Lug to Shell Junction in the new and Cold Condition (no corrosion applied).

Attachment dimensions (C11P, C22P etc.) may be modified accounting for attachment welds where applicable.

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

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	0.0000	mm
Vessel Diameter	Dv	2464.300	mm
Vessel Thickness	Tv	17.850	mm
Design Temperature	T1	37.8	C
Attachment Type	Type	Round	
Diameter Basis for Nozzle	Nbasis	ID	
Corrosion Allowance for Nozzle	Can	0.0000	mm
Nozzle Diameter	Dn	219.100	mm
Nozzle Thickness	Tn	12.700	mm
Nozzle Cold S.I. Allowable	SNmc	137.90	N/mm^2
Nozzle Hot S.I. Allowable	SNmh	137.90	N/mm^2
Thickness of Reinforcing Pad	Tpad	18.000	mm
Diameter of Reinforcing Pad	Dpad	356.000	mm
Design Internal Pressure	Dp	0.000	barg
Include Pressure Thrust		No	

External Forces and Moments in WRC 107/537 Convention:

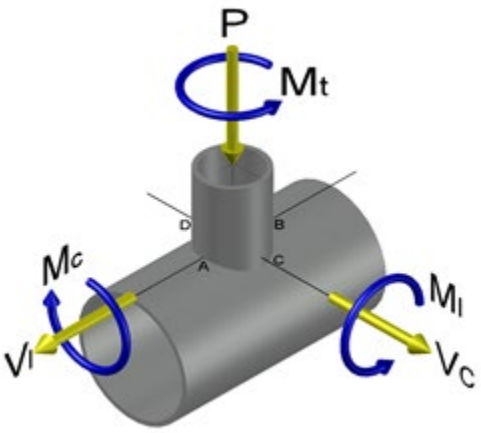
Radial Load	(SUS)	P	0.0	kgf
Longitudinal Shear	(SUS)	Vl	5564.4	kgf
Circumferential Shear	(SUS)	Vc	0.0	kgf
Circumferential Moment	(SUS)	Mc	0.0	kgm

Longitudinal Moment	(SUS)	Ml	333.9	kgm
Torsional Moment	(SUS)	Mt	0.0	kgm

Use Interactive Control		No
WRC107 Version	Version	March 1979

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

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



WRC 107/537 has dimensional limitations that can be found in the bulletin's Foreword and which can also be inferred by review of the non-dimensional curve limits.

Stress Attenuation Diameter (for Insert Plates) per WRC 297:
```
  = NozzleOD + 2 * 1.65 * sqrt( Rmean( t - ca ) )
  = 244.5 + 2 * 1.65 * sqrt( 1241.075 ( 17.85 - 0 ) )
  = 735.670 mm
```

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	0.0	kgf
Circumferential Shear	VC	0.0	kgf
Longitudinal Shear	VL	5564.4	kgf
Circumferential Moment	MC	0.0	kgm
Longitudinal Moment	ML	333.9	kgm
Torsional Moment	MT	0.0	kgm

Dimensionless Parameters used : Gamma = 34.87

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.086	4C	6.264	(A,B)
N(PHI) / (P/Rm)	0.086	3C	5.722	(C,D)
M(PHI) / (P)	0.086	2C1	0.109	(A,B)
M(PHI) / (P)	0.086	1C	0.142	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.086	3A	0.839	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.086	1A	0.100	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.086	3B	2.913	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.086	1B	0.050	(A,B,C,D)

N(x) / (P/Rm)	0.086	3C	5.722	(A,B)
N(x) / (P/Rm)	0.086	4C	6.264	(C,D)
M(x) / (P)	0.086	1C1	0.148	(A,B)
M(x) / (P)	0.086	2C	0.109	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.086	4A	1.174	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.086	2A	0.056	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.086	4B	0.830	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.086	2B	0.081	(A,B,C,D)

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction (N/mm^2)

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. ML	-2.0	-2.0	2.0	2.0	0.0	0.0	0.0	0.0
Circ. Bend. ML	-7.1	7.1	7.1	-7.1	0.0	0.0	0.0	0.0
Tot. Circ. Str.	-9.1	5.1	9.1	-5.1	0.0	0.0	0.0	0.0
Long. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. ML	-0.6	-0.6	0.6	0.6	0.0	0.0	0.0	0.0
Long. Bend. ML	-11.5	11.5	11.5	-11.5	0.0	0.0	0.0	0.0
Tot. Long. Str.	-12.1	11.0	12.1	-11.0	0.0	0.0	0.0	0.0
Shear VC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-4.0	-4.0	4.0	4.0
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	0.0	0.0	0.0	0.0	-4.0	-4.0	4.0	4.0
Str. Int.	12.1	11.0	12.1	11.0	7.9	7.9	7.9	7.9

Dimensionless Parameters used : Gamma = 69.53

Dimensionless Loads for Cylindrical Shells at Pad Edge:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.125	4C	10.669	(A,B)
N(PHI) / (P/Rm)	0.125	3C	7.675	(C,D)
M(PHI) / (P)	0.125	2C1	0.049	(A,B)
M(PHI) / (P)	0.125	1C	0.084	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.125	3A	2.700	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.125	1A	0.082	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.125	3B	7.865	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.125	1B	0.032	(A,B,C,D)
N(x) / (P/Rm)	0.125	3C	7.675	(A,B)
N(x) / (P/Rm)	0.125	4C	10.669	(C,D)
M(x) / (P)	0.125	1C1	0.086	(A,B)
M(x) / (P)	0.125	2C	0.050	(C,D)

N(x) / (MC/(Rm**2 * Beta))	0.125	4A	4.622	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.125	2A	0.041	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.125	4B	2.699	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.125	2B	0.043	(A,B,C,D)

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Edge of Reinforcing Pad (N/mm^2)

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. ML	-7.5	-7.5	7.5	7.5	0.0	0.0	0.0	0.0
Circ. Bend. ML	-12.5	12.5	12.5	-12.5	0.0	0.0	0.0	0.0
Tot. Circ. Str.	-20.0	5.1	20.0	-5.1	0.0	0.0	0.0	0.0
Long. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. ML	-2.6	-2.6	2.6	2.6	0.0	0.0	0.0	0.0
Long. Bend. ML	-17.1	17.1	17.1	-17.1	0.0	0.0	0.0	0.0
Tot. Long. Str.	-19.6	14.5	19.6	-14.5	0.0	0.0	0.0	0.0
Shear VC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-5.5	-5.5	5.5	5.5
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	0.0	0.0	0.0	0.0	-5.5	-5.5	5.5	5.5
Str. Int.	20.0	14.5	20.0	14.5	10.9	10.9	10.9	10.9

WRC 107/537 Stress Summations:

Vessel Stress Summation at Attachment Junction (N/mm^2)

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Pl (SUS)	-2.0	-2.0	2.0	2.0	0.0	0.0	0.0	0.0
Circ. Q (SUS)	-7.1	7.1	7.1	-7.1	0.0	0.0	0.0	0.0
Long. Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Pl (SUS)	-0.6	-0.6	0.6	0.6	0.0	0.0	0.0	0.0
Long. Q (SUS)	-11.5	11.5	11.5	-11.5	0.0	0.0	0.0	0.0
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	0.0	0.0	0.0	0.0	-4.0	-4.0	4.0	4.0
Shear Q (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Pm+Pl (SUS)	2.0	2.0	2.0	2.0	7.9	7.9	7.9	7.9
Pm+Pl+Q (Total)	12.1	11.0	12.1	11.0	7.9	7.9	7.9	7.9

Vessel Stress Summation Comparison (N/mm^2):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	0.00	137.90	Passed
Pm+Pl (SUS)	7.93	206.85	Passed
Pm+Pl+Q (TOTAL)	12.10	413.70	Passed

The Pm+Pl+Q allowable above was based on the rules of ASME VIII-2 Part 4, 4.1.6.3 (a)&(b) or per ASME VIII-2, 5.5.6.1(1)&(2) Part 5 as applicable.

The Pm+Pl+Q allowable was based on a temperature range cycling from ambient to design temperature.

WRC 107/537 Stress Summations:

Vessel Stress Summation at Reinforcing Pad Edge (N/mm^2)

Type of Stress	Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Pl (SUS)		-7.5	-7.5	7.5	7.5	0.0	0.0	0.0	0.0
Circ. Q (SUS)		-12.5	12.5	12.5	-12.5	0.0	0.0	0.0	0.0
Long. Pm (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Pl (SUS)		-2.6	-2.6	2.6	2.6	0.0	0.0	0.0	0.0
Long. Q (SUS)		-17.1	17.1	17.1	-17.1	0.0	0.0	0.0	0.0
Shear Pm (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)		0.0	0.0	0.0	0.0	-5.5	-5.5	5.5	5.5
Shear Q (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pm (SUS)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pm+Pl (SUS)		7.5	7.5	7.5	7.5	10.9	10.9	10.9	10.9
Pm+Pl+Q (Total)		20.0	14.5	20.0	14.5	10.9	10.9	10.9	10.9

Vessel Stress Summation Comparison (N/mm^2):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	0.00	137.90	Passed
Pm+Pl (SUS)	10.93	206.85	Passed
Pm+Pl+Q (TOTAL)	19.98	413.70	Passed

The Pm+Pl+Q allowable above was based on the rules of ASME VIII-2 Part 4, 4.1.6.3 (a)&(b) or per ASME VIII-2, 5.5.6.1(1)&(2) Part 5 as applicable.

The Pm+Pl+Q allowable was based on a temperature range cycling from ambient to design temperature.

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RESULTS FOR LEGS : Operating Case Description: LEGS

Legs attached to: node 20

Section Properties : I Beam HE200B

European Structural Steel Data

Overall Leg Length		1440.000	mm
Effective Leg Length	Leglen	1240.000	mm
Distance Leg Up Side of Vessel		350.000	mm
Number of Legs	Nleg	4	
Cross Sectional Area for HE200B	Aleg	78.100	cm^2
Section Inertia (strong axis)		5695.972	cm^4
Section Inertia (weak axis)		2002.990	cm^4
Section Modulus (strong axis)		570002.312	mm³
Section Modulus (weak axis)		200000.812	mm³
Radius of Gyration (strong axis)		85.400	mm
Radius of Gyration (weak axis)		50.700	mm

Leg Orientation - Weak Axis

Overturning Moment at top of Legs		7472.8	kgm
Total Weight Load at top of Legs	W	6869.9	kgf
Total Shear force at top of Legs		4809.0	kgf
Additional force in Leg due to Bracing	Fadd	0.0	kgf
Occasional Load Factor	Occfac	1.333	
Effective Leg End Condition Factor	k	1.000	

Note: The Legs are Not Cross Braced

The Leg Shear Force includes Wind, Seismic, and Applied Load Effects.

Pad Width along Circumference	C11P	300.000	mm
Pad Length along Vessel Axis	C22P	350.000	mm
Pad Thickness	Tpad	18.000	mm

Maximum Shear at top of one Leg [Vleg]:
= (max(Wind, Seismic, Blast) + applied forces)(Imax / Itot)
= (4809)(5696/15407)
= 1777.87 kgf

Axial Compression, Leg furthest from the Neutral Axis [Sma]:
= W/Nleg + (Mleg/(Nlegm*Rn))/Aleg
= 67370/4 + (73277640/(2 * 1361))/7810
= 5.60 N/mm^2

Axial Compression, Leg closest to the Neutral Axis [Sva]:
= (W / Nleg) / Aleg
= (6870/4)/78.1
= 2.16 N/mm^2

Allowable Compressive Stress for the Selected Leg (KL/r < Cc) [Sa]:
= Occfac(1-(kl/r)²/(2*Cc²))Fy/(5/3+3(Kl/r)/(8*Cc)-(Kl/r³)/(8*Cc³)
= 1.333(1-(24.46)²/(2*127.2²))248.2/(5/3+3(24.46)/(8*127.2)-(24.46³)/(8*127.2³)
= 186.87 N/mm^2

Bending at the Bottom of the Leg closest to the NA. [S]:
= (Vleg * Leglen / Smdwa)
= (1778 * 1240/200001)
= 108.10 N/mm^2

Allowable Bending Stress[Sb]:
= (0.6 * Fy * Occfac)
= (0.6 * 248.2 * 1.333)
= 198.53 N/mm^2

AISC Unity Check [Sc](must be <= to 1 and > 0) :
= (Sma/Sa)+(0.85*S)/((1-Sma/Spex)*Sb)
= (5.604/186.9)+(0.85 *108.1)/((1 -5.604/2334) *198.5)
= 0.4939

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

Rectangular Attachment Parameter	C11	200.000	mm
Rectangular Attachment Parameter	C22	330.950	mm

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

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	1.5000	mm
Vessel Diameter	Dv	2464.300	mm
Vessel Thickness	Tv	17.850	mm
Design Temperature	T1	90.0	C
Vessel Material		SA-516 70	
Vessel UNS Number		K02700	
Vessel Cold S.I. Allowable	Smc	137.90	N/mm^2
Vessel Hot S.I. Allowable	Smh	137.90	N/mm^2

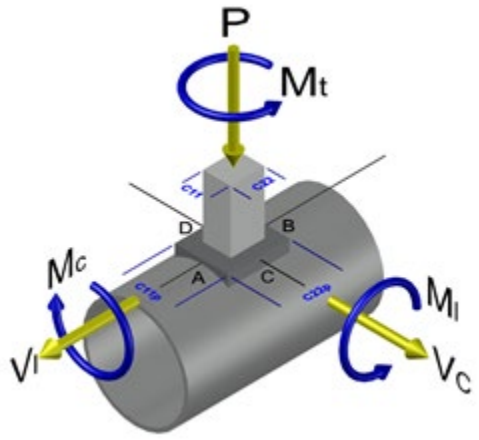
See ASME VIII Div. 1, UG-23(e), for determination of the SPS allowable.

Attachment Type	Type	Rectangular	
Parameter C11	C11	200.00	mm
Parameter C22	C22	330.95	mm
Thickness of Reinforcing Pad	Tpad	18.000	mm
Pad Parameter C11P	C11p	300.000	mm
Pad Parameter C22P	C22p	350.000	mm
Design Internal Pressure	Dp	12.000	barg
Include Pressure Thrust		No	
Vessel Centerline Direction Cosine	Vx	0.000	
Vessel Centerline Direction Cosine	Vy	1.000	
Vessel Centerline Direction Cosine	Vz	0.000	
Nozzle Centerline Direction Cosine	Nx	1.000	
Nozzle Centerline Direction Cosine	Ny	0.000	
Nozzle Centerline Direction Cosine	Nz	0.000	
Global Force (SUS)	Fx	0.0	kgf
Global Force (SUS)	Fy	1717.5	kgf
Global Force (SUS)	Fz	0.0	kgf
Global Moment (SUS)	Mx	0.0	kgm
Global Moment (SUS)	My	0.0	kgm
Global Moment (SUS)	Mz	190.6	kgm
Internal Pressure (SUS)	P	12.00	barg
Include Pressure Thrust		No	
Global Force (OCC)	Fx	1777.9	kgf
Global Force (OCC)	Fy	2745.3	kgf

Global Force (OCC)	Fz	0.0	kgf
Global Moment (OCC)	Mx	0.0	kgm
Global Moment (OCC)	My	0.0	kgm
Global Moment (OCC)	Mz	1407.0	kgm
Occasional Internal Pressure (OCC)	Pvar	0.00	barg

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

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



WRC 107/537 has dimensional limitations that can be found in the bulletin's Foreword and which can also be inferred by review of the non-dimensional curve limits.

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	0.0	kgf
Circumferential Shear	VC	0.0	kgf
Longitudinal Shear	VL	1717.5	kgf
Circumferential Moment	MC	0.0	kgm
Longitudinal Moment	ML	-190.6	kgm
Torsional Moment	MT	0.0	kgm

Dimensionless Parameters used : Gamma = 36.41

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.129	4C	6.103	(A,B)
N(PHI) / (P/Rm)	0.129	3C	4.905	(C,D)
M(PHI) / (P)	0.096	2C1	0.096	(A,B)
M(PHI) / (P)	0.096	1C	0.129	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.095	3A	0.995	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.103	1A	0.096	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.112	3B	3.808	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.108	1B	0.045	(A,B,C,D)
N(x) / (P/Rm)	0.114	3C	5.271	(A,B)

N(x) / (P/Rm)	0.114	4C	6.278	(C,D)
M(x) / (P)	0.116	1C1	0.117	(A,B)
M(x) / (P)	0.116	2C	0.079	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.095	4A	1.435	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.123	2A	0.049	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.112	4B	1.103	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.122	2B	0.065	(A,B,C,D)

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction (N/mm^2)

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. ML	1.0	1.0	-1.0	-1.0	0.0	0.0	0.0	0.0
Circ. Bend. ML	3.1	-3.1	-3.1	3.1	0.0	0.0	0.0	0.0
Tot. Circ. Str.	4.2	-2.1	-4.2	2.1	0.0	0.0	0.0	0.0
Long. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. ML	0.4	0.4	-0.4	-0.4	0.0	0.0	0.0	0.0
Long. Bend. ML	4.0	-4.0	-4.0	4.0	0.0	0.0	0.0	0.0
Tot. Long. Str.	4.4	-3.6	-4.4	3.6	0.0	0.0	0.0	0.0
Shear VC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-0.7	-0.7	0.7	0.7
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	0.0	0.0	0.0	0.0	-0.7	-0.7	0.7	0.7
Str. Int.	4.4	3.6	4.4	3.6	1.5	1.5	1.5	1.5

Dimensionless Parameters used : Gamma = 75.95

Dimensionless Loads for Cylindrical Shells at Pad Edge:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.142	4C	10.883	(A,B)
N(PHI) / (P/Rm)	0.142	3C	7.125	(C,D)
M(PHI) / (P)	0.127	2C1	0.045	(A,B)
M(PHI) / (P)	0.127	1C	0.079	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.127	3A	2.968	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.137	1A	0.077	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.134	3B	8.258	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.134	1B	0.028	(A,B,C,D)
N(x) / (P/Rm)	0.135	3C	7.497	(A,B)
N(x) / (P/Rm)	0.135	4C	11.159	(C,D)
M(x) / (P)	0.137	1C1	0.076	(A,B)
M(x) / (P)	0.137	2C !	0.041	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.127	4A	5.223	(A,B,C,D)

```
M(x)   / ( MC/(Rm    * Beta) )   0.153   2A        0.035   (A,B,C,D)
N(x)   / ( ML/(Rm**2 * Beta) )   0.134   4B        3.025   (A,B,C,D)
M(x)   / ( ML/(Rm    * Beta) )   0.141   2B        0.034   (A,B,C,D)
```

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

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Edge of Reinforcing Pad (N/mm^2)

Type of Stress	Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb.	P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Bend.	P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb.	MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb.	MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb.	ML	4.1	4.1	-4.1	-4.1	0.0	0.0	0.0	0.0
Circ. Bend.	ML	7.1	-7.1	-7.1	7.1	0.0	0.0	0.0	0.0
Tot. Circ. Str.		11.2	-3.0	-11.2	3.0	0.0	0.0	0.0	0.0
Long. Memb.	P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend.	P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb.	MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend.	MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb.	ML	1.5	1.5	-1.5	-1.5	0.0	0.0	0.0	0.0
Long. Bend.	ML	8.1	-8.1	-8.1	8.1	0.0	0.0	0.0	0.0
Tot. Long. Str.		9.7	-6.6	-9.7	6.6	0.0	0.0	0.0	0.0
Shear	VC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear	VL	0.0	0.0	0.0	0.0	-1.5	-1.5	1.5	1.5
Shear	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear		0.0	0.0	0.0	0.0	-1.5	-1.5	1.5	1.5
Str. Int.		11.2	6.6	11.2	6.6	2.9	2.9	2.9	2.9

WRC 107 Stress Calculation for OCCasional loads:

Radial Load	P	1777.9	kgf
Circumferential Shear	VC	0.0	kgf
Longitudinal Shear	VL	2745.3	kgf
Circumferential Moment	MC	0.0	kgm
Longitudinal Moment	ML	-1407.0	kgm
Torsional Moment	MT	0.0	kgm

Dimensionless Parameters used : Gamma = 36.41

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction (N/mm^2)

Type of Stress	Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb.	P	-2.5	-2.5	-2.5	-2.5	-2.0	-2.0	-2.0	-2.0
Circ. Bend.	P	-8.5	8.5	-8.5	8.5	-11.4	11.4	-11.4	11.4
Circ. Memb.	MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb.	MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Circ. Memb. ML	7.6	7.6	-7.6	-7.6	0.0	0.0	0.0	0.0
Circ. Bend. ML	23.2	-23.2	-23.2	23.2	0.0	0.0	0.0	0.0
Tot. Circ. Str.	19.9	-9.6	-41.8	21.6	-13.4	9.4	-13.4	9.4
Long. Memb. P	-2.1	-2.1	-2.1	-2.1	-2.5	-2.5	-2.5	-2.5
Long. Bend. P	-10.3	10.3	-10.3	10.3	-7.0	7.0	-7.0	7.0
Long. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. ML	2.9	2.9	-2.9	-2.9	0.0	0.0	0.0	0.0
Long. Bend. ML	29.7	-29.7	-29.7	29.7	0.0	0.0	0.0	0.0
Tot. Long. Str.	20.1	-18.6	-45.1	35.0	-9.6	4.5	-9.6	4.5
Shear VC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-1.2	-1.2	1.2	1.2
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	0.0	0.0	0.0	0.0	-1.2	-1.2	1.2	1.2
Str. Int.	20.1	18.6	45.1	35.0	13.8	9.7	13.8	9.7

Dimensionless Parameters used : Gamma = 75.95
Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Edge of Reinforcing Pad (N/mm^2)

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-9.3	-9.3	-9.3	-9.3	-6.1	-6.1	-6.1	-6.1
Circ. Bend. P	-17.6	17.6	-17.6	17.6	-31.0	31.0	-31.0	31.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. ML	30.3	30.3	-30.3	-30.3	0.0	0.0	0.0	0.0
Circ. Bend. ML	52.3	-52.3	-52.3	52.3	0.0	0.0	0.0	0.0
Tot. Circ. Str.	55.5	-13.7	-109.5	30.3	-37.2	24.9	-37.2	24.9
Long. Memb. P	-6.4	-6.4	-6.4	-6.4	-9.6	-9.6	-9.6	-9.6
Long. Bend. P	-29.6	29.6	-29.6	29.6	-16.1	16.1	-16.1	16.1
Long. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. ML	11.4	11.4	-11.4	-11.4	0.0	0.0	0.0	0.0
Long. Bend. ML	59.8	-59.8	-59.8	59.8	0.0	0.0	0.0	0.0
Tot. Long. Str.	35.2	-25.3	-107.3	71.6	-25.6	6.5	-25.6	6.5
Shear VC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-2.4	-2.4	2.4	2.4
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	0.0	0.0	0.0	0.0	-2.4	-2.4	2.4	2.4
Str. Int.	55.5	25.3	109.5	71.6	37.6	25.2	37.6	25.2

WRC 107/537 Stress Summations:

Vessel Stress Summation at Attachment Junction (N/mm^2)

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	42.5	43.7	42.5	43.7	42.5	43.7	42.5	43.7
Circ. Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Pm(TOTAL)	42.5	43.7	42.5	43.7	42.5	43.7	42.5	43.7
Circ. Pl (SUS)	1.0	1.0	-1.0	-1.0	0.0	0.0	0.0	0.0
Circ. Pl (OCC)	5.1	5.1	-10.1	-10.1	-2.0	-2.0	-2.0	-2.0
Circ. Pl(TOTAL)	6.2	6.2	-11.1	-11.1	-2.0	-2.0	-2.0	-2.0
Circ. Q (SUS)	3.1	-3.1	-3.1	3.1	0.0	0.0	0.0	0.0
Circ. Q (OCC)	14.7	-14.7	-31.7	31.7	-11.4	11.4	-11.4	11.4
Circ. Q (TOTAL)	17.9	-17.9	-34.9	34.9	-11.4	11.4	-11.4	11.4
Long. Pm (SUS)	21.3	21.3	21.3	21.3	21.3	21.3	21.3	21.3
Long. Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Pm(TOTAL)	21.3	21.3	21.3	21.3	21.3	21.3	21.3	21.3
Long. Pl (SUS)	0.4	0.4	-0.4	-0.4	0.0	0.0	0.0	0.0
Long. Pl (OCC)	0.8	0.8	-5.0	-5.0	-2.5	-2.5	-2.5	-2.5
Long. Pl(TOTAL)	1.1	1.1	-5.4	-5.4	-2.5	-2.5	-2.5	-2.5
Long. Q (SUS)	4.0	-4.0	-4.0	4.0	0.0	0.0	0.0	0.0
Long. Q (OCC)	19.4	-19.4	-40.1	40.1	-7.0	7.0	-7.0	7.0
Long. Q (TOTAL)	23.4	-23.4	-44.1	44.1	-7.0	7.0	-7.0	7.0
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pm(TOTAL)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	0.0	0.0	0.0	0.0	-0.7	-0.7	0.7	0.7
Shear Pl (OCC)	0.0	0.0	0.0	0.0	-1.2	-1.2	1.2	1.2
Shear Pl(TOTAL)	0.0	0.0	0.0	0.0	-1.9	-1.9	1.9	1.9
Shear Q (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Q (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Q (TOTAL)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pm (SUS)	42.5	43.7	42.5	43.7	42.5	43.7	42.5	43.7
Pm (SUS+OCC)	42.5	43.7	42.5	43.7	42.5	43.7	42.5	43.7
Pm+Pl (SUS)	43.5	44.7	41.5	42.7	42.5	43.7	42.5	43.7
Pm+Pl (SUS+OCC)	48.7	49.9	31.4	32.6	40.7	41.9	40.7	41.9
Pm+Pl+Q (Total)	66.6	33.0	28.3	67.5	29.3	53.3	29.3	53.3

Vessel Stress Summation Comparison (N/mm^2):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	43.71	137.90	Passed
Pm (SUS+OCC)	43.71	165.48	Passed
Pm+Pl (SUS)	44.74	206.85	Passed
Pm+Pl (SUS+OCC)	49.88	248.22	Passed
Pm+Pl+Q (TOTAL)	67.47	481.39	Passed

The Pm+Pl+Q allowable above was based on the rules of ASME VIII-2 Part 4, 4.1.6.3 (a)&(b) or per ASME VIII-2, 5.5.6.1(1)&(2) Part 5 as applicable.

The Pm+Pl+Q allowable was based on a temperature range cycling from ambient to design temperature.

WRC 107/537 Stress Summations:

Vessel Stress Summation at Reinforcing Pad Edge (N/mm^2)

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	90.0	91.2	90.0	91.2	90.0	91.2	90.0	91.2
Circ. Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Pm(TOTAL)	90.0	91.2	90.0	91.2	90.0	91.2	90.0	91.2
Circ. Pl (SUS)	4.1	4.1	-4.1	-4.1	0.0	0.0	0.0	0.0
Circ. Pl (OCC)	20.9	20.9	-39.6	-39.6	-6.1	-6.1	-6.1	-6.1
Circ. Pl(TOTAL)	25.0	25.0	-43.7	-43.7	-6.1	-6.1	-6.1	-6.1
Circ. Q (SUS)	7.1	-7.1	-7.1	7.1	0.0	0.0	0.0	0.0
Circ. Q (OCC)	34.6	-34.6	-69.9	69.9	-31.0	31.0	-31.0	31.0
Circ. Q (TOTAL)	41.7	-41.7	-77.0	77.0	-31.0	31.0	-31.0	31.0
Long. Pm (SUS)	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
Long. Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Pm(TOTAL)	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
Long. Pl (SUS)	1.5	1.5	-1.5	-1.5	0.0	0.0	0.0	0.0
Long. Pl (OCC)	5.0	5.0	-17.8	-17.8	-9.6	-9.6	-9.6	-9.6
Long. Pl(TOTAL)	6.5	6.5	-19.4	-19.4	-9.6	-9.6	-9.6	-9.6
Long. Q (SUS)	8.1	-8.1	-8.1	8.1	0.0	0.0	0.0	0.0
Long. Q (OCC)	30.2	-30.2	-89.4	89.4	-16.1	16.1	-16.1	16.1
Long. Q (TOTAL)	38.4	-38.4	-97.5	97.5	-16.1	16.1	-16.1	16.1
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pm(TOTAL)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	0.0	0.0	0.0	0.0	-1.5	-1.5	1.5	1.5
Shear Pl (OCC)	0.0	0.0	0.0	0.0	-2.4	-2.4	2.4	2.4
Shear Pl(TOTAL)	0.0	0.0	0.0	0.0	-3.8	-3.8	3.8	3.8
Shear Q (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Q (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Q (TOTAL)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pm (SUS)	90.0	91.2	90.0	91.2	90.0	91.2	90.0	91.2
Pm (SUS+OCC)	90.0	91.2	90.0	91.2	90.0	91.2	90.0	91.2
Pm+Pl (SUS)	94.1	95.3	85.9	87.1	90.0	91.2	90.0	91.2
Pm+Pl (SUS+OCC)	115.0	116.2	46.2	47.4	84.1	85.3	84.1	85.3
Pm+Pl+Q (Total)	156.7	74.5	71.9	124.4	53.2	116.3	53.2	116.3

Vessel Stress Summation Comparison (N/mm^2):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	91.15	137.90	Passed
Pm (SUS+OCC)	91.15	165.48	Passed
Pm+Pl (SUS)	95.25	206.85	Passed
Pm+Pl (SUS+OCC)	116.18	248.22	Passed
Pm+Pl+Q (TOTAL)	156.68	481.39	Passed

The Pm+Pl+Q allowable above was based on the rules of ASME VIII-2 Part 4, 4.1.6.3 (a)&(b) or per ASME VIII-2, 5.5.6.1(1)&(2) Part 5 as applicable.

The Pm+Pl+Q allowable was based on a temperature range cycling from ambient to design temperature.

Bolting Size Requirement for Leg Baseplates :

Baseplate Material		SA-516 70	
Baseplate Allowable Stress	SBA	137.90	N/mm^2
Baseplate Length	B	400.0000	mm
Baseplate Width	D	400.0000	mm
Baseplate Thickness	BTHK	40.0000	mm
Leg Dimension Along Baseplate Length	d	199.9996	mm
Leg Dimension Along Baseplate Width	b	199.9996	mm
Dist. from the Leg Edge to Bolt Hole Center	z	50.0000	mm
Bolt Material		SA-307 B	
Bolt Allowable Tensile Stress	STBA	48.26	N/mm^2
Bolt Allowable Shear Stress	SBShear	28.96	N/mm^2
Anchor Bolt Nominal Diameter	BOD	33.0000	mm
Number of Anchor Bolts in Tension per Leg	NB	3	
Total Number of Anchors Bolt per Leg	NBT	6	
Bolt Corrosion Allowance	bca	0.0000	mm
Ultimate 28-day Concrete Strength	FCPRIME	20.685	N/mm^2

Leg Baseplate and Bolting Analysis, including Moments

Shear Stress in a Single Bolt [taub]:
  = Shear Force/(Bolt Area * Number of Bolts)
  = 4809/(6.302 * 24)
  = 3.1 N/mm^2. Must be less than 29.0 N/mm^2.

I-Beam Leg

Base Plate Available Area [AA]:
  = B * D
  = 400 * 400
  = 1600.000 cm^2

Clearance Between The Bolt And The Leg Edge [BCL]:
  = z - BOD / 2
  = 50 - 33/2
  = 33.500 mm

Moment at Baseplate [MOMENT]:
  = Vleg * Lleg
  = 1778 * 1440
  = 2560.182 kgm

Axial Load on the baseplate [P]:
  = 1854.787 kgf, based on governing load combinatioN

Eccentricity [e]:
  = MOMENT * Conv_Factor / P
  = 2560 * 9807/1855
  = 1380.283 mm, > D/6 [Plate Uplift Condition]

Clearance [a]:
  = (D - d)/2
  = (400 - 200)/2
  = 100.000 mm

Modular Ratio of Steel/Concrete [n]:
  = ES/EC
  = 203402/21526
  = 9.449

Dimension [F]:
  = 0.5 * d + z
  = 0.5 * 200 + 50
  = 150.000 mm

Dimension [K1]:
= 3(e - 0.5 * D)
= 3(1380 - 0.5 * 400)
= 3540.848 mm

Value [K2]:
= 6 * n * Ast/B(F + e)
= 6 * 9.449 * 18.91/400 (150 + 1380)
= 4100.733 cm^2

Distance [K3]:
= -K2(0.5 * D + F)
= -4101 (0.5 * 400 + 150)
= -1435255.750 mm³

Solving For The Effective Bearing Length Using Iteration [Y]:
:: Y³ + K1 * Y² + K2 * Y + K3 = 0
:: Y³ + 3541 * Y² + 4101 * Y - 1435255 = 0
= 149.330 mm

Term [NUM]:
= D/2 - Y/3 - e
= 400/2 - 149.3/3 - 1380
= -1230.059 mm

Term [DENOM]:
= D/2 - Y/3 + F
= 400/2 - 149.3/3 + 150
= 300.223 mm

Total Bolt Tension Force [T]:
= - P * NUM/DENOM
= - 1855 * -1230/300.2
= 7599.346 kgf

Overturning Moment Due To Bolt In Tension [Mt]:
= T(0.5 * D + F - Y)
= 7599 (0.5 * 400 + 150 - 149.3)
= 1524.988 kgm

Bearing Pressure [FC]:
= 2(P + T)/(Y * B)
= 2(1855 + 7599)/(149.3 * 400)
= 31.04 barg [<= FCPRIME (206.84)]

Equivalent Bearing Pressure [f1]:
= FC(Y - a)/Y
= 31.04 (149.3 - 100)/149.3
= 10.254 barg

Overturning Moment Due To Bearing Pressure [Mc]:
= (a² * B/6) * (f1 + 2 * FC)
= (100² * 400/6) * (10.25 + 2 * 31.04)
= 491.793 kgm

The Baseplate Required Thickness [TREQ]:
= sqrt(6 * max(Mt, Mc) / (B * 1.5 * SBA))
= sqrt(6 * 1525/(400 * 206.9))
= 32.931 mm

Required bolt area per D. Moss [ABREQM]:
= T/STBA
= 7599/48.26

= 15.4409 cm^2 [< Ast (18.91) --> PASSED]

Distance from Top of Legs to Vessel CG [CD_DIST]:
= 1347 mm

Total Overturning Moment at Baseplate [Mbb]:
= (Mleg / max(CD_DIST, minDist)) * (CD_DIST + Lleg)
= (7473/max(1347, 38.1)) * (1347 + 1440)
= 15461.718 kgm

Required Total Bolt Area per Leg per H. Bednar [ABREQB]:
= (1/(Nleg * STBA)) * ((4 * Mbb/(Rn * 2)) - W)
= (1/(4 * 48.26)) * ((4 * 15462/(2722)) - 7419)
= 7.7727 cm^2

Available Total Bolt Corr. Area per Leg [ABAVL]:
= As * NBT
= 6.302 * 6
= 37.8131 cm^2 [> ABREQB (7.77) --> PASSED]

Baseplate & Bolting Summary of Results: (mm, cm^2)

	Actual	Required	Pass/Fail
Baseplate Thickness	40.000	32.931	Pass
Bolt Root Area (Bednar)	37.81	7.77	Pass
Bolt Root Area (D. Moss)	18.91	15.44	Pass

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

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

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RESULTS FOR LEGS : HydroTest Case Description: LEGS

Legs attached to: node 20

Section Properties : I Beam HE200B

European Structural Steel Data

Overall Leg Length		1440.000	mm
Effective Leg Length	Leglen	1240.000	mm
Distance Leg Up Side of Vessel		350.000	mm
Number of Legs	Nleg	4	
Cross Sectional Area for HE200B	Aleg	78.100	cm^2
Section Inertia (strong axis)		5695.972	cm^4
Section Inertia (weak axis)		2002.990	cm^4
Section Modulus (strong axis)		570002.312	mm³
Section Modulus (weak axis)		200000.812	mm³
Radius of Gyration (strong axis)		85.400	mm
Radius of Gyration (weak axis)		50.700	mm

Leg Orientation - Weak Axis

Overturning Moment at top of Legs		1312.6	kgm
Total Weight Load at top of Legs	W	29978.2	kgf
Total Shear force at top of Legs		765.4	kgf
Additional force in Leg due to Bracing	Fadd	0.0	kgf
Occasional Load Factor	Occfac	1.333	
Effective Leg End Condition Factor	k	1.000	

Note: The Legs are Not Cross Braced

The Leg Shear Force includes Wind, Seismic, and Applied Load Effects.

Pad Width along Circumference	C11P	300.000	mm
Pad Length along Vessel Axis	C22P	350.000	mm
Pad Thickness	Tpad	18.000	mm

Maximum Shear at top of one Leg [Vleg]:
= (max(Wind, Seismic, Blast) + applied forces)(Imax / Itot)
= (765.4)(5696/15407)
= 282.98 kgf

Axial Compression, Leg furthest from the Neutral Axis [Sma]:
= W/Nleg + (Mleg/(Nlegm*Rn))/Aleg
= 293981/4 + (12870725/(2 * 1361))/7810
= 10.02 N/mm^2

Axial Compression, Leg closest to the Neutral Axis [Sva]:
= (W / Nleg) / Aleg
= (29978/4)/78.1
= 9.41 N/mm^2

Allowable Compressive Stress for the Selected Leg (KL/r < Cc) [Sa]:
= Occfac(1-(kl/r)²/(2*Cc²))Fy/(5/3+3(Kl/r)/(8*Cc)-(Kl/r³)/(8*Cc³)
= 1.333(1-(24.46)²/(2*127.2²))248.2/(5/3+3(24.46)/(8*127.2)-(24.46³)/(8*127.2³)
= 186.87 N/mm^2

Bending at the Bottom of the Leg closest to the NA. [S]:
= (Vleg * Leglen / Smdwa)
= (283 * 1240/200001)
= 17.21 N/mm^2

Allowable Bending Stress[Sb]:
= (0.6 * Fy * Occfac)
= (0.6 * 248.2 * 1.333)
= 198.53 N/mm^2

AISC Unity Check [Sc](must be <= to 1 and > 0) :
= (Sma/Sa)+(0.85*S)/((1-Sma/Spex)*Sb)
= (10.02/186.9)+(0.85 *17.21)/((1 -10.02/2334) *198.5)
= 0.1276

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

Rectangular Attachment Parameter	C11	200.000	mm
Rectangular Attachment Parameter	C22	330.950	mm

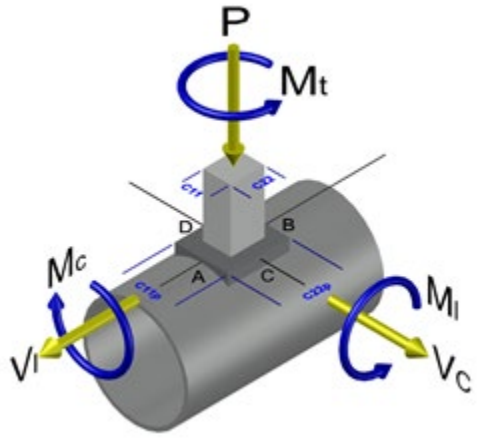
Input Echo, WRC107/537 Item 1, Description: LEGS

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	0.0000	mm
Vessel Diameter	Dv	2464.300	mm
Vessel Thickness	Tv	17.850	mm
Design Temperature	T1	90.0	C
Vessel Material		SA-516 70	
Vessel UNS Number		K02700	
Vessel Cold S.I. Allowable	Smc	179.27	N/mm^2
Vessel Hot S.I. Allowable	Smh	179.27	N/mm^2
Attachment Type	Type	Rectangular	
Parameter C11	C11	200.00	mm
Parameter C22	C22	330.95	mm
Thickness of Reinforcing Pad	Tpad	18.000	mm
Pad Parameter C11P	C11p	300.000	mm
Pad Parameter C22P	C22p	350.000	mm
Design Internal Pressure	Dp	12.000	barg
Include Pressure Thrust		No	
Vessel Centerline Direction Cosine	Vx	0.000	
Vessel Centerline Direction Cosine	Vy	1.000	
Vessel Centerline Direction Cosine	Vz	0.000	
Nozzle Centerline Direction Cosine	Nx	1.000	
Nozzle Centerline Direction Cosine	Ny	0.000	
Nozzle Centerline Direction Cosine	Nz	0.000	
Global Force (SUS)	Fx	0.0	kgf
Global Force (SUS)	Fy	7494.5	kgf
Global Force (SUS)	Fz	0.0	kgf
Global Moment (SUS)	Mx	0.0	kgm
Global Moment (SUS)	My	0.0	kgm
Global Moment (SUS)	Mz	831.9	kgm
Internal Pressure (SUS)	P	12.00	barg
Include Pressure Thrust		No	
Global Force (OCC)	Fx	283.0	kgf
Global Force (OCC)	Fy	482.2	kgf
Global Force (OCC)	Fz	0.0	kgf
Global Moment (OCC)	Mx	0.0	kgm
Global Moment (OCC)	My	0.0	kgm

Global Moment (OCC)	Mz	229.0	kgm
Occasional Internal Pressure (OCC)	Pvar	5.57	barg

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

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



WRC 107/537 has dimensional limitations that can be found in the bulletin's Foreword and which can also be inferred by review of the non-dimensional curve limits.

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	0.0	kgf
Circumferential Shear	VC	0.0	kgf
Longitudinal Shear	VL	7494.5	kgf
Circumferential Moment	MC	0.0	kgm
Longitudinal Moment	ML	-831.9	kgm
Torsional Moment	MT	0.0	kgm

Dimensionless Parameters used : Gamma = 34.87

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.129	4C	5.879	(A,B)
N(PHI) / (P/Rm)	0.129	3C	4.735	(C,D)
M(PHI) / (P)	0.096	2C1	0.098	(A,B)
M(PHI) / (P)	0.096	1C	0.131	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.095	3A	0.929	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.103	1A	0.097	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.112	3B	3.589	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.108	1B	0.045	(A,B,C,D)
N(x) / (P/Rm)	0.114	3C	5.083	(A,B)
N(x) / (P/Rm)	0.114	4C	6.043	(C,D)
M(x) / (P)	0.116	1C1	0.118	(A,B)
M(x) / (P)	0.116	2C	0.081	(C,D)

N(x) / (MC/(Rm**2 * Beta))	0.095	4A	1.346	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.124	2A	0.049	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.112	4B	1.037	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.122	2B	0.066	(A,B,C,D)

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction (N/mm^2)

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. ML	4.1	4.1	-4.1	-4.1	0.0	0.0	0.0	0.0
Circ. Bend. ML	12.7	-12.7	-12.7	12.7	0.0	0.0	0.0	0.0
Tot. Circ. Str.	16.8	-8.6	-16.8	8.6	0.0	0.0	0.0	0.0
Long. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. ML	1.5	1.5	-1.5	-1.5	0.0	0.0	0.0	0.0
Long. Bend. ML	16.3	-16.3	-16.3	16.3	0.0	0.0	0.0	0.0
Tot. Long. Str.	17.9	-14.8	-17.9	14.8	0.0	0.0	0.0	0.0
Shear VC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-3.1	-3.1	3.1	3.1
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	0.0	0.0	0.0	0.0	-3.1	-3.1	3.1	3.1
Str. Int.	17.9	14.8	17.9	14.8	6.2	6.2	6.2	6.2

Dimensionless Parameters used : Gamma = 69.53

Dimensionless Loads for Cylindrical Shells at Pad Edge:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.142	4C	10.123	(A,B)
N(PHI) / (P/Rm)	0.142	3C	6.828	(C,D)
M(PHI) / (P)	0.128	2C1	0.048	(A,B)
M(PHI) / (P)	0.128	1C	0.082	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.127	3A	2.706	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.138	1A	0.078	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.134	3B	7.625	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.134	1B	0.030	(A,B,C,D)
N(x) / (P/Rm)	0.136	3C	7.162	(A,B)
N(x) / (P/Rm)	0.136	4C	10.368	(C,D)
M(x) / (P)	0.137	1C1	0.079	(A,B)
M(x) / (P)	0.137	2C	0.044	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.127	4A	4.660	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.154	2A	0.036	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.134	4B	2.737	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.141	2B	0.037	(A,B,C,D)

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Edge of Reinforcing Pad (N/mm^2)

Type of Stress	Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb.	P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Bend.	P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb.	MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb.	MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb.	ML	15.1	15.1	-15.1	-15.1	0.0	0.0	0.0	0.0
Circ. Bend.	ML	27.2	-27.2	-27.2	27.2	0.0	0.0	0.0	0.0
Tot. Circ. Str.		42.4	-12.1	-42.4	12.1	0.0	0.0	0.0	0.0
Long. Memb.	P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend.	P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb.	MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend.	MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb.	ML	5.6	5.6	-5.6	-5.6	0.0	0.0	0.0	0.0
Long. Bend.	ML	32.4	-32.4	-32.4	32.4	0.0	0.0	0.0	0.0
Tot. Long. Str.		38.0	-26.7	-38.0	26.7	0.0	0.0	0.0	0.0
Shear	VC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear	VL	0.0	0.0	0.0	0.0	-5.9	-5.9	5.9	5.9
Shear	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear		0.0	0.0	0.0	0.0	-5.9	-5.9	5.9	5.9
Str. Int.		42.4	26.7	42.4	26.7	11.8	11.8	11.8	11.8

WRC 107 Stress Calculation for OCCasional loads:

Radial Load	P	283.0	kgf
Circumferential Shear	VC	0.0	kgf
Longitudinal Shear	VL	482.2	kgf
Circumferential Moment	MC	0.0	kgm
Longitudinal Moment	ML	-229.0	kgm
Torsional Moment	MT	0.0	kgm

Dimensionless Parameters used : Gamma = 34.87

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Attachment Junction (N/mm^2)

Type of Stress	Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb.	P	-0.4	-0.4	-0.4	-0.4	-0.3	-0.3	-0.3	-0.3
Circ. Bend.	P	-1.3	1.3	-1.3	1.3	-1.7	1.7	-1.7	1.7
Circ. Memb.	MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb.	MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb.	ML	1.1	1.1	-1.1	-1.1	0.0	0.0	0.0	0.0
Circ. Bend.	ML	3.5	-3.5	-3.5	3.5	0.0	0.0	0.0	0.0
Tot. Circ. Str.		3.0	-1.5	-6.2	3.3	-2.0	1.4	-2.0	1.4
Long. Memb.	P	-0.3	-0.3	-0.3	-0.3	-0.4	-0.4	-0.4	-0.4

Long. Bend. P	-1.5	1.5	-1.5	1.5	-1.0	1.0	-1.0	1.0
Long. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. ML	0.4	0.4	-0.4	-0.4	0.0	0.0	0.0	0.0
Long. Bend. ML	4.5	-4.5	-4.5	4.5	0.0	0.0	0.0	0.0
Tot. Long. Str.	3.1	-2.9	-6.8	5.3	-1.4	0.7	-1.4	0.7
Shear VC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-0.2	-0.2	0.2	0.2
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	0.0	0.0	0.0	0.0	-0.2	-0.2	0.2	0.2
Str. Int.	3.1	2.9	6.8	5.3	2.0	1.5	2.0	1.5

Dimensionless Parameters used : Gamma = 69.53
Stress Concentration Factors: Kn = 1.00, Kb = 1.00

Stresses in the Vessel at the Edge of Reinforcing Pad (N/mm^2)

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-1.3	-1.3	-1.3	-1.3	-0.9	-0.9	-0.9	-0.9
Circ. Bend. P	-2.5	2.5	-2.5	2.5	-4.3	4.3	-4.3	4.3
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. ML	4.2	4.2	-4.2	-4.2	0.0	0.0	0.0	0.0
Circ. Bend. ML	7.5	-7.5	-7.5	7.5	0.0	0.0	0.0	0.0
Tot. Circ. Str.	7.9	-2.1	-15.4	4.6	-5.2	3.5	-5.2	3.5
Long. Memb. P	-0.9	-0.9	-0.9	-0.9	-1.3	-1.3	-1.3	-1.3
Long. Bend. P	-4.1	4.1	-4.1	4.1	-2.3	2.3	-2.3	2.3
Long. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. ML	1.6	1.6	-1.6	-1.6	0.0	0.0	0.0	0.0
Long. Bend. ML	8.9	-8.9	-8.9	8.9	0.0	0.0	0.0	0.0
Tot. Long. Str.	5.4	-4.1	-15.5	10.6	-3.6	1.0	-3.6	1.0
Shear VC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-0.4	-0.4	0.4	0.4
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	0.0	0.0	0.0	0.0	-0.4	-0.4	0.4	0.4
Str. Int.	7.9	4.1	15.5	10.6	5.2	3.5	5.2	3.5

WRC 107/537 Stress Summations:

Vessel Stress Summation at Attachment Junction (N/mm^2)

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	40.7	41.9	40.7	41.9	40.7	41.9	40.7	41.9
Circ. Pm (OCC)	18.9	19.4	18.9	19.4	18.9	19.4	18.9	19.4

Circ. Pm(TOTAL)	59.5	61.3	59.5	61.3	59.5	61.3	59.5	61.3
Circ. Pl (SUS)	4.1	4.1	-4.1	-4.1	0.0	0.0	0.0	0.0
Circ. Pl (OCC)	0.8	0.8	-1.5	-1.5	-0.3	-0.3	-0.3	-0.3
Circ. Pl(TOTAL)	4.8	4.8	-5.6	-5.6	-0.3	-0.3	-0.3	-0.3
Circ. Q (SUS)	12.7	-12.7	-12.7	12.7	0.0	0.0	0.0	0.0
Circ. Q (OCC)	2.2	-2.2	-4.8	4.8	-1.7	1.7	-1.7	1.7
Circ. Q (TOTAL)	14.9	-14.9	-17.5	17.5	-1.7	1.7	-1.7	1.7
Long. Pm (SUS)	20.3	20.3	20.3	20.3	20.3	20.3	20.3	20.3
Long. Pm (OCC)	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4
Long. Pm(TOTAL)	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8
Long. Pl (SUS)	1.5	1.5	-1.5	-1.5	0.0	0.0	0.0	0.0
Long. Pl (OCC)	0.1	0.1	-0.7	-0.7	-0.4	-0.4	-0.4	-0.4
Long. Pl(TOTAL)	1.7	1.7	-2.3	-2.3	-0.4	-0.4	-0.4	-0.4
Long. Q (SUS)	16.3	-16.3	-16.3	16.3	0.0	0.0	0.0	0.0
Long. Q (OCC)	3.0	-3.0	-6.0	6.0	-1.0	1.0	-1.0	1.0
Long. Q (TOTAL)	19.3	-19.3	-22.4	22.4	-1.0	1.0	-1.0	1.0
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pm(TOTAL)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	0.0	0.0	0.0	0.0	-3.1	-3.1	3.1	3.1
Shear Pl (OCC)	0.0	0.0	0.0	0.0	-0.2	-0.2	0.2	0.2
Shear Pl(TOTAL)	0.0	0.0	0.0	0.0	-3.3	-3.3	3.3	3.3
Shear Q (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Q (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Q (TOTAL)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pm (SUS)	40.7	41.9	40.7	41.9	40.7	41.9	40.7	41.9
Pm (SUS+OCC)	59.5	61.3	59.5	61.3	59.5	61.3	59.5	61.3
Pm+Pl (SUS)	44.7	45.9	36.6	37.8	41.1	42.3	41.1	42.3
Pm+Pl (SUS+OCC)	64.4	66.1	54.0	55.7	59.6	61.3	59.6	61.3
Pm+Pl+Q (Total)	79.3	51.2	36.5	73.2	57.9	63.0	57.9	63.0

Vessel Stress Summation Comparison (N/mm^2):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	41.85	179.27	Passed
Pm (SUS+OCC)	61.30	215.12	Passed
Pm+Pl (SUS)	45.93	268.90	Passed
Pm+Pl (SUS+OCC)	66.13	322.69	Passed
Pm+Pl+Q (TOTAL)	79.31	537.81	Passed

The Pm+Pl+Q allowable above was based on the rules of ASME VIII-2 Part 4, 4.1.6.3 (a)&(b) or per ASME VIII-2, 5.5.6.1(1)&(2) Part 5 as applicable.

The Pm+Pl+Q allowable was based on a temperature range cycling from ambient to design temperature.

WRC 107/537 Stress Summations:

Vessel Stress Summation at Reinforcing Pad Edge (N/mm^2)

Type of Stress	Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl

Circ. Pm (SUS)	82.2	83.4	82.2	83.4	82.2	83.4	82.2	83.4
Circ. Pm (OCC)	38.2	38.8	38.2	38.8	38.2	38.8	38.2	38.8
Circ. Pm(TOTAL)	120.4	122.2	120.4	122.2	120.4	122.2	120.4	122.2
Circ. Pl (SUS)	15.1	15.1	-15.1	-15.1	0.0	0.0	0.0	0.0
Circ. Pl (OCC)	2.9	2.9	-5.4	-5.4	-0.9	-0.9	-0.9	-0.9
Circ. Pl(TOTAL)	18.0	18.0	-20.6	-20.6	-0.9	-0.9	-0.9	-0.9
Circ. Q (SUS)	27.2	-27.2	-27.2	27.2	0.0	0.0	0.0	0.0
Circ. Q (OCC)	5.0	-5.0	-10.0	10.0	-4.3	4.3	-4.3	4.3
Circ. Q (TOTAL)	32.2	-32.2	-37.2	37.2	-4.3	4.3	-4.3	4.3
Long. Pm (SUS)	41.1	41.1	41.1	41.1	41.1	41.1	41.1	41.1
Long. Pm (OCC)	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1
Long. Pm(TOTAL)	60.2	60.2	60.2	60.2	60.2	60.2	60.2	60.2
Long. Pl (SUS)	5.6	5.6	-5.6	-5.6	0.0	0.0	0.0	0.0
Long. Pl (OCC)	0.7	0.7	-2.4	-2.4	-1.3	-1.3	-1.3	-1.3
Long. Pl(TOTAL)	6.3	6.3	-8.1	-8.1	-1.3	-1.3	-1.3	-1.3
Long. Q (SUS)	32.4	-32.4	-32.4	32.4	0.0	0.0	0.0	0.0
Long. Q (OCC)	4.8	-4.8	-13.1	13.1	-2.3	2.3	-2.3	2.3
Long. Q (TOTAL)	37.2	-37.2	-45.4	45.4	-2.3	2.3	-2.3	2.3
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pm(TOTAL)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	0.0	0.0	0.0	0.0	-5.9	-5.9	5.9	5.9
Shear Pl (OCC)	0.0	0.0	0.0	0.0	-0.4	-0.4	0.4	0.4
Shear Pl(TOTAL)	0.0	0.0	0.0	0.0	-6.3	-6.3	6.3	6.3
Shear Q (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Q (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Q (TOTAL)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pm (SUS)	82.2	83.4	82.2	83.4	82.2	83.4	82.2	83.4
Pm (SUS+OCC)	120.4	122.2	120.4	122.2	120.4	122.2	120.4	122.2
Pm+Pl (SUS)	97.4	98.6	67.1	68.3	83.1	84.2	83.1	84.2
Pm+Pl (SUS+OCC)	138.5	140.2	99.9	101.6	120.2	122.0	120.2	122.0
Pm+Pl+Q (Total)	170.7	108.0	62.6	138.9	115.9	126.3	115.9	126.3

Vessel Stress Summation Comparison (N/mm^2):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	83.44	179.27	Passed
Pm (SUS+OCC)	122.20	215.12	Passed
Pm+Pl (SUS)	98.58	268.90	Passed
Pm+Pl (SUS+OCC)	140.24	322.69	Passed
Pm+Pl+Q (TOTAL)	170.70	537.81	Passed

The Pm+Pl+Q allowable above was based on the rules of ASME VIII-2 Part 4, 4.1.6.3 (a)&(b) or per ASME VIII-2, 5.5.6.1(1)&(2) Part 5 as applicable.

The Pm+Pl+Q allowable was based on a temperature range cycling from ambient to design temperature.

Bolting Size Requirement for Leg Baseplates :

Baseplate Material		SA-516 70	
Baseplate Allowable Stress	SBA	137.90	N/mm^2
Baseplate Length	B	400.0000	mm
Baseplate Width	D	400.0000	mm
Baseplate Thickness	BTHK	40.0000	mm
Leg Dimension Along Baseplate Length	d	199.9996	mm

Leg Dimension Along Baseplate Width	b	199.9996	mm
Dist. from the Leg Edge to Bolt Hole Center	z	50.0000	mm
Bolt Material		SA-307 B	
Bolt Allowable Tensile Stress	STBA	48.26	N/mm^2
Bolt Allowable Shear Stress	SBShear	28.96	N/mm^2
Anchor Bolt Nominal Diameter	BOD	33.0000	mm
Number of Anchor Bolts in Tension per Leg	NB	3	
Total Number of Anchors Bolt per Leg	NBT	6	
Bolt Corrosion Allowance	bca	0.0000	mm
Ultimate 28-day Concrete Strength	FCPRIME	20.685	N/mm^2

Leg Baseplate and Bolting Analysis, including Moments

Shear Stress in a Single Bolt [taub]:
= Shear Force/(Bolt Area * Number of Bolts)
= 4809/(6.302 * 24)
= 3.1 N/mm^2. Must be less than 29.0 N/mm^2.

I-Beam Leg

Base Plate Available Area [AA]:
= B * D
= 400 * 400
= 1600.000 cm^2

Clearance Between The Bolt And The Leg Edge [BCL]:
= z - BOD / 2
= 50 - 33/2
= 33.500 mm

Moment at Baseplate [MOMENT]:
= Vleg * Lleg
= 283 * 1440
= 407.493 kgm

Axial Load on the baseplate [P]:
= 1854.787 kgf, based on governing load combinatioN

Eccentricity [e]:
= MOMENT * Conv_Factor / P
= 407.5 * 9807/1855
= 219.694 mm, > D/6 [Plate Uplift Condition]

Clearance [a]:
= (D - d)/2
= (400 - 200)/2
= 100.000 mm

Modular Ratio of Steel/Concrete [n]:
= ES/EC
= 203402/21526
= 9.449

Dimension [F]:
= 0.5 * d + z
= 0.5 * 200 + 50
= 150.000 mm

Dimension [K1]:
= 3(e - 0.5 * D)
= 3(219.7 - 0.5 * 400)
= 59.081 mm

Value [K2]:
  = 6 * n * Ast/B(F + e)
  = 6 * 9.449 * 18.91/400 (150 + 219.7)
  = 990.676 cm^2

Distance [K3]:
  = -K2(0.5 * D + F)
  = -990.7 (0.5 * 400 + 150)
  = -346736.500 mm³

Solving For The Effective Bearing Length Using Iteration [Y]:
  :: Y³ + K1 * Y² + K2 * Y + K3 = 0
  :: Y³ + 59.08 * Y² + 990.7 * Y - 346736 = 0
  = 217.659 mm

Term [NUM]:
  = D/2 - Y/3 - e
  = 400/2 - 217.7/3 - 219.7
  = -92.247 mm

Term [DENOM]:
  = D/2 - Y/3 + F
  = 400/2 - 217.7/3 + 150
  = 277.447 mm

Total Bolt Tension Force [T]:
  = - P * NUM/DENOM
  = - 1855 * -92.25/277.4
  = 616.688 kgf

Overturning Moment Due To Bolt In Tension [Mt]:
  = T(0.5 * D + F - Y)
  = 616.7 (0.5 * 400 + 150 - 217.7)
  = 81.615 kgm

Bearing Pressure [FC]:
  = 2(P + T)/(Y * B)
  = 2(1855 + 616.7)/(217.7 * 400)
  = 5.57 barg [<= FCPRIME (206.84)]

Equivalent Bearing Pressure [f1]:
  = FC(Y - a)/Y
  = 5.567 (217.7 - 100)/217.7
  = 3.010 barg

Overturning Moment Due To Bearing Pressure [Mc]:
  = (a² * B/6) * (f1 + 2 * FC)
  = (100² * 400/6) * (3.01 + 2 * 5.567)
  = 96.161 kgm

The Baseplate Required Thickness [TREQ]:
  = sqrt(6 * max(Mt, Mc) / (B * 1.5 * SBA))
  = sqrt(6 * 96.16/(400 * 206.9))
  = 8.269 mm

Required bolt area per D. Moss [ABREQM]:
  = T/STBA
  = 616.7/48.26
  = 1.2530 cm^2 [< Ast (18.91) --> PASSED]

Distance from Top of Legs to Vessel CG [CD_DIST]:
  = 1543 mm

Total Overturning Moment at Baseplate [Mbb]:

```
  = ( Mleg / max( CD_DIST, minDist ) ) * ( CD_DIST + Lleg )
  = ( 1313/max( 1543, 38.1 ) ) * ( 1543 + 1440 )
  = 2537.539 kgm
```

Required Total Bolt Area per Leg per H. Bednar [ABREQB]:

```
  = ( 1/( Nleg * STBA ) ) * ( ( 4 * Mbb/( Rn * 2 ) ) - W )
  = ( 1/( 4 * 48.26 )) * ( ( 4 * 2538/( 2722 ) ) - 7419 )
  = -1.8745 cm^2 --> (No tension in bolts)
```

Baseplate & Bolting Summary of Results: (mm, cm^2)

	Actual	Required	Pass/Fail
Baseplate Thickness	40.000	8.269	Pass
Bolt Root Area (D. Moss)	18.91	1.25	Pass

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

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

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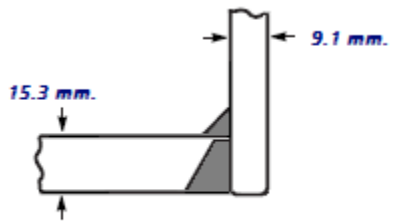
Input, Nozzle Desc: Drain From: 10

Pressure for Reinforcement Calculations	P	12.600	barg
Temperature for Internal Pressure	Temp	90	°C
Parent Material [Impact Tested]		SA-516 70	
Parent Allowable Stress at Temperature	Sv	137.90	N/mm^2
Parent Allowable Stress At Ambient	Sva	137.90	N/mm^2
Inside Diameter of Elliptical Head	D	2469.40	mm
Aspect Ratio of Elliptical Head	Ar	2.00	
Head Finished (Minimum) Thickness	t	15.3000	mm
Head Internal Corrosion Allowance	c	1.5000	mm
Head External Corrosion Allowance	co	0.0000	mm
Distance from Head Centerline	L1	0.0000	mm
User Entered Minimum Design Metal Temperature		-29.00	°C

Type of Element Connected to the Parent : Nozzle

Material [Impact Tested]		SA-333 6	
Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N/mm^2
Allowable Stress At Ambient	Sna	117.90	N/mm^2
Diameter Basis (for tr calc only)		Inside	
Layout Angle		0.00	deg
Diameter		1.0000	iN
Size and Thickness Basis		Nominal	
Nominal Thickness		XXS	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	1.5000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	100.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	12.7500	mm
Inside Projection	h	0.0000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm
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            0.599  iN
Actual Thickness Used in Calculation                  0.358  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)
  = 12.6*2472*0.899/(2*137.9*1-0.2*12.6)
  = 10.1638 mm
```

Reqd thk per App. 1 of Nozzle Wall, trn [Int. Press]
```
  = R( exp([P/(Sn*E)] - 1 ) per Appendix 1-2 (a)(1)
  = 9.107(exp([12.6/(117.9*1]-1)
  = 0.0979 mm
```

UG-40, Limits of Reinforcement: [Internal Pressure]
```
Parallel to Vessel Wall (Diameter Limit)          Dl    61.0010  mm
Parallel to Vessel Wall                       Rn+tn+t    30.5005  mm
Normal to Vessel Wall (Thickness Limit), no pad   Tlnp    18.9830  mm
```

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 = 1.5979 mm
Wall Thickness per UG16(b),                      tr16b = 4.0000 mm
Wall Thickness, shell/head, internal pressure     trb1 = 12.7880 mm
Wall Thickness                 tb1 = max(trb1, tr16b) = 12.7880 mm
Wall Thickness                 tb2 = max(trb2, tr16b) = 4.0000 mm
Wall Thickness per table UG-45                    tb3 = 4.4464 mm
```

Determine Nozzle Thickness candidate [tb]:
```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 4.446, max( 12.79, 4 ) ]
  = 4.4464 mm
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
```
  = max( ta, tb )
  = max( 1.598, 4.446 )
  = 4.4464 mm
```

Available Nozzle Neck Thickness = 0.875 * 9.093 = 7.957 mm -> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

```
Impact Test Temperature provided per Specification     -46 °C

Calculated Minimum Design Metal Temperature           -104 °C
```

Nozzle-Shell/Head Weld for the Nozzle (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

Impact Test Temperature provided per Specification -46 °C

Calculated Minimum Design Metal Temperature -104 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

Flange MDMT including Temperature reduction per UCS-66.1:

MDMT of ASME B16.5/47 flange per Matl. Specification -46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2) -65 °C

Where the Stress Reduction Ratio per UCS-66(i)(2) is :
Design Pressure/Ambient Rating = 12.60/19.60 = 0.643

Weld Size Calculations, Description: Drain

Intermediate Calc. for nozzle/shell Welds Tmin 7.5932 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	5.3152 = 0.7 * tmiN	7.0700 = 0.7 * Wo mm

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 : 0.0624 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 115.3624 mm

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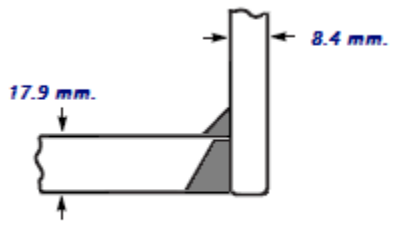
Input, Nozzle Desc: PG From: 20

Pressure for Reinforcement Calculations	P	12.600	barg
Temperature for Internal Pressure	Temp	90	°C
Parent Material [Impact Tested]		SA-516 70	
Parent Allowable Stress at Temperature	Sv	137.90	N/mm^2
Parent Allowable Stress At Ambient	Sva	137.90	N/mm^2
Inside Diameter of Cylindrical Shell	D	2464.00	mm
Shell Finished (Minimum) Thickness	t	17.8500	mm
Shell Internal Corrosion Allowance	c	1.5000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		360.00	mm
User Entered Minimum Design Metal Temperature		-29.00	°C

Type of Element Connected to the Parent : Nozzle

Material [Impact Tested]		SA-350 LF2	
Material UNS Number		K03011	
Material Specification/Type		Forgings	
Allowable Stress at Temperature	Sn	137.90	N/mm^2
Allowable Stress At Ambient	Sna	137.90	N/mm^2
Diameter Basis (for tr calc only)		Outside	
Layout Angle		-15.00	deg
Diameter		1.5000	iN
Size and Thickness Basis		Actual	
Actual Thickness	tn	8.3820	mm
Corrosion Allowance	can	1.5000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	32.7750	mm
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	14.8500	mm
Inside Projection	h	0.0000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm

The Pressure Design option was Design Pressure + static head.



Reinforcement CALCULATION, Description: PG

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

Actual Outside Diameter Used in Calculation		1.500	iN

Actual Thickness Used in Calculation 0.330 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)
= 12.6*1234/(137.9*1-0.6*12.6)
= 11.3334 mm

Reqd thk per App. 1 of Nozzle Wall, trn [Int. Press]
= Ro(1 - exp(-P/(Sn*E))) per Appendix 1-2 (a)(1)
= 19.05(1-exp(-12.6/(137.9*1)))
= 0.1733 mm

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

Parallel to Vessel Wall (Diameter Limit)	Dl	70.8000	mm
Parallel to Vessel Wall	Rn+tn+t	35.4000	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	17.2050	mm

Taking a UG-36(c)(3)(a) exemption for nozzle: PG.
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	= 1.6733 mm
Wall Thickness per UG16(b),	tr16b	= 4.0000 mm
Wall Thickness, shell/head, internal pressure	trb1	= 12.8333 mm
Wall Thickness	tb1 = max(trb1, tr16b)	= 12.8333 mm
Wall Thickness	tb2 = max(trb2, tr16b)	= 4.0000 mm
Wall Thickness per table UG-45	tb3	= 4.6200 mm

Determine Nozzle Thickness candidate [tb]:
= min[tb3, max(tb1,tb2)]
= min[4.62, max(12.83, 4)]
= 4.6200 mm

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
= max(ta, tb)
= max(1.673, 4.62)
= 4.6200 mm

Available Nozzle Neck Thickness = 8.3820 mm -> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle-Shell/Head Weld for the Nozzle (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

Impact Test Temperature provided per Specification -46 °C

Calculated Minimum Design Metal Temperature -104 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

Weld Size Calculations, Description: PG

Intermediate Calc. for nozzle/shell Welds Tmin 6.8820 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.8174 = 0.7 * tmiN	7.0700 = 0.7 * Wo mm

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 : 0.1473 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 50.7723 mm

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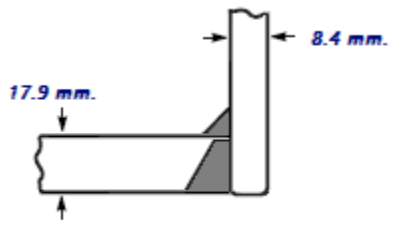
Input, Nozzle Desc: PT From: 20

Pressure for Reinforcement Calculations	P	12.600	barg
Temperature for Internal Pressure	Temp	90	°C
Parent Material [Impact Tested]		SA-516 70	
Parent Allowable Stress at Temperature	Sv	137.90	N/mm^2
Parent Allowable Stress At Ambient	Sva	137.90	N/mm^2
Inside Diameter of Cylindrical Shell	D	2464.00	mm
Shell Finished (Minimum) Thickness	t	17.8500	mm
Shell Internal Corrosion Allowance	c	1.5000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		1060.00	mm
User Entered Minimum Design Metal Temperature		-29.00	°C

Type of Element Connected to the Parent : Nozzle

Material [Impact Tested]		SA-350 LF2	
Material UNS Number		K03011	
Material Specification/Type		Forgings	
Allowable Stress at Temperature	Sn	137.90	N/mm^2
Allowable Stress At Ambient	Sna	137.90	N/mm^2
Diameter Basis (for tr calc only)		Outside	
Layout Angle		15.00	deg
Diameter		1.5000	iN
Size and Thickness Basis		Actual	
Actual Thickness	tn	8.3820	mm
Corrosion Allowance	can	1.5000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	32.7750	mm
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	14.8500	mm
Inside Projection	h	0.0000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm

The Pressure Design option was Design Pressure + static head.



Reinforcement CALCULATION, Description: PT

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

Actual Outside Diameter Used in Calculation		1.500	iN

Actual Thickness Used in Calculation 0.330 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)
= 12.6*1234/(137.9*1-0.6*12.6)
= 11.3334 mm

Reqd thk per App. 1 of Nozzle Wall, trn [Int. Press]
= Ro(1 - exp(-P/(Sn*E))) per Appendix 1-2 (a)(1)
= 19.05(1-exp(-12.6/(137.9*1)))
= 0.1733 mm

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

Parallel to Vessel Wall (Diameter Limit)	Dl	70.8000	mm
Parallel to Vessel Wall	Rn+tn+t	35.4000	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	17.2050	mm

Taking a UG-36(c)(3)(a) exemption for nozzle: PT.
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 = 1.6733 mm
Wall Thickness per UG16(b),	tr16b = 4.0000 mm
Wall Thickness, shell/head, internal pressure	trb1 = 12.8333 mm
Wall Thickness	tb1 = max(trb1, tr16b) = 12.8333 mm
Wall Thickness	tb2 = max(trb2, tr16b) = 4.0000 mm
Wall Thickness per table UG-45	tb3 = 4.6200 mm

Determine Nozzle Thickness candidate [tb]:
= min[tb3, max(tb1,tb2)]
= min[4.62, max(12.83, 4)]
= 4.6200 mm

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
= max(ta, tb)
= max(1.673, 4.62)
= 4.6200 mm

Available Nozzle Neck Thickness = 8.3820 mm -> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle-Shell/Head Weld for the Nozzle (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

Impact Test Temperature provided per Specification		-46 °C
Calculated Minimum Design Metal Temperature		-104 °C
Gov. MDMT of the nozzle to shell joint welded assembly :		-104 °C

Weld Size Calculations, Description: PT

Intermediate Calc. for nozzle/shell Welds	Tmin	6.8820	mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.8174 = 0.7 * tmiN	7.0700 = 0.7 * Wo mm

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 : 0.1473 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 50.7723 mm

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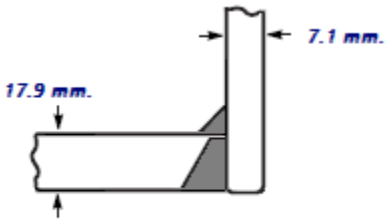
Input, Nozzle Desc: TG From: 20

Pressure for Reinforcement Calculations	P	12.600	barg
Temperature for Internal Pressure	Temp	90	°C
Parent Material [Impact Tested]		SA-516 70	
Parent Allowable Stress at Temperature	Sv	137.90	N/mm^2
Parent Allowable Stress At Ambient	Sva	137.90	N/mm^2
Inside Diameter of Cylindrical Shell	D	2464.00	mm
Shell Finished (Minimum) Thickness	t	17.8500	mm
Shell Internal Corrosion Allowance	c	1.5000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		360.00	mm
User Entered Minimum Design Metal Temperature		-29.00	°C

Type of Element Connected to the Parent : Nozzle

Material [Impact Tested]		SA-333 6	
Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N/mm^2
Allowable Stress At Ambient	Sna	117.90	N/mm^2
Diameter Basis (for tr calc only)		Outside	
Layout Angle		15.00	deg
Diameter		1.5000	iN
Size and Thickness Basis		Nominal	
Nominal Thickness		160	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	1.5000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	75.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	14.8500	mm
Inside Projection	h	0.0000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm
Flange Class		150	
Flange Grade		GR 1.1	

The Pressure Design option was Design Pressure + static head.



Reinforcement CALCULATION, Description: TG

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

```
Actual Outside Diameter Used in Calculation          1.900  iN
Actual Thickness Used in Calculation                 0.281  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)
  = 12.6*1234/(137.9*1-0.6*12.6)
  = 11.3334 mm
```

Reqd thk per UG-37(a) of Nozzle Wall, trn [Int. Press]
```
  = P*Ro/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
  = 12.6*24.13/(117.9*1+0.4*12.6)
  = 0.2568 mm
```

UG-40, Limits of Reinforcement: [Internal Pressure]
```
Parallel to Vessel Wall (Diameter Limit)           Dl    80.9600  mm
Parallel to Vessel Wall                        Rn+tn+t   40.4800  mm
Normal to Vessel Wall (Thickness Limit), no pad  Tlnp    14.0935  mm
```

Taking a UG-36(c)(3)(a) exemption for nozzle: TG.
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 = 1.7568 mm
Wall Thickness per UG16(b),                      tr16b = 4.0000 mm
Wall Thickness, shell/head, internal pressure     trb1 = 12.8333 mm
Wall Thickness                 tb1 = max(trb1, tr16b) = 12.8333 mm
Wall Thickness                 tb2 = max(trb2, tr16b) = 4.0000 mm
Wall Thickness per table UG-45                   tb3 = 4.7200 mm
```

Determine Nozzle Thickness candidate [tb]:
```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 4.72, max( 12.83, 4 ) ]
  = 4.7200 mm
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
```
  = max( ta, tb )
  = max( 1.757, 4.72 )
  = 4.7200 mm
```

Available Nozzle Neck Thickness = 0.875 * 7.137 = 6.245 mm -> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

```
Impact Test Temperature provided per Specification    -46 °C

Calculated Minimum Design Metal Temperature          -104 °C
```

Nozzle-Shell/Head Weld for the Nozzle (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

Impact Test Temperature provided per Specification -46 °C

Calculated Minimum Design Metal Temperature -104 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

Flange MDMT including Temperature reduction per UCS-66.1:

MDMT of ASME B16.5/47 flange per Matl. Specification -46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2) -65 °C

Where the Stress Reduction Ratio per UCS-66(i)(2) is :
Design Pressure/Ambient Rating = 12.60/19.60 = 0.643

Weld Size Calculations, Description: TG

Intermediate Calc. for nozzle/shell Welds Tmin 5.6374 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	3.9462 = 0.7 * tmiN	7.0700 = 0.7 * Wo mm

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 : 0.2363 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 93.0863 mm

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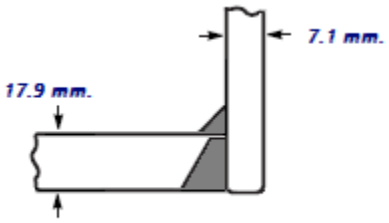
Input, Nozzle Desc: TT From: 20

Pressure for Reinforcement Calculations	P	12.600	barg
Temperature for Internal Pressure	Temp	90	°C
Parent Material [Impact Tested]		SA-516 70	
Parent Allowable Stress at Temperature	Sv	137.90	N/mm^2
Parent Allowable Stress At Ambient	Sva	137.90	N/mm^2
Inside Diameter of Cylindrical Shell	D	2464.00	mm
Shell Finished (Minimum) Thickness	t	17.8500	mm
Shell Internal Corrosion Allowance	c	1.5000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		1060.00	mm
User Entered Minimum Design Metal Temperature		-29.00	°C

Type of Element Connected to the Parent : Nozzle

Material [Impact Tested]		SA-333 6	
Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N/mm^2
Allowable Stress At Ambient	Sna	117.90	N/mm^2
Diameter Basis (for tr calc only)		Outside	
Layout Angle		-15.00	deg
Diameter		1.5000	iN
Size and Thickness Basis		Nominal	
Nominal Thickness		160	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	1.5000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	75.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	14.8500	mm
Inside Projection	h	0.0000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm
Flange Class		150	
Flange Grade		GR 1.1	

The Pressure Design option was Design Pressure + static head.



Reinforcement CALCULATION, Description: TT

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

Actual Outside Diameter Used in Calculation	1.900	iN
Actual Thickness Used in Calculation	0.281	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)
= 12.6*1234/(137.9*1-0.6*12.6)
= 11.3334 mm

Reqd thk per UG-37(a) of Nozzle Wall, trn [Int. Press]
= P*Ro/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
= 12.6*24.13/(117.9*1+0.4*12.6)
= 0.2568 mm

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

Parallel to Vessel Wall (Diameter Limit)	Dl	80.9600	mm
Parallel to Vessel Wall	Rn+tn+t	40.4800	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	14.0935	mm

Taking a UG-36(c)(3)(a) exemption for nozzle: TT.
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 = 1.7568 mm
Wall Thickness per UG16(b),	tr16b = 4.0000 mm
Wall Thickness, shell/head, internal pressure	trb1 = 12.8333 mm
Wall Thickness	tb1 = max(trb1, tr16b) = 12.8333 mm
Wall Thickness	tb2 = max(trb2, tr16b) = 4.0000 mm
Wall Thickness per table UG-45	tb3 = 4.7200 mm

Determine Nozzle Thickness candidate [tb]:
= min[tb3, max(tb1,tb2)]
= min[4.72, max(12.83, 4)]
= 4.7200 mm

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
= max(ta, tb)
= max(1.757, 4.72)
= 4.7200 mm

Available Nozzle Neck Thickness = 0.875 * 7.137 = 6.245 mm -> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

Impact Test Temperature provided per Specification	-46 °C
Calculated Minimum Design Metal Temperature	-104 °C

Nozzle-Shell/Head Weld for the Nozzle (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

Impact Test Temperature provided per Specification -46 °C

Calculated Minimum Design Metal Temperature -104 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

Flange MDMT including Temperature reduction per UCS-66.1:

MDMT of ASME B16.5/47 flange per Matl. Specification -46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2) -65 °C

Where the Stress Reduction Ratio per UCS-66(i)(2) is :
Design Pressure/Ambient Rating = 12.60/19.60 = 0.643

Weld Size Calculations, Description: TT

Intermediate Calc. for nozzle/shell Welds Tmin 5.6374 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	3.9462 = 0.7 * tmiN	7.0700 = 0.7 * Wo mm

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 : 0.2363 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 93.0863 mm

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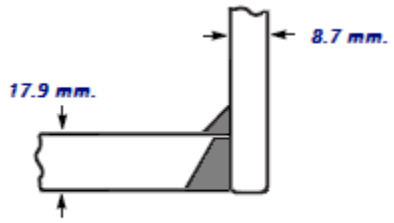
Input, Nozzle Desc: IN/OUT From: 20

Pressure for Reinforcement Calculations	P	12.600	barg
Temperature for Internal Pressure	Temp	90	°C
Parent Material [Impact Tested]		SA-516 70	
Parent Allowable Stress at Temperature	Sv	137.90	N/mm^2
Parent Allowable Stress At Ambient	Sva	137.90	N/mm^2
Inside Diameter of Cylindrical Shell	D	2464.00	mm
Shell Finished (Minimum) Thickness	t	17.8500	mm
Shell Internal Corrosion Allowance	c	1.5000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		360.00	mm
User Entered Minimum Design Metal Temperature		-29.00	°C

Type of Element Connected to the Parent : Nozzle

Material [Impact Tested]		SA-333 6	
Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N/mm^2
Allowable Stress At Ambient	Sna	117.90	N/mm^2
Diameter Basis (for tr calc only)		Outside	
Layout Angle		180.00	deg
Diameter		2.0000	iN
Size and Thickness Basis		Nominal	
Nominal Thickness		160	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	1.5000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	32.7750	mm
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	14.8500	mm
Inside Projection	h	0.0000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm
Flange Class		150	
Flange Grade		GR 1.1	

The Pressure Design option was Design Pressure + static head.



Reinforcement CALCULATION, Description: IN/OUT

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

Actual Outside Diameter Used in Calculation	2.375	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)
= 12.6*1234/(137.9*1-0.6*12.6)
= 11.3334 mm

Reqd thk per UG-37(a) of Nozzle Wall, trn [Int. Press]
= P*Ro/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
= 12.6*30.16/(117.9*1+0.4*12.6)
= 0.3210 mm

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

Parallel to Vessel Wall (Diameter Limit)	Dl	93.0250	mm
Parallel to Vessel Wall	Rn+tn+t	46.5125	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	18.0940	mm

Taking a UG-36(c)(3)(a) exemption for nozzle: IN/OUT.
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 = 1.8210 mm
Wall Thickness per UG16(b),	tr16b = 4.0000 mm
Wall Thickness, shell/head, internal pressure	trb1 = 12.8333 mm
Wall Thickness	tb1 = max(trb1, tr16b) = 12.8333 mm
Wall Thickness	tb2 = max(trb2, tr16b) = 4.0000 mm
Wall Thickness per table UG-45	tb3 = 4.9200 mm

Determine Nozzle Thickness candidate [tb]:
= min[tb3, max(tb1,tb2)]
= min[4.92, max(12.83, 4)]
= 4.9200 mm

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
= max(ta, tb)
= max(1.821, 4.92)
= 4.9200 mm

Available Nozzle Neck Thickness = 0.875 * 8.738 = 7.645 mm -> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

Impact Test Temperature provided per Specification	-46 °C
Calculated Minimum Design Metal Temperature	-104 °C

Nozzle-Shell/Head Weld for the Nozzle (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

Impact Test Temperature provided per Specification -46 °C

Calculated Minimum Design Metal Temperature -104 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

Flange MDMT including Temperature reduction per UCS-66.1:

MDMT of ASME B16.5/47 flange per Matl. Specification -46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2) -65 °C

Where the Stress Reduction Ratio per UCS-66(i)(2) is :
Design Pressure/Ambient Rating = 12.60/19.60 = 0.643

Weld Size Calculations, Description: IN/OUT

Intermediate Calc. for nozzle/shell Welds Tmin 7.2376 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	5.0663 = 0.7 * tmiN	7.0700 = 0.7 * Wo mm

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 : 0.3693 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 50.9942 mm

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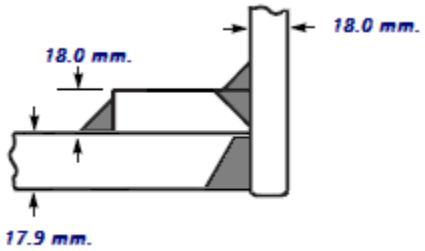
Input, Nozzle Desc: MAN HOLE From: 20

Pressure for Reinforcement Calculations	P	12.600	barg
Temperature for Internal Pressure	Temp	90	°C
Parent Material [Impact Tested]		SA-516 70	
Parent Allowable Stress at Temperature	Sv	137.90	N/mm^2
Parent Allowable Stress At Ambient	Sva	137.90	N/mm^2
Inside Diameter of Cylindrical Shell	D	2464.00	mm
Shell Finished (Minimum) Thickness	t	17.8500	mm
Shell Internal Corrosion Allowance	c	1.5000	mm
Shell External Corrosion Allowance	co	0.0000	mm
Distance from Bottom/Left Tangent		560.00	mm
User Entered Minimum Design Metal Temperature		-29.00	°C

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	137.90	N/mm^2
Allowable Stress At Ambient	Sna	137.90	N/mm^2
Diameter Basis (for tr calc only)		Outside	
Layout Angle		270.00	deg
Diameter		24.0000	iN
Size and Thickness Basis		Actual	
Actual Thickness	tn	18.0000	mm
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	1.5000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	75.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	15.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	14.8500	mm
Inside Projection	h	0.0000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm
Pad Material		SA-516 70	
Pad Allowable Stress at Temperature	Sp	137.90	N/mm^2
Pad Allowable Stress At Ambient	Spa	137.90	N/mm^2
Diameter of Pad along vessel surface	Dp	810.0000	mm
Thickness of Pad	te	18.0000	mm
Weld leg size between Pad and Shell	Wp	18.0000	mm
Groove weld depth between Pad and Nozzle	Wgpn	18.0000	mm
Reinforcing Pad Width		100.2000	mm
This is a Manway or Access Opening.			
Flange Class		150	
Flange Grade		GR 1.1	

The Pressure Design option was Design Pressure + static head.



Reinforcement CALCULATION, Description: MAN HOLE

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

```
Actual Outside Diameter Used in Calculation          24.000  iN
Actual Thickness Used in Calculation                  0.709  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)
= 12.6*1234/(137.9*1-0.6*12.6)
= 11.3334 mm
```

Reqd thk per UG-37(a) of Nozzle Wall, trn [Int. Press]
```
= P*Ro/(Sn*E+0.4*P) per Appendix 1-1 (a)(1)
= 12.6*304.8/(137.9*1+0.4*12.6)
= 2.7750 mm
```

UG-40, Limits of Reinforcement: [Internal Pressure]
```
Parallel to Vessel Wall (Diameter Limit)           Dl  1153.2001  mm
Parallel to Vessel Wall, opening length             d   576.6000  mm
Normal to Vessel Wall (Thickness Limit), pad side Tlwp   40.8750  mm
```

Weld Strength Reduction Factor [fr1]:
```
= min( 1, Sn/Sv )
= min( 1, 137.9/137.9 )
= 1.000
```

Weld Strength Reduction Factor [fr2]:
```
= min( 1, Sn/Sv )
= min( 1, 137.9/137.9 )
= 1.000
```

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

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

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

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	65.348	NA	NA
Area in Shell	A1	28.926	NA	NA
Area in Nozzle Wall	A2	11.220	NA	NA
Area in Inward Nozzle	A3	0.000	NA	NA

Area in Welds	A41+A42+A43	5.490	NA	NA
Area in Element	A5	36.072	NA	NA
TOTAL AREA AVAILABLE	Atot	81.708	NA	NA

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 degs.

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

SELECTION OF POSSIBLE REINFORCING PADS:	Diameter	Thickness	
Based on given Pad Thickness:	719.1105	18.0000	mm
Based on given Pad Diameter:	810.0001	9.8363	mm
Based on Shell or Nozzle Thickness:	720.0308	17.8500	mm

Area Required [A]:
= (d * tr*F + 2 * tn * tr*F * (1-fr1)) UG-37(c)
= (576.6*11.33*1+2*16.5*11.33*1*(1-1))
= 65.348 cm^2

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:
= d(E1*t - F*tr) - 2 * tn(E1*t - F*tr) * (1 - fr1)
= 576.6 (1 * 16.35 - 1 * 11.33) - 2 * 16.5
(1 * 16.35 - 1 * 11.33) * (1 - 1)
= 28.926 cm^2

Area Available in Nozzle Wall Projecting Outward [A2]:
= (2 * Tlwp) * (tn - trn) * fr2
= (2 * 40.88) * (16.5 - 2.775) * 1
= 11.220 cm^2

Area Available in Welds [A41 + A42 + A43]:
= Wo² * fr3 + (Wi-can/0.707)² * fr2 + Wp² * fr4
= 15² * 1 + (0)² * 1 + 18² * 1
= 5.490 cm^2

Area Available in Element [A5]:
= (min(Dp,DL)-(Nozzle OD))*(min(tp,Tlwp,te)) * fr4
= (810 - 609.6) * 18 * 1
= 36.072 cm^2

UG-45 Minimum Nozzle Neck Thickness Requirement:
Wall Thickness for Internal/External pressures ta = 4.2750 mm

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
= ta
= 4.2750 mm

Available Nozzle Neck Thickness = 18.0000 mm -> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld, Curve: B

GovrN thk, tg = 18, tr = 2.775, c = 1.5 mm, E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.168, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-11 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-104 °C

Min Metal Temp. w/o impact per UG-20(f) -29 °C

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

GovrN thk, tg = 18, tr = 2.775, c = 1.5 mm, E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.168, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -11 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C
Min Metal Temp. w/o impact per UG-20(f) -29 °C

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

GovrN thk, tg = 18, tr = 2.775, c = 1.5 mm, E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.168, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -11 °C
Min Metal Temp. at Required thickness (UCS 66.1) -104 °C
Min Metal Temp. w/o impact per UG-20(f) -29 °C

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

GovrN thk, tg = 17.85, tr = 11.33, c = 1.5 mm, E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.693, Temp. Reduction = 17 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -11 °C
Min Metal Temp. at Required thickness (UCS 66.1) -28 °C
Min Metal Temp. w/o impact per UG-20(f) -29 °C

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

GovrN thk, tg = 17.85, tr = 11.33, c = 1.5 mm, E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.693, Temp. Reduction = 17 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -11 °C
Min Metal Temp. at Required thickness (UCS 66.1) -28 °C
Min Metal Temp. w/o impact per UG-20(f) -29 °C

Gov. MDMT of the Nozzle : -29 °C
Gov. MDMT of the Reinforcement Pad : -29 °C
Gov. MDMT of the nozzle to shell joint welded assembly : -29 °C

Flange MDMT including Temperature reduction per UCS-66.1:

MDMT of ASME B16.5/47 flange per Matl. Specification -46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2) -48 °C

Where the Stress Reduction Ratio per UCS-66(i)(2) is :
Design Pressure/Ambient Rating = 12.60/19.60 = 0.643

Weld Size Calculations, Description: MAN HOLE

Intermediate Calc. for nozzle/shell Welds Tmin 16.5000 mm
Intermediate Calc. for pad/shell Welds TminPad 16.5000 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	6.0000 = Min per Code	10.6050 = 0.7 * Wo mm
Pad Weld	8.2500 = 0.5*TminPad	12.7260 = 0.7 * Wp mm

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

Weld Load [W]:

= max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)
= max(0, (65.35 - 28.93 + 2 * 16.5 * 1 *
(1 * 16.35 - 11.33))137.9)
= 53543.28 kgf

Note: F is always set to 1.0 throughout the calculatioN

Weld Load [W1]:
= (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
= (11.22 + 36.07 + 5.49 - 0 * 1) * 137.9
= 74220.38 kgf

Weld Load [W2]:
= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
= (11.22 + 0 + 2.25 + (5.396)) * 137.9
= 26528.24 kgf

Weld Load [W3]:
= (A2+A3+A4+A5+(2*tn*t*fr1))*S
= (11.22 + 0 + 5.49 + 36.07 + (5.396)) * 137.9
= 81807.34 kgf

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:
= (pi/2) * Dlo * Wo * 0.49 * Snw
= (3.142/2.0) * 609.6 * 15 * 0.49 * 137.9
= 98966. kgf

Shear, Pad Element Weld [Spew]:
= (pi/2) * DP * WP * 0.49 * SEW
= (3.142/2.0) * 810 * 18 * 0.49 * 137.9
= 157801. kgf

Shear, Nozzle Wall [Snw]:
= (pi *(Dlr + Dlo)/4) * (Thk - Can) * 0.7 * Sn
= (3.142 * 296.6) * (18 - 1.5) * 0.7 * 137.9
= 151309. kgf

Tension, Pad Groove Weld [Tpgw]:
= (pi/2) * Dlo * Wgpn * 0.74 * Seg
= (3.142/2) * 609.6 * 18 * 0.74 * 137.9
= 179351. kgf

Tension, Shell Groove Weld [Tngw]:
= (pi/2) * Dlo * Wgnvi * 0.74 * Sng
= (3.142/2.0) * 609.6 * (14.85 - 0) * 0.74 * 137.9
= 147965. kgf

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

Strength of Failure Paths:

Failure Path [Path 1-1]:
= (SPEW + SNW) = (157801 + 151309) = 309110 kgf

Failure Path [Path 2-2]:
= (Sonw + Tpgw + Tngw + Sinw)
= (98966 + 179351 + 147965 + 0) = 426283 kgf

Failure Path [Path 3-3]:
= (Spew + Tngw + Sinw)
= (157801 + 147965 + 0) = 305766 kgf

Summary of Failure Path Calculations:

```
 Path 1-1 = 309110  kgf, must exceed W = 53543 kgf    or W1 = 74220 kgf
 Path 2-2 = 426282  kgf, must exceed W = 53543 kgf    or W2 = 26528 kgf
 Path 3-3 = 305765  kgf, must exceed W = 53543 kgf    or W3 = 81807 kgf
```

Maximum Allowable Pressure for this Nozzle at this Location:

```
 Converged Maximum Allowable Pressure in the Operating case: 14.14 barg
```

The Drop for this Nozzle is : 38.2994 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 131.1494 mm

Percent Elongation Calculations:

```
 % Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro))  3.043 %
```



Nozzle Layout or placement warning. Area for reinforcement
may have been used that might not actually exist in this situatioN
Please check the nozzle geometry and placement carefully.

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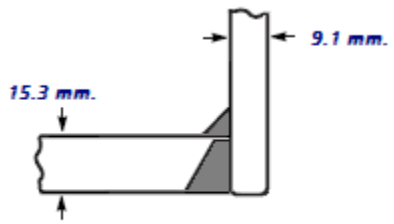
Input, Nozzle Desc: Vent From: 50

Pressure for Reinforcement Calculations	P	12.000	barg
Temperature for Internal Pressure	Temp	90	°C
Parent Material [Impact Tested]		SA-516 70	
Parent Allowable Stress at Temperature	Sv	137.90	N/mm^2
Parent Allowable Stress At Ambient	Sva	137.90	N/mm^2
Inside Diameter of Elliptical Head	D	2469.40	mm
Aspect Ratio of Elliptical Head	Ar	2.00	
Head Finished (Minimum) Thickness	t	15.3000	mm
Head Internal Corrosion Allowance	c	1.5000	mm
Head External Corrosion Allowance	co	0.0000	mm
Distance from Head Centerline	L1	0.0000	mm
User Entered Minimum Design Metal Temperature		-29.00	°C

Type of Element Connected to the Parent : Nozzle

Material [Impact Tested]		SA-333 6	
Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N/mm^2
Allowable Stress At Ambient	Sna	117.90	N/mm^2
Diameter Basis (for tr calc only)		Inside	
Layout Angle		0.00	deg
Diameter		1.0000	iN
Size and Thickness Basis		Nominal	
Nominal Thickness		XXS	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	1.5000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	100.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	12.7500	mm
Inside Projection	h	0.0000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm
Flange Class		150	
Flange Grade		GR 1.1	

The Pressure Design option was Design Pressure + static head.



Reinforcement CALCULATION, Description: Vent

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

```
Actual Inside Diameter Used in Calculation            0.599  iN
Actual Thickness Used in Calculation                  0.358  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)
  = 12*2472*0.899/(2*137.9*1-0.2*12)
  = 9.6794 mm
```

Reqd thk per App. 1 of Nozzle Wall, trn [Int. Press]
```
  = R( exp([P/(Sn*E)] - 1 ) per Appendix 1-2 (a)(1)
  = 9.107(exp([12/(117.9*1]-1)
  = 0.0932 mm
```

UG-40, Limits of Reinforcement: [Internal Pressure]
```
Parallel to Vessel Wall (Diameter Limit)           Dl    61.0010  mm
Parallel to Vessel Wall                        Rn+tn+t    30.5005  mm
Normal to Vessel Wall (Thickness Limit), no pad   Tlnp    18.9830  mm
```

Taking a UG-36(c)(3)(a) exemption for nozzle: Vent.
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 = 1.5932 mm
Wall Thickness per UG16(b),                      tr16b = 4.0000 mm
Wall Thickness, shell/head, internal pressure     trb1 = 12.2500 mm
Wall Thickness                 tb1 = max(trb1, tr16b) = 12.2500 mm
Wall Thickness                 tb2 = max(trb2, tr16b) = 4.0000 mm
Wall Thickness per table UG-45                    tb3 = 4.4464 mm
```

Determine Nozzle Thickness candidate [tb]:
```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 4.446, max( 12.25, 4 ) ]
  = 4.4464 mm
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
```
  = max( ta, tb )
  = max( 1.593, 4.446 )
  = 4.4464 mm
```

Available Nozzle Neck Thickness = 0.875 * 9.093 = 7.957 mm -> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

```
Impact Test Temperature provided per Specification    -46 °C

Calculated Minimum Design Metal Temperature          -104 °C
```

Nozzle-Shell/Head Weld for the Nozzle (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

Impact Test Temperature provided per Specification -46 °C

Calculated Minimum Design Metal Temperature -104 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

Flange MDMT including Temperature reduction per UCS-66.1:

MDMT of ASME B16.5/47 flange per Matl. Specification -46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2) -67 °C

Where the Stress Reduction Ratio per UCS-66(i)(2) is :
Design Pressure/Ambient Rating = 12.00/19.60 = 0.612

Weld Size Calculations, Description: Vent

Intermediate Calc. for nozzle/shell Welds Tmin 7.5932 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	5.3152 = 0.7 * tmiN	7.0700 = 0.7 * Wo mm

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 : 0.0624 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 115.3624 mm

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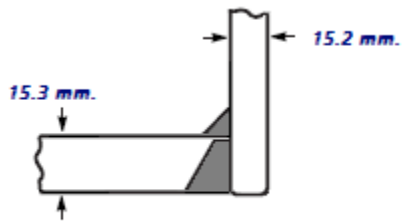
Input, Nozzle Desc: PSV From: 50

Pressure for Reinforcement Calculations	P	12.600	barg
Temperature for Internal Pressure	Temp	90	°C
Parent Material [Impact Tested]		SA-516 70	
Parent Allowable Stress at Temperature	Sv	137.90	N/mm^2
Parent Allowable Stress At Ambient	Sva	137.90	N/mm^2
Inside Diameter of Elliptical Head	D	2469.40	mm
Aspect Ratio of Elliptical Head	Ar	2.00	
Head Finished (Minimum) Thickness	t	15.3000	mm
Head Internal Corrosion Allowance	c	1.5000	mm
Head External Corrosion Allowance	co	0.0000	mm
Distance from Head Centerline	L1	500.0000	mm
User Entered Minimum Design Metal Temperature		-29.00	°C

Type of Element Connected to the Parent : Nozzle

Material [Impact Tested]		SA-333 6	
Material UNS Number		K03006	
Material Specification/Type		Smls. & wld. pipe	
Allowable Stress at Temperature	Sn	117.90	N/mm^2
Allowable Stress At Ambient	Sna	117.90	N/mm^2
Diameter Basis (for tr calc only)		Inside	
Layout Angle		0.00	deg
Diameter		3.0000	iN
Size and Thickness Basis		Nominal	
Nominal Thickness		XXS	
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	1.5000	mm
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	100.0000	mm
Weld leg size between Nozzle and Pad/Shell	Wo	9.0000	mm
Groove weld depth between Nozzle and Vessel	Wgnv	12.7500	mm
Inside Projection	h	0.0000	mm
Weld leg size, Inside Element to Shell	Wi	0.0000	mm
Flange Class		150	
Flange Grade		GR 1.1	

The Pressure Design option was Design Pressure + static head.



Note : Checking Nozzle in the Meridional directioN

Reinforcement CALCULATION, Description: PSV

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

Actual Inside Diameter Used in Calculation	2.300	iN
Actual Thickness Used in Calculation	0.600	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)
= 12.6*2472*0.899/(2*137.9*1-0.2*12.6)
= 10.1638 mm

Reqd thk per UG-37(a) of Nozzle Wall, trn [Int. Press]
= P*R/(Sn*E-0.6*P) per UG-27 (c)(1)
= 12.6*30.71/(117.9*1-0.6*12.6)
= 0.3303 mm

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

Parallel to Vessel Wall (Diameter Limit)	Dl	125.7965	mm
Parallel to Vessel Wall, opening length	d	62.8983	mm
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	34.3500	mm

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

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

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

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

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	6.798	NA	NA
Area in Shell	A1	2.142	NA	NA
Area in Nozzle Wall	A2	8.036	NA	NA
Area in Inward Nozzle	A3	0.000	NA	NA
Area in Welds	A41+A42+A43	0.693	NA	NA
Area in Element	A5	0.000	NA	NA
TOTAL AREA AVAILABLE	Atot	10.871	NA	NA

The Internal Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations	77.55	degs.

The area available without a pad is Sufficient.

Area Required [A]:
= (d * tr*F + 2 * tn * tr*F * (1-fr1)) UG-37(c)
= (62.9*10.16*1+2*13.74*10.16*1*(1-0.855))

= 6.798 cm^2

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:
= d(E1*t - F*tr) - 2 * tn(E1*t - F*tr) * (1 - fr1)
= 62.9 (1 * 13.8 - 1 * 10.16) - 2 * 13.74
(1 * 13.8 - 1 * 10.16) * (1 - 0.855)
= 2.142 cm^2

Area Available in Nozzle Projecting Outward [A2]:
= (2 * tlnp)(tn - trn)fr2/sin(alpha3)
= (2 * 34.35)(13.74 - 0.33)0.855/sin(78.55)
= 8.036 cm^2

See ASME VIII-1 2011(a) Appendix L, L-7.7.7(b) for more informatioN

Area Available in Inward Weld + Outward Weld [A41 + A43]:
= Wo² * fr2 + (Wi-can/0.707)² * fr2
= 9² * 0.855 + (0)² * 0.855
= 0.693 cm^2

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

Impact Test Temperature provided per Specification -46 °C

Calculated Minimum Design Metal Temperature -104 °C

Nozzle-Shell/Head Weld for the Nozzle (Impact tested) :

Note:
This Material was specified as being an Impact Tested (Low Temperature) Material.

Impact Test Temperature provided per Specification -46 °C

Calculated Minimum Design Metal Temperature -104 °C

Gov. MDMT of the nozzle to shell joint welded assembly : -104 °C

Flange MDMT including Temperature reduction per UCS-66.1:

MDMT of ASME B16.5/47 flange per Matl. Specification -46 °C
Flange MDMT with Temp reduction per UCS-66(i)(2) -65 °C

Where the Stress Reduction Ratio per UCS-66(i)(2) is :
Design Pressure/Ambient Rating = 12.60/19.60 = 0.643

Weld Size Calculations, Description: PSV

Intermediate Calc. for nozzle/shell Welds Tmin 13.7400 mm

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	6.0000 = Min per Code	6.3630 = 0.7 * Wo mm

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

Weld Load [W]:
= max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)

```
  = max( 0, (6.798 - 2.142 + 2 * 13.74 * 0.855 *
    (1 * 13.8 - 10.16 ) )137.9 )
  = 7748.05 kgf
```

Note: F is always set to 1.0 throughout the calculatioN

Weld Load [W1]:
```
  = (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
  = ( 8.036 + 0 + 0.693 - 0 * 0.855 ) * 137.9
  = 12274.08 kgf
```

Weld Load [W2]:
```
  = (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
  = ( 8.036 + 0 + 0.693 + ( 3.242 ) ) * 137.9
  = 16833.20 kgf
```

Weld Load [W3]:
```
  = (A2+A3+A4+A5+(2*tn*t*fr1))*S
  = ( 8.036 + 0 + 0.693 + 0 + ( 3.242 ) ) * 137.9
  = 16833.20 kgf
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:
```
  = (pi/2) * Dlo * Wo * 0.49 * Snw
  = ( 3.142/2.0 ) * 91.04 * 9 * 0.49 * 117.9
  = 7582. kgf
```

Shear, Nozzle Wall [Snw]:
```
  = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
  = (3.142 * 38.48 ) * ( 15.24 - 1.5 ) * 0.7 * 117.9
  = 13980. kgf
```

Tension, Shell Groove Weld [Tngw]:
```
  = (pi/2) * Dlo * Wgnvi * 0.74 * Sng
  = ( 3.142/2.0 ) * 91.04 * ( 12.75 - 0 ) * 0.74 * 137.9
  = 18973. kgf
```

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

Strength of Failure Paths:

Failure Path [Path 1-1]:
```
  = ( SONW + SNW ) = ( 7582 + 13980 ) = 21562 kgf
```

Failure Path [Path 2-2]:
```
  = ( Sonw + Tpgw + Tngw + Sinw )
  = ( 7582 + 0 + 18973 + 0 ) = 26554 kgf
```

Failure Path [Path 3-3]:
```
  = ( Sonw + Tngw + Sinw )
  = ( 7582 + 18973 + 0 ) = 26554 kgf
```

Summary of Failure Path Calculations:
```
 Path 1-1 = 21561   kgf, must exceed W = 7748 kgf     or W1 = 12274 kgf
 Path 2-2 = 26554   kgf, must exceed W = 7748 kgf     or W2 = 16833 kgf
 Path 3-3 = 26554   kgf, must exceed W = 7748 kgf     or W3 = 16833 kgf
```

Maximum Allowable Pressure for this Nozzle at this Location:
```
 Converged Maximum Allowable Pressure in the Operating case: 14.8 barg
```

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

Note : Checking Nozzle in the Latitudinal directioN

Reinforcement CALCULATION, Description: PSV

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

```
Actual Inside Diameter Used in Calculation            2.300  iN
Actual Thickness Used in Calculation                  0.600  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)
  = 12.6*2472*0.899/(2*137.9*1-0.2*12.6)
  = 10.1638 mm
```

Reqd thk per UG-37(a) of Nozzle Wall, trn [Int. Press]
```
  = P*R/(Sn*E-0.6*P) per UG-27 (c)(1)
  = 12.6*30.71/(117.9*1-0.6*12.6)
  = 0.3303 mm
```

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

```
Parallel to Vessel Wall (Diameter Limit)          Dl   122.8400  mm
Parallel to Vessel Wall, opening length            d    61.4200  mm
Normal to Vessel Wall (Thickness Limit), no pad  Tlnp   34.3500  mm
```

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

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	6.648	NA	NA
Area in Shell	A1	2.088	NA	NA
Area in Nozzle Wall	A2	7.876	NA	NA
Area in Inward Nozzle	A3	0.000	NA	NA
Area in Welds	A41+A42+A43	0.693	NA	NA
Area in Element	A5	0.000	NA	NA
TOTAL AREA AVAILABLE	Atot	10.657	NA	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)
  = (61.42*10.16*1+2*13.74*10.16*1*(1-0.855))
  = 6.648 cm^2
```

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:
```
  = d( E1*t - F*tr ) - 2 * tn( E1*t - F*tr ) * ( 1 - fr1 )
  = 61.42 ( 1 * 13.8 - 1 * 10.16 ) - 2 * 13.74
    ( 1 * 13.8 - 1 * 10.16 ) * ( 1 - 0.855 )
  = 2.088 cm^2
```

Area Available in Nozzle Projecting Outward [A2]:
```
  = ( 2 * tlnp )( tn - trn )fr2
  = ( 2 * 34.35 )( 13.74 - 0.33 )0.855
  = 7.876 cm^2
```

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

= 9² * 0.855 + (0)² * 0.855
= 0.693 cm^2

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

```
Wall Thickness for Internal/External pressures      ta = 1.8303 mm
Wall Thickness per UG16(b),                      tr16b = 4.0000 mm
Wall Thickness, shell/head, internal pressure     trb1 = 12.7880 mm
Wall Thickness                 tb1 = max(trb1, tr16b) = 12.7880 mm
Wall Thickness                 tb2 = max(trb2, tr16b) = 4.0000 mm
Wall Thickness per table UG-45                    tb3 = 6.3000 mm
```

Determine Nozzle Thickness candidate [tb]:
= min[tb3, max(tb1,tb2)]
= min[6.3, max(12.79, 4)]
= 6.3000 mm

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
= max(ta, tb)
= max(1.83, 6.3)
= 6.3000 mm

Available Nozzle Neck Thickness = 0.875 * 15.240 = 13.335 mm -> OK

Weld Size Calculations, Description: PSV

```
Intermediate Calc. for nozzle/shell Welds   Tmin     13.7400  mm
```

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	6.0000 = Min per Code	6.3630 = 0.7 * Wo mm

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

Weld Load [W]:
= max(0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)
= max(0, (6.648 - 2.088 + 2 * 13.74 * 0.855 *
(1 * 13.8 - 10.16))137.9)
= 7612.36 kgf

Note: F is always set to 1.0 throughout the calculatioN

Weld Load [W1]:
= (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
= (7.876 + 0 + 0.693 - 0 * 0.855) * 137.9
= 12049.21 kgf

Weld Load [W2]:
= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
= (7.876 + 0 + 0.693 + (3.242)) * 137.9
= 16608.33 kgf

Weld Load [W3]:
= (A2+A3+A4+A5+(2*tn*t*fr1))*S
= (7.876 + 0 + 0.693 + 0 + (3.242)) * 137.9
= 16608.33 kgf

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:
= (pi/2) * Dlo * Wo * 0.49 * Snw
= (3.142/2.0) * 88.9 * 9 * 0.49 * 117.9
= 7404. kgf

Shear, Nozzle Wall [Snw]:

= (pi *(Dlr + Dlo)/4) * (Thk - Can) * 0.7 * Sn
= (3.142 * 37.58) * (15.24 - 1.5) * 0.7 * 117.9
= 13651. kgf

Tension, Shell Groove Weld [Tngw]:
= (pi/2) * Dlo * Wgnvi * 0.74 * Sng
= (3.142/2.0) * 88.9 * (12.75 - 0) * 0.74 * 137.9
= 18527. kgf

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

Strength of Failure Paths:

Failure Path [Path 1-1]:
= (SONW + SNW) = (7404 + 13651) = 21055 kgf

Failure Path [Path 2-2]:
= (Sonw + Tpgw + Tngw + Sinw)
= (7404 + 0 + 18527 + 0) = 25930 kgf

Failure Path [Path 3-3]:
= (Sonw + Tngw + Sinw)
= (7404 + 18527 + 0) = 25930 kgf

Summary of Failure Path Calculations:

Path 1-1 = 21055	kgf, must exceed W = 7612 kgf	or W1 = 12049 kgf
Path 2-2 = 25930	kgf, must exceed W = 7612 kgf	or W2 = 16608 kgf
Path 3-3 = 25930	kgf, must exceed W = 7612 kgf	or W3 = 16608 kgf

Maximum Allowable Pressure for this Nozzle at this Location:
Converged Maximum Allowable Pressure in the Operating case: 14.8 barg

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

The Drop for this Nozzle is : 10.6838 mm
The Cut Length for this Nozzle is, Drop + Ho + H + T : 126.3790 mm

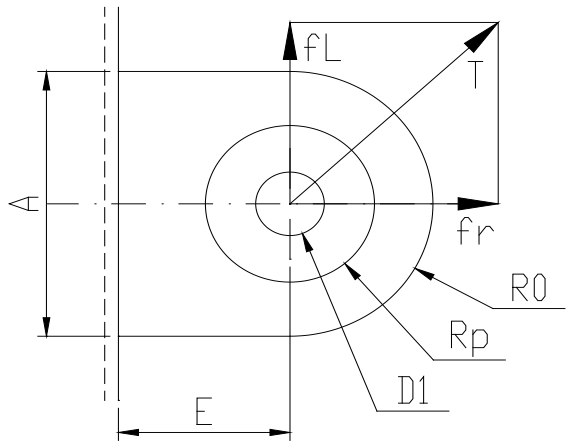
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CLIENTE : **ROSETTI MARINO** ***CUSTOMER***	**COMM:** : **166/24** ***JOB:***	
	ITEM: : **AIR RECEIVER**	

Dimensionamento dei golfari di sollevamento

Design calculation of tailing lug

M	peso del serbatoio durante il sollevamento *weight of vessel during erection*	7411	kg
P	peso del serbatoio durante il sollevamento *weight of vessel during erection*	72702	N
R_0	raggio esterno del golfare *outside radius of tailing lug*	125	mm
R_p	raggio esterno del rinforzo *outside radius of pad eye*	0	mm
D_1	diametro del foro del golfare *hole diameter*	60	mm
t_L	spessore del golfare *thickness of tailing lug*	20	mm
t_p	spessore del rinforzo *thickness of pad eye*	0	mm
A	larghezza del golfare *width of tailing lug*	250	mm
E	sporgenza del golfare *protruding of tailing lug*	150	mm
n_s	numero di golfari *number of tailing lug*	1	
l_s	lunghezza della saldatura *length of weld*	250	mm
w_s	dimensione minima della saldatura *minimum size of weld*	15	mm
	materiale tailing lug *tailing lug material*	SA 516 Gr.70	
F_S	sollecitazione ammissibile del golfare *allowable stress of lifting lug*	138	MPa
F_w	sollecitazione ammissibile della saldatura *allowable stress of weld*	138	MPa
C_d	coefficiente dinamico *dinamic coefficient*	2	



Sforzi nei golfari
Stress in the tailing lug

$$T = \frac{P \times C_d}{n_s}$$

145403,82

Area richiesta al foro della spina, A_r
Area required at pin hole, A_r

$$A_r = \frac{T}{F_s}$$

1054

Area disponibile al foro della spina, A_r
Area available at pin hole, A_r

$$A_a = (2 \times R_0 \times t_L) + \left(2 \times (2 \times R_p \times t_p)\right) - (D_1 \times t_L) - (2 \times D_1 \times t_p)$$

3800

Ok!

Momento flettente nel golfare, M_b (posizione verticale)
Bending moment in lug, M_b (vertical position)

$$f_L = T \qquad M_b = f_L \times E$$

21810573

Modulo d'inerzia del golfare, Z
Section modulus of lug, Z

$$Z = \frac{t_L \times A^2}{6}$$

208333

Sforzo nel golfare, σ_b
Bending stress in lug, σ_b

$$\sigma_b = \frac{M_b}{Z}$$

104,7

Ok!

Sforzi nella saldatura
Stress in the weld

$$A_{Rw} = 2 \times w_s \times l_s \times 0.707$$

5302,5

$$\tau_W = \frac{T}{A_{RW}}$$

27,42

Ok!

REV.	DESCRIZIONE DESCRIPTION	EMESSO ISSUED	APPROVATO APPROVED	DATA DATE
01	REVISION	GT	TM	28-mag-24
00	ISSUE	GT	TM	21-mag-24