Base Load Power Hub (BLPH)

NITROGEN GENERATION PACKAGE
NITROGEN RECEIVER CALCULATION

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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 : ...\N2 Receiver R2.pvdb

Date of Analysis : Dec 21,2024 8:58am

PV Elite 26 SP1, March 2024

Vessel Design Summary:

ASME Code, Section VIII Division 1, 2023

Diameter Spec : 2000.000 mm. OD		
Vessel Design Length, Tangent to Tangent	3120.00	mm.
Distance of Bottom Tangent above Grade	0.00	mm.
Specified Datum Line Distance	60.00	mm.
Internal Design Temperature	80	°C
Internal Design Pressure	12.000	barg
External Design Temperature	-8	°C
Maximum Allowable Working Pressure	12.72	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	12.500	0.00	12.770	3.0000	No	No
Cylinder	12.500	0.00	13.460	3.0000	N/A	No
Cylinder	12.500	0.00	13.460	3.0000	N/A	No
Ellipse	12.500	0.00	12.770	3.0000	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	15.0	12.5	12.0	...	1.00	0.85

Cylinder	2000.0	2000.0	15.0	14.9	13.6	...	0.85	0.85
Cylinder	3000.0	1000.0	15.0	14.9	13.6	...	0.85	0.85
Ellipse	3060.0	60.0	15.0	12.5	12.0	...	1.00	0.85

Loads for Foundation/Support Design:

Total Wind Shear on top of all Legs	1394.	kgf
Total Earthquake Shear on top of all Legs	2437.	kgf
Total Wind Moment at top of all Legs	1692.	kg.m.
Total Earthquake Moment at top of all Legs	2802.	Kg.m.
Wind Load Case Test Moment on Support	558.	Kg.m.
Test Case Wind Shear on Support	460.	Kgf
Max. Wind Shear on one Leg (top & bottom)	516.	Kgf
Max. Earthq. Shear on one Leg (top & bottom)	901.	Kgf
Max. Wind Moment at base of one Leg	665.	Kg.m.
Max. Earthquake Moment at base of one Leg	1162.	Kg.m.
Max. Vertical Load (Wt. + Wind) on one Leg	1632.	Kgf
Max. Vertical Load (Wt. + Eq.) on one Leg	2133.	Kgf

For the Pressure Test Case:

Max. Wind Shear on one Leg (top & bottom)	170.	Kgf
Max. Wind Moment at base of one Leg	219.	Kg.m.
Max. Vertical Load (Wt. + Wind) on one Leg	4132.	Kgf
Max. Vertical Load (Wt. + Eq.) on one Leg	3880.	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	0.035	n/a	Passed
LEGS	WRC-107/537	0.730	n/a	Passed
LEGS	WRC-107/537	0.543	n/a	Passed

Weights:

Fabricated - Bare W/O Removable Internals	3994.0	kg.
Shop Test - Fabricated + Water (Full)	15520.5	kg.
Shipping - Fab. + Rem. Intls.+ Shipping App.	3994.0	kg.
Erected - Fab. + Rem. Intls.+ Insul. (etc)	3994.0	kg.
Empty - Fab. + Intls. + Details + Wghts.	3994.0	kg.
Operating - Empty + Operating Liquid (No CA)	3994.0	kg.
Field Test - Empty Weight + Water (Full)	15520.5	kg.

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Nozzle Calculation Summary (barg & mm.):

Description	MAWP	Ext	MAPNC	UG-45	[tr]	Weld Path	Areas or Stresses
Drain	12.77	...	...	OK	5.95	OK	No Calc[*]
PG	13.46	...	...	OK	6.12	OK	No Calc[*]
PT	13.46	...	...	OK	6.12	OK	No Calc[*]
IN/OUT	13.46	...	...	OK	5.95	OK	No Calc[*]
MAN HOLE	12.72	...	...	...		OK	Passed
PSV	12.77	...	...	OK	6.42	OK	No Calc[*]

Nozzle MAWP Summary:

Minimum MAWP Nozzles	:	12.72 Nozzle	: MAN HOLE
Minimum MAWP Shells/Flanges	:	12.72 Element	:
Minimum MAPnc Shells/Flanges	:	17.43 Element	:
Computed Vessel M.A.W.P.	:	12.72 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	52.401
20	PG	360.000	75.000	61.800
20	PT	360.000	105.000	61.800
20	IN/OUT	360.000	180.000	57.101
20	MAN HOLE	460.000	270.000	764.800
50	PSV	0.000	0.000	97.700

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	...	...	112.58	150
IN/OUT	1.000 in	XXS	WNF	1.315	9.093	...	...	47.77	150
PG	1.500 in	Actual	None	1.500	8.382	...	...	47.81	...
PT	1.500 in	Actual	None	1.500	8.382	...	...	47.81	...
PSV	2.000 in	160	WNF	2.375	8.738	...	...	112.75	150
MAN HOLE	16.000 in	Actual	WNF	16.000	15.000	510.00	15.00	68.81	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	12.500	10.000	...	...	...
IN/OUT	SA-333 6	14.850	10.000	...	...	...
PG	SA-350 LF2	14.850	10.000	...	...	...
PT	SA-350 LF2	14.850	10.000	...	...	...
PSV	SA-333 6	12.500	10.000	...	...	...
MAN HOLE	SA-516 70	14.850	15.000	10.000	15.000	...

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
IN/OUT	300.000	180.0	32.78	0.00	Node: 20
PG	300.000	75.0	32.78	0.00	Node: 20
PT	300.000	105.0	32.78	0.00	Node: 20
PSV	...	0.0	100.00	0.00	Node: 50
MAN HOLE	400.000	270.0	32.78	0.00	Node: 20

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Bill of Materials:

QTY	DESCRIPTION	MATERIAL
2	ELLIPTICAL HEAD: 2.0 X 1, 15.0mm. THK X 1975.0mm. ID X 60.0mm.	SA-516 70
4	LEGS, SHAPE: HE200B 1290.0mm	...
4	BASEPLATES: 400.0mm X 400.0mm X 40.0mm	SA-516 70
24	BASEPLATE BOLTS: 30.0mm	SA-307 B
4	LEG RE-PADS: 300.000mm X 350.000mm X 15.000mm	SA-516 70
2	TRUNNIONS:	SA-516 70
2	TRUNNION PADS: 320.0mm OD X 219.1mm ID X 15.0mm THK	
1	CLASS 150 GR 1.1, 16.0" BLIND FLANGE(S)	SA-350 LF2
1	CYLINDRICAL SEGMENT 15.0mm. THK X 3008.9mm. X 2000.0mm.	SA-516 70
1	CYLINDRICAL SEGMENT 15.0mm. THK X 2991.7mm. X 2000.0mm.	SA-516 70
1	CYLINDRICAL SEGMENT 15.0mm. THK X 189.1mm. X 2000.0mm.	SA-516 70
1	CYLINDRICAL SEGMENT 15.0mm. THK X 3002.7mm. X 1000.0mm.	SA-516 70
1	CYLINDRICAL SEGMENT 15.0mm. THK X 3187.1mm. X 1000.0mm.	SA-516 70
1	CYLINDRICAL SEGMENT 15.0mm. THK X 0.0mm. X 1000.0mm.	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	-29	-29	0.997	12.500	1.00	No
	[7]	!	-29	-40	-29	0.796	15.000	1.00	No
	[8]	!	-29	-40	-29	0.806	14.850	0.85	No
	[8]	!	-29	-40	-29	0.806	14.850	0.85	No
	[10]	!	-29	-29	-29	0.997	12.500	1.00	No
	[7]	!	-29	-40	-29	0.796	15.000	1.00	No
Drain	[1]	!	-46	-104		0.023	7.957	1.00	No
Nozzle Flg	[5]	!	-46	-66					
PG	[1]	!	-46	-104		0.032	8.382	1.00	No
PT	[1]	!	-46	-104		0.032	8.382	1.00	No
IN/OUT	[1]	!	-46	-104		0.036	7.957	1.00	No
Nozzle Flg	[5]	!	-46	-66					
MAN HOLE	[1]	B	-16	-30	-29	0.760	14.850	1.00	No
Nozzle Flg	[5]	B	-46	-48					
PSV	[1]	!	-46	-104		0.054	7.645	1.00	No
Nozzle Flg	[5]	!	-46	-67					
Nozl. Bolting	[22]		-48			1.000	63.500	1.00	No
Warmest MDMT:			-16	-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	cm²
Moment	ft. lbs.	0.1383	Kg.m.
Stress	lbs./sq.in.	0.0069	N./mm²
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./cm³
Ins. Density	lbs./cu.ft.	0.1600E-04	kg./cm³
Fluid Density	lbs./cu.ft.	0.1600E-04	kg./cm³
Wind Speed	miles/hr	1.6093	Km/hr
Tray Weight	lbs./sq.ft.	0.0005	Kgs/cm²
Inertia	in.^4	41.6231	cm^4
G Load	G's	1.0000	g's
Wind Load	lbs./sq.ft.	4.8825	Kgs/m²
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	80.0	°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	2000	mm.
Element Thickness	12.5	mm.
Internal Corrosion Allowance	3	mm.
Nominal Thickness	15	mm.
External Corrosion Allowance	0	mm.
Design Internal Pressure	12	barg
Design Temperature Internal Pressure	80	°C
Design External Pressure	0	barg
Design Temperature External Pressure	-8	°C
Effective Diameter Multiplier	1.2	

Material Name	SA-516 70 [Impact Tested]	
Allowable Stress, Ambient	137.9	N./mm²
Allowable Stress, Operating	137.9	N./mm²
Allowable Stress, Hydrotest	179.27	N./mm²
Material Density	0.00775	kg./cm³
P Number Thickness	30.988	mm.
Yield Stress, Operating	242.93	N./mm²
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)	1.9812	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	30	
Element Type	Cylinder	
Description		
Distance "FROM" to "TO"	2000	mm.
Element Outside Diameter	2000	mm.
Element Thickness	14.85	mm.
Internal Corrosion Allowance	3	mm.
Nominal Thickness	15	mm.
External Corrosion Allowance	0	mm.
Design Internal Pressure	12	barg
Design Temperature Internal Pressure	80	°C
Design External Pressure	0	barg
Design Temperature External Pressure	-8	°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	75.0	
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	300	mm.
Nozzle Diameter	1.5	in.
Nozzle Schedule	None	
Nozzle Class	None	
Layout Angle	105.0	
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	IN/OUT	
Dist. from "FROM" Node / Offset dist	300	mm.
Nozzle Diameter	1	in.
Nozzle Schedule	XXS	
Nozzle Class	150	
Layout Angle	180.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	1.6319	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	400	mm.
Nozzle Diameter	16	in.
Nozzle Schedule	None	
Nozzle Class	150	
Layout Angle	270.0	
Blind Flange (Y/N)	Y	
Weight of Nozzle (Used if > 0)	74.097	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	2220	mm.
Leg Orientation	2	
Number of Legs	4	
Section Identifier	HE200B	
Length of Legs	1290	mm.

Element#	3/4	
Element From Node	30	
Element To Node	50	
Element Type	Cylinder	
Description		
Distance "FROM" to "TO"	1000	mm.
Element Outside Diameter	2000	mm.
Element Thickness	14.85	mm.
Internal Corrosion Allowance	3	mm.
Nominal Thickness	15	mm.
External Corrosion Allowance	0	mm.
Design Internal Pressure	12	barg

Design Temperature Internal Pressure	80	°C
Design External Pressure	0	barg
Design Temperature External Pressure	-8	°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	2000	mm.
Element Thickness	12.5	mm.
Internal Corrosion Allowance	3	mm.
Nominal Thickness	15	mm.
External Corrosion Allowance	0	mm.
Design Internal Pressure	12	barg
Design Temperature Internal Pressure	80	°C
Design External Pressure	0	barg
Design Temperature External Pressure	-8	°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	PSV	
Dist. from "FROM" Node / Offset dist	0	mm.
Nozzle Diameter	2	in.
Nozzle Schedule	160	
Nozzle Class	150	
Layout Angle	0.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	4.5645	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	30	...	2060	...	2000
30	50	...	3060	...	1000
50	60	...	3120	...	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./mm²	Element#
10	20	12.5	15	3	2000	137.9	1
20	30	12.5	15	3	2000	117.22	2
30	50	12.5	15	3	2000	117.22	3
50	60	12.5	15	3	2000	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	12.77	17.43	12.5	11.9559	1
20	30	12	13.46	17.51	14.85	13.6195	2
30	50	12	13.46	17.51	14.85	13.6195	3
50	60	12	12.77	17.43	12.5	11.9559	4
Minimum			12.72	17.43			

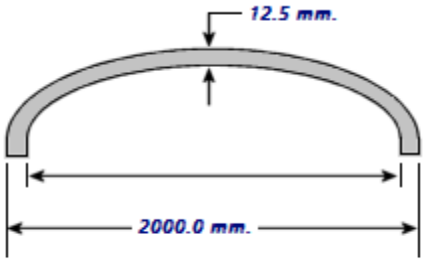
MAWP: 12.72 barg, limited by: Nozzle Reinforcement.

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	12.500 barg	Int. Design Temperature	80 °C
Material	SA-516 70	Ext. Design Temperature	-8 °C
Length	60.000 mm.	External Pressure Chart	CS-2
		UNS Number	K02700
Int. Corr. All. c	3.0000 mm.	Allowable Stress (ope) S	137.9 N./mm²
Ext. Corr. All. ce	0.0000 mm.	Allowable Stress (amb) Sa	137.9 N./mm²
Outside Diameter Do	2000.000 mm.	Actual Stress	129.9 N./mm²
Spec. Min. Thk t or e	12.5000 mm.	Spec. Nominal Thk.	15.000 mm.
Surface Area	47355.8 cm²	SG of Contents	0.000
Element Volume	1192442.6 cm³	Weight of Contents	0.0 Kgf
Empty Weight	594.6 Kgf	Operating Weight	594.6 Kgf
		Comp. All. Ope. Stress	108.5 N./mm²
		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: 24.812 mm.
Head inner surface maximum deviation inside the specified shape, 0.625% of D: 12.406 mm.

Required Thickness due to Internal Pressure [tr]:
= (P*Do*Kcor)/(2*S*E+2*P*(Kcor-0.1)) per Appendix 1-4 (c)
= (12.5*2000*0.996)/(2*137.9*1+2*12.5*(0.996-0.1))
= 8.9559 + 3.0000 = 11.9559 mm.

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
Less Operating Hydrostatic Head Pressure of 0.500 barg
= (2*S*E*t)/(Kcor*Do-2*t*(Kcor-0.1)) per Appendix 1-4 (c)
= (2*137.9*1*9.5)/(0.996*2000-2*9.5*(0.996-0.1))
= 13.27 - 0.5 = 12.77 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*12.5)/(1*2000-2*12.5*(1-0.1))

= 17.43 barg

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(Kcor*Do-2*t*(Kcor-0.1)))/(2*E*t)
= (12.5*(0.996*2000-2*9.5*(0.996-0.1)))/(2*1*9.5)
= 129.938 N./mm²

Straight Flange Required Thickness:
= (P*Ro)/(S*E+0.4*P) + ca per Appendix 1-1 (a)(1)
= (12.5*1000)/(137.9*1+0.4*12.5)+3
= 12.032 mm.

Straight Flange Maximum Allowable Working Pressure:
Less Operating Hydrostatic Head Pressure of 0.500 barg
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (137.9 * 1 * 12)/(1000 - 0.4 * 12)
= 16.63 - 0.5 = 16.13 barg

Factor K, corroded condition [Kcor]:
= (2 + (Inside Diameter/(2 * Inside Head Depth))²)/6
= (2 + (1981/(2 * 496.8))²)/6
= 0.995980

Percent Elong. per UCS-79, VIII-1-01-57 (75*tnom/Rf)*(1-Rf/Ro) 3.286 %

MDMT Calculations in the Knuckle Portion:

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

MDMT Calculations in the Head Straight Flange:

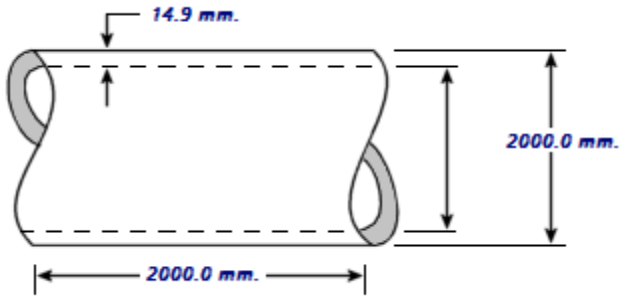
Note: This Element/Detail was specified as being Impact Tested.

Tolerance for Formed Heads per UG-81(a):
Head inner surface maximum deviation outside the specified shape, 1.25% of D: 24.812 mm.
Head inner surface maximum deviation inside the specified shape, 0.625% of D: 12.406 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	12.500 barg		Int. Design Temperature	80 °C	
Material	SA-516 70		Ext. Design Temperature	-8 °C	
Length	2000.000 mm.		External Pressure Chart	CS-2	
			UNS Number	K02700	
Int. Corr. All. c	3.0000 mm.		Allowable Stress (ope) S	137.9 N./mm²	
Ext. Corr. All. ce	0.0000 mm.		Allowable Stress (amb) Sa	137.9 N./mm²	
Outside Diameter Do	2000.000 mm.		Actual Stress	123.5 N./mm²	
Spec. Min. Thk t or e	14.8500 mm.		Spec. Nominal Thk.	15.000 mm.	
Surface Area	125682.6 cm²		SG of Contents	0.000	
Element Volume	6099053.0 cm³		Weight of Contents	0.0 Kgf	
Empty Weight	1450.2 Kgf		Operating Weight	1450.2 Kgf	
			Comp. All. Ope. Stress	115.8 N./mm²	

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)
= (12.5*1000)/(137.9*0.85+0.4*12.5)
= 10.6195 + 3.0000 = 13.6195 mm.

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
Less Operating Hydrostatic Head Pressure of 0.500 barg
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (137.9*0.85*11.85)/(1000-0.4*11.85)
= 13.96 - 0.5 = 13.46 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*14.85)/(1000-0.4*14.85)
= 17.51 barg

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(Ro-0.4*t))/(E*t)
= (12.5*((1000-0.4*11.85))/(0.85*11.85)

= 123.519 N./mm²

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 0.756 %

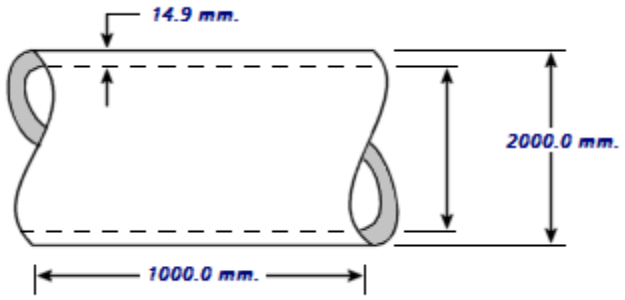
Minimum Design Metal Temperature Results:

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	12.500 barg	Int. Design Temperature	80 °C
Material	SA-516 70	Ext. Design Temperature	-8 °C
Length	1000.000 mm.	External Pressure Chart	CS-2
		UNS Number	K02700
Int. Corr. All. c	3.0000 mm.	Allowable Stress (ope) S	137.9 N./mm²
Ext. Corr. All. ce	0.0000 mm.	Allowable Stress (amb) Sa	137.9 N./mm²
Outside Diameter Do	2000.000 mm.	Actual Stress	123.5 N./mm²
Spec. Min. Thk t or e	14.8500 mm.	Spec. Nominal Thk.	15.000 mm.
Surface Area	62841.3 cm²	SG of Contents	0.000
Element Volume	3049526.5 cm³	Weight of Contents	0.0 Kgf
Empty Weight	725.1 Kgf	Operating Weight	725.1 Kgf
		Comp. All. Ope. Stress	115.8 N./mm²

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)
= (12.5*1000)/(137.9*0.85+0.4*12.5)
= 10.6195 + 3.0000 = 13.6195 mm.

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
Less Operating Hydrostatic Head Pressure of 0.500 barg
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (137.9*0.85*11.85)/(1000-0.4*11.85)
= 13.96 - 0.5 = 13.46 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*14.85)/(1000-0.4*14.85)
= 17.51 barg

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(Ro-0.4*t))/(E*t)
= (12.5*((1000-0.4*11.85))/(0.85*11.85)

= 123.519 N./mm²

% Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro)) 0.756 %

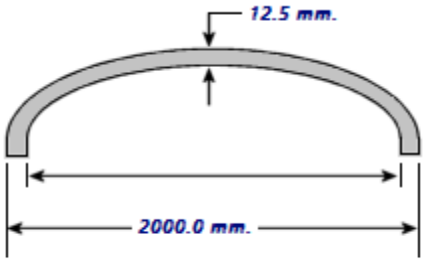
Minimum Design Metal Temperature Results:

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	12.500 barg	Int. Design Temperature	80 °C
Material	SA-516 70	Ext. Design Temperature	-8 °C
Length	60.000 mm.	External Pressure Chart	CS-2
		UNS Number	K02700
Int. Corr. All. c	3.0000 mm.	Allowable Stress (ope) S	137.9 N./mm²
Ext. Corr. All. ce	0.0000 mm.	Allowable Stress (amb) Sa	137.9 N./mm²
Outside Diameter Do	2000.000 mm.	Actual Stress	129.9 N./mm²
Spec. Min. Thk t or e	12.5000 mm.	Spec. Nominal Thk.	15.000 mm.
Surface Area	47355.8 cm²	SG of Contents	0.000
Element Volume	1192442.6 cm³	Weight of Contents	0.0 Kgf
Empty Weight	594.6 Kgf	Operating Weight	594.6 Kgf
		Comp. All. Ope. Stress	108.5 N./mm²
		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: 24.812 mm.
Head inner surface maximum deviation inside the specified shape, 0.625% of D: 12.406 mm.

Required Thickness due to Internal Pressure [tr]:
= (P*Do*Kcor)/(2*S*E+2*P*(Kcor-0.1)) per Appendix 1-4 (c)
= (12.5*2000*0.996)/(2*137.9*1+2*12.5*(0.996-0.1))
= 8.9559 + 3.0000 = 11.9559 mm.

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
Less Operating Hydrostatic Head Pressure of 0.500 barg
= (2*S*E*t)/(Kcor*Do-2*t*(Kcor-0.1)) per Appendix 1-4 (c)
= (2*137.9*1*9.5)/(0.996*2000-2*9.5*(0.996-0.1))
= 13.27 - 0.5 = 12.77 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*12.5)/(1*2000-2*12.5*(1-0.1))

= 17.43 barg

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(Kcor*Do-2*t*(Kcor-0.1)))/(2*E*t)
= (12.5*(0.996*2000-2*9.5*(0.996-0.1)))/(2*1*9.5)
= 129.938 N./mm²

Straight Flange Required Thickness:
= (P*Ro)/(S*E+0.4*P) + ca per Appendix 1-1 (a)(1)
= (12.5*1000)/(137.9*1+0.4*12.5)+3
= 12.032 mm.

Straight Flange Maximum Allowable Working Pressure:
Less Operating Hydrostatic Head Pressure of 0.500 barg
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (137.9 * 1 * 12)/(1000 - 0.4 * 12)
= 16.63 - 0.5 = 16.13 barg

Factor K, corroded condition [Kcor]:
= (2 + (Inside Diameter/(2 * Inside Head Depth))^2)/6
= (2 + (1981/(2 * 496.8))^2)/6
= 0.995980

Percent Elong. per UCS-79, VIII-1-01-57 (75*tnom/Rf)*(1-Rf/Ro) 3.286 %

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: 24.812 mm.
Head inner surface maximum deviation inside the specified shape, 0.625% of D: 12.406 mm.

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Hydrostatic Test Pressure Results:

UG99(b)	= 1.30 * M.A.W.P. * Sa/S	16.539 barg
UG99b(b)(35)	= 1.30 * Design Pres * Sa/S	15.600 barg
UG99(c)	= 1.30 * M.A.P. - Head(Hyd)	22.608 barg
UG100	= 1.10 * M.A.W.P. * Sa/S	13.995 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.	12.723 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./mm² & barg):

From	To	Stress	Allowable	Ratio	Pressure
10	20	138.9	179.3	0.775	17.56
20	30	137.9	179.3	0.769	17.51
30	50	136.3	179.3	0.761	17.31
50	60	136.2	179.3	0.760	17.21

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

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
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
PSV	Nozzle	117.90	117.90	1.000
Minimum				1.000

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

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./mm²):

Description	Ambient	Operating	Ratio
Drain	2.52	153.28	0.016

PG	3.27	179.27	0.018
PT	3.27	179.27	0.018
IN/OUT	2.51	153.28	0.016
MAN HOLE	22.97	179.27	0.128
PSV	5.25	153.28	0.034

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./mm²
10	20	No Calc	2000	9.5	0.00065972	65.9574
20	30	3449.17	2000	11.85	0.0003482	34.8118
30	50	3449.17	2000	11.85	0.0003482	34.8118
50	60	No Calc	2000	9.5	0.00065972	65.9574

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	12.5	No Calc	...	3.481
20	30	14.85	No Calc	...	2.75
30	50	14.85	No Calc	...	2.75
50	60	12.5	No Calc	...	3.481
Minimum					2.75

External Pressure Calculations:

From	To	Actual Length Bet. Stiffeners mm.	Allowable Length Bet. Stiffeners mm.	Ring Inertia Required cm^4	Ring Inertia Available cm^4
10	20	No Calc	No Calc	No Calc	No Calc
20	30	3449.17	No Calc	No Calc	No Calc
30	50	3449.17	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	594.63	1192442	475.704	1202781	...
20	30	1450.19	6099053	1161.9	6136256	...
30	50	725.097	3049526	580.95	3068128	...
50	60	594.63	1192442	475.704	1202781	...
Total		3364	11533464.00	2694	11609948.00	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	1.9812	...	-597.5	...	Drain
20	Nozl	0.28886	259.216	300	-967.407	PG
20	Nozl	0.28886	-259.216	300	-967.407	PT
20	Nozl	1.63186	-1001.53	300	...	IN/OUT
20	Nozl	74.097	...	400	1001.53	MAN HOLE
20	Legs	512.88	...	-295	...	LEGS
50	Nozl	4.5645	...	597.5	...	PSV
30	Trun	33.7444	...	750	...	Trunnions

Total Weight of Each Detail Type:

Nozzles	82.9
Legs	512.9
Trunnions	33.7
Sum of the Detail Weights	629.5 kg.

Weight Summation Results: (kg.)

	Fabricated	Shop Test	Shipping	Erected	Empty	Operating
Main Elements	3364.5	3364.5	3364.5	3364.5	3364.5	3364.5
Nozzles	82.9	82.9	82.9	82.9	82.9	82.9
Legs	512.9	512.9	512.9	512.9	512.9	512.9
Trunnions	33.7	33.7	33.7	33.7	33.7	33.7
Test Liquid	...	11526.4	...	...	...	...
Totals	3994.0	15520.5	3994.0	3994.0	3994.0	3994.0

Weight Summary:

Fabricated Wt.	- Bare Weight without Removable Internals	3994.0 kg.
Shop Test Wt.	- Fabricated Weight + Water (Full)	15520.5 kg.
Shipping Wt.	- Fab. Weight + removable Intls.+ Shipping App.	3994.0 kg.
Erected Wt.	- Fab. Wt + or - loose items (trays,platforms etc.)	3994.0 kg.
Ope. Wt. no Liq	- Fab. Weight + Internals. + Details + Weights	3994.0 kg.
Operating Wt.	- Empty Weight + Operating Liq. Uncorroded	3994.0 kg.
Field Test Wt.	- Empty Weight + Water (Full)	15520.5 kg.

Weights used in Vortex Shedding Calculations:

Mass of the Upper 1/3 of the Vertical Vessel (operating)	1049.6 kg.

Mass of the Upper 1/3 of the Vertical Vessel (filled w/water) 4795.7 kg.
Mass of the Upper 1/3 of the Vertical Vessel (empty) 1309.8 kg.

Surface Areas of Elements:

From	To	Outside Surface Area cm²	Inside Surface Area cm²
10	20	47355.8	46005
20	30	125683	123798
30	50	62841.3	61898.8
50	60	47355.8	46005
Total		283235.5	277706.4 cm²
Total		304.9	298.9 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. Kg.m.	Oper. Wgt. No Liquid kg.
10	20	596.611	596.611	1788.33	...	596.611
20	Legs	267.137	267.137	1333.82	73.6532	267.137
Legs	30	1259.36	1259.36	6288.01	...	1259.36
30	50	758.841	758.841	3806.51	...	758.841
50	60	599.194	599.194	1790.91	...	599.194

Cumulative Vessel Weight

From	To	Cumulative Ope Wgt. No Liquid kg.	Cumulative Oper. Wgt. kg.	Cumulative Hydro. Wgt. kg.
10	20	...	...	...
20	Legs	-596.611	-596.611	-1788.33
Legs	30	2617.4	2617.4	11885.4
30	50	1358.04	1358.04	5597.42
50	60	599.194	599.194	1790.91

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

Cumulative Vessel Moment

From	To	Cumulative Empty Mom. Kg.m.	Cumulative Oper. Mom. Kg.m.	Cumulative Hydro. Mom. Kg.m.
10	20	...	...	...
20	Legs	73.6532	73.6532	73.6532
Legs	30	...	...	...
30	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	18.30	19.60	80	150	GR 1.1	...	...	...	...
IN/OUT	18.30	19.60	80	150	GR 1.1	...	...	...	...
MAN HOLE	18.30	19.60	80	150	GR 1.1	...	...	...	...
PSV	18.30	19.60	80	150	GR 1.1	...	...	...	...
Min Rating	18.300	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( 9.772/( 386 * |( 316.1 )| ))) Imperial units
  = 17.784 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 49.4595 Hz.

Natural Frequency [fn]:
```
  = 1 / ( 2 * pi * sqrt( wyy /( 386 * |( wy )| )))
  = 1/( 2 * pi * sqrt( 9.772/( 386 * |( 316.1 )| ))) Imperial units
  = 17.784 Hz.
```

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

The Natural Frequency for the Vessel (Ope...) is 49.4595 Hz.

Natural Frequency [fn]:
```
  = 1 / ( 2 * pi * sqrt( wyy /( 386 * |( wy )| )))
  = 1/( 2 * pi * sqrt( 857/( 386 * |( 6444 )| ))) Imperial units
  = 8.575 Hz.
```

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

The Natural Frequency for the Vessel (Filled) is 24.4563 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	3796.504	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/m³) * Vref² - Metric Units
= 0.00261 * Vref² - Imperial Units
= 0.00261(based on mph units) * 144²
= 20.9 psf
In chosen units:
= 102 Kgs/m²

Dynamic Coefficient - per Section 9 [Cd]
Average Diameter = 2000 mm.
H/D = 3120/2000 = 1.56

From Section 9:
Cd = 1.05

Roughness Coefficient- paragraph 8.2 [cr(z)]
Wind Height for first element = 323.5 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 * 1.098
= 155.1 Kgf

Summary:

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

	mm.	Kgs/m²			cm²	Kgf
Node 10 - 20	323.496	102.031	1.883	0.901	10982.6	155.099
Node 20 - 30	1553.750	102.031	1.883	0.901	48000.0	677.867
Node 30 - 50	3053.750	102.031	2.104	0.973	24000.0	378.603
Node 50 - 60	3796.504	102.031	2.221	1.010	10982.6	182.922

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
 :: 0/3120 = 0

 :: [ D / L² ] * 10⁴ < 8 (English Units, ft.)
 :: [ 6.562/10.24² ] * 10⁴ = 626.2 [Geometry Violation]
```

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

```
  = W / ( L * Dr²)
  = 3324/( 3120 * 2000² )
  = 0.26633E-06
```

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

```
  = W * Dl/ ( L * Dr² )
  = 3324 * 0.03/( 3120 * 2000² )
  = 0.499
```

Compute the critical wind velocity [Vc]:

```
  = 3.4 * f * Dr
  = 3.4 * 49.46 * 6.562
  = 1103.427 mile/hr  [1775.746 Km/hr]
```

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

```
  = V30 * ( L / ( 30 + BaseHeight ))^0.143
  = 144 * ( 3120/( 30 + 0 ))^0.143
  = 123.476 Km/hr
```

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

```
  = Vw * Gh
  = 123.5 * 1
  = 123.476 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 49.4595 Hz.

Wind Load Calculation:

From	To	Wind Height mm.	Wind Diameter mm.	Wind Area cm²	Wind Pressure Kgs/m²	Element Wind Load Kgf
10	20	323.496	2400	10982.6	141.222	155.099
20	30	1553.75	2400	48000	141.222	677.867
30	50	3053.75	2400	24000	157.751	378.603
50	60	3796.5	2400	10982.6	166.556	182.922

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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 49.4595 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	596.611	417.628	417.628	...
20	Legs	410	267.137	186.996	186.996	...
Legs	30	1235	1259.36	881.554	881.554	...
30	50	2560	758.841	531.189	531.189	...
50	60	3090	599.194	419.436	419.436	...

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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 Kg.m.	Earthquake Bending Kg.m.
10	20	592.754	...	...	...	...
20	Legs	175	155.099	417.628	37.6516	101.383
Legs	30	825	1394.49	2436.8	1691.85	2802.44
30	50	2150	561.524	950.625	416.636	786.866
50	60	2892.75	182.922	419.436	44.4059	101.822

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	...	0.31229	0.31229	0.00036243
20	Legs	155.099	0.31233	0.31244	0.00036331
Legs	30	1394.49	0.31394	0.31642	0.00036577
30	50	561.524	0.31814	0.31993	0.00036604
50	60	182.922	0.32004	0.32015	0.00036604

Critical Wind Velocity for Tower Vibration:

From	To	1st Crit. Wind Speed Km/hr	2nd Crit. Wind Speed Km/hr
10	20	2130.9	13318.1
20	30	2130.9	13318.1
30	50	2130.9	13318.1
50	60	2130.9	13318.1

Allowable deflection at the Tower Top (Ope)(6.000"/100ft. Criteria)
Allowable deflection : 15.600 Actual deflection : 0.320 mm.

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Longitudinal Stress Constants:

From	To	Metal Area New cm²	Metal Area Corroded cm²	Section Modulus New mm³	Section Modulus Corroded mm³
10	20	780.49	594.068	38539768	29422564
20	30	926.124	740.144	45623604	36571208
30	50	926.124	740.144	45623604	36571208
50	60	780.49	594.068	38539768	29422564

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Longitudinal Allowable Stresses:

From	To	Tensile N./mm²	Hydrotest Tensile N./mm²	Compressive N./mm²	Hydrotest Compressive N./mm²
10	20	140.658	182.855	-108.49	-117.405
20	Legs	140.658	182.855	-115.755	-122.453
Legs	30	140.658	182.855	-115.755	-122.453
30	50	140.658	182.855	-115.755	-122.453
50	60	140.658	182.855	-108.49	-117.405

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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./mm²	Longitudinal Stress External Pressure N./mm²	Longitudinal Stress Hydrotest Pressure N./mm²
10	20	64.9183	...	67.4427
20	30	51.8706	...	56.5799
30	50	51.8706	...	56.5799
50	60	64.9183	...	67.4427

Longitudinal Stresses due to Weight Loads for these Conditions:

From	To	Wght. Str. Empty N./mm²	Wght. Str. Operating N./mm²	Wght. Str. Hydrotest N./mm²	Wght. Str. Emp. Mom. N./mm²	Wght. Str. Opr. Mom. N./mm²
10	20	...	...	...	...	...
20	Legs	0.07905	0.07905	0.18937	0.01975	0.01975
Legs	30	-0.3468	-0.3468	-0.27716	...	...
30	50	-0.17994	-0.17994	-0.1438	...	...
50	60	-0.098915	-0.098915	-0.075289	...	...

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

From	To	Wght. Str. Hyd. Mom. N./mm²	Bend. Str. Oper. Wind N./mm²	Bend. Str. Oper. Equ. N./mm²	Bend. Str. Hyd. Wind N./mm²	Bend. Str. Hyd. Equ. N./mm²
10	20	...	...	...	...	...
20	Legs	0.015831	0.010096	0.027186	0.0026707	...
Legs	30	...	0.45367	0.75148	0.12001	...
30	50	...	0.11172	0.211	0.029553	...
50	60	...	0.014801	0.033938	0.0037288	...

Longitudinal Stresses due to these Conditions:

From	To	Vortex Shedding Operating Case N./mm²	Vortex Shedding Empty Case N./mm²	Vortex Shedding Test Case N./mm²	Earthquake Empty Case N./mm²
10	20	...	...	...	...
20	Legs	...	...	...	0.027186
Legs	30	...	...	...	0.75148
30	50	...	...	...	0.211
50	60	...	...	...	0.033938

Longitudinal Stresses due to Applied Axial Forces:

		Longitudinal Stress	Longitudinal Stress

From	To	Y Forces Wind N./mm²	Y Forces Seismic N./mm²
10	20	...	...
20	Legs	...	...
Legs	30	...	...
30	50	...	...
50	60	...	...

Longitudinal Stresses due to User Forces and Moments:

From	To	Wind For/Mom Corroded N./mm²	Earthquake For/Mom Corroded N./mm²	Wind For/Mom No Corrosion N./mm²	Earthquake For/Mom No Corrosion N./mm²
10	20	...	...	...	...
20	Legs	...	...	...	...
Legs	30	...	...	...	...
30	50	...	...	...	...
50	60	...	...	...	...

Bending Stresses due to Blast Load:

From	To	Bending Stress N./mm²
10	20	...
20	Legs	...
Legs	30	...
30	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	108.49	0.0000	0.0000
20	0.11	140.66		115.75	0.0008	
20	0.11	140.66	-0.80	115.75	0.0008	0.0069
30		140.66	-0.29	115.75		0.0025
50		140.66	-0.11	108.49		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	108.49	0.0000	0.0000
20	0.13	140.66		115.75	0.0009	
20	0.40	140.66	-1.10	115.75	0.0029	0.0095
30	0.03	140.66	-0.39	115.75	0.0002	0.0034
50		140.66	-0.13	108.49		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	108.49	0.0000	0.0000
20	0.11	140.66		115.75	0.0008	
20	0.11	140.66	-0.80	115.75	0.0008	0.0069
30		140.66	-0.29	115.75		0.0025
50		140.66	-0.11	108.49		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	108.49	0.0000	0.0000
20	0.13	140.66		115.75	0.0009	
20	0.40	140.66	-1.10	115.75	0.0029	0.0095
30	0.03	140.66	-0.39	115.75	0.0002	0.0034
50		140.66	-0.13	108.49		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	182.86	0.00	117.41	0.0000	0.0000
20	0.21	182.86		122.45	0.0011	
20		182.86	-0.40	122.45		0.0032
30		182.86	-0.17	122.45		0.0014
50		182.86	-0.08	117.41		0.0007

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	182.86	0.00	117.41	0.0000	0.0000
20	0.21	182.86		122.45	0.0011	
20		182.86	-0.28	122.45		0.0023
30		182.86	-0.14	122.45		0.0012
50		182.86	-0.08	117.41		0.0006

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	64.92	140.66		108.49	0.4615	
20	51.98	140.66		115.75	0.3695	
20	51.98	140.66		115.75	0.3695	
30	51.80	140.66		115.75	0.3683	
50	64.83	140.66		108.49	0.4609	

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	64.92	140.66		108.49	0.4615	
20	52.00	140.66		115.75	0.3697	
20	52.28	140.66		115.75	0.3716	
30	51.90	140.66		115.75	0.3690	
50	64.85	140.66		108.49	0.4611	

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	108.49	0.0000	0.0000
20	0.11	140.66		115.75	0.0008	
20	0.11	140.66	-0.80	115.75	0.0008	0.0069
30		140.66	-0.29	115.75		0.0025
50		140.66	-0.11	108.49		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	108.49	0.0000	0.0000
20	0.13	140.66		115.75	0.0009	
20	0.40	140.66	-1.10	115.75	0.0029	0.0095
30	0.03	140.66	-0.39	115.75	0.0002	0.0034
50		140.66	-0.13	108.49		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	67.44	182.86		117.41	0.3688	
20	56.79	182.86		122.45	0.3106	
20	56.42	182.86		122.45	0.3086	
30	56.47	182.86		122.45	0.3088	
50	67.37	182.86		117.41	0.3684	

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	67.44	182.86		117.41	0.3688	
20	56.79	182.86		122.45	0.3105	
20	56.30	182.86		122.45	0.3079	
30	56.44	182.86		122.45	0.3086	
50	67.37	182.86		117.41	0.3684	

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	64.92	140.66		108.49	0.4615	
20	51.97	140.66		115.75	0.3695	
20	51.52	140.66		115.75	0.3663	
30	51.69	140.66		115.75	0.3675	
50	64.82	140.66		108.49	0.4608	

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	64.92	140.66		108.49	0.4615	
20	51.93	140.66		115.75	0.3692	
20	51.59	140.66		115.75	0.3668	
30	51.73	140.66		115.75	0.3677	
50	64.84	140.66		108.49	0.4610	

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	64.92	140.66		108.49	0.4615	
20	51.97	140.66		115.75	0.3695	
20	51.52	140.66		115.75	0.3663	

30	51.69	140.66		115.75	0.3675
50	64.82	140.66		108.49	0.4608

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	64.92	140.66		108.49	0.4615	
20	51.97	140.66		115.75	0.3695	
20	51.52	140.66		115.75	0.3663	
30	51.69	140.66		115.75	0.3675	
50	64.82	140.66		108.49	0.4608	

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	108.49	0.0000	0.0000
20	0.10	140.66		115.75	0.0007	
20		140.66	-0.35	115.75		0.0030
30		140.66	-0.18	115.75		0.0016
50		140.66	-0.10	108.49		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	64.92	140.66		108.49	0.4615	
20	51.97	140.66		115.75	0.3695	
20	51.52	140.66		115.75	0.3663	
30	51.69	140.66		115.75	0.3675	
50	64.82	140.66		108.49	0.4608	

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	108.49	0.0000	0.0000
20	0.10	140.66		115.75	0.0007	
20		140.66	-0.35	115.75		0.0030
30		140.66	-0.18	115.75		0.0016
50		140.66	-0.10	108.49		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	64.92	140.66		108.49	0.4615	
20	51.97	140.66		115.75	0.3695	
20	51.52	140.66		115.75	0.3663	
30	51.69	140.66		115.75	0.3675	
50	64.82	140.66		108.49	0.4608	

Absolute Maximum of the all of the Stress Ratio's 0.4615

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	64.9	...	...	...	64.9	+ Tens

Element # 1	64.9	...	...	...	...	-	Comp
Element # 2	51.9	0.1	...	...	52.0	+	Tens
Element # 2	51.9	0.1	-0.0	-0.0	...	-	Comp
Element # 2	51.9	-0.3	...	0.5	52.0	+	Tens
Element # 2	51.9	-0.3	...	-0.5	...	-	Comp
Element # 3	51.9	-0.2	...	0.1	51.8	+	Tens
Element # 3	51.9	-0.2	...	-0.1	...	-	Comp
Element # 4	64.9	-0.1	...	...	64.8	+	Tens
Element # 4	64.9	-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	608.202 mm.
Center of Gravity of the Legs	-235.000 mm.
Center of Gravity of the Trunnions	2810.000 mm.
Center of Gravity of Bare Shell New and Cold	1560.000 mm.
Center of Gravity of Bare Shell Corroded	1560.000 mm.
Vessel CG in the Operating Condition	1271.981 mm.
Vessel CG in the Fabricated (Shop/Empty) Condition	1320.318 mm.
Vessel CG in the Test Condition	1498.320 mm.

Rigging Analysis Results:

- Lifting weight based on the user selected calculated empty weight

Total Effective Length of Vessel for this analysis		3120.00 mm.
Total vessel weight (No Liquid)	Twt	3994.03 Kgf
Impact weight multiplication factor	Imp	1.50
Design lifting weight, DWT = Imp * Twt		5991.04 Kgf
Elevation of the Tailing Lug (bottom)		0.00 mm.
Elevation of the Lifting Lug (top)		2810.00 mm.
Design Reaction force at the tailing lug		3176.07 Kgf
Design Reaction force at the Trunnions		2814.97 Kgf
CG distance during field lifting operation		1320.32 mm.
CG distance from tailing lug		1320.32 mm.
CG distance from the nearer lifting lug/trunnion		1320.32 mm.
Compressive Allowable Increase Factor		1.00

Critical Values: (N./mm², mm.)

	Max Stress	Elevation	Allowables	
Bending	0.12	2860.00	102.04	(UG-23)
Shear	0.26	2660.00	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 Kg.m.	Bending Stress N./mm²	Shear Force Kgf	Shear Stress N./mm²
0.00	0.0	0.0	371.7	0.0
460.00	147.9	0.0	44.0	0.0
1660.00	456.6	0.1	869.9	0.1
2460.00	10.9	0.0	2034.2	0.2
3060.00	316.4	0.1	178.6	0.0

Unity Check (Actual Stress / Allowable Stress):

Maximum Unity Check is 0.00114 at elevation 2860 mm. - Must be <=1

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

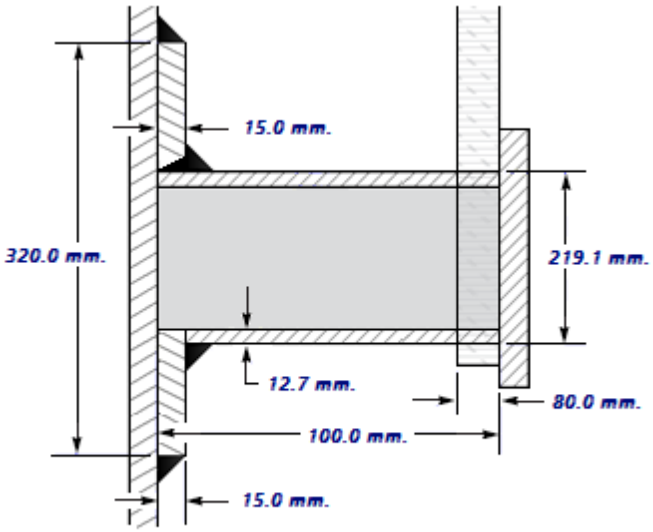
--- Plot data successfully generated ...----

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Trunnion Analysis:

Input Data:

Trunnion Material		SA-516 70	
Trunnion Yield Stress	Sy	262.01	N./mm²
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	15.0000	mm.
Pad Edge Fillet Weld Thk	Tfp	15.0000	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./mm²):

Bending Stress Allowable:	172.9	N./mm²
Shear Stress Allowable:	104.8	N./mm²
Bearing Stress Allowable:	196.5	N./mm²

Angle	Trunnion Lifting Load	Bending Stress	Shear Stress	Bearing Stress	Unity Check	Pass Fail
0	1407.5	2.1	1.7	0.8	0.028	Pass
5	1459.6	2.1	1.7	0.8	0.029	Pass
10	1509.1	2.2	1.8	0.8	0.030	Pass
15	1556.9	2.3	1.9	0.9	0.031	Pass
20	1603.8	2.3	1.9	0.9	0.032	Pass
25	1650.6	2.4	2.0	0.9	0.033	Pass
30	1697.9	2.5	2.0	0.9	0.034	Pass
35	1746.5	2.6	2.1	1.0	0.035	Pass
40	1797.2	2.6	2.1	1.0	0.036	Pass
45	1851.1	2.7	2.2	1.0	0.037	Pass
50	1909.2	2.8	2.3	1.1	0.038	Pass
55	1973.3	2.9	2.3	1.1	0.039	Pass

60	2045.3	3.0	2.4	1.1	0.041	Pass
65	2128.3	3.1	2.5	1.2	0.042	Pass
70	2226.4	3.3	2.7	1.2	0.044	Pass
75	2346.4	3.4	2.8	1.3	0.047	Pass
80	2499.0	3.7	3.0	1.4	0.050	Pass
85	2703.1	4.0	3.2	1.5	0.054	Pass
90	2995.5	4.4	3.6	1.7	0.059	Pass

Trunnion Calculation Results:

Trunnion Lifting Load [Tlf]:
= Resultant Load * Impact Factor
= 1997 * 1.5
= 2995.5 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 * 2996
= 179.7 Kg.m.

Trunnion Calculated Bending Stress [Sbc]:
= Tmom * 9.807/Z
= 179.7 * 9.807/401811
= 4.39 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 cm²

Trunnion Calculated Shear Stress [Ssc]:
= Tlf/Txsa
= 2996/82.35
= 3.57 N./mm [Passed] Ssc < 0.4 * Sy * Occfac (104.80)

Trunnion Unity Check [Uchk]:
= Sbc/Sba + Ssc/Ssa
= 4.387/172.9 + 3.567/104.8
= 0.059 [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
= 179.7/37703
= 4.767 Kgf/mm.

Required Fillet Weld Leg Size at Edge of Trunnion [Wsr]:
= max(10mm, fs/(0.4 * Sy))
= max(10mm, 4.767/(0.4 * 262))
= 10.000 mm.

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

= 175.3 cm²

Trunnion Bearing Stress [Sbec]:
= Tlf/Tbca
= 2996/175.3
= 1.68 N./mm [Passed] Sbec < min(0.75 * SY * Occfac, 0.9 * Sy) (196.51)

Summary of Results:

Trunnion Unity Check Value: 0.0594 Must be less than or equal to 1

Comparison of Stress Values versus Allowables: (N./mm²)

Type of Stress	Actual	Allowable	Pass/Fail
Bending Stress	4.39	172.93	Pass
Shear Stress	3.57	104.80	Pass
Bearing Stress	1.68	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	1970.300	mm.
Vessel Thickness	Tv	14.850	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./mm²
Nozzle Hot S.I. Allowable	SNmh	137.90	N./mm²
Thickness of Reinforcing Pad	Tpad	15.000	mm.
Diameter of Reinforcing Pad	Dpad	350.000	mm.
Design Internal Pressure	Dp	0.000	barg
Include Pressure Thrust		No	

External Forces and Moments in WRC 107/537 Convention:

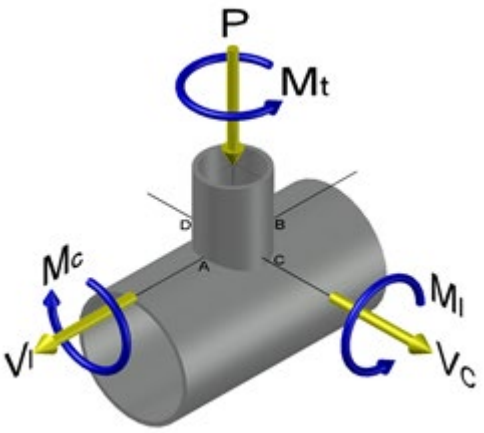
Radial Load	(SUS)	P	0.0	Kgf
Longitudinal Shear	(SUS)	Vl	2995.5	Kgf
Circumferential Shear	(SUS)	Vc	0.0	Kgf
Circumferential Moment	(SUS)	Mc	0.0	Kg.m.

Longitudinal Moment	(SUS)	Ml	179.7	Kg.m.
Torsional Moment	(SUS)	Mt	0.0	Kg.m.

Use Interactive Control		No
WRC107 Version	Version	March 1979

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

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( 992.575 ( 14.85 - 0 ) )
  = 645.144 mm.
```

WRC 107 Stress Calculation for SUStained loads:

Radial Load	P	0.0	Kgf
Circumferential Shear	VC	0.0	Kgf
Longitudinal Shear	VL	2995.5	Kgf
Circumferential Moment	MC	0.0	Kg.m.
Longitudinal Moment	ML	179.7	Kg.m.
Torsional Moment	MT	0.0	Kg.m.

Dimensionless Parameters used : Gamma = 33.50

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.107	4C	5.892	(A,B)
N(PHI) / (P/Rm)	0.107	3C	5.073	(C,D)
M(PHI) / (P)	0.107	2C1	0.090	(A,B)
M(PHI) / (P)	0.107	1C	0.123	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.107	3A	0.988	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.107	1A	0.096	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.107	3B	3.336	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.107	1B	0.046	(A,B,C,D)

N(x) / (P/Rm)	0.107	3C	5.073	(A,B)
N(x) / (P/Rm)	0.107	4C	5.892	(C,D)
M(x) / (P)	0.107	1C1	0.129	(A,B)
M(x) / (P)	0.107	2C	0.090	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.107	4A	1.455	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.107	2A	0.052	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.107	4B	0.949	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.107	2B	0.073	(A,B,C,D)

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

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

Type of Stress Load	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	-1.8	-1.8	1.8	1.8	0.0	0.0	0.0	0.0
Circ. Bend. ML	-5.1	5.1	5.1	-5.1	0.0	0.0	0.0	0.0
Tot. Circ. Str.	-6.9	3.2	6.9	-3.2	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	-0.5	-0.5	0.5	0.5	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.	-8.6	7.6	8.6	-7.6	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	-2.6	-2.6	2.6	2.6
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	0.0	0.0	0.0	0.0	-2.6	-2.6	2.6	2.6
Str. Int.	8.6	7.6	8.6	7.6	5.1	5.1	5.1	5.1

Dimensionless Parameters used : Gamma = 66.84

Dimensionless Loads for Cylindrical Shells at Pad Edge:

Curves read for 1979	Beta	Figure		Value	Location
N(PHI) / (P/Rm)	0.154	4C		9.425	(A,B)
N(PHI) / (P/Rm)	0.154	3C		6.186	(C,D)
M(PHI) / (P)	0.154	2C1		0.037	(A,B)
M(PHI) / (P)	0.154	1C	!	0.071	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.154	3A		2.669	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.154	1A		0.075	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.154	3B		6.870	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.154	1B		0.026	(A,B,C,D)
N(x) / (P/Rm)	0.154	3C		6.186	(A,B)
N(x) / (P/Rm)	0.154	4C		9.425	(C,D)
M(x) / (P)	0.154	1C1		0.072	(A,B)
M(x) / (P)	0.154	2C	!	0.038	(C,D)

N(x) / (MC/(Rm**2 * Beta))	0.154	4A	5.020	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.154	2A	0.036	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.154	4B	2.673	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.154	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./mm²)

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	-5.4	-5.4	5.4	5.4	0.0	0.0	0.0	0.0
Circ. Bend. ML	-8.1	8.1	8.1	-8.1	0.0	0.0	0.0	0.0
Tot. Circ. Str.	-13.4	2.7	13.4	-2.7	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	-2.1	-2.1	2.1	2.1	0.0	0.0	0.0	0.0
Long. Bend. ML	-10.6	10.6	10.6	-10.6	0.0	0.0	0.0	0.0
Tot. Long. Str.	-12.7	8.5	12.7	-8.5	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	-3.6	-3.6	3.6	3.6
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	0.0	0.0	0.0	0.0	-3.6	-3.6	3.6	3.6
Str. Int.	13.4	8.5	13.4	8.5	7.2	7.2	7.2	7.2

WRC 107/537 Stress Summations:

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

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Pl (SUS)	-1.8	-1.8	1.8	1.8	0.0	0.0	0.0	0.0
Circ. Q (SUS)	-5.1	5.1	5.1	-5.1	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)	-0.5	-0.5	0.5	0.5	0.0	0.0	0.0	0.0
Long. Q (SUS)	-8.1	8.1	8.1	-8.1	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	-2.6	-2.6	2.6	2.6

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)	1.8	1.8	1.8	1.8	5.1	5.1	5.1	5.1
Pm+Pl+Q (Total)	8.6	7.6	8.6	7.6	5.1	5.1	5.1	5.1

Vessel Stress Summation Comparison (N./mm²):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	0.00	137.90	Passed
Pm+Pl (SUS)	5.12	206.85	Passed
Pm+Pl+Q (TOTAL)	8.61	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./mm²)

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)	-5.4	-5.4	5.4	5.4	0.0	0.0	0.0	0.0
Circ. Q (SUS)	-8.1	8.1	8.1	-8.1	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)	-2.1	-2.1	2.1	2.1	0.0	0.0	0.0	0.0
Long. Q (SUS)	-10.6	10.6	10.6	-10.6	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	-3.6	-3.6	3.6	3.6
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)	5.4	5.4	5.4	5.4	7.2	7.2	7.2	7.2
Pm+Pl+Q (Total)	13.4	8.5	13.4	8.5	7.2	7.2	7.2	7.2

Vessel Stress Summation Comparison (N./mm²):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	0.00	137.90	Passed
Pm+Pl (SUS)	7.20	206.85	Passed
Pm+Pl+Q (TOTAL)	13.44	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		1290.000	mm.
Effective Leg Length	Leglen	1090.000	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	mm^3
Section Modulus (weak axis)		200000.812	mm^3
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		2802.4	Kg.m.
Total Weight Load at top of Legs	W	3481.1	Kgf
Total Shear force at top of Legs		2436.8	Kgf
Additional force in Leg due to Bracing	Fadd	0.0	Kgf
Occasional Load Factor	Occfac	1.000	
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	15.000	mm.

Maximum Shear at top of one Leg [Vleg]:
= (max(Wind, Seismic, Blast) + applied forces)(Imax / Itot)
= (2437)(5696/15407)
= 900.88 Kgf

Axial Compression, Leg furthest from the Neutral Axis [Sma]:
= W/Nleg + (Mleg/(Nlegm*Rn))/Aleg
= 34138/4 + (27480394/(2 * 1110))/7810
= 2.68 $N./mm^2$

Axial Compression, Leg closest to the Neutral Axis [Sva]:
= (W / Nleg) / Aleg
= (3481/4)/78.1
= 1.09 $N./mm^2$

Allowable Compressive Stress for the Selected Leg (KL/r < Cc) [Sa]:
= Occfac(1-(kl/r)^2/(2*Cc^2))Fy/(5/3+3(Kl/r)/(8*Cc)-(Kl/r^3)/(8*Cc^3)
= 1(1-(21.5)^2/(2*127.2^2))248.2/(5/3+3(21.5)/(8*127.2)-(21.5^3)/(8*127.2^3)
= 141.47 $N./mm^2$

Bending at the Bottom of the Leg closest to the N.A. [S]:
= (Vleg * Leglen / Smdwa)
= (900.9 * 1090/200001)
= 48.15 $N./mm^2$

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

AISC Unity Check [Sc](must be <= to 1 and > 0) :
= (Sma/Sa)+(0.85*S)/((1-Sma/Spex)*Sb)
= (2.678/141.5)+(0.85 *48.15)/((1 -2.678/2266) *148.9)
= 0.2941

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	3.0000	mm.
Vessel Diameter	Dv	1970.300	mm.
Vessel Thickness	Tv	14.850	mm.
Design Temperature	T1	80.0	C
Vessel Material		SA-516 70	
Vessel UNS Number		K02700	
Vessel Cold S.I. Allowable	Smc	137.90	N./mm²
Vessel Hot S.I. Allowable	Smh	137.90	N./mm²

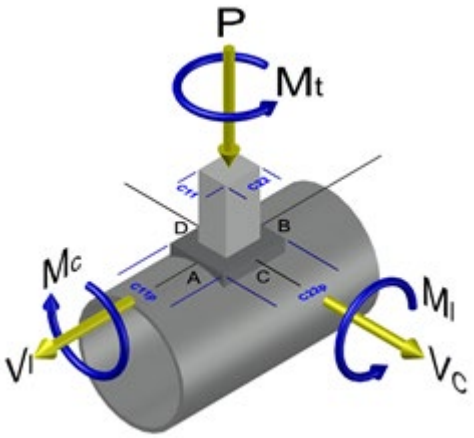
See ASME VIII Div. 1, UG-23(e), for determination of the SPS allowable.

Attachment Type	Type	Rectangular	
Parameter C11	C11	200.00	mm.
Parameter C22	C22	330.95	mm.
Thickness of Reinforcing Pad	Tpad	15.000	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	870.3	Kgf
Global Force (SUS)	Fz	0.0	Kgf
Global Moment (SUS)	Mx	0.0	Kg.m.
Global Moment (SUS)	My	0.0	Kg.m.
Global Moment (SUS)	Mz	95.7	Kg.m.
Internal Pressure (SUS)	P	12.00	barg
Include Pressure Thrust		No	
Global Force (OCC)	Fx	900.9	Kgf
Global Force (OCC)	Fy	1262.4	Kgf

Global Force (OCC)	Fz	0.0	Kgf
Global Moment (OCC)	Mx	0.0	Kg.m.
Global Moment (OCC)	My	0.0	Kg.m.
Global Moment (OCC)	Mz	629.8	Kg.m.
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	870.3	Kgf
Circumferential Moment	MC	0.0	Kg.m.
Longitudinal Moment	ML	-95.7	Kg.m.
Torsional Moment	MT	0.0	Kg.m.

Dimensionless Parameters used : Gamma = 37.30

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.161	4C	5.735	(A,B)
N(PHI) / (P/Rm)	0.161	3C	4.246	(C,D)
M(PHI) / (P)	0.120	2C1	0.075	(A,B)
M(PHI) / (P)	0.120	1C	0.108	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.118	3A	1.251	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.129	1A	0.091	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.140	3B	4.122	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.134	1B	0.039	(A,B,C,D)
N(x) / (P/Rm)	0.142	3C	4.697	(A,B)

N(x) / (P/Rm)	0.142	4C	6.047	(C,D)
M(x) / (P)	0.145	1C1	0.096	(A,B)
M(x) / (P)	0.145	2C	0.059	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.118	4A	1.875	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.154	2A	0.044	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.140	4B	1.330	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.152	2B	0.053	(A,B,C,D)

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

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

Type of Stress Load	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	0.9	0.9	-0.9	-0.9	0.0	0.0	0.0	0.0
Circ. Bend. ML	2.3	-2.3	-2.3	2.3	0.0	0.0	0.0	0.0
Tot. Circ. Str.	3.1	-1.4	-3.1	1.4	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	2.7	-2.7	-2.7	2.7	0.0	0.0	0.0	0.0
Tot. Long. Str.	3.1	-2.3	-3.1	2.3	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	-0.5	-0.5	0.5	0.5
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	-0.5	-0.5	0.5	0.5
Str. Int.	3.1	2.3	3.1	2.3	1.0	1.0	1.0	1.0

Dimensionless Parameters used : Gamma = 83.89

Dimensionless Loads for Cylindrical Shells at Pad Edge:

Curves read for 1979	Beta	Figure		Value	Location
N(PHI) / (P/Rm)	0.178	4C		10.412	(A,B)
N(PHI) / (P/Rm)	0.178	3C		5.682	(C,D)
M(PHI) / (P)	0.159	2C1		0.030	(A,B)
M(PHI) / (P)	0.159	1C	!	0.067	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.159	3A		3.282	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.170	1A		0.067	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.167	3B		7.710	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.167	1B		0.019	(A,B,C,D)
N(x) / (P/Rm)	0.169	3C		6.079	(A,B)
N(x) / (P/Rm)	0.169	4C		10.698	(C,D)
M(x) / (P)	0.171	1C1		0.057	(A,B)
M(x) / (P)	0.171	2C	!	0.036	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.159	4A		6.791	(A,B,C,D)

```
M(x)   / ( MC/(Rm    * Beta) )   0.190   2A        0.028   (A,B,C,D)
N(x)   / ( ML/(Rm**2 * Beta) )   0.167   4B        3.281   (A,B,C,D)
M(x)   / ( ML/(Rm    * Beta) )   0.175   2B        0.023   (A,B,C,D)
```

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

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

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

Type of Stress	Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb.	P	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	3.3	3.3	-3.3	-3.3	0.0	0.0	0.0	0.0
Circ. Bend.	ML	4.7	-4.7	-4.7	4.7	0.0	0.0	0.0	0.0
Tot. Circ. Str.		8.0	-1.4	-8.0	1.4	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	1.4	1.4	-1.4	-1.4	0.0	0.0	0.0	0.0
Long. Bend.	ML	5.3	-5.3	-5.3	5.3	0.0	0.0	0.0	0.0
Tot. Long. Str.		6.7	-3.8	-6.7	3.8	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	-1.0	-1.0	1.0	1.0
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	-1.0	-1.0	1.0	1.0
Str. Int.		8.0	3.8	8.0	3.8	2.1	2.1	2.1	2.1

WRC 107 Stress Calculation for OCCasional loads:

```
Radial Load                              P        900.9  Kgf
Circumferential Shear                    VC         0.0  Kgf
Longitudinal Shear                       VL      1262.4  Kgf
Circumferential Moment                   MC         0.0  Kg.m.
Longitudinal Moment                      ML      -629.8  Kg.m.
Torsional Moment                         MT         0.0  Kg.m.

Dimensionless Parameters used :   Gamma = 37.30
```

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

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

Type of Stress	Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb.	P	-1.9	-1.9	-1.9	-1.9	-1.4	-1.4	-1.4	-1.4
Circ. Bend.	P	-5.5	5.5	-5.5	5.5	-7.9	7.9	-7.9	7.9
Circ. Memb.	MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb.	MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Circ. Memb. ML	5.9	5.9	-5.9	-5.9	0.0	0.0	0.0	0.0
Circ. Bend. ML	14.8	-14.8	-14.8	14.8	0.0	0.0	0.0	0.0
Tot. Circ. Str.	13.3	-5.3	-28.1	12.5	-9.3	6.5	-9.3	6.5
Long. Memb. P	-1.5	-1.5	-1.5	-1.5	-2.0	-2.0	-2.0	-2.0
Long. Bend. P	-7.1	7.1	-7.1	7.1	-4.4	4.4	-4.4	4.4
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	2.5	2.5	-2.5	-2.5	0.0	0.0	0.0	0.0
Long. Bend. ML	17.9	-17.9	-17.9	17.9	0.0	0.0	0.0	0.0
Tot. Long. Str.	11.8	-9.9	-29.0	21.0	-6.3	2.4	-6.3	2.4
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.	13.3	9.9	29.0	21.0	9.5	6.6	9.5	6.6

Dimensionless Parameters used : Gamma = 83.89
Stress Concentration Factors: Kn = 1.00, Kb = 1.00

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

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P	-7.8	-7.8	-7.8	-7.8	-4.3	-4.3	-4.3	-4.3
Circ. Bend. P	-11.4	11.4	-11.4	11.4	-25.5	25.5	-25.5	25.5
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	21.8	21.8	-21.8	-21.8	0.0	0.0	0.0	0.0
Circ. Bend. ML	30.8	-30.8	-30.8	30.8	0.0	0.0	0.0	0.0
Tot. Circ. Str.	33.5	-5.4	-71.9	12.6	-29.7	21.2	-29.7	21.2
Long. Memb. P	-4.6	-4.6	-4.6	-4.6	-8.0	-8.0	-8.0	-8.0
Long. Bend. P	-21.3	21.3	-21.3	21.3	-13.6	13.6	-13.6	13.6
Long. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. ML	9.4	9.4	-9.4	-9.4	0.0	0.0	0.0	0.0
Long. Bend. ML	34.7	-34.7	-34.7	34.7	0.0	0.0	0.0	0.0
Tot. Long. Str.	18.2	-8.4	-70.0	42.0	-21.6	5.5	-21.6	5.5
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	-1.5	-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.	33.5	8.4	71.9	42.0	30.0	21.4	30.0	21.4

WRC 107/537 Stress Summations:

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

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	43.6	44.8	43.6	44.8	43.6	44.8	43.6	44.8
Circ. Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Pm(TOTAL)	43.6	44.8	43.6	44.8	43.6	44.8	43.6	44.8
Circ. Pl (SUS)	0.9	0.9	-0.9	-0.9	0.0	0.0	0.0	0.0
Circ. Pl (OCC)	4.0	4.0	-7.8	-7.8	-1.4	-1.4	-1.4	-1.4
Circ. Pl(TOTAL)	4.9	4.9	-8.7	-8.7	-1.4	-1.4	-1.4	-1.4
Circ. Q (SUS)	2.3	-2.3	-2.3	2.3	0.0	0.0	0.0	0.0
Circ. Q (OCC)	9.3	-9.3	-20.3	20.3	-7.9	7.9	-7.9	7.9
Circ. Q (TOTAL)	11.6	-11.6	-22.6	22.6	-7.9	7.9	-7.9	7.9
Long. Pm (SUS)	21.8	21.8	21.8	21.8	21.8	21.8	21.8	21.8
Long. Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Pm(TOTAL)	21.8	21.8	21.8	21.8	21.8	21.8	21.8	21.8
Long. Pl (SUS)	0.4	0.4	-0.4	-0.4	0.0	0.0	0.0	0.0
Long. Pl (OCC)	1.0	1.0	-4.0	-4.0	-2.0	-2.0	-2.0	-2.0
Long. Pl(TOTAL)	1.3	1.3	-4.4	-4.4	-2.0	-2.0	-2.0	-2.0
Long. Q (SUS)	2.7	-2.7	-2.7	2.7	0.0	0.0	0.0	0.0
Long. Q (OCC)	10.9	-10.9	-25.0	25.0	-4.4	4.4	-4.4	4.4
Long. Q (TOTAL)	13.6	-13.6	-27.7	27.7	-4.4	4.4	-4.4	4.4
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pm(TOTAL)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	0.0	0.0	0.0	0.0	-0.5	-0.5	0.5	0.5
Shear Pl (OCC)	0.0	0.0	0.0	0.0	-0.7	-0.7	0.7	0.7
Shear Pl(TOTAL)	0.0	0.0	0.0	0.0	-1.2	-1.2	1.2	1.2
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)	43.6	44.8	43.6	44.8	43.6	44.8	43.6	44.8
Pm (SUS+OCC)	43.6	44.8	43.6	44.8	43.6	44.8	43.6	44.8
Pm+Pl (SUS)	44.5	45.7	42.7	43.9	43.6	44.8	43.6	44.8
Pm+Pl (SUS+OCC)	48.5	49.7	34.9	36.1	42.2	43.4	42.2	43.4
Pm+Pl+Q (Total)	60.1	38.1	22.7	58.7	34.3	51.4	34.3	51.4

Vessel Stress Summation Comparison (N./mm²):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	44.77	137.90	Passed
Pm (SUS+OCC)	44.77	165.48	Passed
Pm+Pl (SUS)	45.67	206.85	Passed
Pm+Pl (SUS+OCC)	49.68	248.22	Passed
Pm+Pl+Q (TOTAL)	60.05	485.85	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./mm²)

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	99.5	100.7	99.5	100.7	99.5	100.7	99.5	100.7
Circ. Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Pm(TOTAL)	99.5	100.7	99.5	100.7	99.5	100.7	99.5	100.7
Circ. Pl (SUS)	3.3	3.3	-3.3	-3.3	0.0	0.0	0.0	0.0
Circ. Pl (OCC)	14.0	14.0	-29.6	-29.6	-4.3	-4.3	-4.3	-4.3
Circ. Pl(TOTAL)	17.3	17.3	-33.0	-33.0	-4.3	-4.3	-4.3	-4.3
Circ. Q (SUS)	4.7	-4.7	-4.7	4.7	0.0	0.0	0.0	0.0
Circ. Q (OCC)	19.4	-19.4	-42.2	42.2	-25.5	25.5	-25.5	25.5
Circ. Q (TOTAL)	24.1	-24.1	-46.9	46.9	-25.5	25.5	-25.5	25.5
Long. Pm (SUS)	49.7	49.7	49.7	49.7	49.7	49.7	49.7	49.7
Long. Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Pm(TOTAL)	49.7	49.7	49.7	49.7	49.7	49.7	49.7	49.7
Long. Pl (SUS)	1.4	1.4	-1.4	-1.4	0.0	0.0	0.0	0.0
Long. Pl (OCC)	4.9	4.9	-14.0	-14.0	-8.0	-8.0	-8.0	-8.0
Long. Pl(TOTAL)	6.3	6.3	-15.4	-15.4	-8.0	-8.0	-8.0	-8.0
Long. Q (SUS)	5.3	-5.3	-5.3	5.3	0.0	0.0	0.0	0.0
Long. Q (OCC)	13.3	-13.3	-56.0	56.0	-13.6	13.6	-13.6	13.6
Long. Q (TOTAL)	18.6	-18.6	-61.3	61.3	-13.6	13.6	-13.6	13.6
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pm(TOTAL)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	0.0	0.0	0.0	0.0	-1.0	-1.0	1.0	1.0
Shear Pl (OCC)	0.0	0.0	0.0	0.0	-1.5	-1.5	1.5	1.5
Shear Pl(TOTAL)	0.0	0.0	0.0	0.0	-2.5	-2.5	2.5	2.5
Shear Q (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Q (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Q (TOTAL)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pm (SUS)	99.5	100.7	99.5	100.7	99.5	100.7	99.5	100.7
Pm (SUS+OCC)	99.5	100.7	99.5	100.7	99.5	100.7	99.5	100.7
Pm+Pl (SUS)	102.8	104.0	96.2	97.4	99.5	100.7	99.5	100.7
Pm+Pl (SUS+OCC)	116.8	118.0	66.5	67.7	95.3	96.5	95.3	96.5
Pm+Pl+Q (Total)	140.9	93.9	46.5	114.7	69.9	122.0	69.9	122.0

Vessel Stress Summation Comparison (N./mm²):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	100.68	137.90	Passed
Pm (SUS+OCC)	100.68	165.48	Passed
Pm+Pl (SUS)	103.99	206.85	Passed
Pm+Pl (SUS+OCC)	118.01	248.22	Passed
Pm+Pl+Q (TOTAL)	140.94	485.85	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./mm²
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./mm²
Bolt Allowable Shear Stress	SBShear	28.96	N./mm²
Anchor Bolt Nominal Diameter	BOD	30.0000	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./mm²

Leg Baseplate and Bolting Analysis, including Moments

Shear Stress in a Single Bolt [taub]:
  = Shear Force/(Bolt Area * Number of Bolts)
  = 2437/(5.03 * 24)
  = 2.0 N./mm². Must be less than 29.0 N./mm².

I-Beam Leg

Base Plate Available Area [AA]:
  = B * D
  = 400 * 400
  = 1600.000 cm²

Clearance Between The Bolt And The Leg Edge [BCL]:
  = z - BOD / 2
  = 50 - 30/2
  = 35.000 mm.

Moment at Baseplate [MOMENT]:
  = Vleg * Lleg
  = 900.9 * 1290
  = 1162.162 Kg.m.

Axial Load on the baseplate [P]:
  = 998.507 Kgf, based on governing load combination.

Eccentricity [e]:
  = MOMENT * Conv_Factor / P
  = 1162 * 9807/998.5
  = 1163.877 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(1164 - 0.5 * 400)
= 2891.631 mm.

Value [K2]:
= 6 * n * Ast/B(F + e)
= 6 * 9.449 * 15.09/400 (150 + 1164)
= 2809.905 cm²

Distance [K3]:
= -K2(0.5 * D + F)
= -2810 (0.5 * 400 + 150)
= -983466.062 mm³

Solving For The Effective Bearing Length Using Iteration [Y]:
:: Y³ + K1 * Y² + K2 * Y + K3 = 0
:: Y³ + 2892 * Y² + 2810 * Y - 983466 = 0
= 139.641 mm.

Term [NUM]:
= D/2 - Y/3 - e
= 400/2 - 139.6/3 - 1164
= -1010.424 mm.

Term [DENOM]:
= D/2 - Y/3 + F
= 400/2 - 139.6/3 + 150
= 303.453 mm.

Total Bolt Tension Force [T]:
= - P * NUM/DENOM
= - 998.5 * -1010/303.5
= 3324.785 Kgf

Overturning Moment Due To Bolt In Tension [Mt]:
= T(0.5 * D + F - Y)
= 3325 (0.5 * 400 + 150 - 139.6)
= 699.411 Kg.m.

Bearing Pressure [FC]:
= 2(P + T)/(Y * B)
= 2(998.5 + 3325)/(139.6 * 400)
= 15.18 barg [<= FCPRIME (206.84)]

Equivalent Bearing Pressure [f1]:
= FC(Y - a)/Y
= 15.18 (139.6 - 100)/139.6
= 4.309 barg

Overturning Moment Due To Bearing Pressure [Mc]:
= (a² * B/6) * (f1 + 2 * FC)
= (100² * 400/6) * (4.309 + 2 * 15.18)
= 235.702 Kg.m.

The Baseplate Required Thickness [TREQ]:
= sqrt(6 * max(Mt, Mc) / (B * 1.5 * SBA))
= sqrt(6 * 699.4/(400 * 206.9))
= 22.302 mm.

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

= 3325/48.26
= 6.7555 cm² [< Ast (15.09) --> PASSED]

Distance from Top of Legs to Vessel CG [CD_DIST]:
= 862 mm.

Total Overturning Moment at Baseplate [Mbb]:
= (Mleg / max(CD_DIST, minDist)) * (CD_DIST + Lleg)
= (2802/max(862, 38.1)) * (862 + 1290)
= 6996.444 Kg.m.

Required Total Bolt Area per Leg per H. Bednar [ABREQB]:
= (1/(Nleg * STBA)) * ((4 * Mbb/(Rn * 2)) - W)
= (1/(4 * 48.26)) * ((4 * 6996/(2220)) - 3994)
= 4.3747 cm²

Available Total Bolt Corr. Area per Leg [ABAVL]:
= As * NBT
= 5.03 * 6
= 30.1779 cm² [> ABREQB (4.37) --> PASSED]

Baseplate & Bolting Summary of Results: (mm., cm²)

	Actual	Required	Pass/Fail
Baseplate Thickness	40.000	22.302	Pass
Bolt Root Area (Bednar)	30.18	4.37	Pass
Bolt Root Area (D. Moss)	15.09	6.76	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		1290.000	mm.
Effective Leg Length	Leglen	1090.000	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	mm^3
Section Modulus (weak axis)		200000.812	mm^3
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		558.3	Kg.m.
Total Weight Load at top of Legs	W	15007.6	Kgf
Total Shear force at top of Legs		460.2	Kgf
Additional force in Leg due to Bracing	Fadd	0.0	Kgf
Occasional Load Factor	Occfac	1.000	
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	15.000	mm.

Maximum Shear at top of one Leg [Vleg]:
= (max(Wind, Seismic, Blast) + applied forces)(Imax / Itot)
= (460.2)(5696/15407)
= 170.13 Kgf

Axial Compression, Leg furthest from the Neutral Axis [Sma]:
= W/Nleg + (Mleg/(Nlegm*Rn))/Aleg
= 147172/4 + (5474738/(2 * 1110))/7810
= 5.03 N./mm²

Axial Compression, Leg closest to the Neutral Axis [Sva]:
= (W / Nleg) / Aleg
= (15008/4)/78.1
= 4.71 N./mm²

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(1-(21.5)²/(2*127.2²))248.2/(5/3+3(21.5)/(8*127.2)-(21.5³)/(8*127.2³)
= 141.47 N./mm²

Bending at the Bottom of the Leg closest to the N.A. [S]:
= (Vleg * Leglen / Smdwa)
= (170.1 * 1090/200001)
= 9.09 N./mm²

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

AISC Unity Check [Sc](must be <= to 1 and > 0) :
= (Sma/Sa)+(0.85*S)/((1-Sma/Spex)*Sb)
= (5.027/141.5)+(0.85 *9.093)/((1 -5.027/2266) *148.9)
= 0.0875

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.

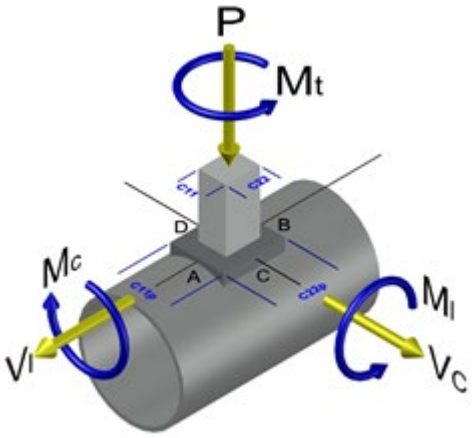
Input Echo, WRC107/537 Item 1, Description: LEGS

Diameter Basis for Vessel	Vbasis	ID	
Cylindrical or Spherical Vessel	Cylsph	Cylindrical	
Internal Corrosion Allowance	Cas	0.0000	mm.
Vessel Diameter	Dv	1970.300	mm.
Vessel Thickness	Tv	14.850	mm.
Design Temperature	T1	80.0	C
Vessel Material		SA-516 70	
Vessel UNS Number		K02700	
Vessel Cold S.I. Allowable	Smc	179.27	N./mm²
Vessel Hot S.I. Allowable	Smh	179.27	N./mm²
Attachment Type	Type	Rectangular	
Parameter C11	C11	200.00	mm.
Parameter C22	C22	330.95	mm.
Thickness of Reinforcing Pad	Tpad	15.000	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	3751.9	Kgf
Global Force (SUS)	Fz	0.0	Kgf
Global Moment (SUS)	Mx	0.0	Kg.m.
Global Moment (SUS)	My	0.0	Kg.m.
Global Moment (SUS)	Mz	412.7	Kg.m.
Internal Pressure (SUS)	P	12.00	barg
Include Pressure Thrust		No	
Global Force (OCC)	Fx	170.1	Kgf
Global Force (OCC)	Fy	251.5	Kgf
Global Force (OCC)	Fz	0.0	Kgf
Global Moment (OCC)	Mx	0.0	Kg.m.
Global Moment (OCC)	My	0.0	Kg.m.

Global Moment (OCC)	Mz	120.4	Kg.m.
Occasional Internal Pressure (OCC)	Pvar	5.47	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	3751.9	Kgf
Circumferential Moment	MC	0.0	Kg.m.
Longitudinal Moment	ML	-412.7	Kg.m.
Torsional Moment	MT	0.0	Kg.m.

Dimensionless Parameters used : Gamma = 33.50

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.161	4C	5.213	(A,B)
N(PHI) / (P/Rm)	0.161	3C	3.917	(C,D)
M(PHI) / (P)	0.120	2C1	0.079	(A,B)
M(PHI) / (P)	0.120	1C	0.112	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.118	3A	1.080	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.129	1A	0.092	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.140	3B	3.677	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.135	1B	0.040	(A,B,C,D)
N(x) / (P/Rm)	0.142	3C	4.317	(A,B)
N(x) / (P/Rm)	0.142	4C	5.495	(C,D)
M(x) / (P)	0.146	1C1	0.100	(A,B)
M(x) / (P)	0.146	2C	0.063	(C,D)

N(x) / (MC/(Rm**2 * Beta))	0.118	4A	1.611	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.155	2A	0.045	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.140	4B	1.165	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.153	2B	0.057	(A,B,C,D)

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

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

Type of Stress Load	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	3.1	3.1	-3.1	-3.1	0.0	0.0	0.0	0.0
Circ. Bend. ML	8.1	-8.1	-8.1	8.1	0.0	0.0	0.0	0.0
Tot. Circ. Str.	11.2	-5.0	-11.2	5.0	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	1.3	1.3	-1.3	-1.3	0.0	0.0	0.0	0.0
Long. Bend. ML	10.1	-10.1	-10.1	10.1	0.0	0.0	0.0	0.0
Tot. Long. Str.	11.4	-8.8	-11.4	8.8	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	-1.9	-1.9	1.9	1.9
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	-1.9	-1.9	1.9	1.9
Str. Int.	11.4	8.8	11.4	8.8	3.7	3.7	3.7	3.7

Dimensionless Parameters used : Gamma = 66.84

Dimensionless Loads for Cylindrical Shells at Pad Edge:

Curves read for 1979	Beta	Figure		Value	Location
N(PHI) / (P/Rm)	0.178	4C		8.782	(A,B)
N(PHI) / (P/Rm)	0.178	3C		5.223	(C,D)
M(PHI) / (P)	0.159	2C1		0.035	(A,B)
M(PHI) / (P)	0.159	1C	!	0.070	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.159	3A		2.655	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.172	1A		0.071	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.167	3B		6.569	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.168	1B		0.023	(A,B,C,D)
N(x) / (P/Rm)	0.169	3C		5.555	(A,B)
N(x) / (P/Rm)	0.169	4C		9.000	(C,D)
M(x) / (P)	0.171	1C1		0.064	(A,B)
M(x) / (P)	0.171	2C	!	0.036	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.159	4A		5.114	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.193	2A		0.030	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.167	4B		2.697	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.177	2B		0.028	(A,B,C,D)

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

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

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

Type of Stress	Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb.	P	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	9.7	9.7	-9.7	-9.7	0.0	0.0	0.0	0.0
Circ. Bend.	ML	15.2	-15.2	-15.2	15.2	0.0	0.0	0.0	0.0
Tot. Circ. Str.		24.9	-5.4	-24.9	5.4	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	4.2	4.2	-4.2	-4.2	0.0	0.0	0.0	0.0
Long. Bend.	ML	17.7	-17.7	-17.7	17.7	0.0	0.0	0.0	0.0
Tot. Long. Str.		21.9	-13.6	-21.9	13.6	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	-3.5	-3.5	3.5	3.5
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	-3.5	-3.5	3.5	3.5
Str. Int.		24.9	13.6	24.9	13.6	7.1	7.1	7.1	7.1

WRC 107 Stress Calculation for OCCasional loads:

Radial Load	P	170.1	Kgf
Circumferential Shear	VC	0.0	Kgf
Longitudinal Shear	VL	251.5	Kgf
Circumferential Moment	MC	0.0	Kg.m.
Longitudinal Moment	ML	-120.4	Kg.m.
Torsional Moment	MT	0.0	Kg.m.

Dimensionless Parameters used : Gamma = 33.50

Stress Concentration Factors: Kn = 1.00, Kb = 1.00

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

Type of Stress	Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb.	P	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2
Circ. Bend.	P	-0.9	0.9	-0.9	0.9	-1.3	1.3	-1.3	1.3
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	0.9	0.9	-0.9	-0.9	0.0	0.0	0.0	0.0
Circ. Bend.	ML	2.4	-2.4	-2.4	2.4	0.0	0.0	0.0	0.0

Tot. Circ. Str.	2.1	-0.9	-4.5	2.1	-1.5	1.0	-1.5	1.0
Long. Memb. P	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3
Long. Bend. P	-1.1	1.1	-1.1	1.1	-0.7	0.7	-0.7	0.7
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	2.9	-2.9	-2.9	2.9	0.0	0.0	0.0	0.0
Tot. Long. Str.	2.0	-1.7	-4.7	3.5	-1.0	0.4	-1.0	0.4
Shear VC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-0.1	-0.1	0.1	0.1
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	0.0	0.0	0.0	0.0	-0.1	-0.1	0.1	0.1
Str. Int.	2.1	1.7	4.7	3.5	1.5	1.1	1.5	1.1

Dimensionless Parameters used : Gamma = 66.84
Stress Concentration Factors: Kn = 1.00, Kb = 1.00

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

Type of Stress	Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Memb. P		-1.0	-1.0	-1.0	-1.0	-0.6	-0.6	-0.6	-0.6
Circ. Bend. P		-1.6	1.6	-1.6	1.6	-3.2	3.2	-3.2	3.2
Circ. Memb. MC		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. ML		2.8	2.8	-2.8	-2.8	0.0	0.0	0.0	0.0
Circ. Bend. ML		4.4	-4.4	-4.4	4.4	0.0	0.0	0.0	0.0
Tot. Circ. Str.		4.7	-1.0	-9.9	2.2	-3.8	2.6	-3.8	2.6
Long. Memb. P		-0.6	-0.6	-0.6	-0.6	-1.0	-1.0	-1.0	-1.0
Long. Bend. P		-2.9	2.9	-2.9	2.9	-1.7	1.7	-1.7	1.7
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		1.2	1.2	-1.2	-1.2	0.0	0.0	0.0	0.0
Long. Bend. ML		5.2	-5.2	-5.2	5.2	0.0	0.0	0.0	0.0
Tot. Long. Str.		2.9	-1.7	-9.9	6.2	-2.7	0.6	-2.7	0.6
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.		4.7	1.7	9.9	6.2	3.8	2.6	3.8	2.6

WRC 107/537 Stress Summations:

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

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

Circ. Pm (SUS)	39.0	40.2	39.0	40.2	39.0	40.2	39.0	40.2
Circ. Pm (OCC)	17.8	18.3	17.8	18.3	17.8	18.3	17.8	18.3
Circ. Pm(TOTAL)	56.8	58.6	56.8	58.6	56.8	58.6	56.8	58.6
Circ. Pl (SUS)	3.1	3.1	-3.1	-3.1	0.0	0.0	0.0	0.0
Circ. Pl (OCC)	0.6	0.6	-1.2	-1.2	-0.2	-0.2	-0.2	-0.2
Circ. Pl(TOTAL)	3.7	3.7	-4.3	-4.3	-0.2	-0.2	-0.2	-0.2
Circ. Q (SUS)	8.1	-8.1	-8.1	8.1	0.0	0.0	0.0	0.0
Circ. Q (OCC)	1.5	-1.5	-3.3	3.3	-1.3	1.3	-1.3	1.3
Circ. Q (TOTAL)	9.6	-9.6	-11.4	11.4	-1.3	1.3	-1.3	1.3
Long. Pm (SUS)	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5
Long. Pm (OCC)	8.9	8.9	8.9	8.9	8.9	8.9	8.9	8.9
Long. Pm(TOTAL)	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.4
Long. Pl (SUS)	1.3	1.3	-1.3	-1.3	0.0	0.0	0.0	0.0
Long. Pl (OCC)	0.1	0.1	-0.6	-0.6	-0.3	-0.3	-0.3	-0.3
Long. Pl(TOTAL)	1.4	1.4	-1.9	-1.9	-0.3	-0.3	-0.3	-0.3
Long. Q (SUS)	10.1	-10.1	-10.1	10.1	0.0	0.0	0.0	0.0
Long. Q (OCC)	1.8	-1.8	-4.1	4.1	-0.7	0.7	-0.7	0.7
Long. Q (TOTAL)	11.9	-11.9	-14.2	14.2	-0.7	0.7	-0.7	0.7
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pm(TOTAL)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	0.0	0.0	0.0	0.0	-1.9	-1.9	1.9	1.9
Shear Pl (OCC)	0.0	0.0	0.0	0.0	-0.1	-0.1	0.1	0.1
Shear Pl(TOTAL)	0.0	0.0	0.0	0.0	-2.0	-2.0	2.0	2.0
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)	39.0	40.2	39.0	40.2	39.0	40.2	39.0	40.2
Pm (SUS+OCC)	56.8	58.6	56.8	58.6	56.8	58.6	56.8	58.6
Pm+Pl (SUS)	42.1	43.3	35.9	37.1	39.2	40.4	39.2	40.4
Pm+Pl (SUS+OCC)	60.5	62.3	52.5	54.3	56.7	58.5	56.7	58.5
Pm+Pl+Q (Total)	70.1	52.7	41.1	65.6	55.5	59.7	55.5	59.7

Vessel Stress Summation Comparison (N./mm²):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	40.22	179.27	Passed
Pm (SUS+OCC)	58.56	215.12	Passed
Pm+Pl (SUS)	43.32	268.90	Passed
Pm+Pl (SUS+OCC)	62.28	322.69	Passed
Pm+Pl+Q (TOTAL)	70.12	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./mm²)

Type of Stress Load	Stress Intensity Values at Au	Al	Bu	Bl	Cu	Cl	Du	Dl
Circ. Pm (SUS)	79.0	80.2	79.0	80.2	79.0	80.2	79.0	80.2
Circ. Pm (OCC)	36.0	36.6	36.0	36.6	36.0	36.6	36.0	36.6
Circ. Pm(TOTAL)	115.1	116.8	115.1	116.8	115.1	116.8	115.1	116.8
Circ. Pl (SUS)	9.7	9.7	-9.7	-9.7	0.0	0.0	0.0	0.0
Circ. Pl (OCC)	1.8	1.8	-3.8	-3.8	-0.6	-0.6	-0.6	-0.6
Circ. Pl(TOTAL)	11.6	11.6	-13.6	-13.6	-0.6	-0.6	-0.6	-0.6
Circ. Q (SUS)	15.2	-15.2	-15.2	15.2	0.0	0.0	0.0	0.0
Circ. Q (OCC)	2.8	-2.8	-6.0	6.0	-3.2	3.2	-3.2	3.2
Circ. Q (TOTAL)	18.0	-18.0	-21.2	21.2	-3.2	3.2	-3.2	3.2
Long. Pm (SUS)	39.5	39.5	39.5	39.5	39.5	39.5	39.5	39.5
Long. Pm (OCC)	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
Long. Pm(TOTAL)	57.5	57.5	57.5	57.5	57.5	57.5	57.5	57.5
Long. Pl (SUS)	4.2	4.2	-4.2	-4.2	0.0	0.0	0.0	0.0
Long. Pl (OCC)	0.6	0.6	-1.8	-1.8	-1.0	-1.0	-1.0	-1.0
Long. Pl(TOTAL)	4.7	4.7	-6.0	-6.0	-1.0	-1.0	-1.0	-1.0
Long. Q (SUS)	17.7	-17.7	-17.7	17.7	0.0	0.0	0.0	0.0
Long. Q (OCC)	2.3	-2.3	-8.1	8.1	-1.7	1.7	-1.7	1.7
Long. Q (TOTAL)	20.0	-20.0	-25.8	25.8	-1.7	1.7	-1.7	1.7
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pm(TOTAL)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	0.0	0.0	0.0	0.0	-3.5	-3.5	3.5	3.5
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	-3.8	-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)	79.0	80.2	79.0	80.2	79.0	80.2	79.0	80.2
Pm (SUS+OCC)	115.1	116.8	115.1	116.8	115.1	116.8	115.1	116.8
Pm+Pl (SUS)	88.7	89.9	69.3	70.5	79.3	80.5	79.3	80.5
Pm+Pl (SUS+OCC)	126.6	128.4	101.5	103.3	114.7	116.5	114.7	116.5
Pm+Pl+Q (Total)	144.6	110.4	80.3	124.5	111.5	119.6	111.5	119.6

Vessel Stress Summation Comparison (N./mm²):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	80.22	179.27	Passed
Pm (SUS+OCC)	116.81	215.12	Passed
Pm+Pl (SUS)	89.94	268.90	Passed
Pm+Pl (SUS+OCC)	128.37	322.69	Passed
Pm+Pl+Q (TOTAL)	144.61	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./mm²

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./mm²
Bolt Allowable Shear Stress	SBShear	28.96	N./mm²
Anchor Bolt Nominal Diameter	BOD	30.0000	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./mm²

Leg Baseplate and Bolting Analysis, including Moments

Shear Stress in a Single Bolt [taub]:
  = Shear Force/(Bolt Area * Number of Bolts)
  = 2437/(5.03 * 24)
  = 2.0 N./mm². Must be less than 29.0 N./mm².

I-Beam Leg

Base Plate Available Area [AA]:
  = B * D
  = 400 * 400
  = 1600.000 cm²

Clearance Between The Bolt And The Leg Edge [BCL]:
  = z - BOD / 2
  = 50 - 30/2
  = 35.000 mm.

Moment at Baseplate [MOMENT]:
  = Vleg * Lleg
  = 170.1 * 1290
  = 219.470 Kg.m.

Axial Load on the baseplate [P]:
  = 998.507 Kgf, based on governing load combination.

Eccentricity [e]:
  = MOMENT * Conv_Factor / P
  = 219.5 * 9807/998.5
  = 219.794 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(219.8 - 0.5 * 400 )
  = 59.383 mm.
```

Value [K2]:
```
  = 6 * n * Ast/B(F + e)
  = 6 * 9.449 * 15.09/400 (150 + 219.8 )
  = 790.855 cm²
```

Distance [K3]:
```
  = -K2( 0.5 * D + F )
  = -790.9 ( 0.5 * 400 + 150 )
  = -276799.062 mm³
```

Solving For The Effective Bearing Length Using Iteration [Y]:
```
  :: Y³ + K1 * Y² + K2 * Y + K3 = 0
  :: Y³ + 59.38 * Y² + 790.9 * Y - 276799 = 0
  = 206.547 mm.
```

Term [NUM]:
```
  = D/2 - Y/3 - e
  = 400/2 - 206.5/3 - 219.8
  = -88.643 mm.
```

Term [DENOM]:
```
  = D/2 - Y/3 + F
  = 400/2 - 206.5/3 + 150
  = 281.151 mm.
```

Total Bolt Tension Force [T]:
```
  = - P * NUM/DENOM
  = - 998.5 * -88.64/281.2
  = 314.817 Kgf
```

Overturning Moment Due To Bolt In Tension [Mt]:
```
  = T(0.5 * D + F - Y)
  = 314.8 (0.5 * 400 + 150 - 206.5 )
  = 45.162 Kg.m.
```

Bearing Pressure [FC]:
```
  = 2(P + T)/(Y * B)
  = 2(998.5 + 314.8 )/(206.5 * 400 )
  = 3.12 barg [ <= FCPRIME ( 206.84)]
```

Equivalent Bearing Pressure [f1]:
```
  = FC(Y - a)/Y
  = 3.118 (206.5 - 100 )/206.5
  = 1.608 barg
```

Overturning Moment Due To Bearing Pressure [Mc]:
```
  = ( a² * B/6 ) * ( f1 + 2 * FC )
  = ( 100² * 400/6 ) * ( 1.608 + 2 * 3.118 )
  = 53.324 Kg.m.
```

The Baseplate Required Thickness [TREQ]:
```
  = sqrt( 6 * max( Mt, Mc ) / ( B * 1.5 * SBA ) )
  = sqrt( 6 * 53.32/( 400 * 206.9 ) )
  = 6.158 mm.
```

Required bolt area per D. Moss [ABREQM]:
```
  = T/STBA
  = 314.8/48.26
  = 0.6397 cm² [ < Ast ( 15.09) --> PASSED ]
```

Distance from Top of Legs to Vessel CG [CD_DIST]:
  = 1088 mm.

Total Overturning Moment at Baseplate [Mbb]:
  = (Mleg / max(CD_DIST, minDist)) * (CD_DIST + Lleg)
  = (558.3/max(1088, 38.1)) * (1088 + 1290)
  = 1220.087 Kg.m.

Required Total Bolt Area per Leg per H. Bednar [ABREQB]:
  = (1/(Nleg * STBA)) * ((4 * Mbb/(Rn * 2)) - W)
  = (1/(4 * 48.26)) * ((4 * 1220/(2220)) - 3994)
  = -0.9122 cm² --> (No tension in bolts)

Baseplate & Bolting Summary of Results: (mm., cm²)

	Actual	Required	Pass/Fail
Baseplate Thickness	40.000	6.158	Pass
Bolt Root Area (D. Moss)	15.09	0.64	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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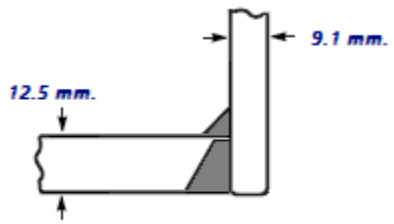
Input, Nozzle Desc: Drain From: 10

Pressure for Reinforcement Calculations	P	12.500	barg
Temperature for Internal Pressure	Temp	80	°C
Parent Material [Impact Tested]		SA-516 70	
Parent Allowable Stress at Temperature	Sv	137.90	N./mm²
Parent Allowable Stress At Ambient	Sva	137.90	N./mm²
Inside Diameter of Elliptical Head	D	1975.00	mm.
Aspect Ratio of Elliptical Head	Ar	2.00	
Head Finished (Minimum) Thickness	t	12.5000	mm.
Head Internal Corrosion Allowance	c	3.0000	mm.
Head External Corrosion Allowance	co	0.0000	mm.
Distance from Head Centerline	L1	0.0000	mm.
User Entered Minimum Design Metal Temperature		-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./mm²
Allowable Stress At Ambient	Sna	117.90	N./mm²
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	3.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	100.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	12.5000	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)
  = 12.5*1981*0.897/(2*137.9*1-0.2*12.5)
  = 8.0651 mm.
```

Reqd thk per App. 1 of Nozzle Wall, trn [Int. Press]
```
  = R( exp([P/(Sn*E)] - 1 ) per Appendix 1-2 (a)(1)
  = 10.61(exp([12.5/(117.9*1]-1)
  = 0.1131 mm.
```

UG-40, Limits of Reinforcement: [Internal Pressure]
```
Parallel to Vessel Wall (Diameter Limit)          Dl    52.4010  mm.
Parallel to Vessel Wall                       Rn+tn+t    26.2005  mm.
Normal to Vessel Wall (Thickness Limit), no pad   Tlnp    15.2330  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 = 3.1131 mm.
Wall Thickness per UG16(b),                      tr16b = 5.5000 mm.
Wall Thickness, shell/head, internal pressure     trb1 = 11.9510 mm.
Wall Thickness                 tb1 = max(trb1, tr16b) = 11.9510 mm.
Wall Thickness                 tb2 = max(trb2, tr16b) = 5.5000 mm.
Wall Thickness per table UG-45                    tb3 = 5.9464 mm.
```

Determine Nozzle Thickness candidate [tb]:
```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 5.946, max( 11.95, 5.5 ) ]
  = 5.9464 mm.
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
```
  = max( ta, tb )
  = max( 3.113, 5.946 )
  = 5.9464 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) -66 °C

Where the Stress Reduction Ratio per UCS-66(i)(2) is :
Design Pressure/Ambient Rating = 12.50/19.60 = 0.638

Weld Size Calculations, Description: Drain

Intermediate Calc. for nozzle/shell Welds Tmin 6.0932 mm.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.2652 = 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 : 0.0781 mm.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 112.5781 mm.

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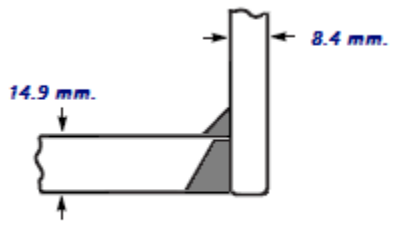
Input, Nozzle Desc: PG From: 20

Pressure for Reinforcement Calculations	P	12.500	barg
Temperature for Internal Pressure	Temp	80	°C
Parent Material [Impact Tested]		SA-516 70	
Parent Allowable Stress at Temperature	Sv	137.90	N./mm²
Parent Allowable Stress At Ambient	Sva	137.90	N./mm²
Inside Diameter of Cylindrical Shell	D	1970.00	mm.
Shell Finished (Minimum) Thickness	t	14.8500	mm.
Shell Internal Corrosion Allowance	c	3.0000	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./mm²
Allowable Stress At Ambient	Sna	137.90	N./mm²
Diameter Basis (for tr calc only)		Outside	
Layout Angle		75.00	deg
Diameter		1.5000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	8.3820	mm.
Corrosion Allowance	can	3.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	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)
= 12.5*988/(137.9*1-0.6*12.5)
= 9.0053 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)
= 12.5*19.05/(137.9*1+0.4*12.5)
= 0.1721 mm.

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

Parallel to Vessel Wall (Diameter Limit)	Dl	61.8000	mm.
Parallel to Vessel Wall	Rn+tn+t	30.9000	mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	13.4550	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	= 3.1721 mm.
Wall Thickness per UG16(b),	tr16b	= 5.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1	= 12.0053 mm.
Wall Thickness	tb1 = max(trb1, tr16b)	= 12.0053 mm.
Wall Thickness	tb2 = max(trb2, tr16b)	= 5.5000 mm.
Wall Thickness per table UG-45	tb3	= 6.1200 mm.

Determine Nozzle Thickness candidate [tb]:
= min[tb3, max(tb1,tb2)]
= min[6.12, max(12.01, 5.5)]
= 6.1200 mm.

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
= max(ta, tb)
= max(3.172, 6.12)
= 6.1200 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 5.3820 mm.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	3.7674 = 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 : 0.1842 mm.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 47.8092 mm.

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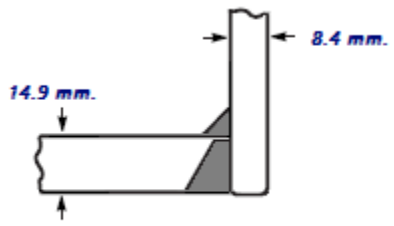
Input, Nozzle Desc: PT From: 20

Pressure for Reinforcement Calculations	P	12.500	barg
Temperature for Internal Pressure	Temp	80	°C
Parent Material [Impact Tested]		SA-516 70	
Parent Allowable Stress at Temperature	Sv	137.90	N./mm²
Parent Allowable Stress At Ambient	Sva	137.90	N./mm²
Inside Diameter of Cylindrical Shell	D	1970.00	mm.
Shell Finished (Minimum) Thickness	t	14.8500	mm.
Shell Internal Corrosion Allowance	c	3.0000	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./mm²
Allowable Stress At Ambient	Sna	137.90	N./mm²
Diameter Basis (for tr calc only)		Outside	
Layout Angle		105.00	deg
Diameter		1.5000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	8.3820	mm.
Corrosion Allowance	can	3.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	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)
= 12.5*988/(137.9*1-0.6*12.5)
= 9.0053 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)
= 12.5*19.05/(137.9*1+0.4*12.5)
= 0.1721 mm.

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

Parallel to Vessel Wall (Diameter Limit)	Dl	61.8000	mm.
Parallel to Vessel Wall	Rn+tn+t	30.9000	mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	13.4550	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	= 3.1721 mm.
Wall Thickness per UG16(b),	tr16b	= 5.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1	= 12.0053 mm.
Wall Thickness	tb1 = max(trb1, tr16b)	= 12.0053 mm.
Wall Thickness	tb2 = max(trb2, tr16b)	= 5.5000 mm.
Wall Thickness per table UG-45	tb3	= 6.1200 mm.

Determine Nozzle Thickness candidate [tb]:
= min[tb3, max(tb1,tb2)]
= min[6.12, max(12.01, 5.5)]
= 6.1200 mm.

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
= max(ta, tb)
= max(3.172, 6.12)
= 6.1200 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 5.3820 mm.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	3.7674 = 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 : 0.1842 mm.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 47.8092 mm.

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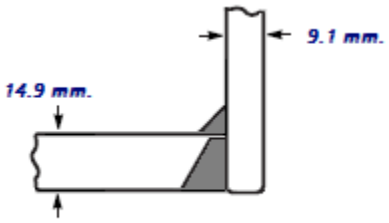
Input, Nozzle Desc: IN/OUT From: 20

Pressure for Reinforcement Calculations	P	12.500	barg
Temperature for Internal Pressure	Temp	80	°C
Parent Material [Impact Tested]		SA-516 70	
Parent Allowable Stress at Temperature	Sv	137.90	N./mm²
Parent Allowable Stress At Ambient	Sva	137.90	N./mm²
Inside Diameter of Cylindrical Shell	D	1970.00	mm.
Shell Finished (Minimum) Thickness	t	14.8500	mm.
Shell Internal Corrosion Allowance	c	3.0000	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./mm²
Allowable Stress At Ambient	Sna	117.90	N./mm²
Diameter Basis (for tr calc only)		Outside	
Layout Angle		180.00	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	3.0000	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	1.315	in.
Actual Thickness Used in Calculation	0.358	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)
= 12.5*988/(137.9*1-0.6*12.5)
= 9.0053 mm.

Reqd thk per App. 1 of Nozzle Wall, trn [Int. Press]
= Ro(1 - exp(-P/(Sn*E))) per Appendix 1-2 (a)(1)
= 16.7(1-exp(-12.5/(117.9*1)))
= 0.1761 mm.

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

Parallel to Vessel Wall (Diameter Limit)	Dl	57.1010	mm.
Parallel to Vessel Wall	Rn+tn+t	28.5505	mm.
Normal to Vessel Wall (Thickness Limit), no pad	Tlnp	15.2330	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 =	3.1761 mm.
Wall Thickness per UG16(b),	tr16b =	5.5000 mm.
Wall Thickness, shell/head, internal pressure	trb1 =	12.0053 mm.
Wall Thickness	tb1 = max(trb1, tr16b) =	12.0053 mm.
Wall Thickness	tb2 = max(trb2, tr16b) =	5.5000 mm.
Wall Thickness per table UG-45	tb3 =	5.9464 mm.

Determine Nozzle Thickness candidate [tb]:
= min[tb3, max(tb1,tb2)]
= min[5.946, max(12.01, 5.5)]
= 5.9464 mm.

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
= max(ta, tb)
= max(3.176, 5.946)
= 5.9464 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) -66 °C

Where the Stress Reduction Ratio per UCS-66(i)(2) is :
Design Pressure/Ambient Rating = 12.50/19.60 = 0.638

Weld Size Calculations, Description: IN/OUT

Intermediate Calc. for nozzle/shell Welds Tmin 6.0932 mm.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.2652 = 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 : 0.1416 mm.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 47.7665 mm.

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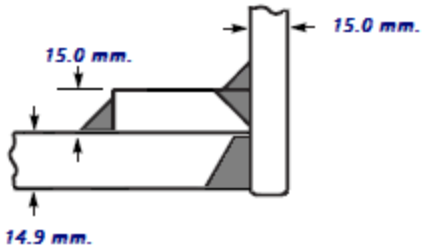
Input, Nozzle Desc: MAN HOLE From: 20

Pressure for Reinforcement Calculations	P	12.500	barg
Temperature for Internal Pressure	Temp	80	°C
Parent Material [Impact Tested]		SA-516 70	
Parent Allowable Stress at Temperature	Sv	137.90	N./mm²
Parent Allowable Stress At Ambient	Sva	137.90	N./mm²
Inside Diameter of Cylindrical Shell	D	1970.00	mm.
Shell Finished (Minimum) Thickness	t	14.8500	mm.
Shell Internal Corrosion Allowance	c	3.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		460.00	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./mm²
Allowable Stress At Ambient	Sna	137.90	N./mm²
Diameter Basis (for tr calc only)		Outside	
Layout Angle		270.00	deg
Diameter		16.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	15.0000	mm.
Flange Material		SA-350 LF2	
Flange Type		Weld Neck Flange	
Corrosion Allowance	can	3.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	32.7750	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./mm²
Pad Allowable Stress At Ambient	Spa	137.90	N./mm²
Diameter of Pad along vessel surface	Dp	510.0000	mm.
Thickness of Pad	te	15.0000	mm.
Weld leg size between Pad and Shell	Wp	10.0000	mm.
Groove weld depth between Pad and Nozzle	Wgpn	15.0000	mm.
Reinforcing Pad Width		51.8000	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          16.000  in.
 Actual Thickness Used in Calculation                  0.591  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)
  = 12.5*988/(137.9*1-0.6*12.5)
  = 9.0053 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)
  = 12.5*203.2/(137.9*1+0.4*12.5)
  = 1.8354 mm.
```

UG-40, Limits of Reinforcement: [Internal Pressure]
```
 Parallel to Vessel Wall (Diameter Limit)            Dl   764.8000  mm.
 Parallel to Vessel Wall, opening length              d   382.4000  mm.
 Normal to Vessel Wall (Thickness Limit), pad side Tlwp    29.6250  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: (cm²)

AREA AVAILABLE, A1 to A5		Design	External	Mapnc
Area Required	Ar	34.436	NA	NA
Area in Shell	A1	10.878	NA	NA
Area in Nozzle Wall	A2	6.023	NA	NA
Area in Inward Nozzle	A3	0.000	NA	NA

Area in Welds	A41+A42+A43	3.249	NA	NA
Area in Element	A5	15.540	NA	NA
TOTAL AREA AVAILABLE	Atot	35.689	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:	501.6449	15.0000	mm.
Based on given Pad Diameter:	510.0000	13.7903	mm.
Based on Shell or Nozzle Thickness:	502.6070	14.8500	mm.

Area Required [A]:
= (d * tr*F + 2 * tn * tr*F * (1-fr1)) UG-37(c)
= (382.4*9.005*1+2*12*9.005*1*(1-1))
= 34.436 cm²

Reinforcement Areas per Figure UG-37.1

Area Available in Shell [A1]:
= d(E1*t - F*tr) - 2 * tn(E1*t - F*tr) * (1 - fr1)
= 382.4 (1 * 11.85 - 1 * 9.005) - 2 * 12
(1 * 11.85 - 1 * 9.005) * (1 - 1)
= 10.878 cm²

Area Available in Nozzle Wall Projecting Outward [A2]:
= (2 * Tlwp) * (tn - trn) * fr2
= (2 * 29.63) * (12 - 1.835) * 1
= 6.023 cm²

Area Available in Welds [A41 + A42 + A43]:
= (Wo² - Ar Lost)*Fr3+((Wi-can/0.707)² - Ar Lost)*fr2 + Wp²*fr4
= (2.249) * 1 + (0) * 1 + 10² * 1
= 3.249 cm²

Area Available in Element [A5]:
= (min(Dp,DL)-(Nozzle OD))*(min(tp,Tlwp,te)) * fr4
= (510 - 406.4) * 15 * 1
= 15.540 cm²

UG-45 Minimum Nozzle Neck Thickness Requirement:
Wall Thickness for Internal/External pressures ta = 4.8354 mm.

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
= ta
= 4.8354 mm.

Available Nozzle Neck Thickness = 15.0000 mm. -> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

Nozzle Neck to Flange Weld, Curve: B

Govrn. thk, tg = 15, tr = 1.835, c = 3 mm., E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.153, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-16 °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 = 15, tr = 1.835, c = 3 mm., E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.153, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -16 °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 = 15, tr = 1.835, c = 3 mm., E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.153, Temp. Reduction = 78 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -16 °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 = 14.85, tr = 9.005, c = 3 mm., E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.76, Temp. Reduction = 13 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -16 °C
Min Metal Temp. at Required thickness (UCS 66.1) -30 °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 = 14.85, tr = 9.005, c = 3 mm., E✱ = 1
Thickness Ratio = tr * E✱/(tg - c) = 0.76, Temp. Reduction = 13 °C

Min Metal Temp. w/o impact per UCS-66, Curve B -16 °C
Min Metal Temp. at Required thickness (UCS 66.1) -30 °C
Min Metal Temp. w/o impact per UG-20(f) -29 °C

Gov. MDMT of the Nozzle : -30 °C
Gov. MDMT of the Reinforcement Pad : -30 °C
Gov. MDMT of the nozzle to shell joint welded assembly : -30 °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 = 12.50/19.60 = 0.638

Weld Size Calculations, Description: MAN HOLE

Intermediate Calc. for nozzle/shell Welds Tmin 12.0000 mm.
Intermediate Calc. for pad/shell Welds TminPad 12.0000 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	6.0000 = 0.5*TminPad	7.0700 = 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, (34.44 - 10.88 + 2 * 12 * 1 *
    (1 * 11.85 - 9.005 ) )137.9 )
  = 34086.25 Kgf
```

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

Weld Load [W1]:

```
  = (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
  = ( 6.023 + 15.54 + 3.249 - 0 * 1 ) * 137.9
  = 34888.51 Kgf
```

Weld Load [W2]:

```
  = (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
  = ( 6.023 + 0 + 2.25 + ( 2.844 ) ) * 137.9
  = 15631.67 Kgf
```

Weld Load [W3]:

```
  = (A2+A3+A4+A5+(2*tn*t*fr1))*S
  = ( 6.023 + 0 + 3.249 + 15.54 + ( 2.844 ) ) * 137.9
  = 38887.63 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 ) * 406.4 * 15 * 0.49 * 137.9
  = 65978. Kgf
```

Shear, Pad Element Weld [Spew]:

```
  = (pi/2) * DP * WP * 0.49 * SEW
  = ( 3.142/2.0 ) * 510 * 10 * 0.49 * 137.9
  = 55198. Kgf
```

Shear, Nozzle Wall [Snw]:

```
  = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
  = (3.142 * 197.2 ) * ( 15 - 3 ) * 0.7 * 137.9
  = 73177. Kgf
```

Tension, Pad Groove Weld [Tpgw]:

```
  = ( pi/2) * Dlo * Wgpn * 0.74 * Seg
  =  (3.142/2 ) * 406.4 * 15 * 0.74 * 137.9
  = 99640. Kgf
```

Tension, Shell Groove Weld [Tngw]:

```
  = (pi/2) * Dlo * ( T - cas ) * 0.74 * Sng
  = ( 3.142/2.0 ) * 406.4 * ( 14.85 - 3 ) * 0.74 * 137.9
  = 78715. Kgf
```

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

Strength of Failure Paths:

Failure Path [Path 1-1]:

```
  = ( SPEW + SNW ) = ( 55198 + 73177 ) = 128374 Kgf
```

Failure Path [Path 2-2]:

```
  = ( Sonw + Tpgw + Tngw + Sinw )
  = ( 65978 + 99640 + 78715 + 0 ) = 244333 Kgf
```

Failure Path [Path 3-3]:

```
  = ( Spew + Tngw + Sinw )
  = ( 55198 + 78715 + 0 ) = 133913 Kgf
```

Summary of Failure Path Calculations:

```
 Path 1-1 = 128374  Kgf, must exceed W = 34086 Kgf    or W1 = 34888 Kgf
 Path 2-2 = 244332  Kgf, must exceed W = 34086 Kgf    or W2 = 15631 Kgf
 Path 3-3 = 133913  Kgf, must exceed W = 34086 Kgf    or W3 = 38887 Kgf
```

Maximum Allowable Pressure for this Nozzle at this Location:

```
 Converged Maximum Allowable Pressure in the Operating case: 12.72 barg
```

The Drop for this Nozzle is : 21.1874 mm.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 68.8123 mm.

Percent Elongation Calculations:

```
 % Elongation per Table UG-79-1 (50*tnom/Rf*(1-Rf/Ro))  3.832 %
```

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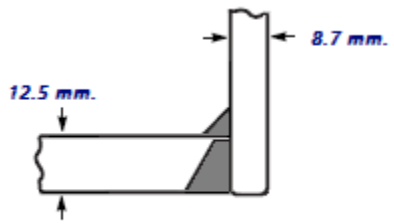
Input, Nozzle Desc: PSV From: 50

Pressure for Reinforcement Calculations	P	12.000	barg
Temperature for Internal Pressure	Temp	80	°C
Parent Material [Impact Tested]		SA-516 70	
Parent Allowable Stress at Temperature	Sv	137.90	N./mm²
Parent Allowable Stress At Ambient	Sva	137.90	N./mm²
Inside Diameter of Elliptical Head	D	1975.00	mm.
Aspect Ratio of Elliptical Head	Ar	2.00	
Head Finished (Minimum) Thickness	t	12.5000	mm.
Head Internal Corrosion Allowance	c	3.0000	mm.
Head External Corrosion Allowance	co	0.0000	mm.
Distance from Head Centerline	L1	0.0000	mm.
User Entered Minimum Design Metal Temperature		-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./mm²
Allowable Stress At Ambient	Sna	117.90	N./mm²
Diameter Basis (for tr calc only)		Inside	
Layout Angle		0.00	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	3.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	100.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	12.5000	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: PSV

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

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

Nozzle input data check completed without errors.

Reqd thk per UG-37(a) of Elliptical Head, tr [Int. Press]
```
= P*D*K1/(2*Sv*E-0.2*P) per Appendix 1-4(c)
= 12*1981*0.897/(2*137.9*1-0.2*12)
= 7.7422 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*24.42/(117.9*1-0.6*12)
= 0.2501 mm.
```

UG-40, Limits of Reinforcement: [Internal Pressure]
```
Parallel to Vessel Wall (Diameter Limit)            Dl    97.6996  mm.
Parallel to Vessel Wall, opening length              d    48.8498  mm.
Normal to Vessel Wall (Thickness Limit), no pad   Tlnp    14.3440  mm.
```

Taking a UG-36(c)(3)(a) exemption for nozzle: PSV.
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 = 3.2501 mm.
Wall Thickness per UG16(b),                      tr16b = 5.5000 mm.
Wall Thickness, shell/head, internal pressure     trb1 = 11.5926 mm.
Wall Thickness                 tb1 = max(trb1, tr16b) = 11.5926 mm.
Wall Thickness                 tb2 = max(trb2, tr16b) = 5.5000 mm.
Wall Thickness per table UG-45                    tb3 = 6.4200 mm.
```

Determine Nozzle Thickness candidate [tb]:
```
= min[ tb3, max( tb1,tb2) ]
= min[ 6.42, max( 11.59, 5.5 ) ]
= 6.4200 mm.
```

Minimum Wall Thickness of Nozzle Necks [tUG-45]:
```
= max( ta, tb )
= max( 3.25, 6.42 )
= 6.4200 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) -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: PSV

Intermediate Calc. for nozzle/shell Welds Tmin 5.7376 mm.

Results Per UW-16.1:

	Required Thickness	Actual Thickness
Nozzle Weld	4.0163 = 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.

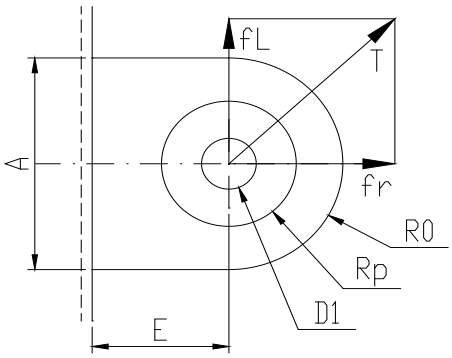
The Drop for this Nozzle is : 0.2544 mm.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 112.7545 mm.

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COES	**CLIENTE** : **ROSETTI MARINO** ***CUSTOMER***	**COMM:** : **167/24** ***JOB:***	
		ITEM: : **N2 RECEIVER**	

Dimensionamento dei golfari di sollevamento
Design calculation of tailing lug

M	peso del serbatoio durante il sollevamento *weight of vessel during erection*	3940	kg
P	peso del serbatoio durante il sollevamento *weight of vessel during erection*	38651	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

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

77302,8

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

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

560

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

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

3800

Ok!

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

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

11595420

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

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

55,7

Ok!

Sforzi nella saldatura
Stress in the weld

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

5302,5

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

14,58

Ok!

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