طرح نگهداشت و افزایش تولید 27 مخزن

MECHANICAL CALCULATION BOOK FOR GLYCOL CARBON FILTER (F-200)

نگهداشت و افزایش تولید میدان نفتی بینک

V00	DEC. 2024	IFI	MFS	M.Fakharian	S.Faramarzpour	
Rev.	**Date**	**Purpose of Issue/Status**	**Prepared by:**	**Checked by:**	**Approved by:**	**CLIENT Approval**

Status:

IFA: Issued For Approval
IFI: Issued For Information
AFC: Approved For Construction

REVISION RECORD SHEET

PAGE	V00	V01	V02	V03	V04
1	X				
2	X				
3	X				
4	X				
5	X				
6	X				
7	X				
8	X				
9	X				
10	X				
11	X				
12	X				
13	X				
14	X				
15	X				
16	X				
17	X				
18	X				
19	X				
20	X				
21	X				
22	X				
23	X				
24	X				
25	X				
26	X				
27	X				
28	X				
29	X				
30	X				
31	X				
32	X				
33	X				
34	X				
35	X				
36	X				
37	X				
38	X				
39	X				
40	X				
41	X				
42	X				
43	X				
44	X				
45	X				
46	X				
47	X				
48	X				
49	X				
50	X				
51	X				
52	X				
53	X				
54	X				
55	X				
56	X				
57	X				
58	X				
59	X				
60	X				
61	X				
62	X				
63	X				
64	X				
65	X				

PAGE	V00	V01	V02	V03	V04
66	X				
67	X				
68	X				
69	X				
70	X				
71	X				
72	X				
73	X				
74	X				
75	X				
76	X				
77	X				
78	X				
79	X				
80	X				
81	X				
82	X				
83	X				
84	X				
85	X				
86	X				
87	X				
88	X				
89	X				
90	X				
91	X				
92	X				
93	X				
94	X				
95	X				
96	X				
97	X				
98	X				
99	X				
100	X				
101	X				
102	X				
103	X				
104	X				
105	X				
106	X				
107	X				
108	X				
109	X				
110	X				
111	X				
112	X				
113	X				
114	X				
115	X				
116	X				
117	X				
118	X				
119					
120					
121					
122					
123					
124					
125					
126					
127					
128					
129					
130					

Table of Contents

DESIGN CALCULATION

In Accordance with ASME Section VIII Division 1

```
ASME Code Version      : 2019

Analysis Performed by :

Job File               : C:\USERS\TECHNICAL2\DESKTOP\BINAK\DESIGN\F-200\F

Date of Analysis       : Dec 28,2024   1:57pm

PV Elite 2020, January 2020
```

ASME Code, Section VIII Division 1, 2019

Diameter Spec : 406.400 mm. OD		
Vessel Design Length, Tangent to Tangent	1523.10	mm.
Distance of Bottom Tangent above Grade	100.00	mm.
Specified Datum Line Distance	0.00	mm.
Internal Design Temperature	100	°C
Internal Design Pressure	7.500	bars
External Design Temperature	100	°C
External Design Pressure	1.034	bars
Maximum Allowable Working Pressure	13.479	bars
External Max. Allowable Working Pressure	1.248	bars
Hydrostatic Test Pressure	9.750	bars
Required Minimum Design Metal Temperature	5.0	°C
Warmest Computed Minimum Design Metal Temperature	-34.0	°C
Wind Design Code	ASCE-2010	
Earthquake Design Code	ASCE 7-2010	

Materials of Construction:

Component Type	Material	Class	Thickness	UNS #	Normalized	Impact Tested
Shell	SA-106 B	...	...	K03006	No	No
Head	SA-234 WPB	...	...	K03006	No	No
Flange	SA-105	...	...	K03504	No	No
Nozzle	SA-105	...	...	K03504	No	No
Re-Pad	SA-516 70	...	...	K02700	No	No
Nozzle Flg	SA-105	...	...	K03504	No	No
Leg Baseplate	SA-283 C	...	...	K02401	No	No
Flg Bolting	SA-193 B7	...	<= 2 1/2	G41400	No	No
Leg Bolting	SA-325	...	...		No	No

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

Element Pressures and MAWP (bars & mm.):

Element Description or Type	Design Pressure + Stat. head	Ext. Press.	Element M.A.W.P	Corrosion Allowance	Str. Flg. Gov.	In Creep Range
Ellipse	7.642	1.03	20.500	6.0000	Yes	No
Cylinder	7.627	1.03	13.500	6.0000	N/A	No
Body Flg	7.500	1.03	17.700	6.0000	N/A	No
Body Flg	7.500	1.03	17.700	6.0000	N/A	No

Liquid Level: 1446.84 mm. Dens.: 999.542 kg/m³ Sp. Gr.: 1.000

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	50.0	50.0	9.5	9.5	7.5	7.5	1.00	1.00
Cylinder	1350.0	1300.0	9.5	8.3	7.5	8.2	1.00	1.00
Body Flg	1477.0	127.0	...	36.6	...	...	1.00	1.00
Body Flg	1523.1	36.6	...	36.6	...	...	1.00	1.00

Loads for Foundation/Support Design:

Factored Loads:

Total Wind Shear on top of all Legs	0.	kN
Total Earthquake Shear on top of all Legs	2.	kN
Total Wind Moment at top of all Legs	94.	N-m
Total Earthquake Moment at top of all Legs	1354.	N-m
Max. Wind Shear on one Leg (top & bottom)	0.	kN
Max. Earthq. Shear on one Leg (top & bottom)	1.	kN
Max. Wind Moment at base of one Leg	137.	N-m
Max. Earthquake Moment at base of one Leg	1072.	N-m
Max. Vertical Load (Wt. + Wind) on one Leg	2.	kN
Max. Vertical Load (Wt. + Eq.) on one Leg	8.	kN

Un-Factored Loads:

Total Wind Shear on top of all Legs	0.	kN
Total Earthquake Shear on top of all Legs	2.	kN
Total Wind Moment at top of all Legs	156.	N-m
Total Earthquake Moment at top of all Legs	1934.	N-m
Max. Wind Shear on one Leg (top & bottom)	0.	kN
Max. Earthq. Shear on one Leg (top & bottom)	2.	kN
Max. Wind Moment at base of one Leg	229.	N-m
Max. Earthquake Moment at base of one Leg	1531.	N-m
Max. Vertical Load (Wt. + Wind) on one Leg	4.	kN
Max. Vertical Load (Wt. + Eq.) on one Leg	11.	kN

Note:
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
LEGS	WRC-107/537	0.551	n/a	Passed
LEGS	WRC-107/537	0.091	n/a	Passed

Weights:

Fabricated	- Bare W/O Removable Internals	391.4	kg.
Shop Test	- Fabricated + Water (Full)	575.3	kg.
Shipping	- Fab. + Rem. Intls.+ Shipping App.	408.9	kg.
Erected	- Fab. + Rem. Intls.+ Insul. (etc)	508.9	kg.
Empty	- Fab. + Intls. + Details + Wghts.	508.9	kg.
Operating	- Empty + Operating Liquid (No CA)	677.4	kg.
Field Test	- Empty Weight + Water (Full)	500.7	kg.

Nozzle Calculation Summary:

Description	MAWP bars	Ext	MAPNC bars	UG-45	[tr] mm.	Weld Path	Areas or Stresses
N04 (1in)	20.5	OK	...	OK	7.50	OK	Passed
N02 (1in)	13.5	OK	...	OK	7.50	OK	Passed
N03 (1in)	13.5	OK	...	OK	7.50	OK	Passed
N01 (1in)	13.5	OK	...	OK	7.50	OK	Passed
N06 (1in)	13.5	OK	...	OK	7.50	OK	Passed
N05 (1in)	17.7	OK	...	OK	9.42	OK	Passed

Nozzle MAWP Summary:

```
Minimum MAWP Nozzles         :          13.5 Nozzle  : N06 (1in)
Minimum MAWP Shells/Flanges  :          13.5 Element :
Minimum MAPnc Shells/Flanges :          19.6 Element :
-----------------------------------------------------
Computed Vessel M.A.W.P.     :          13.5 bars
```

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

Check the Spatial Relationship between the Nozzles:

From Node	Nozzle Description	Y Coordinate mm.	Layout Angle deg	Dia. Limit mm.
10	N04 (1in)	0.000	0.000	74.800
20	N02 (1in)	150.000	0.000	74.800
20	N03 (1in)	350.000	180.000	74.800
20	N01 (1in)	1250.000	180.000	74.800
20	N06 (1in)	1250.000	0.000	74.800
40	N05 (1in)	0.000	0.000	111.952

The nozzle spacing is computed by the following:

= Sqrt($ll^2 + lc^2$) where

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

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

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

No interference violations have been detected !

Checking Multiple Nozzles on Flat Head per ASME Sec. VIII Div. 1 UG-39

Comparing Nozzles on Element from Node: 40 to: 50

Note: No Nozzle pairs found on this element.

UG-39 Nozzle Diameter and Distance to Edge Checks:

Nozzle Description	Nozzle dia. mm.	Head Dia. /2 mm.	Distance from Edge mm.	Nozzle dia./4 mm.
N05 (1in)	37.4	223.69	273.05	9.35

No Multiple Nozzle spacing violations detected!

Bill of Materials:

QTY	DESCRIPTION	MATERIAL
1	ELLIPTICAL HEAD: 2.0 X 1, 9.5mm. THK X 387.4mm. ID X 50.0mm.	SA-234 WPB
1	CYLINDER: 9.5mm. THK X 389.7mm. ID X 1300.0mm.	SA-106 B
1	BODY FLANGE: 36.6mm. THK X 389.7mm. OD	SA-105
1	BODY FLANGE: 36.6mm. THK X 596.9mm. OD	SA-105
1	INSULATION: 151mm X 50mm THK	
1	INSULATION: 1300mm X 50mm THK	
3	LEGS, SHAPE: L80X80X10 999mm	...
3	BASEPLATES: 200mm X 200mm X 18mm	SA-283 C
3	BASEPLATE BOLTS: 20mm	SA-325
3	LEG RE-PADS: 200mm X 200mm X 8mm	SA-106 B
1	INSULATION: 127mm X 50mm THK	
1	INSULATION: 36mm X 50mm THK	
1	GASKET: 463mm. OD X 422mm. ID	...
16	BODY FLANGE BOLTS: 25mm. DIA	SA-193 B7
32	NUTS FOR BODY FLANGE BOLTS: 25mm. DIA	...
1	NAMEPLATE	...

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 in	Flg Class
N04 (1in)	1.000 in	Actual	LW	2.000	12.700	...	...	160.4	150
N02 (1in)	1.000 in	Actual	LW	2.000	12.700	...	...	160.0	150
N03 (1in)	1.000 in	Actual	LW	2.000	12.700	...	...	160.0	150
N01 (1in)	1.000 in	Actual	LW	2.000	12.700	...	...	160.0	150
N06 (1in)	1.000 in	Actual	LW	2.000	12.700	...	...	160.0	150
N05 (1in)	1.000 in	Actual	LW	2.000	12.700	150.00	8.00	236.6	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
N04 (1in)	SA-105	8.334	10.000	...	...	...
N02 (1in)	SA-105	8.334	10.000	...	...	...
N03 (1in)	SA-105	8.334	10.000	...	...	...
N01 (1in)	SA-105	8.334	10.000	...	...	...
N06 (1in)	SA-105	8.334	10.000	...	...	...
N05 (1in)	SA-105	12.000	10.000	8.000	8.000	...

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
N04 (1in)	...	0.0	150.00	0.00	Node: 10
N02 (1in)	150.000	0.0	150.00	0.00	Node: 20
N03 (1in)	350.000	180.0	150.00	0.00	Node: 20
N01 (1in)	1250.000	180.0	150.00	0.00	Node: 20
N06 (1in)	1250.000	0.0	150.00	0.00	Node: 20
N05 (1in)	...	0.0	200.00	0.00	Node: 40

Minimum Design Metal Temperature Results Summary :

Description	Notes	Curve	Basic MDMT °C	Reduced MDMT °C	UG-20(f) MDMT °C	Thickness ratio	Gov Thk mm.	E*	PWHT reqd
Nozzle Flg	[5]	A	-18	-48					
Nozzle Flg	[5]	A	-18	-48					
	[10]	B	-29	-48	-29	0.634	9.525	1.00	Yes
	[7]	B	-29	-48	-29	0.663	9.525	1.00	Yes
	[8]	B	-29	-48	-29	0.495	8.334	1.00	Yes
N04 (1in)	[1]	A	-8	-104	-29	0.321	9.525	1.00	Yes
Nozzle Flg	[5]	A	-29	-48					
N02 (1in)	[1]	A	-8	-34	-29	0.555	8.334	1.00	Yes
Nozzle Flg	[5]	A	-29	-48					
N03 (1in)	[1]	A	-8	-34	-29	0.553	8.334	1.00	Yes
Nozzle Flg	[5]	A	-29	-48					
N01 (1in)	[1]	A	-8	-35	-29	0.547	8.334	1.00	Yes
Nozzle Flg	[5]	A	-29	-48					
N06 (1in)	[1]	A	-8	-35	-29	0.547	8.334	1.00	Yes
Nozzle Flg	[5]	A	-29	-48					
N05 (1in)	[1]	A	-8	-104	-29	0.053	8.000	1.00	Yes
Nozzle Flg	[5]	A	-18	-48					
Bolting	[21]		-48						
Warmest MDMT:			-8	-34					

Required Minimum Design Metal Temperature 5.0 °C
Warmest Computed Minimum Design Metal Temperature -34.0 °C

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

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

UCS-66(i) was not considered.

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

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

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

There were no geometry errors or warnings.

PV Elite Vessel Analysis Program: Input Data

Design Internal Pressure (for Hydrotest)	7.5	bars
Design Internal Temperature	100.0	°C
Type of Hydrotest	UG-99(b) Note [36]	
Hydrotest Position	Vertical	
Projection of Nozzle from Vessel Top	0	mm.
Projection of Nozzle from Vessel Bottom	0	mm.
Minimum Design Metal Temperature	5.0	°C
Type of Construction	Welded	
Special Service	Lethal	
Degree of Radiography	RT-1	
Use Higher Longitudinal Stresses (Flag)	N	
Select t for Internal Pressure (Flag)	N	
Select t for External Pressure (Flag)	N	
Select t for Axial Stress (Flag)	N	
Select Location for Stiff. Rings (Flag)	N	
Consider Vortex Shedding	N	
Perform a Corroded Hydrotest	Y	

Load Case 1	NP+EW+WI+FW+BW
Load Case 2	NP+EW+EE+FS+BS
Load Case 3	NP+OW+WI+FW+BW
Load Case 4	NP+OW+EQ+FS+BS
Load Case 5	NP+HW+HI
Load Case 6	NP+HW+HE
Load Case 7	IP+OW+WI+FW+BW
Load Case 8	IP+OW+EQ+FS+BS
Load Case 9	EP+OW+WI+FW+BW
Load Case 10	EP+OW+EQ+FS+BS
Load Case 11	HP+HW+HI
Load Case 12	HP+HW+HE
Load Case 13	IP+WE+EW
Load Case 14	IP+WF+CW
Load Case 15	IP+VO+OW
Load Case 16	IP+VE+EW
Load Case 17	NP+VO+OW
Load Case 18	FS+BS+IP+OW
Load Case 19	FS+BS+EP+OW

Wind Design Code		ASCE-7 2010	
Wind Load Reduction Scale Factor		0.600	
Basic Wind Speed	[V]	120	Km/hr
Surface Roughness Category		C: Open Terrain	
Importance Factor		1.0	
Type of Surface		Moderately Smooth	
Base Elevation		100	mm.
Percent Wind for Hydrotest		33.0	
Using User defined Wind Press. Vs Elev.		N	
Height of Hill or Escarpment	H or Hh	0	mm.
Distance Upwind of Crest	Lh	0	mm.
Distance from Crest to the Vessel	x	0	mm.
Type of Terrain (Hill, Escarpment)		Flat	

Damping Factor (Beta) for Wind (Ope)		0.0100
Damping Factor (Beta) for Wind (Empty)		0.0000
Damping Factor (Beta) for Wind (Filled)		0.0000
Seismic Design Code		ASCE 7-2010
Seismic Load Reduction Scale Factor		0.700
Importance Factor		1.250
Table Value Fa		1.111
Table Value Fv		1.575
Short Period Acceleration value Ss		1.377
Long Period Acceleration Value Sl		0.367
Moment Reduction Factor Tau		1.000
Force Modification Factor R		2.500
Site Class		C
Component Elevation Ratio	z/h	0.000
Amplification Factor	Ap	0.000
Force Factor		0.000
Consider Vertical Acceleration		No
Minimum Acceleration Multiplier		0.000
User Value of Sds (used if > 0)		1.020
User Value of Sd1 (used if > 0)		0.385
Design Pressure + Static Head		Y
Consider MAP New and Cold in Noz. Design		N
Consider External Loads for Nozzle Des.		Y
Use ASME VIII-1 Appendix 1-9		N
Material Database Year	Current w/Addenda or Code Year	

Configuration Directives:

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

Complete Listing of Vessel Elements and Details:

Element From Node	10	
Element To Node	20	
Element Type	Elliptical	
Description		
Distance "FROM" to "TO"	50	mm.
Element Outside Diameter	406.4	mm.
Element Thickness	9.525	mm.
Internal Corrosion Allowance	6	mm.

Nominal Thickness	9.525	mm.
External Corrosion Allowance	0	mm.
Design Internal Pressure	7.5	bars
Design Temperature Internal Pressure	100	°C
Design External Pressure	1.034	bars
Design Temperature External Pressure	100	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-234 WPB	
Allowable Stress, Ambient	117.9	N./mm²
Allowable Stress, Operating	117.9	N./mm²
Allowable Stress, Hydrotest	217.2	N./mm²
Material Density	7750.4	kg/m³
P Number Thickness	30.988	mm.
Yield Stress, Operating	220.3	N./mm²
UCS-66 Chart Curve Designation	B	
External Pressure Chart Name	CS-2	
UNS Number	K03006	
Product Form	Smls. & wld. fittings	
Efficiency, Longitudinal Seam	1.0	
Efficiency, Circumferential Seam	1.0	
Elliptical Head Factor	2.0	
Weld is pre-Heated	No	
Element From Node	10	
Detail Type	Liquid	
Detail ID	Liquid: 10	
Dist. from "FROM" Node / Offset dist	-96.838	mm.
Height/Length of Liquid	146.84	mm.
Liquid Density	999.54	kg/m³
Element From Node	10	
Detail Type	Insulation	
Detail ID	Ins: 10	
Dist. from "FROM" Node / Offset dist	-101.6	mm.
Height/Length of Insulation	151.6	mm.
Thickness of Insulation	50	mm.
Density	125	kg/m³
Element From Node	10	
Detail Type	Nozzle	
Detail ID	N04 (1in)	
Dist. from "FROM" Node / Offset dist	0	mm.
Nozzle Diameter	1	in.
Nozzle Schedule	None	
Nozzle Class	150	
Layout Angle	0.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0.03182	kN
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-105	

Element From Node	20	
Element To Node	30	

Element Type	Cylinder	
Description		
Distance "FROM" to "TO"	1300	mm.
Element Outside Diameter	406.4	mm.
Element Thickness	8.3344	mm.
Internal Corrosion Allowance	6	mm.
Nominal Thickness	9.525	mm.
External Corrosion Allowance	0	mm.
Design Internal Pressure	7.5	bars
Design Temperature Internal Pressure	100	°C
Design External Pressure	1.034	bars
Design Temperature External Pressure	100	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-106 B	
Allowable Stress, Ambient	117.9	N./mm²
Allowable Stress, Operating	117.9	N./mm²
Allowable Stress, Hydrotest	217.2	N./mm²
Material Density	7750.4	kg/m³
P Number Thickness	30.988	mm.
Yield Stress, Operating	220.3	N./mm²
UCS-66 Chart Curve Designation	B	
External Pressure Chart Name	CS-2	
UNS Number	K03006	
Product Form	Smls. pipe	
Efficiency, Longitudinal Seam	1.0	
Efficiency, Circumferential Seam	1.0	
Weld is pre-Heated	No	
Element From Node	20	
Detail Type	Liquid	
Detail ID	Liquid: 20	
Dist. from "FROM" Node / Offset dist	0	mm.
Height/Length of Liquid	1300	mm.
Liquid Density	999.54	kg/m³
Element From Node	20	
Detail Type	Insulation	
Detail ID	Ins: 20	
Dist. from "FROM" Node / Offset dist	0	mm.
Height/Length of Insulation	1300	mm.
Thickness of Insulation	50	mm.
Density	125	kg/m³
Element From Node	20	
Detail Type	Nozzle	
Detail ID	N02 (1in)	
Dist. from "FROM" Node / Offset dist	100	mm.
Nozzle Diameter	1	in.
Nozzle Schedule	None	
Nozzle Class	150	
Layout Angle	0.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0.03182	kN
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-105	

Element From Node	20	
Detail Type	Nozzle	
Detail ID	N03 (1in)	
Dist. from "FROM" Node / Offset dist	300	mm.
Nozzle Diameter	1	in.
Nozzle Schedule	None	
Nozzle Class	150	
Layout Angle	180.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0	kN
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-105	

Element From Node	20	
Detail Type	Nozzle	
Detail ID	N01 (1in)	
Dist. from "FROM" Node / Offset dist	1200	mm.
Nozzle Diameter	1	in.
Nozzle Schedule	None	
Nozzle Class	150	
Layout Angle	180.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0.03182	kN
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-105	

Element From Node	20	
Detail Type	Nozzle	
Detail ID	N06 (1in)	
Dist. from "FROM" Node / Offset dist	1200	mm.
Nozzle Diameter	1	in.
Nozzle Schedule	None	
Nozzle Class	150	
Layout Angle	0.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0.03182	kN
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-105	

Element From Node	20	
Detail Type	Leg	
Detail ID	LEGS	
Dist. from "FROM" Node / Offset dist	200	mm.
Diameter at Leg Centerline	455.24	mm.
Leg Orientation	3	
Number of Legs	3	
Section Identifier	L80X80X10	
Length of Legs	1000	mm.

Element From Node	20	
Detail Type	Weight	
Detail ID	FILTER	
Dist. from "FROM" Node / Offset dist	625	mm.
Miscellaneous Weight	0.9806	kN

Offset from Element Centerline	0	mm.

Element From Node	30	
Element To Node	40	
Element Type	Flange	
Description		
Distance "FROM" to "TO"	127	mm.
Flange Inside Diameter	389.73	mm.
Element Thickness	36.576	mm.
Internal Corrosion Allowance	6	mm.
Nominal Thickness	0	mm.
External Corrosion Allowance	0	mm.
Design Internal Pressure	7.5	bars
Design Temperature Internal Pressure	100	°C
Design External Pressure	1.034	bars
Design Temperature External Pressure	100	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-105	
Allowable Stress, Ambient	137.9	N./mm²
Allowable Stress, Operating	137.9	N./mm²
Allowable Stress, Hydrotest	223.4	N./mm²
Material Density	7750.4	kg/m³
P Number Thickness	30.988	mm.
Yield Stress, Operating	226.5	N./mm²
UCS-66 Chart Curve Designation	A	
External Pressure Chart Name	CS-2	
UNS Number	K03504	
Product Form	Forgings	
Perform Flange Stress Calculation (Y/N)	Y	
Weight of Standard Flange	0	kN
Class of Standard Flange		
Grade of Standard Flange		
Weld is pre-Heated	No	

Element From Node	30	
Detail Type	Insulation	
Detail ID	Ins: 30	
Dist. from "FROM" Node / Offset dist	0	mm.
Height/Length of Insulation	127	mm.
Thickness of Insulation	50	mm.
Density	125	kg/m³

Element From Node	40	
Element To Node	50	
Element Type	Flange	
Description		
Distance "FROM" to "TO"	36.576	mm.
Flange Inside Diameter	596.9	mm.
Element Thickness	36.576	mm.
Internal Corrosion Allowance	6	mm.
Nominal Thickness	0	mm.

External Corrosion Allowance	0	mm.
Design Internal Pressure	7.5	bars
Design Temperature Internal Pressure	100	°C
Design External Pressure	1.034	bars
Design Temperature External Pressure	100	°C
Effective Diameter Multiplier	1.2	
Material Name	SA-105	
Perform Flange Stress Calculation (Y/N)	Y	
Weight of Standard Flange	0	kN
Class of Standard Flange		
Grade of Standard Flange		
Weld is pre-Heated	No	

Element From Node	40	
Detail Type	Insulation	
Detail ID	Ins: 40	
Dist. from "FROM" Node / Offset dist	0	mm.
Height/Length of Insulation	36.576	mm.
Thickness of Insulation	50	mm.
Density	125	kg/m^3

Element From Node	40	
Detail Type	Nozzle	
Detail ID	N05 (1in)	
Dist. from "FROM" Node / Offset dist	0	mm.
Nozzle Diameter	1	in.
Nozzle Schedule	None	
Nozzle Class	150	
Layout Angle	0.0	
Blind Flange (Y/N)	N	
Weight of Nozzle (Used if > 0)	0.0471	kN
Grade of Attached Flange	GR 1.1	
Nozzle Matl	SA-105	

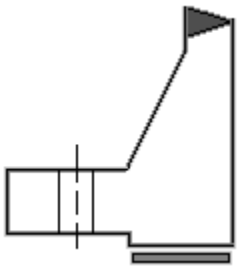
XY Coordinate Calculations:

From	To	X (Horiz.) mm.	Y (Vert.) mm.	DX (Horiz.) mm.	DY (Vert.) mm.
10	20	...	50	...	50
20	30	...	1350	...	1300
30	40	...	1477	...	127
40	50	...	1523.1	...	36.576

Flange Input Data Values **Description: FLANGE :**

Item: Node 30 to 40

Description of Flange Geometry (Type)		Integral Weld Neck	
Design Pressure	P	7.50	bars
Design Temperature		100	°C
Internal Corrosion Allowance	ci	6.0000	mm.
External Corrosion Allowance	ce	0.0000	mm.
Use Corrosion Allowance in Thickness Calcs.		No	
Flange Inside Diameter	B	389.731	mm.
Flange Outside Diameter	A	596.900	mm.
Flange Thickness	t	36.5760	mm.
Thickness of Hub at Small End	go	8.3344	mm.
Thickness of Hub at Large End	g1	33.7344	mm.
Length of Hub	h	90.4240	mm.
Flange Material		SA-105	
Flange Material UNS number		K03504	
Flange Allowable Stress At Temperature	Sfo	137.90	N./mm²
Flange Allowable Stress At Ambient	Sfa	137.90	N./mm²
Bolt Material		SA-193 B7	
Bolt Allowable Stress At Temperature	Sb	172.38	N./mm²
Bolt Allowable Stress At Ambient	Sa	172.38	N./mm²
Diameter of Bolt Circle	C	539.750	mm.
Nominal Bolt Diameter	a	25.4000	mm.
Type of Threads		TEMA Thread Series	
Number of Bolts		16	
Flange Face Outside Diameter	Fod	469.900	mm.
Flange Face Inside Diameter	Fid	389.731	mm.
Flange Facing Sketch		1, Code Sketch 1a	
Gasket Outside Diameter	Go	463.550	mm.
Gasket Inside Diameter	Gi	422.402	mm.
Gasket Factor	m	3.0000	
Gasket Design Seating Stress	y	68.95	N./mm²
Column for Gasket Seating		2, Code Column II	
Gasket Thickness	tg	3.1750	mm.
Flange Class		150	
Flange Grade		GR 1.1	
Flange Series	Series	A	



ASME Code, Section VIII Division 1, 2019

Hub Small End Required Thickness due to Internal Pressure:
= (P*(D/2+Ca))/(S*E-0.6*P) per UG-27 (c)(1)
= (7.5*(390/2+6))/(138*1-0.6*7.5)+Ca
= 7.0961 mm.

Hub Small End Hub MAWP:
= (S*E*t)/(R+0.6*t) per UG-27 (c)(1)
= (138 * 1 * 2.33)/(201 + 0.6 * 2.33)
= 15.914 bars

Corroded Flange ID,	Bcor = B+2*Fcor	401.731	mm.
Corroded Large Hub,	g1Cor = g1-ci	27.734	mm.
Corroded Small Hub,	g0Cor = go-ci	2.334	mm.
Code R Dimension,	R = ((C-Bcor)/2)-g1cor	41.275	mm.
Gasket Contact Width,	N = (Go - Gi) / 2	20.574	mm.
Basic Gasket Width,	bo = N / 2	10.287	mm.
Effective Gasket Width,	b = Cb sqrt(bo)	8.082	mm.
Gasket Reaction Diameter,	G = Go - 2 * b	447.386	mm.

Basic Flange and Bolt Loads:

Hydrostatic End Load due to Pressure [H]:
= 0.785 * G² * Peq
= 0.79 * 447² * 7.5
= 117.897 kN
Contact Load on Gasket Surfaces [Hp]:
= 2 * b * Pi * G * m * P
= 2 * 8.08 * 3.14 * 447 * 3 * 7.5
= 51.117 kN
Hydrostatic End Load at Flange ID [Hd]:
= Pi * Bcor² * P / 4
= 3.14 * 402² *7.5/4
= 95.063 kN
Pressure Force on Flange Face [Ht]:
= H - Hd
= 118 - 95.1
= 22.834 kN
Operating Bolt Load [Wm1]:
= max(H + Hp + H'p, 0)

```
  = max( 118 + 51.1 + 0, 0 )
  = 169.014 kN
```
Gasket Seating Bolt Load [Wm2]:
```
  = y * b * Pi * G  + yPart * bPart * lp
  = 68.9*8.08*3.141*447+0*0*0
  = 783.177 kN
```
Required Bolt Area [Am]:
```
  = Maximum of Wm1/Sb, Wm2/Sa
  = Maximum of 169/172, 783/172
  = 45.438 cm²
```

Min. Gasket Contact Width (Brownell Young) [Not an ASME Calc] [Nmin]:
```
  = Ab * Sa/( y * Pi * (Go + Gi) )
  = 56.9  * 172/(68.9 * 3.14 * (464 + 422 ) )
  = 5.109 mm.
```

Flange Design Bolt Load, Gasket Seating [W]:
```
  = Sa * ( Am + Ab ) / 2
  = 172 * ( 45.4 + 56.9 )/2
  = 881.76 kN
```
Gasket Load for the Operating Condition [HG]:
```
  = Wm1 - H
  = 169 - 118
  = 51.12 kN
```

Moment Arm Calculations:

Distance to Gasket Load Reaction [hg]:
```
  = (C - G ) / 2
  = ( 540 - 447 )/2
  = 46.1822 mm.
```
Distance to Face Pressure Reaction [ht]:
```
  = ( R + g1 + hg ) / 2
  = ( 41.3 + 27.7 + 46.2 )/2
  = 57.5959 mm.
```
Distance to End Pressure Reaction [hd]:
```
  = R + ( g1 / 2 )
  = 41.3 + ( 27.7/2.0 )
  = 55.1423 mm.
```

Summary of Moments for Internal Pressure: (N-m)

```
Loading                 Force  |   Distance |  Bolt Corr |         Moment  |
-------------------------------------------------------------------------------
End Pressure,   Md         95. |    55.1423 |     1.0978 |           5757. |
Face Pressure,  Mt         23. |    57.5959 |     1.0978 |           1444. |
Gasket Load,    Mg         51. |    46.1822 |     1.0978 |           2593. |
Gasket Seating, Matm      882. |    46.1822 |     1.0978 |          44722. |

Total Moment for Operation,      Mop                              9794. N-m
Total Moment for Gasket seating, Matm                            44722. N-m
```

You chose not to perform Stress Calculations on this Standard Flange.
The pressure rating of the flange will be used to check code compliance.

```
Estimated Finished Weight of Flange at given Thk.       64.5 kg.
Estimated Unfinished Weight of Forging at given Thk    158.0 kg.
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c)      -18 °C
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b)        -48 °C
```

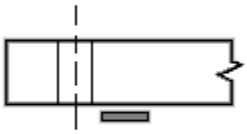
Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :

```
Design Pressure/Ambient Rating = 7.50/19.60 = 0.383
```

Flange Input Data Values **Description: FLANGE :**

Item: Node 40 to 50

Description of Flange Geometry (Type)		Blind	
Design Pressure	P	7.50	bars
Design Temperature		100	°C
Internal Corrosion Allowance	ci	6.0000	mm.
External Corrosion Allowance	ce	0.0000	mm.
Use Corrosion Allowance in Thickness Calcs.		Yes	
Flange Outside Diameter	A	596.900	mm.
Flange Thickness	t	36.5760	mm.
Flange Material		SA-105	
Flange Material UNS number		K03504	
Flange Allowable Stress At Temperature	Sfo	137.90	N./mm²
Flange Allowable Stress At Ambient	Sfa	137.90	N./mm²
Bolt Material		SA-193 B7	
Bolt Allowable Stress At Temperature	Sb	172.38	N./mm²
Bolt Allowable Stress At Ambient	Sa	172.38	N./mm²
Diameter of the Load Reaction, Long Span	D	0.000	mm.
Diameter of the Load Reaction, Short Span	d	0.000	mm.
Perimeter along the Center of the Bolts	L	1695.675	mm.
Diameter of Bolt Circle	C	539.750	mm.
Nominal Bolt Diameter	a	25.4000	mm.
Type of Threads		TEMA Thread Series	
Number of Bolts		16	
Flange Face Outside Diameter	Fod	469.900	mm.
Flange Face Inside Diameter	Fid	389.731	mm.
Flange Facing Sketch		1, Code Sketch 1a	
Gasket Outside Diameter	Go	463.550	mm.
Gasket Inside Diameter	Gi	422.402	mm.
Gasket Factor	m	3.0000	
Gasket Design Seating Stress	y	68.95	N./mm²
Column for Gasket Seating		2, Code Column II	
Gasket Thickness	tg	3.1750	mm.
Flange Class		150	
Flange Grade		GR 1.1	



ASME Code, Section VIII Division 1, 2019

```
Gasket Contact Width,        N = (Go - Gi) / 2          20.574  mm.
Basic Gasket Width,         bo = N / 2                  10.287  mm.
Effective Gasket Width,      b = Cb sqrt(bo)             8.082  mm.
Gasket Reaction Diameter,    G = Go - 2 * b            447.386  mm.
```

Basic Flange and Bolt Loads:

Hydrostatic End Load due to Pressure [H]:
```
= 0.785 * G² * Peq
= 0.79 * 447² * 7.5
= 117.897 kN
```
Contact Load on Gasket Surfaces [Hp]:
```
= 2 * b * Pi * G * m * P
= 2 * 8.08 * 3.14 * 447 * 3 * 7.5
= 51.117 kN
```
Operating Bolt Load [Wm1]:
```
= max( H + Hp + H'p, 0 )
= max( 118 + 51.1 + 0, 0 )
= 169.014 kN
```
Gasket Seating Bolt Load [Wm2]:
```
= y * b * Pi * G  + yPart * bPart * lp
= 68.9*8.08*3.141*447+0*0*0
= 783.177 kN
```
Required Bolt Area [Am]:
```
= Maximum of Wm1/Sb, Wm2/Sa
= Maximum of 169/172, 783/172
= 45.438 cm²
```

Min. Gasket Contact Width (Brownell Young) [Not an ASME Calc] [Nmin]:
```
= Ab * Sa/( y * Pi * (Go + Gi) )
= 56.9  * 172/(68.9 * 3.14 * (464 + 422 ) )
= 5.109 mm.
```

Flange Design Bolt Load, Gasket Seating [W]:
```
= Sa * ( Am + Ab ) / 2
= 172 * ( 45.4 + 56.9 )/2
= 881.76 kN
```
Gasket Load for the Operating Condition [HG]:
```
= Wm1
```

= 169.01 kN

Moment Arm Calculations:

Distance to Gasket Load Reaction [hg]:

= (C - G) / 2
= (540 - 447)/2
= 46.1822 mm.

You chose not to perform Stress Calculations on this Standard Flange.
The pressure rating of the flange will be used to check code compliance.

Estimated Finished Weight of Flange at given Thk. 79.3 kg.
Estimated Unfinished Weight of Forging at given Thk 79.3 kg.

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c) -18 °C
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b) -48 °C

Where the Stress Reduction Ratio per UCS-66(b)(1)(-b) is :
Design Pressure/Ambient Rating = 7.50/19.60 = 0.383

Element Thickness, Pressure, Diameter and Allowable Stress :

From	To	Int. Press + Liq. Hd bars	Nominal Thickness mm.	Total Corr Allowance mm.	Element Diameter mm.	Allowable Stress(SE) N./mm²
10	20	7.6418	9.525	6	406.4	117.9
20	30	7.6274	9.525	6	406.4	117.9
30	40	7.5	...	6	389.73	137.9
40	50	7.5	...	6	596.9	137.9

Element Required Thickness and MAWP :

From	To	Design Pressure bars	M.A.W.P. Corroded bars	M.A.P. New & Cold bars	Minimum Thickness mm.	Required Thickness mm.
10	20	7.5	20.5	57.7	9.525	7.5
20	30	7.5	13.5	49.2	8.33437	7.5
30	40	7.5	17.7	19.6	36.576	No Calc
40	50	7.5	17.7	19.6	36.576	No Calc
Minimum			13.5	19.6		

MAWP: 13.5 bars, limited by: Cylinder.

Elements Suitable for Design Internal Pressure.

Internal Pressure Calculation Results:

ASME Code, Section VIII Division 1, 2019

Elliptical Head From 10 To 20 SA-234 WPB , UCS-66 Crv. B at 100 °C

Material UNS Number: K03006

Required Thickness due to Internal Pressure [tr]:

```
= (P*Do*Kcor)/(2*S*E+2*P*(Kcor-0.1)) per Appendix 1-4 (c)
= (7.64*406*0.96)/(2*118*1+2*7.64*(0.96-0.1))
= 1.2596 + 6.0000 = 7.2596 mm.
```

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

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

Less Operating Hydrostatic Head Pressure of 0.142 bars

```
= (2*S*E*t)/(Kcor*Do-2*t*(Kcor-0.1)) per Appendix 1-4 (c)
= (2*118*1*3.52)/(0.96*406-2*3.52*(0.96-0.1))
= 21.6 - 0.14 = 21.5  bars
```

Maximum Allowable Pressure, New and Cold [MAPNC]:

```
= (2*S*E*t)/(K*Do-2*t*(K-0.1)) per Appendix 1-4 (c)
= (2*118*1*9.52)/(1*406-2*9.52*(1-0.1))
```

= 57.7 bars

Actual stress at given pressure and thickness, corroded [Sact]:
= (P*(Kcor*Do-2*t*(Kcor-0.1)))/(2*E*t)
= (7.64*(0.96*406-2*3.52*(0.96-0.1)))/(2*1*3.52)
= 41.707 N./mm²

Straight Flange Required Thickness:
= (P*Ro)/(S*E+0.4*P) + ca per Appendix 1-1 (a)(1)
= (7.64*203)/(118*1+0.4*7.64)+6
= 7.314 mm.

Straight Flange Maximum Allowable Working Pressure:
Less Operating Hydrostatic Head Pressure of 0.132 bars
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (118 * 1 * 3.52)/(203 - 0.4 * 3.52)
= 20.6 - 0.13 = 20.5 bars

Factor K, corroded condition [Kcor]:
= (2 + (Inside Diameter/(2 * Inside Head Depth))²)/6
= (2 + (399/(2 * 103))²)/6
= 0.961671

MDMT Calculations in the Knuckle Portion:

Govrn. thk, tg = 9.52, tr = 2.24, c = 6 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.63, Temp. Reduction = 20 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-48 °C

MDMT Calculations in the Head Straight Flange:

Govrn. thk, tg = 9.52, tr = 2.34, c = 6 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.66, Temp. Reduction = 19 °C

Min Metal Temp. w/o impact per UCS-66, Curve B	-29 °C
Min Metal Temp. at Required thickness (UCS 66.1)	-48 °C

Note:
Post Weld Heat Treatment is required for this Element/Joint and it was specified as being heat treated.

Cylindrical Shell From 20 To 30 SA-106 B , UCS-66 Crv. B at 100 °C
Material UNS Number: K03006

Required Thickness due to Internal Pressure [tr]:
= (P*Ro) / (S*E+0.4*P) per Appendix 1-1 (a)(1)
= (7.63*203)/(118*1+0.4*7.63)
= 1.3113 + 6.0000 = 7.3113 mm.

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

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
Less Operating Hydrostatic Head Pressure of 0.127 bars

```
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (118*1*2.33)/(203-0.4*2.33)
= 13.6 - 0.13 = 13.5  bars
```

Maximum Allowable Pressure, New and Cold [MAPNC]:

```
= (S*E*t)/(Ro-0.4*t) per Appendix 1-1 (a)(1)
= (118*1*8.33)/(203-0.4*8.33)
= 49.2 bars
```

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

```
= (P*(Ro-0.4*t))/(E*t)
= (7.63*((203-0.4*2.33))/(1*2.33)
= 66.093 N./mm²
```

Minimum Design Metal Temperature Results:

Govrn. thk, tg = 8.33, tr = 1.16, c = 6 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.5, Temp. Reduction = 33 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve B          -29 °C
Min Metal Temp. at Required thickness (UCS 66.1)        -48 °C
```

Note:
Post Weld Heat Treatment is required for this Element/Joint and it was specified as being heat treated.

Note: Heads and Shells Exempted to -20F (-29C) by paragraph UG-20F

Hydrostatic Test Pressure Results:

```
Pressure per UG99b     = 1.30 * M.A.W.P. * Sa/S          17.522  bars
Pressure per UG99b[36] = 1.30 * Design Pres * Sa/S         9.750  bars
Pressure per UG99c     = 1.30 * M.A.P. - Head(Hyd)       25.476  bars
Pressure per UG100     = 1.10 * M.A.W.P. * Sa/S          14.827  bars
Pressure per PED       = max(1.43*DP, 1.25*DP*ratio)     10.725  bars
Pressure per App 27-4  = M.A.W.P.                        13.479  bars
```

UG-99(b) Note 36, Test Pressure Calculation:

```
= Test Factor * Design Pressure * Stress Ratio
= 1.3 * 7.5 * 1
= 9.750 bars
```

Vertical Test performed per: UG-99b (Note 36)

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 & bars):

From To	Stress	Allowable	Ratio	Pressure
10 20	54.1	217.2	0.249	9.91
20 30	85.7	217.2	0.395	9.89

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

Description	Pad/Nozzle	Ambient	Operating	Ratio
N04 (1in)	Nozzle	137.90	137.90	1.000
N02 (1in)	Nozzle	137.90	137.90	1.000
N03 (1in)	Nozzle	137.90	137.90	1.000
N01 (1in)	Nozzle	137.90	137.90	1.000
N06 (1in)	Nozzle	137.90	137.90	1.000
N05 (1in)	Nozzle	137.90	137.90	1.000
N05 (1in)	Pad	137.90	137.90	1.000
Minimum				1.000

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

Description	Ambient	Operating	Ratio
	117.90	117.90	1.000
	117.90	117.90	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
N04 (1in)	3.36	223.40	0.015
N02 (1in)	3.35	223.40	0.015
N03 (1in)	3.35	223.40	0.015
N01 (1in)	3.32	223.40	0.015
N06 (1in)	3.32	223.40	0.015
N05 (1in)	3.31	223.40	0.015

Elements Suitable for Test Pressure.

External Pressure Calculation Results :

External Pressure Calculations:

From	To	Section Length mm.	Outside Diameter mm.	Corroded Thickness mm.	Factor A	Factor B N./mm²
10	20	No Calc	406.4	3.525	0.0012047	90.8192
20	30	1382.28	406.4	2.33437	0.00016302	16.298
30	40	No Calc	...	30.576	No Calc	No Calc
40	50	No Calc	...	30.576	No Calc	No Calc

External Pressure Calculations:

From	To	External Actual T. mm.	External Required T. mm.	External Design Pressure bars	External M.A.W.P. bars
10	20	9.525	7.5	1.034	8.75
20	30	8.33437	8.16742	1.034	1.25
30	40	36.576	No Calc	1.034	No Calc
40	50	36.576	No Calc	1.034	No Calc
Minimum					1.25

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	1382.28	1651.3	No Calc	No Calc
30	40	No Calc	No Calc	No Calc	No Calc
40	50	No Calc	No Calc	No Calc	No Calc

Elements Suitable for External Pressure.

ASME Code, Section VIII Division 1, 2019

Elliptical Head From 10 to 20 Ext. Chart: CS-2 at 100 °C

Elastic Modulus from Chart: CS-2 at 100 °C: 199943392.000 KPa.

Results for Maximum Allowable Ext. Pressure				MAEP
Tca	Outer Dia	Do/t	Factor A	Factor B
3.525	406.40	115.29	0.0012047	90.82

MAEP = B/(K0*Do/t) = 90.8/(0.9 *115) = 8.75 bars

Results for Required Thickness				Tca
Tca	Outer Dia	Do/t	Factor A	Factor B
1.052	406.40	386.26	0.0003596	35.95

MAEP = B/(K0*Do/t) = 35.9/(0.9 *386) = 1.03 bars

*Check the requirements of UG-33(a)(1) using P = 1.67 * External Design pressure for this head.*

Material UNS Number: K03006

Required Thickness due to Internal Pressure [tr]:
= (P*D*Kcor)/(2*S*E-0.2*P) Appendix 1-4(c)
= (1.73*399*0.96)/(2*118*1-0.2*1.73)
= 0.2813 + 6.0000 = 6.2813 mm.

Max. Allowable Working Pressure at given Thickness, corroded [MAWP]:
= ((2*S*E*t)/(Kcor*D+0.2*t))/1.67 per Appendix 1-4 (c)
= ((2*118*1*3.52)/(0.96*399+0.2*3.52))/1.67
= 12.9 bars

Maximum Allowable External Pressure [MAEP]:
= min(MAEP, MAWP)
= min(8.75, 12.9)
= 8.752 bars

Thickness requirements per UG-33(a)(1) govern the required thickness of this head.

Cylindrical Shell From 20 to 30 Ext. Chart: CS-2 at 100 °C

Elastic Modulus from Chart: CS-2 at 100 °C: 199943392.000 KPa.

Results for Maximum Allowable Ext. Pressure — MAEP

Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B
2.334	406.40	1382.28	174.09	3.4013	0.0001630	16.30

MAEP = (4*B)/(3*(Do/t)) = (4*16.3)/(3*174) = 1.25 bars

Results for Required Thickness — Tca

Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B
2.167	406.40	1382.28	187.50	3.4013	0.0001455	14.54

MAEP = (4*B)/(3*(Do/t)) = (4*14.5)/(3*188) = 1.03 bars

Results for Maximum Stiffened Length — Slen

Tca	Outer Dia	Slen	Do/t	L/D	Factor A	Factor B
2.334	406.40	1651.30	174.09	4.0632	0.0001352	13.51

MAEP = (4*B)/(3*(Do/t)) = (4*13.5)/(3*174) = 1.03 bars

Element and Detail Weights:

From	To	Element Metal Wgt. kg.	Element ID Volume Cm.	Corroded Metal Wgt. kg.	Corroded ID Volume Cm.	Extra due Misc % kg.
10	20	18.5192	13502.1	6.85354	14602.2	1.85192
20	30	120.376	155111	45.2181	164810	12.0376
30	40	64.5322	15426	57.1898	16100.6	6.45322
40	50	79.3267	...	79.3267	...	7.93267
Total		282	184038.69	188	195512.31	28

Weight of Details:

From	Type	Weight of Detail kg.	X Offset, Dtl. Cent. mm.	Y Offset, Dtl. Cent. mm.	Description
10	Liqd	13.4938	...	-48.4185	Liquid: 10
10	Insl	1.80306	...	-25.8	Ins: 10
10	Nozl	3.56901	...	-221.844	N04 (1in)
20	Liqd	155.016	...	650	Liquid: 20
20	Insl	11.6501	...	650	Ins: 20
20	Nozl	3.56901	207.566	100	N02 (1in)
20	Nozl	3.56916	207.566	300	N03 (1in)
20	Nozl	3.56901	207.566	1200	N01 (1in)
20	Nozl	3.56901	207.566	1200	N06 (1in)
20	Legs	57.2332	...	-300	LEGS
20	Wght	100	...	625	FILTER
30	Insl	1.88291	...	63.5	Ins: 30
40	Insl	2.18681	...	18.288	Ins: 40
40	Nozl	5.28403	...	136.576	N05 (1in)

Total Weight of Each Detail Type:

Liquid	168.5
Insulation	17.5
Nozzles	23.1
Legs	57.2
Weights	100.0
Sum of the Detail Weights	366.4 kg.

Weight Summation Results: (kg.)

	Fabricated	Shop Test	Shipping	Erected	Empty	Operating
Main Elements	311.0	311.0	311.0	311.0	311.0	311.0
Nozzles	23.1	23.1	23.1	23.1	23.1	23.1
Legs	57.2	57.2	57.2	57.2	57.2	57.2
Insulation	...	...	17.5	17.5	17.5	17.5
Empty Weights	...	...	...	100.0	100.0	...

Ope Weights	...	...	...	...	...	100.0
Ope. Liquid	...	...	...	...	...	168.5
Test Liquid	...	183.9	...	...	...	...
Totals	391.4	575.3	408.9	508.9	508.9	677.4

Field Installation Options:

Miscellaneous Weight Percent: 10.0 %

Note that the above value for the miscellaneous weight percent has been applied to the shells/heads/flange/tubesheets/tubes etc. in the weight calculations for metallic components.

Weight Summary:

Fabricated Wt.	- Bare Weight without Removable Internals	391.4 kg.
Shop Test Wt.	- Fabricated Weight + Water (Full)	575.3 kg.
Shipping Wt.	- Fab. Weight + removable Intls.+ Shipping App.	408.9 kg.
Erected Wt.	- Fab. Wt + or - loose items (trays,platforms etc.)	508.9 kg.
Ope. Wt. no Liq	- Fab. Weight + Internals. + Details + Weights	508.9 kg.
Operating Wt.	- Empty Weight + Operating Liq. Uncorroded	677.4 kg.
Field Test Wt.	- Empty Weight + Water (Full)	500.7 kg.
Mass of the Upper 1/3 of the Vertical Vessel		222.4 kg.

Note: The Field Test weight as computed in the corroded condition.

Outside Surface Areas of Elements:

From	To	Surface Area cm²
10	20	2428.69
20	30	16694.9
30	40	3590.02
40	50	3484.17
Total		26197.799 cm²

Element and Detail Weights:

From	To	Total Ele. Empty Wgt. kg.	Total. Ele. Oper. Wgt. kg.	Total. Ele. Hydro. Wgt. kg.	Total Dtl. Offset Mom. N-m	Oper. Wgt. No Liquid kg.
10	20	25.7431	39.2369	27.5043	...	25.7431
20	Legs	39.7446	63.5932	36.9808	4.47221	39.7446
Legs	30	218.595	349.763	203.394	24.5971	218.595
30	40	72.8683	72.8683	80.8825	...	72.8683
40	50	94.7302	94.7302	94.7302	...	94.7302

Cumulative Vessel Weight

From	To	Cumulative Ope Wgt. No Liquid kg.	Cumulative Oper. Wgt. kg.	Cumulative Hydro. Wgt. kg.
10	20	...	...	...
20	Legs	-25.7431	-39.2369	-27.5043
Legs	30	386.194	517.361	379.007
30	40	167.598	167.598	175.613
40	50	94.7302	94.7302	94.7302

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

Cumulative Vessel Moment

From	To	Cumulative Empty Mom. N-m	Cumulative Oper. Mom. N-m	Cumulative Hydro. Mom. N-m
10	20	...	...	...
20	Legs	4.47221	4.47221	4.47221
Legs	30	24.5971	24.5971	24.5971
30	40	...	...	...
40	50	...	...	...

Nozzle Flange MAWP Results: (bars & °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
N04 (1in)	17.70	19.60	100	150	GR 1.1	...	...	...	...
N02 (1in)	17.70	19.60	100	150	GR 1.1	...	...	...	...
N03 (1in)	17.70	19.60	100	150	GR 1.1	...	...	...	...
N01 (1in)	17.70	19.60	100	150	GR 1.1	...	...	...	...
N06 (1in)	17.70	19.60	100	150	GR 1.1	...	...	...	...
N05 (1in)	17.70	19.60	100	150	GR 1.1	...	...	...	...
Min Rating	17.700	19.600 bars [for Core Elements]					0.000	0.000	0.000

ANSI Ratings are per ANSI/ASME B16.5 2013 Metric Edition

Warning:
There are nozzles in this model, but no flange MAWPs were de-rated. Be sure this is what you intended. There is a check box in the nozzle dialog that instructs PV Elite to perform the de-rating for each nozzle flange. See ASME VIII-1, UG-44(b) for more information.

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 22.2618 Hz.

The Natural Frequency for the Vessel (Ope...) is 20.0868 Hz.

The Natural Frequency for the Vessel (Filled) is 22.2981 Hz.

Input Values:

Wind Design Code		ASCE-7 2010	
Wind Load Reduction Scale Factor		0.600	
Basic Wind Speed	[V]	120	Km/hr
Surface Roughness Category		C: Open Terrain	
Importance Factor		1.0	
Type of Surface		Moderately Smooth	
Base Elevation		100	mm.
Percent Wind for Hydrotest		33.0	
Using User defined Wind Press. Vs Elev.		N	
Height of Hill or Escarpment	H or Hh	0	mm.
Distance Upwind of Crest	Lh	0	mm.
Distance from Crest to the Vessel	x	0	mm.
Type of Terrain (Hill, Escarpment)		Flat	
Damping Factor (Beta) for Wind (Ope)		0.0100	
Damping Factor (Beta) for Wind (Empty)		0.0000	
Damping Factor (Beta) for Wind (Filled)		0.0000	

Wind Analysis Results

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

```
= min(0.85, 0.925((1 + 1.7 * gQ * Izbar * Q )/( 1 + 1.7 * gV * Izbar)))
= min(0.85,0.925((1+1.7*3.4*0.23*0.98)/(1+1.7*3.4*0.23)))
= min(0.85, 0.91 )
= 0.850
```

Natural Frequency of Vessel (Operating)		20.087 Hz
Natural Frequency of Vessel (Empty)		22.262 Hz
Natural Frequency of Vessel (Test)		22.298 Hz
Force Coefficient	[Cf]	0.533
Structure Height to Diameter ratio		3.008
Height to top of Structure		1523.101 mm.

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

Sample Calculation for the First Element

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

Value of [Alpha] and [Zg]:

```
Exposure Category: C from Table 26.9.1
Alpha = 9.5 : Zg = 274320 mm.
```

Effective Height [z]:

```
= Centroid Height + Vessel Base Elevation
= 116 + 100 = 216 mm.
= 0.71 ft. Imperial Units
```

Velocity Pressure coefficient evaluated at height z [Kz]:

```
Because z (0.71 ft.) < 15 ft.
```

$= 2.01 * (15 / Zg)^{2 / Alpha}$
$= 2.01 * (15/900)^{2/9.5}$
$= 0.85$

Type of Hill: No Hill

Wind Directionality Factor [Kd]:
$= 0.95$, per Table 26.6-1

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

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

Velocity Pressure evaluated at height z, Imperial Units [qz]:
$= max(16, 0.00256 * Kz * Kzt * Kd * V(mph)^2)$
$= max(16, 0.00256 * 0.85 * 1 * 0.95 * 74.6^2)$
$= 16$ psf [78.1] Kgs/m^2

Force on the first element [F]:
$= qz * G * Cf * WindArea$
$= 16 * 0.85 * 0.53 * 1.13$
$= 8.2$ lbs. [0.036] kN

Element	Hgt (z) mm.	K1	K2	K3	Kz	Kzt	qz Kgs/m^2
Node 10 to 20	216.4	0.000	0.000	0.000	0.849	1.000	78.120
Node 20 to 30	896.8	0.000	0.000	0.000	0.849	1.000	78.120
Node 30 to 40	1610.3	0.000	0.000	0.000	0.849	1.000	78.120
Node 40 to 50	1701.7	0.000	0.000	0.000	0.849	1.000	78.120

Wind Vibration Calculations

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

Nomenclature

Cf - Correction factor for natural frequency
D - Average internal diameter of vessel mm.
Df - Damping Factor < 0.75 Unstable, > 0.95 Stable
Dr - Average internal diameter of top half of vessel mm.
f - Natural frequency of vibration (Hertz)
f1 - Natural frequency of bare vessel based on a unit value of $(D/L^2)(10^4)$
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 kN

```
Ws  - Cor. vessel weight excl. weight of parts which do not effect stiff. kN
 Z  - Maximum amplitude of vibration at top of vessel mm.
Dl  - Logarithmic decrement ( taken as 0.03 for Welded Structures )
Vp  - Vib. Chance, <= 0.31416E-08 (High); 0.31416E-08 < 0.39270E-08 (Probable)
P30 - wind pressure 30 feet above the base
```

Check other Conditions and Basic Assumptions:

```
#1 - Total Cone Length / Total Length < 0.5
     0/1523 = 0

#2 - ( D / L² ) * 10⁴ < 8.0 (English Units)
   - ( 1.66/5² ) * 10⁴ = 665 [Geometry Violation]
```

Compute the vibration possibility. If Vp > 0.39270E-08 no chance. [Vp]:

```
  = W / ( L * Dr²)
  = 5.63/( 1523 * 412² )
  = 0.21786E-07
```

Since Vp is > 0.39270E-08 no further vibration analysis is required !

Wind Loads on Masses/Equipment/Piping

ID	Wind Area cm²	Elevation mm.	Pressure Kgs/m²	Force kN
FILTER	0.00	775.00	78.12	0.00

The Natural Frequency for the Vessel (Ope...) is 20.0868 Hz.

Wind Load Calculation:

From	To	Wind Height mm.	Wind Diameter mm.	Wind Area cm²	Wind Pressure Kgs/m²	Element Wind Load kN
10	20	216.435	607.68	1050.11	78.12	0.021886
20	30	896.837	607.68	7899.84	78.12	0.16464
30	40	1610.34	587.677	746.35	78.12	0.015555
40	50	1701.65	836.28	305.878	78.12	0.0063749

Note:
The Wind Loads calculated and printed in the Wind Load calculation report have been factored by the input scalar/load reduction factor of: 0.600.

Be sure the wind speed is in accordance with the specified wind design code.

Earthquake Load Calculation:

Input Values:

Seismic Design Code		ASCE 7-2010
Seismic Load Reduction Scale Factor		0.700
Importance Factor		1.250
Table Value Fa		1.111
Table Value Fv		1.575
Short Period Acceleration value Ss		1.377
Long Period Acceleration Value Sl		0.367
Moment Reduction Factor Tau		1.000
Force Modification Factor R		2.500
Site Class		C
Component Elevation Ratio	z/h	0.000
Amplification Factor	Ap	0.000
Force Factor		0.000
Consider Vertical Acceleration		No
Minimum Acceleration Multiplier		0.000
User Value of Sds (used if > 0)		1.020
User Value of Sd1 (used if > 0)		0.385

Seismic Analysis Results:

```
Sms = Fa * Ss = 1.11 * 1.38 = 1.53
Sm1 = Fv * S1 = 1.58 * 0.37 = 0.58
Sds = 2/3 * Sms = 2/3 * 1.53 = 1.02

Sds = Max( 0.8*Sds, SdsUser )
    = Max( 0.82, 1.02 )
    = 1.020

Sd1 = 2/3 * Sm1 = 2/3 * 0.58 = 0.39

Sd1 = Max( 0.8*Sd1, Sd1User )
    = Max( 0.31, 0.38 )
    = 0.385
```

Check Approximate Fundamental Period from 12.8-7 [Ta]:

$= Ct * hn^{x}$ where Ct = 0.020, x = 0.75 and hn = Structural Height (ft.)

$= 0.020 * (7.43^{0.75})$

= 0.090 seconds

The Coefficient Cu from Table 12.8-1 is : 1.400

Fundamental Period (1/Frequency) [T]:

= (1/Natural Frequency) = (1/20.1)

= 0.050

Check the Value of T which is the smaller of Cu*Ta and T:

= Minimum Value of (1.4 * 0.09, 0.05) per 12.8.2

= 0.050

As the time period is < 0.06 second, use section 15.4.2.

Compute the Base Shear per equation 15.4-5, [V]:

```
  = 0.3 * Sds * W * I
  = 0.3 * 1.02 * 6.08 * 1.25
  = 2.326 kN

 Final Base Shear,       V = 1.63 kN
```

Distribute the Base shear force to each element according to the equations
Fx = Cvx * V (eqn. 12.8-11) and the vertical distribution factor
Cvx = $Wx*hx^k/(\text{ Sum of } Wi*hi^k)$ and k is an exponent which is related
to the period of Vibration.

In this case, the value of k was 1

The Natural Frequency for the Vessel (Ope...) is 20.0868 Hz.

Earthquake Load Calculation:

From	To	Earthquake Height mm.	Earthquake Weight kN	Element Ope Load kN	Element Emp Load kN	Element Vertical Load kN
10	20	25	0.38476	0.0029457	0.0017708	...
20	Legs	250	0.62359	0.047743	0.027339	...
Legs	30	800	3.42977	0.84027	0.48117	...
30	40	1413.5	0.71455	0.30931	0.2834	...
40	50	1504.81	0.92892	0.42808	0.39223	...

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

The following table is for the Operating Case.

Wind/Earthquake Shear, Bending:

From	To	Distance to Support mm.	Cumulative Wind Shear kN	Earthquake Shear kN	Wind Bending N-m	Earthquake Bending N-m
10	20	289.927	...	...	...	...
20	Legs	100	0.021886	0.0029457	1.96893	0.26501
Legs	30	550	0.18313	1.5806	93.88	1354.11
30	40	1163.5	0.02193	0.73739	1.97546	85.9483
40	50	1254.81	0.0063749	0.42808	0.11663	7.83192

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: 0.600; Earthquake: 0.700.

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

Wind Deflection Calculations:

The following table is for the Operating Case.

Wind Deflection:

From	To	Cumulative Wind Shear kN	Centroid Deflection mm.	Elem. End Deflection mm.	Elem. Ang. Rotation
10	20	...	0.11415	0.11415	0.00016972
20	Legs	0.021886	0.1142	0.11434	0.00017151
Legs	30	0.18313	0.11639	0.11945	0.00017551
30	40	0.02193	0.11982	0.12018	0.00017551
40	50	0.0063749	0.12029	0.1204	0.00017551

Critical Wind Velocity for Tower Vibration:

From	To	1st Crit. Wind Speed Km/hr	2nd Crit. Wind Speed Km/hr
10	20	219.122	1369.51
20	30	219.122	1369.51
30	40	211.909	1324.43
40	50	301.553	1884.7

Allowable deflection at the Tower Top (Ope)(6.000"/100ft. Criteria)
Allowable deflection : 7.616 Actual deflection : 0.120 mm.

Longitudinal Stress Constants:

From	To	Metal Area New cm²	Metal Area Corroded cm²	Section Modulus New mm.³	Section Modulus Corroded mm.³
10	20	118.76	44.6149	1151363	445492
20	30	104.226	29.6328	1016397	297630
30	40	104.226	29.6328	1016397	297630
40	50	104.226	29.6328	1016397	297630

Longitudinal Allowable Stresses:

From	To	Tensile N./mm²	Hydrotest Tensile N./mm²	Compressive N./mm²	Hydrotest Compressive N./mm²
10	20	117.9	217.2	-105.537	-126.645
20	Legs	117.9	217.2	-95.6475	-114.777
Legs	30	117.9	217.2	-95.6475	-114.777
30	40	137.9	223.4	-95.6475	-114.777
40	50	137.9	223.4	-95.6475	-114.777

Longitudinal Stress Report

Note: Longitudinal Operating and Empty Stresses are computed in the corroded condition. Stresses due to loads in the hydrostatic test cases have also been computed in the corroded 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	21.0932	-3.00652	27.4212
20	30	32.1194	-4.52658	41.7553
30	40	...	...	...
40	50	...	...	...

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	0.085196	0.12985	0.091024	0.015021	0.015021
Legs	30	-1.27809	-1.19916	-1.27809	0.082617	0.082617
30	40	-0.55466	-0.55466	-0.55466	...	...
40	50	-0.3135	-0.3135	-0.3135	...	...

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	0.015021	0.0066132	0.00089011	0.0021824	...
Legs	30	0.082617	0.31532	4.54818	0.10406	...
30	40	...	0.0066352	0.28868	0.0021896	...
40	50	...	0.00039174	0.026306	0.00012927	...

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	...	...	...	0.00053509
Legs	30	...	...	...	3.6401

30	40	...	...	...	0.26451
40	50	...	...	...	0.024103

Longitudinal Stresses due to Applied Axial Forces:

From	To	Longitudinal Stress Y Forces Wind N./mm²	Longitudinal Stress Y Forces Seismic N./mm²
10	20	...	...
20	Legs	...	...
Legs	30	...	...
30	40	...	...
40	50	...	...

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	40	...	...	...	...
40	50	...	...	...	...

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
```

General Notes:

Case types HI and HE are in the 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	117.90	0.00	105.54	0.0000	0.0000
20	0.11	117.90		95.65	0.0009	
20		117.90	-1.68	95.65		0.0175

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	117.90	0.00	105.54	0.0000	0.0000
20	0.10	117.90		95.65	0.0009	
20	2.44	117.90	-5.00	95.65	0.0207	0.0523

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	117.90	0.00	105.54	0.0000	0.0000
20	0.15	117.90		95.65	0.0013	
20		117.90	-1.60	95.65		0.0167

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	117.90	0.00	105.54	0.0000	0.0000
20	0.15	117.90		95.65	0.0012	
20	3.43	117.90	-5.83	95.65	0.0291	0.0610

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	217.20	0.00	126.64	0.0000	0.0000
20	0.11	217.20		114.78	0.0005	
20		217.20	-1.46	114.78		0.0128

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	217.20	0.00	126.64	0.0000	0.0000
20	0.11	217.20		114.78	0.0005	
20		217.20	-1.36	114.78		0.0119

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	21.09	117.90		105.54	0.1789	
20	32.27	117.90		95.65	0.2737	
20	31.32	117.90		95.65	0.2656	

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	21.09	117.90		105.54	0.1789	
20	32.27	117.90		95.65	0.2737	
20	35.55	117.90		95.65	0.3015	

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

From	Tensile	All. Tens.	Comp.	All. Comp.	Tens.	Comp.

Node	Stress	Stress	Stress	Stress	Ratio	Ratio
10		117.90	-3.01	105.54		0.0285
20		117.90	-4.42	95.65		0.0462
20		117.90	-6.12	95.65		0.0640

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		117.90	-3.01	105.54		0.0285
20		117.90	-4.41	95.65		0.0461
20		117.90	-10.36	95.65		0.1083

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	27.42	217.20		126.64	0.1262	
20	41.86	217.20		114.78	0.1927	
20	40.66	217.20		114.78	0.1872	

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	27.42	217.20		126.64	0.1262	
20	41.86	217.20		114.78	0.1927	
20	40.56	217.20		114.78	0.1867	

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	21.09	117.90		105.54	0.1789	
20	32.22	117.90		95.65	0.2733	
20	30.92	117.90		95.65	0.2623	

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	21.09	117.90		105.54	0.1789	
20	32.16	117.90		95.65	0.2727	
20	31.78	117.90		95.65	0.2695	

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	21.09	117.90		105.54	0.1789	
20	32.26	117.90		95.65	0.2737	
20	31.00	117.90		95.65	0.2630	

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	21.09	117.90		105.54	0.1789	
20	32.22	117.90		95.65	0.2733	
20	30.92	117.90		95.65	0.2623	

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	117.90	0.00	105.54	0.0000	0.0000
20	0.14	117.90		95.65	0.0012	
20		117.90	-1.28	95.65		0.0134

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	21.09	117.90		105.54	0.1789	
20	32.26	117.90		95.65	0.2737	
20	31.00	117.90		95.65	0.2630	

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		117.90	-3.01	105.54		0.0285
20		117.90	-4.41	95.65		0.0461
20		117.90	-5.81	95.65		0.0607

Absolute Maximum of the all of the Stress Ratio's 0.3015

Element From : 20 to : 30
Governing Load Case 8 : IP+OW+EQ+FS+BS

Element Description	Long Pressure Stress	Weight + Axial Load Stress	Eccentric Moment Stress	Wind or Earthquake Stress	Combined Stress	Which Side
Element # 1	21.1	...	...	...	21.1	+ Tens
Element # 1	21.1	...	...	...	...	- Comp
Element # 2	32.1	0.1	...	...	32.3	+ Tens
Element # 2	32.1	0.1	-0.0	-0.0	...	- Comp
Element # 2	32.1	-1.2	0.1	4.5	35.6	+ Tens
Element # 2	32.1	-1.2	-0.1	-4.5	...	- Comp

Shop/Field Installation Options :

Insulation is installed in the Shop.

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

Center of Gravity of the Liquid	640.069 mm.
Center of Gravity of the Insulation	802.424 mm.
Center of Gravity of the Nozzles	799.501 mm.
Center of Gravity of the Legs	-250.000 mm.
Center of Gravity of the Added Weights (Operating)	675.000 mm.
Center of Gravity of the Added Weights (Empty)	675.000 mm.
Center of Gravity of Bare Shell New and Cold	1041.421 mm.
Center of Gravity of Bare Shell Corroded	1228.708 mm.
Vessel CG in the Operating Condition	781.563 mm.
Vessel CG in the Fabricated (Shop/Empty) Condition	804.962 mm.
Vessel CG in the Test Condition	778.935 mm.

RESULTS FOR LEGS : Operating Case Description: LEGS

Legs attached to: node 20

Section Properties : Single Angle L80X80X10

European Structural Steel Data

Overall Leg Length		1000.000	mm.
Effective Leg Length	Leglen	850.000	mm.
Distance Leg Up Side of Vessel		200.000	mm.
Number of Legs	Nleg	3	
Cross Sectional Area for L80X80X10	Aleg	15.100	cm^2
Section Inertia (strong axis)		87.500	cm**4
Section Inertia (weak axis)		87.500	cm**4
Section Modulus (strong axis)		15400.062	$mm.^3$
Section Modulus (weak axis)		15400.062	$mm.^3$
Radius of Gyration (strong axis)		24.100	mm.
Radius of Gyration (weak axis)		24.100	mm.

Leg Orientation - Diagonal

Overturning Moment at top of Legs		1354.1	N-m
Total Weight Load at top of Legs	W	6.1	kN
Total Shear force at top of Legs		1.6	kN
Additional force in Leg due to Bracing	Fadd	0.0	kN
Occasional Load Factor	Occfac	1.333	
Effective Leg End Condition Factor	k	1.000	

Note: The Legs are Not Cross Braced
The Leg Shear Force includes Wind and Seismic Effects

Pad Width along Circumference	C11P	200.000	mm.
Pad Length along Vessel Axis	C22P	200.000	mm.
Pad Thickness	Tpad	8.000	mm.

Maximum Shear at top of one Leg [Vleg]:
= (max(Wind, Seismic) + applied forces)(Imax / Itot)
= (1.63)(141/215)
= 1.07 kN

Axial Compression, Leg furthest from the Neutral Axis [Sma]:
= W/Nleg + (Mleg/(Nlegm*Rn))/Aleg
= 6133/3 + (1353570/(1 * 228))/1510
= 5.29 $N./mm^2$

Axial Compression, Leg closest to the Neutral Axis [Sva]:
= (W / Nleg) / Aleg
= (6.13/3)/15.1
= 1.35 $N./mm^2$

Computing Principal Axis and Inertias for Angle.
Leg lengths and thickness: 80.000 80.000 10.0000

```
Distance to geometric centroid:   23.400      23.400
Arm about YY:                     18.400      21.600
Arm about ZZ:                     16.600      18.400
Leg areas:                        8.0000      7.0000
Geometric inertia components YY:  27.751      61.242
Geometric inertia components ZZ:  64.711      24.282
Geometric inertias Iy & Iz:       88.993      88.993
Product of inertia:              0.52256E+06
Mohrs Radius:                     31.888
Average Inertia:                  88.993

QFACT =   1.0000        FBZ          =  0.16383
Principal Axis Inertias (Z&W)        =   36.738      141.25
Angle to Principal Axis              =   45.000
Distances to extreme fibers CW & CZ  =   56.568      23.476
FOB from Eq 5-5                      =   2.2916
Bending allowables Fby & Fbz         =  0.16383     0.16383

Shear Center Coordinates Wo & Zo:   25.095      0.0000
Values for Elastic Flexural-Torsional Buckling Stress:
E,    G,      J,   R0²:    29500.      11346.     0.12093      2.8032
AREA, LENGTH, Kw,  Kz:     2.3405      33.465      1.0000      1.0000
H,    Few,    Fez, Fej:   0.65177      376.96      98.044      209.13
Fe computed from C4-1:     164.66

Initial (Kl/r)max, & (Kl/r)equiv     =   54.494      42.051
Final (Kl/r)max, & Cc                =   54.494      127.18
Fa based on Eq 4-1                   =  0.12403

                              Actual   Allowable
Weak Axis Bending    :         41.14      218.38   N./mm²
Strong Axis Bending  :         25.79      218.38   N./mm²
Axial Compression    :          5.29      165.34   N./mm²

UNITY CHECKS ARE: H1-1     0.000
                  H1-2     0.000
                  H1-3     0.338

AISC Unity Check :   0.338 Should be <= to 1
```

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

```
Rectangular Attachment Parameter          C11     113.137  mm.
Rectangular Attachment Parameter          C22     180.950  mm.
```

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

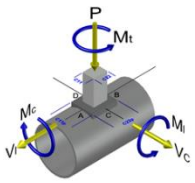
```
Diameter Basis for Vessel                Vbasis      ID
Cylindrical or Spherical Vessel          Cylsph      Cylindrical
Internal Corrosion Allowance               Cas      6.0000  mm.
Vessel Diameter                             Dv     389.731  mm.
Vessel Thickness                            Tv       8.334  mm.

Design Temperature                          T1       100.0  °C
```

Attachment Type	Type	Rectangular	
Parameter C11	C11	113.14	mm.
Parameter C22	C22	180.95	mm.
Thickness of Reinforcing Pad	Tpad	8.000	mm.
Pad Parameter C11P	C11p	200.000	mm.
Pad Parameter C22P	C22p	200.000	mm.
Design Internal Pressure	Dp	7.500	bars
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	kN
Global Force (SUS)	Fy	2.0	kN
Global Force (SUS)	Fz	0.0	kN
Global Moment (SUS)	Mx	0.0	N-m
Global Moment (SUS)	My	0.0	N-m
Global Moment (SUS)	Mz	49.9	N-m
Internal Pressure (SUS)	P	7.50	bars
Include Pressure Thrust		No	
Global Force (OCC)	Fx	1.1	kN
Global Force (OCC)	Fy	5.9	kN
Global Force (OCC)	Fz	0.0	kN
Global Moment (OCC)	Mx	0.0	N-m
Global Moment (OCC)	My	0.0	N-m
Global Moment (OCC)	Mz	600.7	N-m
Occasional Internal Pressure (OCC)	Pvar	0.00	bars

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

Note:
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 Stress Calculation for SUStained loads:

Radial Load	P	0.0	kN
Circumferential Shear	VC	0.0	kN
Longitudinal Shear	VL	2.0	kN
Circumferential Moment	MC	0.0	N-m
Longitudinal Moment	ML	-49.9	N-m
Torsional Moment	MT	0.0	N-m

Dimensionless Parameters used : Gamma = 19.94

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure	Value	Location
N(PHI) / (P/Rm)	0.431	4C	2.122	(A,B)
N(PHI) / (P/Rm)	0.431	3C	1.120	(C,D)
M(PHI) / (P)	0.326	2C1	0.026	(A,B)
M(PHI) / (P)	0.326	1C !	0.058	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.321	3A	0.852	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.352	1A	0.075	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.375	3B	1.643	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.366	1B	0.018	(A,B,C,D)
N(x) / (P/Rm)	0.382	3C	1.301	(A,B)
N(x) / (P/Rm)	0.382	4C	2.316	(C,D)
M(x) / (P)	0.391	1C1	0.039	(A,B)
M(x) / (P)	0.391	2C !	0.030	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.321	4A	1.744	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.424	2A	0.031	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.375	4B	0.772	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.412	2B	0.026	(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 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	0.4	0.4	-0.4	-0.4	0.0	0.0	0.0	0.0
Circ. Bend. ML	0.7	-0.7	-0.7	0.7	0.0	0.0	0.0	0.0
Tot. Circ. Str.	1.1	-0.2	-1.1	0.2	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	0.3	0.3	-0.3	-0.3	0.0	0.0	0.0	0.0
Long. Bend. ML	0.8	-0.8	-0.8	0.8	0.0	0.0	0.0	0.0
Tot. Long. Str.	1.1	-0.6	-1.1	0.6	0.0	0.0	0.0	0.0
Shear VC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-0.5	-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.	1.1	0.6	1.1	0.6	1.1	1.1	1.1	1.1

Dimensionless Parameters used : Gamma = 86.55

Dimensionless Loads for Cylindrical Shells at Pad edge:

Curves read for 1979	Beta	Figure		Value	Location
N(PHI) / (P/Rm)	0.495	4C		3.806	(A,B)
N(PHI) / (P/Rm)	0.495	3C		1.124	(C,D)
M(PHI) / (P)	0.495	2C1		0.002	(A,B)
M(PHI) / (P)	0.495	1C	!	0.067	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.495	3A		1.166	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.495	1A		0.053	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.495	3B		1.981	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.495	1B		0.002	(A,B,C,D)
N(x) / (P/Rm)	0.495	3C		1.124	(A,B)
N(x) / (P/Rm)	0.495	4C		3.806	(C,D)
M(x) / (P)	0.495	1C1		0.006	(A,B)
M(x) / (P)	0.495	2C	!	0.036	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.495	4A		6.180	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.495	2A		0.021	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.495	4B		1.032	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.495	2B		0.003	(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	2.1	2.1	-2.1	-2.1	0.0	0.0	0.0	0.0
Circ. Bend. ML	1.1	-1.1	-1.1	1.1	0.0	0.0	0.0	0.0
Tot. Circ. Str.	3.2	1.0	-3.2	-1.0	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	1.1	1.1	-1.1	-1.1	0.0	0.0	0.0	0.0
Long. Bend. ML	1.8	-1.8	-1.8	1.8	0.0	0.0	0.0	0.0
Tot. Long. Str.	2.9	-0.7	-2.9	0.7	0.0	0.0	0.0	0.0
Shear VC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear VL	0.0	0.0	0.0	0.0	-2.2	-2.2	2.2	2.2
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	-2.2	-2.2	2.2	2.2
Str. Int.	3.2	1.7	3.2	1.7	4.4	4.4	4.4	4.4

WRC 107 Stress Calculation for OCCasional loads:

Radial Load	P	1.1	kN
Circumferential Shear	VC	0.0	kN
Longitudinal Shear	VL	5.9	kN
Circumferential Moment	MC	0.0	N-m
Longitudinal Moment	ML	-600.7	N-m
Torsional Moment	MT	0.0	N-m

Dimensionless Parameters used : Gamma = 19.94

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	-1.1	-1.1	-1.1	-1.1	-0.6	-0.6	-0.6	-0.6
Circ. Bend. P	-1.6	1.6	-1.6	1.6	-3.5	3.5	-3.5	3.5
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	5.3	5.3	-5.3	-5.3	0.0	0.0	0.0	0.0

Circ. Bend. ML	7.9	-7.9	-7.9	7.9	0.0	0.0	0.0	0.0
Tot. Circ. Str.	10.5	-2.2	-15.9	3.2	-4.1	2.9	-4.1	2.9
Long. Memb. P	-0.7	-0.7	-0.7	-0.7	-1.2	-1.2	-1.2	-1.2
Long. Bend. P	-2.3	2.3	-2.3	2.3	-1.8	1.8	-1.8	1.8
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	3.2	3.2	-3.2	-3.2	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.	10.4	-5.2	-16.4	8.6	-3.0	0.6	-3.0	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	-1.6	-1.6	1.6	1.6
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	-1.6	-1.6	1.6	1.6
Str. Int.	10.5	5.2	16.4	8.6	5.2	3.9	5.2	3.9

Dimensionless Parameters used : Gamma = 86.55

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	-8.6	-8.6	-8.6	-8.6	-2.6	-2.6	-2.6	-2.6
Circ. Bend. P	-2.9	2.9	-2.9	2.9	-79.4	79.4	-79.4	79.4
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Memb. ML	25.2	25.2	-25.2	-25.2	0.0	0.0	0.0	0.0
Circ. Bend. ML	13.4	-13.4	-13.4	13.4	0.0	0.0	0.0	0.0
Tot. Circ. Str.	27.1	6.1	-50.2	-17.5	-81.9	76.8	-81.9	76.8
Long. Memb. P	-2.6	-2.6	-2.6	-2.6	-8.6	-8.6	-8.6	-8.6
Long. Bend. P	-7.0	7.0	-7.0	7.0	-42.5	42.5	-42.5	42.5
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	13.1	13.1	-13.1	-13.1	0.0	0.0	0.0	0.0
Long. Bend. ML	21.3	-21.3	-21.3	21.3	0.0	0.0	0.0	0.0
Tot. Long. Str.	25.0	-3.8	-44.0	12.6	-51.1	33.8	-51.1	33.8
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	-6.4	-6.4	6.4	6.4
Shear MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tot. Shear	0.0	0.0	0.0	0.0	-6.4	-6.4	6.4	6.4
Str. Int.	27.1	9.9	50.2	30.2	83.2	77.7	83.2	77.7

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)	14.2	15.0	14.2	15.0	14.2	15.0	14.2	15.0
Circ. Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ. Pm(TOTAL)	14.2	15.0	14.2	15.0	14.2	15.0	14.2	15.0
Circ. Pl (SUS)	0.4	0.4	-0.4	-0.4	0.0	0.0	0.0	0.0
Circ. Pl (OCC)	4.2	4.2	-6.3	-6.3	-0.6	-0.6	-0.6	-0.6
Circ. Pl(TOTAL)	4.6	4.6	-6.8	-6.8	-0.6	-0.6	-0.6	-0.6
Circ. Q (SUS)	0.7	-0.7	-0.7	0.7	0.0	0.0	0.0	0.0
Circ. Q (OCC)	6.4	-6.4	-9.5	9.5	-3.5	3.5	-3.5	3.5
Circ. Q (TOTAL)	7.0	-7.0	-10.2	10.2	-3.5	3.5	-3.5	3.5
Long. Pm (SUS)	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
Long. Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Pm(TOTAL)	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
Long. Pl (SUS)	0.3	0.3	-0.3	-0.3	0.0	0.0	0.0	0.0
Long. Pl (OCC)	2.6	2.6	-3.9	-3.9	-1.2	-1.2	-1.2	-1.2
Long. Pl(TOTAL)	2.8	2.8	-4.2	-4.2	-1.2	-1.2	-1.2	-1.2
Long. Q (SUS)	0.8	-0.8	-0.8	0.8	0.0	0.0	0.0	0.0
Long. Q (OCC)	7.8	-7.8	-12.5	12.5	-1.8	1.8	-1.8	1.8
Long. Q (TOTAL)	8.7	-8.7	-13.3	13.3	-1.8	1.8	-1.8	1.8
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	-1.6	-1.6	1.6	1.6
Shear Pl(TOTAL)	0.0	0.0	0.0	0.0	-2.1	-2.1	2.1	2.1
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)	14.2	15.0	14.2	15.0	14.2	15.0	14.2	15.0
Pm (SUS+OCC)	14.2	15.0	14.2	15.0	14.2	15.0	14.2	15.0
Pm+Pl (SUS)	14.6	15.4	13.8	14.5	14.3	15.0	14.3	15.0
Pm+Pl (SUS+OCC)	18.8	19.6	7.5	8.2	14.2	14.9	14.2	14.9
Pm+Pl+Q (Total)	25.9	12.6	10.4	18.4	10.8	18.3	10.8	18.3

Vessel Stress Summation Comparison (N./mm²):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	14.96	117.90	Passed
Pm (SUS+OCC)	14.96	141.48	Passed
Pm+Pl (SUS)	15.40	176.85	Passed
Pm+Pl (SUS+OCC)	19.58	212.22	Passed
Pm+Pl+Q (TOTAL)	25.85	353.70	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)	64.2	64.9	64.2	64.9	64.2	64.9	64.2	64.9
Circ.	Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Circ.	Pm(TOTAL)	64.2	64.9	64.2	64.9	64.2	64.9	64.2	64.9
Circ.	Pl (SUS)	2.1	2.1	-2.1	-2.1	0.0	0.0	0.0	0.0
Circ.	Pl (OCC)	16.6	16.6	-33.9	-33.9	-2.6	-2.6	-2.6	-2.6
Circ.	Pl(TOTAL)	18.7	18.7	-36.0	-36.0	-2.6	-2.6	-2.6	-2.6
Circ.	Q (SUS)	1.1	-1.1	-1.1	1.1	0.0	0.0	0.0	0.0
Circ.	Q (OCC)	10.5	-10.5	-16.3	16.3	-79.4	79.4	-79.4	79.4
Circ.	Q (TOTAL)	11.6	-11.6	-17.4	17.4	-79.4	79.4	-79.4	79.4
Long.	Pm (SUS)	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1
Long.	Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long.	Pm(TOTAL)	32.1	32.1	32.1	32.1	32.1	32.1	32.1	32.1
Long.	Pl (SUS)	1.1	1.1	-1.1	-1.1	0.0	0.0	0.0	0.0
Long.	Pl (OCC)	10.6	10.6	-15.7	-15.7	-8.6	-8.6	-8.6	-8.6
Long.	Pl(TOTAL)	11.7	11.7	-16.8	-16.8	-8.6	-8.6	-8.6	-8.6
Long.	Q (SUS)	1.8	-1.8	-1.8	1.8	0.0	0.0	0.0	0.0
Long.	Q (OCC)	14.4	-14.4	-28.3	28.3	-42.5	42.5	-42.5	42.5
Long.	Q (TOTAL)	16.2	-16.2	-30.1	30.1	-42.5	42.5	-42.5	42.5
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	-2.2	-2.2	2.2	2.2
Shear	Pl (OCC)	0.0	0.0	0.0	0.0	-6.4	-6.4	6.4	6.4
Shear	Pl(TOTAL)	0.0	0.0	0.0	0.0	-8.6	-8.6	8.6	8.6
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)	64.2	64.9	64.2	64.9	64.2	64.9	64.2	64.9
Pm (SUS+OCC)	64.2	64.9	64.2	64.9	64.2	64.9	64.2	64.9
Pm+Pl (SUS)	66.3	67.0	62.1	62.8	64.3	65.1	64.3	65.1
Pm+Pl (SUS+OCC)	82.8	83.6	28.2	28.9	63.4	64.2	63.4	64.2
Pm+Pl+Q (Total)	94.5	72.0	25.6	46.4	27.0	142.7	27.0	142.7

Vessel Stress Summation Comparison (N./mm²):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	64.92	117.90	Passed
Pm (SUS+OCC)	64.92	141.48	Passed
Pm+Pl (SUS)	67.01	176.85	Passed
Pm+Pl (SUS+OCC)	83.59	212.22	Passed
Pm+Pl+Q (TOTAL)	142.69	353.70	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.

Bolting Size Requirement for Leg Baseplates :

Baseplate Material		SA-283 C	
Baseplate Allowable Stress	SBA	108.25	N./mm²
Baseplate Length	B	200.0000	mm.
Baseplate Width	D	200.0000	mm.
Baseplate Thickness	BTHK	18.0000	mm.
Leg Dimension Along Baseplate Length	d	79.9998	mm.
Leg Dimension Along Baseplate Width	b	79.9998	mm.
Bolt Circle Diameter	BCD	410.6000	mm.
Bolt Material		SA-325	
Bolt Allowable Tensile Stress	STBA	300.00	N./mm²
Bolt Allowable Shear Stress	SBShear	180.00	N./mm²
Anchor Bolt Nominal Diameter	BOD	20.0000	mm.
Number of Anchor Bolts in Tension per Leg	NB	1	
Total Number of Anchors Bolt per Leg	NBT	1	
Ultimate 28-day Concrete Strength	FCPRIME	20.685	N./mm²

Shear Stress in a Single Bolt [taub]:
= Shear Force / (2 * Bolt Area * Number of Bolts)
= 1.63/(2 * 2.17 * 1)
= 3.8 N./mm². Must be less than 180.0 N./mm².

Plate thickness required (5/8"; 16mm) per D. Moss

Since there is only 1 bolt, the standard computation for this

geometry is not possible. A reasonable bolt size should be selected. Per Megyesy, use a 1 inch (25.4 mm) bolt.

Computing the required bolt area based on a standard method not including the baseplate's interaction with the foundation.

Calculation of Load per Bolt, Wind Empty [W,wind]:

```
= (( 4 * Moment/BCD ) - Weight )/Num Bolts
= (( 4 * 93.9/411 ) - 4.99 )/3
= -1.359 kN
```

Calculation of Load per Bolt, Seismic Operating [W,seismic]:

```
= (( 4 * Moment/BCD ) - Weight )/Num Bolts
= (( 4 * 1354/411 ) - 6.64 )/3
= 2.181 kN
```

Calculation of Maximum Load per Bolt [Wmax]:

```
= max( W,wind, W,seismic )
= max( -1.36, 2.18 )
= 2.181 kN
```

Area Available in a Single Bolt, corroded [Ab]:

```
= 2.171 cm²
```

Required Area of a single Bolt, Simplified Method:

```
= Wmax / Bolt Allowable Stress
= 2.18/280708
= 0.073 cm²
```

Note: The Seismic Operating case governs.

RESULTS FOR LEGS : HydroTest Case Description: LEGS

Legs attached to: node 20

Section Properties : Single Angle L80X80X10

European Structural Steel Data

Overall Leg Length		1000.000	mm.
Effective Leg Length	Leglen	850.000	mm.
Distance Leg Up Side of Vessel		200.000	mm.
Number of Legs	Nleg	3	
Cross Sectional Area for L80X80X10	Aleg	15.100	cm^2
Section Inertia (strong axis)		87.500	cm**4
Section Inertia (weak axis)		87.500	cm**4
Section Modulus (strong axis)		15400.062	$mm.^3$
Section Modulus (weak axis)		15400.062	$mm.^3$
Radius of Gyration (strong axis)		24.100	mm.
Radius of Gyration (weak axis)		24.100	mm.

Leg Orientation - Diagonal

Overturning Moment at top of Legs		31.0	N-m
Total Weight Load at top of Legs	W	5.1	kN
Total Shear force at top of Legs		0.1	kN
Additional force in Leg due to Bracing	Fadd	0.0	kN
Occasional Load Factor	Occfac	1.333	
Effective Leg End Condition Factor	k	1.000	

Note: The Legs are Not Cross Braced
The Leg Shear Force includes Wind and Seismic Effects

Pad Width along Circumference	C11P	200.000	mm.
Pad Length along Vessel Axis	C22P	200.000	mm.
Pad Thickness	Tpad	8.000	mm.

Maximum Shear at top of one Leg [Vleg]:
= (max(Wind, Seismic) + applied forces)(Imax / Itot)
= (0.069)(141/215)
= 0.05 kN

Axial Compression, Leg furthest from the Neutral Axis [Sma]:
= W/Nleg + (Mleg/(Nlegm*Rn))/Aleg
= 5132/3 + (30968/(1 * 228))/1510
= 1.22 $N./mm^2$

Axial Compression, Leg closest to the Neutral Axis [Sva]:
= (W / Nleg) / Aleg
= (5.13/3)/15.1
= 1.13 $N./mm^2$

Computing Principal Axis and Inertias for Angle.
Leg lengths and thickness: 80.000 80.000 10.0000

```
Distance to geometric centroid:   23.400      23.400
Arm about YY:                     18.400      21.600
Arm about ZZ:                     16.600      18.400
Leg areas:                        8.0000      7.0000
Geometric inertia components YY:  27.751      61.242
Geometric inertia components ZZ:  64.711      24.282
Geometric inertias Iy & Iz:       88.993      88.993
Product of inertia:              0.52256E+06
Mohrs Radius:                     31.888
Average Inertia:                  88.993

QFACT =   1.0000        FBZ          =  0.16383
Principal Axis Inertias (Z&W)        =   36.738      141.25
Angle to Principal Axis              =   45.000
Distances to extreme fibers CW & CZ  =   56.568      23.476
FOB from Eq 5-5                      =   2.2916
Bending allowables Fby & Fbz         =  0.16383     0.16383

Shear Center Coordinates Wo & Zo:   25.095      0.0000
Values for Elastic Flexural-Torsional Buckling Stress:
E,    G,      J,   R0²:    29500.      11346.     0.12093      2.8032
AREA, LENGTH, Kw,  Kz:     2.3405      33.465      1.0000      1.0000
H,    Few,    Fez, Fej:   0.65177      376.96      98.044      209.13
Fe computed from C4-1:     164.66

Initial (Kl/r)max, & (Kl/r)equiv     =   54.494      42.051
Final (Kl/r)max, & Cc                =   54.494      127.18
Fa based on Eq 4-1                   =  0.12403

                              Actual   Allowable
Weak Axis Bending    :          1.74      218.38   N./mm²
Strong Axis Bending  :          1.09      218.38   N./mm²
Axial Compression    :          1.22      165.34   N./mm²

UNITY CHECKS ARE: H1-1     0.000
                  H1-2     0.000
                  H1-3     0.020

AISC Unity Check :   0.020 Should be <= to 1
```

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

```
Rectangular Attachment Parameter          C11     113.137  mm.
Rectangular Attachment Parameter          C22     180.950  mm.
```

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

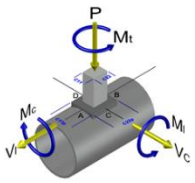
```
Diameter Basis for Vessel                Vbasis      ID
Cylindrical or Spherical Vessel          Cylsph      Cylindrical
Internal Corrosion Allowance               Cas      0.0000  mm.
Vessel Diameter                             Dv     389.731  mm.
Vessel Thickness                            Tv       8.334  mm.

Design Temperature                          T1       100.0  °C
```

Attachment Type	Type	Rectangular	
Parameter C11	C11	113.14	mm.
Parameter C22	C22	180.95	mm.
Thickness of Reinforcing Pad	Tpad	8.000	mm.
Pad Parameter C11P	C11p	200.000	mm.
Pad Parameter C22P	C22p	200.000	mm.
Design Internal Pressure	Dp	7.500	bars
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	kN
Global Force (SUS)	Fy	1.7	kN
Global Force (SUS)	Fz	0.0	kN
Global Moment (SUS)	Mx	0.0	N-m
Global Moment (SUS)	My	0.0	N-m
Global Moment (SUS)	Mz	41.8	N-m
Internal Pressure (SUS)	P	7.50	bars
Include Pressure Thrust		No	
Global Force (OCC)	Fx	0.0	kN
Global Force (OCC)	Fy	0.1	kN
Global Force (OCC)	Fz	0.0	kN
Global Moment (OCC)	Mx	0.0	N-m
Global Moment (OCC)	My	0.0	N-m
Global Moment (OCC)	Mz	22.6	N-m
Occasional Internal Pressure (OCC)	Pvar	2.37	bars

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

Note:
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 Stress Calculation for SUStained loads:

Radial Load	P	0.0	kN
Circumferential Shear	VC	0.0	kN
Longitudinal Shear	VL	1.7	kN
Circumferential Moment	MC	0.0	N-m
Longitudinal Moment	ML	-41.8	N-m
Torsional Moment	MT	0.0	N-m

Dimensionless Parameters used : Gamma = 12.43

Dimensionless Loads for Cylindrical Shells at Attachment Junction:

Curves read for 1979	Beta	Figure		Value	Location
N(PHI) / (P/Rm)	0.437	4C		1.551	(A,B)
N(PHI) / (P/Rm)	0.437	3C		0.962	(C,D)
M(PHI) / (P)	0.331	2C1		0.038	(A,B)
M(PHI) / (P)	0.331	1C		0.061	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.326	3A	!	0.521	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.358	1A		0.081	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.381	3B	!	1.301	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.372	1B		0.023	(A,B,C,D)
N(x) / (P/Rm)	0.388	3C		1.094	(A,B)
N(x) / (P/Rm)	0.388	4C		1.669	(C,D)
M(x) / (P)	0.396	1C1		0.049	(A,B)
M(x) / (P)	0.396	2C	!	0.032	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.326	4A	!	1.044	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.433	2A		0.036	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.381	4B	!	0.527	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.419	2B		0.035	(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 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	0.2	0.2	-0.2	-0.2	0.0	0.0	0.0	0.0
Circ. Bend. ML	0.3	-0.3	-0.3	0.3	0.0	0.0	0.0	0.0
Tot. Circ. Str.	0.5	-0.1	-0.5	0.1	0.0	0.0	0.0	0.0
Long. Memb. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. ML	0.1	0.1	-0.1	-0.1	0.0	0.0	0.0	0.0
Long. Bend. ML	0.4	-0.4	-0.4	0.4	0.0	0.0	0.0	0.0
Tot. Long. Str.	0.5	-0.3	-0.5	0.3	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	-0.3	-0.3	0.3	0.3
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	-0.3	-0.3	0.3	0.3
Str. Int.	0.5	0.3	0.5	0.3	0.6	0.6	0.6	0.6

Dimensionless Parameters used : Gamma = 23.88

Dimensionless Loads for Cylindrical Shells at Pad edge:

Curves read for 1979	Beta	Figure		Value	Location
N(PHI) / (P/Rm)	0.502	4C	!	2.068	(A,B)
N(PHI) / (P/Rm)	0.502	3C	!	0.928	(C,D)
M(PHI) / (P)	0.502	2C1	!	0.009	(A,B)
M(PHI) / (P)	0.502	1C	!	0.059	(C,D)
N(PHI) / (MC/(Rm**2 * Beta))	0.502	3A	!	0.707	(A,B,C,D)
M(PHI) / (MC/(Rm * Beta))	0.502	1A	!	0.064	(A,B,C,D)
N(PHI) / (ML/(Rm**2 * Beta))	0.502	3B	!	1.190	(A,B,C,D)
M(PHI) / (ML/(Rm * Beta))	0.502	1B	!	0.009	(A,B,C,D)
N(x) / (P/Rm)	0.502	3C	!	0.928	(A,B)
N(x) / (P/Rm)	0.502	4C	!	2.068	(C,D)
M(x) / (P)	0.502	1C1	!	0.021	(A,B)
M(x) / (P)	0.502	2C	!	0.030	(C,D)
N(x) / (MC/(Rm**2 * Beta))	0.502	4A	!	2.436	(A,B,C,D)
M(x) / (MC/(Rm * Beta))	0.502	2A	!	0.028	(A,B,C,D)
N(x) / (ML/(Rm**2 * Beta))	0.502	4B	!	0.644	(A,B,C,D)
M(x) / (ML/(Rm * Beta))	0.502	2B	!	0.015	(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	0.3	0.3	-0.3	-0.3	0.0	0.0	0.0	0.0
Circ. Bend. ML	0.3	-0.3	-0.3	0.3	0.0	0.0	0.0	0.0
Tot. Circ. Str.	0.6	-0.0	-0.6	0.0	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	0.2	0.2	-0.2	-0.2	0.0	0.0	0.0	0.0
Long. Bend. ML	0.6	-0.6	-0.6	0.6	0.0	0.0	0.0	0.0
Tot. Long. Str.	0.7	-0.4	-0.7	0.4	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.	0.7	0.4	0.7	0.4	1.0	1.0	1.0	1.0

WRC 107 Stress Calculation for OCCasional loads:

Radial Load	P	0.0	kN
Circumferential Shear	VC	0.0	kN
Longitudinal Shear	VL	0.1	kN
Circumferential Moment	MC	0.0	N-m
Longitudinal Moment	ML	-22.6	N-m
Torsional Moment	MT	0.0	N-m

Dimensionless Parameters used : Gamma = 12.43

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	-0.1	0.1	-0.1	0.1
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	0.1	0.1	-0.1	-0.1	0.0	0.0	0.0	0.0

Circ. Bend. ML	0.2	-0.2	-0.2	0.2	0.0	0.0	0.0	0.0
Tot. Circ. Str.	0.2	-0.0	-0.3	0.1	-0.1	0.0	-0.1	0.0
Long. Memb. P	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0
Long. Bend. P	-0.1	0.1	-0.1	0.1	-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	0.1	0.1	-0.1	-0.1	0.0	0.0	0.0	0.0
Long. Bend. ML	0.2	-0.2	-0.2	0.2	0.0	0.0	0.0	0.0
Tot. Long. Str.	0.2	-0.1	-0.3	0.2	-0.1	0.0	-0.1	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	-0.0	-0.0	0.0	0.0
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	-0.0	-0.0	0.0	0.0
Str. Int.	0.2	0.1	0.3	0.2	0.1	0.1	0.1	0.1

Dimensionless Parameters used : Gamma = 23.88
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	-0.1	-0.1	-0.1	-0.1	-0.0	-0.0	-0.0	-0.0
Circ. Bend. P	-0.0	0.0	-0.0	0.0	-0.2	0.2	-0.2	0.2
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	0.2	0.2	-0.2	-0.2	0.0	0.0	0.0	0.0
Circ. Bend. ML	0.2	-0.2	-0.2	0.2	0.0	0.0	0.0	0.0
Tot. Circ. Str.	0.2	-0.0	-0.4	-0.0	-0.3	0.2	-0.3	0.2
Long. Memb. P	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1	-0.1
Long. Bend. P	-0.1	0.1	-0.1	0.1	-0.1	0.1	-0.1	0.1
Long. Memb. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Bend. MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Long. Memb. ML	0.1	0.1	-0.1	-0.1	0.0	0.0	0.0	0.0
Long. Bend. ML	0.3	-0.3	-0.3	0.3	0.0	0.0	0.0	0.0
Tot. Long. Str.	0.3	-0.2	-0.5	0.3	-0.2	0.1	-0.2	0.1
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	-0.0	-0.0	0.0	0.0
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	-0.0	-0.0	0.0	0.0
Str. Int.	0.3	0.2	0.5	0.3	0.3	0.2	0.3	0.2

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)	8.6	9.3	8.6	9.3	8.6	9.3	8.6	9.3
Circ. Pm (OCC)	2.7	3.0	2.7	3.0	2.7	3.0	2.7	3.0
Circ. Pm(TOTAL)	11.3	12.3	11.3	12.3	11.3	12.3	11.3	12.3
Circ. Pl (SUS)	0.2	0.2	-0.2	-0.2	0.0	0.0	0.0	0.0
Circ. Pl (OCC)	0.1	0.1	-0.1	-0.1	-0.0	-0.0	-0.0	-0.0
Circ. Pl(TOTAL)	0.3	0.3	-0.3	-0.3	-0.0	-0.0	-0.0	-0.0
Circ. Q (SUS)	0.3	-0.3	-0.3	0.3	0.0	0.0	0.0	0.0
Circ. Q (OCC)	0.1	-0.1	-0.2	0.2	-0.1	0.1	-0.1	0.1
Circ. Q (TOTAL)	0.4	-0.4	-0.5	0.5	-0.1	0.1	-0.1	0.1
Long. Pm (SUS)	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
Long. Pm (OCC)	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Long. Pm(TOTAL)	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
Long. Pl (SUS)	0.1	0.1	-0.1	-0.1	0.0	0.0	0.0	0.0
Long. Pl (OCC)	0.0	0.0	-0.1	-0.1	-0.0	-0.0	-0.0	-0.0
Long. Pl(TOTAL)	0.1	0.1	-0.2	-0.2	-0.0	-0.0	-0.0	-0.0
Long. Q (SUS)	0.4	-0.4	-0.4	0.4	0.0	0.0	0.0	0.0
Long. Q (OCC)	0.2	-0.2	-0.3	0.3	-0.0	0.0	-0.0	0.0
Long. Q (TOTAL)	0.5	-0.5	-0.7	0.7	-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 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	-0.3	-0.3	0.3	0.3
Shear Pl (OCC)	0.0	0.0	0.0	0.0	-0.0	-0.0	0.0	0.0
Shear Pl(TOTAL)	0.0	0.0	0.0	0.0	-0.3	-0.3	0.3	0.3
Shear Q (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Q (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Q (TOTAL)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pm (SUS)	8.6	9.3	8.6	9.3	8.6	9.3	8.6	9.3
Pm (SUS+OCC)	11.3	12.3	11.3	12.3	11.3	12.3	11.3	12.3
Pm+Pl (SUS)	8.8	9.5	8.4	9.2	8.6	9.4	8.6	9.4
Pm+Pl (SUS+OCC)	11.6	12.6	11.0	12.0	11.3	12.3	11.3	12.3
Pm+Pl+Q (Total)	12.0	12.2	10.5	12.5	11.2	12.4	11.2	12.4

Vessel Stress Summation Comparison (N./mm²):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	9.34	217.20	Passed
Pm (SUS+OCC)	12.29	260.64	Passed
Pm+Pl (SUS)	9.52	325.80	Passed
Pm+Pl (SUS+OCC)	12.56	390.96	Passed
Pm+Pl+Q (TOTAL)	12.46	651.60	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)	17.2	17.9	17.2	17.9	17.2	17.9	17.2	17.9
Circ. Pm (OCC)	5.4	5.7	5.4	5.7	5.4	5.7	5.4	5.7
Circ. Pm(TOTAL)	22.6	23.6	22.6	23.6	22.6	23.6	22.6	23.6
Circ. Pl (SUS)	0.3	0.3	-0.3	-0.3	0.0	0.0	0.0	0.0
Circ. Pl (OCC)	0.1	0.1	-0.2	-0.2	-0.0	-0.0	-0.0	-0.0
Circ. Pl(TOTAL)	0.4	0.4	-0.5	-0.5	-0.0	-0.0	-0.0	-0.0
Circ. Q (SUS)	0.3	-0.3	-0.3	0.3	0.0	0.0	0.0	0.0
Circ. Q (OCC)	0.1	-0.1	-0.2	0.2	-0.2	0.2	-0.2	0.2
Circ. Q (TOTAL)	0.5	-0.5	-0.5	0.5	-0.2	0.2	-0.2	0.2
Long. Pm (SUS)	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6
Long. Pm (OCC)	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
Long. Pm(TOTAL)	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3
Long. Pl (SUS)	0.2	0.2	-0.2	-0.2	0.0	0.0	0.0	0.0
Long. Pl (OCC)	0.1	0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
Long. Pl(TOTAL)	0.2	0.2	-0.3	-0.3	-0.1	-0.1	-0.1	-0.1
Long. Q (SUS)	0.6	-0.6	-0.6	0.6	0.0	0.0	0.0	0.0
Long. Q (OCC)	0.2	-0.2	-0.4	0.4	-0.1	0.1	-0.1	0.1
Long. Q (TOTAL)	0.8	-0.8	-0.9	0.9	-0.1	0.1	-0.1	0.1
Shear Pm (SUS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pm (OCC)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pm(TOTAL)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shear Pl (SUS)	0.0	0.0	0.0	0.0	-0.5	-0.5	0.5	0.5
Shear Pl (OCC)	0.0	0.0	0.0	0.0	-0.0	-0.0	0.0	0.0
Shear Pl(TOTAL)	0.0	0.0	0.0	0.0	-0.6	-0.6	0.6	0.6
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)	17.2	17.9	17.2	17.9	17.2	17.9	17.2	17.9
Pm (SUS+OCC)	22.6	23.6	22.6	23.6	22.6	23.6	22.6	23.6
Pm+Pl (SUS)	17.5	18.2	16.9	17.6	17.2	17.9	17.2	17.9
Pm+Pl (SUS+OCC)	23.0	24.0	22.1	23.1	22.6	23.6	22.6	23.6
Pm+Pl+Q (Total)	23.5	23.5	21.5	23.6	22.4	23.8	22.4	23.8

Vessel Stress Summation Comparison (N./mm²):

Type of Stress Int.	Max. S.I.	S.I. Allowable	Result
Pm (SUS)	17.92	217.20	Passed
Pm (SUS+OCC)	23.59	260.64	Passed
Pm+Pl (SUS)	18.22	325.80	Passed
Pm+Pl (SUS+OCC)	24.00	390.96	Passed
Pm+Pl+Q (TOTAL)	23.82	651.60	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-283 C	
Baseplate Allowable Stress	SBA	108.25	N./mm²
Baseplate Length	B	200.0000	mm.
Baseplate Width	D	200.0000	mm.
Baseplate Thickness	BTHK	18.0000	mm.
Leg Dimension Along Baseplate Length	d	79.9998	mm.
Leg Dimension Along Baseplate Width	b	79.9998	mm.
Bolt Circle Diameter	BCD	410.6000	mm.
Bolt Material		SA-325	
Bolt Allowable Tensile Stress	STBA	300.00	N./mm²
Bolt Allowable Shear Stress	SBShear	180.00	N./mm²
Anchor Bolt Nominal Diameter	BOD	20.0000	mm.
Number of Anchor Bolts in Tension per Leg	NB	1	
Total Number of Anchors Bolt per Leg	NBT	1	
Ultimate 28-day Concrete Strength	FCPRIME	20.685	N./mm²

Shear Stress in a Single Bolt [taub]:
= Shear Force / (2 * Bolt Area * Number of Bolts)
= 1.63/(2 * 2.17 * 1)
= 3.8 N./mm². Must be less than 180.0 N./mm².

Plate thickness required (5/8"; 16mm) per D. Moss

Since there is only 1 bolt, the standard computation for this

geometry is not possible. A reasonable bolt size should be selected. Per Megyesy, use a 1 inch (25.4 mm) bolt.

Input, Nozzle Desc: N04 (1in) **From: 10**

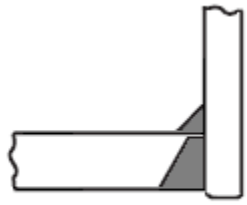
Pressure for Reinforcement Calculations	P	7.642	bars
Temperature for Internal Pressure	Temp	100	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material		SA-234 WPB	
Shell Allowable Stress at Temperature	Sv	117.90	N./mm²
Shell Allowable Stress At Ambient	Sva	117.90	N./mm²
Inside Diameter of Elliptical Head	D	387.35	mm.
Aspect Ratio of Elliptical Head	Ar	2.00	
Head Finished (Minimum) Thickness	t	9.5250	mm.
Head Internal Corrosion Allowance	c	6.0000	mm.
Head External Corrosion Allowance	co	0.0000	mm.
Distance from Head Centerline	L1	0.0000	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

Type of Element Connected to the Shell : Nozzle

Material		SA-105	
Material UNS Number		K03504	
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)		ID	
Layout Angle		0.00	deg
Diameter		1.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	12.7000	mm.
Flange Material		SA-105	
Flange Type		Long Weld Neck	
Corrosion Allowance	can	6.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	150.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	8.3344	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.

Nozzle Sketch (may not represent actual weld type/configuration)



Insert/Set-in Nozzle No Pad, no Inside projection

Reinforcement CALCULATION, Description: N04 (1in)

ASME Code, Section VIII, Div. 1, 2019, UG-37 to UG-45

```
Actual Inside Diameter Used in Calculation          1.000  in.
Actual Thickness Used in Calculation                0.500  in.
```

Note:
Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

```
= (P*K1*D))/(2*Sv*E-0.2*P) per UG-37(a)(3)
= (7.64*0.88*399)/(2 *118*1-0.2*7.64)
= 1.1333 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)
= (7.64*18.7)/(138*1-0.6*7.64)
= 0.1040 mm.
```

Required Nozzle thickness under External Pressure per UG-28 : 0.2564 mm.

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

```
Parallel to Vessel Wall (Diameter Limit)          Dl    74.8000  mm.
Parallel to Vessel Wall, opening length            d    37.4000  mm.
Normal to Vessel Wall (Thickness Limit), no pad  Tlnp    8.8125  mm.
```

Weld Strength Reduction Factor [fr1]:

```
= min( 1, Sn/Sv )
= min( 1, 138/118 )
= 1.000
```

Weld Strength Reduction Factor [fr2]:

```
= min( 1, Sn/Sv )
= min( 1, 138/118 )
```

= 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	0.424	0.280	NA
Area in Shell	A1	0.895	0.757	NA
Area in Nozzle Wall	A2	1.163	1.136	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	0.986	0.986	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	3.043	2.879	NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Sufficient.

Area Required [A]:
= 0.5(d * tr*F + 2 * tn * tr*F(1-fr1)) per UG-37(d)
= 0.5(37.4*1.5*1+2*6.7*1.5*1(1-1))
= 0.280 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)
= 37.4 (1 * 3.52 - 1 * 1.5) - 2 * 6.7
(1 * 3.52 - 1 * 1.5) * (1 - 1)
= 0.757 cm²

Area Available in Nozzle Projecting Outward [A2]:
= (2 * tlnp)(tn - trn)fr2
= (2 * 8.81)(6.7 - 0.26)1
= 1.136 cm²

Area Available in Inward Weld + Outward Weld [A41 + A43]:
= (Wo² - Area Lost)*fr2 + ((Wi-can/0.707)² - Area Lost)*fr2
= (10² - 0.014) * 1 + (0² -0) * 1
= 0.986 cm²

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

Wall Thickness for Internal/External pressures ta = 6.2564 mm.
Wall Thickness per UG16(b), tr16b = 7.5000 mm.
Wall Thickness, shell/head, internal pressure trb1 = 7.2455 mm.
Wall Thickness tb1 = max(trb1, tr16b) = 7.5000 mm.
Wall Thickness tb2 = max(trb2, tr16b) = 7.5000 mm.

```
Wall Thickness per table UG-45                    tb3 = 9.4200 mm.
```

Determine Nozzle Thickness candidate [tb]:

```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 9.42, max( 7.5, 7.5 ) ]
  = 7.5000 mm.
```

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

```
  = max( ta, tb )
  = max( 6.26, 7.5 )
  = 7.5000 mm.
```

Available Nozzle Neck Thickness = 12.7000 mm. --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

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

Govrn. thk, tg = 9.52, tr = 1.13, c = 6 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.32, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve A          -8 °C
Min Metal Temp. at Required thickness (UCS 66.1)      -104 °C
Min Metal Temp. w/o impact per UG-20(f)                -29 °C

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

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c)     -29 °C
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b)       -48 °C
```

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

```
Design Pressure/Ambient Rating = 7.64/19.60 = 0.390
```

Weld Size Calculations, Description: N04 (1in)

```
Intermediate Calc. for nozzle/shell Welds   Tmin      3.5250  mm.
```

Results Per UW-16.1:

```
                      Required Thickness    Actual Thickness
Nozzle Weld          2.4675 = 0.7 * tmin.  7.0700 = 0.7 * Wo mm.
```

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

Weld Load [W]:

```
  = max( 0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)
  = max( 0, (0.28 - 0.76 + 2 * 6.7 * 1 *
    (1 * 3.52 - 1.5 ) )118 )
  = max( 0, -2.42) kN
```

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

Weld Load [W1]:

```
= (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
= ( 1.14 + 0 + 0.99 - 0 * 1 ) * 118
= 25.01 kN
```

Weld Load [W2]:

```
= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
= ( 1.14 + 0 + 0.99 + ( 0.47 ) ) * 118
= 30.58 kN
```

Weld Load [W3]:

```
= (A2+A3+A4+A5+(2*tn*t*fr1))*S
= ( 1.14 + 0 + 0.99 + 0 + ( 0.47 ) ) * 118
= 30.58 kN
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

```
= (pi/2) * Dlo * Wo * 0.49 * Snw
= ( 3.14/2.0 ) * 50.8 * 10 * 0.49 * 118
= 46. kN
```

Shear, Nozzle Wall [Snw]:

```
= (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
= (3.14 * 22 ) * ( 12.7 - 6 ) * 0.7 * 138
= 45. kN
```

Tension, Shell Groove Weld [Tngw]:

```
= (pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
= ( 3.14/2.0 ) * 50.8 * ( 8.33 - 6 ) * 0.74 * 138
= 19. kN
```

Strength of Failure Paths:

```
PATH11 = ( SONW + SNW ) = ( 46.1 + 44.8 ) = 90.9 kN
PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
       = ( 46.1 + 0 + 19 + 0 ) = 65.1 kN
PATH33 = ( Sonw + Tngw + Sinw )
       = ( 46.1 + 19 + 0 ) = 65.1 kN
```

Summary of Failure Path Calculations:

```
Path 1-1 = 90 kN , must exceed W = 0 kN  or W1 = 25 kN
Path 2-2 = 65 kN , must exceed W = 0 kN  or W2 = 30 kN
Path 3-3 = 65 kN , must exceed W = 0 kN  or W3 = 30 kN
```

Maximum Allowable Pressure for this Nozzle at this Location:

```
 Converged Max. Allow. Pressure in Operating case   20.6  bars
```

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

```
 Nozzle is O.K. for the External Pressure           1.03  bars
```

The Drop for this Nozzle is : 0.9067 mm.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 160.4317 mm.

Input, Nozzle Desc: N02 (1in) **From: 20**

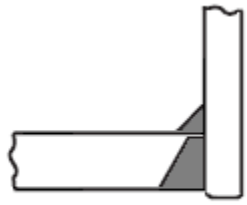
Pressure for Reinforcement Calculations	P	7.618	bars
Temperature for Internal Pressure	Temp	100	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material		SA-106 B	
Shell Allowable Stress at Temperature	Sv	117.90	N./mm²
Shell Allowable Stress At Ambient	Sva	117.90	N./mm²
Inside Diameter of Cylindrical Shell	D	387.35	mm.
Design Length of Section	L	1382.2792	mm.
Shell Finished (Minimum) Thickness	t	8.3344	mm.
Shell Internal Corrosion Allowance	c	6.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		150.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

Type of Element Connected to the Shell : Nozzle

Material		SA-105	
Material UNS Number		K03504	
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)		ID	
Layout Angle		0.00	deg
Diameter		1.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	12.7000	mm.
Flange Material		SA-105	
Flange Type		Long Weld Neck	
Corrosion Allowance	can	6.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	150.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	8.3344	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.

Nozzle Sketch (may not represent actual weld type/configuration)



Insert/Set-in Nozzle No Pad, no Inside projection

Reinforcement CALCULATION, Description: N02 (1in)

ASME Code, Section VIII, Div. 1, 2019, UG-37 to UG-45

```
Actual Inside Diameter Used in Calculation          1.000  in.
Actual Thickness Used in Calculation                0.500  in.
```

Note:
Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

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)
= (7.62*200)/(118*1-0.6*7.62)
= 1.2952 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)
= (7.62*18.7)/(138*1-0.6*7.62)
= 0.1036 mm.
```

Required Nozzle thickness under External Pressure per UG-28 : 0.2564 mm.

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

```
Parallel to Vessel Wall (Diameter Limit)          Dl    74.8000  mm.
Parallel to Vessel Wall, opening length            d    37.4000  mm.
Normal to Vessel Wall (Thickness Limit), no pad  Tlnp    5.8359  mm.
```

Weld Strength Reduction Factor [fr1]:

```
= min( 1, Sn/Sv )
= min( 1, 138/118 )
= 1.000
```

Weld Strength Reduction Factor [fr2]:

```
= min( 1, Sn/Sv )
= min( 1, 138/118 )
```

= 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	0.484	0.405	NA
Area in Shell	A1	0.389	0.062	NA
Area in Nozzle Wall	A2	0.770	0.752	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	0.827	0.827	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	1.985	1.641	NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Sufficient.

Area Required [A]:
= 0.5(d * tr*F + 2 * tn * tr*F(1-fr1)) per UG-37(d)
= 0.5(37.4*2.17*1+2*6.7*2.17*1(1-1))
= 0.405 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)
= 37.4 (1 * 2.33 - 1 * 2.17) - 2 * 6.7
(1 * 2.33 - 1 * 2.17) * (1 - 1)
= 0.062 cm²

Area Available in Nozzle Projecting Outward [A2]:
= (2 * tlnp)(tn - trn)fr2
= (2 * 5.84)(6.7 - 0.26)1
= 0.752 cm²

Area Available in Inward Weld + Outward Weld [A41 + A43]:
= (Wo² - Area Lost)*fr2 + ((Wi-can/0.707)² - Area Lost)*fr2
= (10² - 0.17) * 1 + (0² -0) * 1
= 0.827 cm²

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

Wall Thickness for Internal/External pressures ta = 6.2564 mm.
Wall Thickness per UG16(b), tr16b = 7.5000 mm.
Wall Thickness, shell/head, internal pressure trb1 = 7.2952 mm.
Wall Thickness tb1 = max(trb1, tr16b) = 7.5000 mm.
Wall Thickness tb2 = max(trb2, tr16b) = 7.5000 mm.

```
Wall Thickness per table UG-45                    tb3 = 9.4200 mm.
```

Determine Nozzle Thickness candidate [tb]:

```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 9.42, max( 7.5, 7.5 ) ]
  = 7.5000 mm.
```

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

```
  = max( ta, tb )
  = max( 6.26, 7.5 )
  = 7.5000 mm.
```

Available Nozzle Neck Thickness = 12.7000 mm. --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

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

Govrn. thk, tg = 8.33, tr = 1.3, c = 6 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.55, Temp. Reduction = 26 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve A          -8 °C
Min Metal Temp. at Required thickness (UCS 66.1)       -34 °C
Min Metal Temp. w/o impact per UG-20(f)                -29 °C

Gov. MDMT of the nozzle to shell joint welded assembly :   -34 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c)     -29 °C
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b)       -48 °C
```

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

```
Design Pressure/Ambient Rating = 7.62/19.60 = 0.389
```

Weld Size Calculations, Description: N02 (1in)

```
Intermediate Calc. for nozzle/shell Welds   Tmin      3.5250  mm.
```

Results Per UW-16.1:

```
                      Required Thickness    Actual Thickness
Nozzle Weld          2.4675 = 0.7 * tmin.  7.0700 = 0.7 * Wo mm.
```

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

Weld Load [W]:

```
  = max( 0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)
  = max( 0, (0.41 - 0.062 + 2 * 6.7 * 1 *
    (1 * 2.33 - 2.17 ) )118 )
  = 4.31 kN
```

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

Weld Load [W1]:

```
  = (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
  = ( 0.75 + 0 + 0.83 - 0 * 1 ) * 118
  = 18.61 kN
```

Weld Load [W2]:

```
  = (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
  = ( 0.75 + 0 + 0.83 + ( 0.31 ) ) * 118
  = 22.30 kN
```

Weld Load [W3]:

```
  = (A2+A3+A4+A5+(2*tn*t*fr1))*S
  = ( 0.75 + 0 + 0.83 + 0 + ( 0.31 ) ) * 118
  = 22.30 kN
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

```
  = (pi/2) * Dlo * Wo * 0.49 * Snw
  = ( 3.14/2.0 ) * 50.8 * 10 * 0.49 * 118
  = 46. kN
```

Shear, Nozzle Wall [Snw]:

```
  = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
  = (3.14 * 22 ) * ( 12.7 - 6 ) * 0.7 * 138
  = 45. kN
```

Tension, Shell Groove Weld [Tngw]:

```
  = (pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
  = ( 3.14/2.0 ) * 50.8 * ( 8.33 - 6 ) * 0.74 * 138
  = 19. kN
```

Strength of Failure Paths:

```
  PATH11 = ( SONW + SNW ) = ( 46.1 + 44.8 ) = 90.9 kN
  PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
         = ( 46.1 + 0 + 19 + 0 ) = 65.1 kN
  PATH33 = ( Sonw + Tngw + Sinw )
         = ( 46.1 + 19 + 0 ) = 65.1 kN
```

Summary of Failure Path Calculations:

```
 Path 1-1 = 90 kN , must exceed W = 4 kN  or W1 = 18 kN
 Path 2-2 = 65 kN , must exceed W = 4 kN  or W2 = 22 kN
 Path 3-3 = 65 kN , must exceed W = 4 kN  or W3 = 22 kN
```

Maximum Allowable Pressure for this Nozzle at this Location:

```
 Converged Max. Allow. Pressure in Operating case   13.6  bars
```

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

```
 Nozzle is O.K. for the External Pressure           1.03  bars
```

The Drop for this Nozzle is : 1.6728 mm.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 160.0072 mm.

Input, Nozzle Desc: N03 (1in) **From: 20**

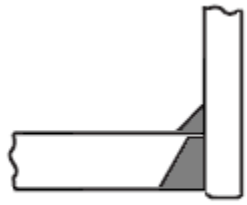
Pressure for Reinforcement Calculations	P	7.598	bars
Temperature for Internal Pressure	Temp	100	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material		SA-106 B	
Shell Allowable Stress at Temperature	Sv	117.90	N./mm²
Shell Allowable Stress At Ambient	Sva	117.90	N./mm²
Inside Diameter of Cylindrical Shell	D	387.35	mm.
Design Length of Section	L	1382.2792	mm.
Shell Finished (Minimum) Thickness	t	8.3344	mm.
Shell Internal Corrosion Allowance	c	6.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		350.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

Type of Element Connected to the Shell : Nozzle

Material		SA-105	
Material UNS Number		K03504	
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)		ID	
Layout Angle		180.00	deg
Diameter		1.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	12.7000	mm.
Flange Material		SA-105	
Flange Type		Long Weld Neck	
Corrosion Allowance	can	6.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	150.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	8.3344	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.

Nozzle Sketch (may not represent actual weld type/configuration)



Insert/Set-in Nozzle No Pad, no Inside projection

Reinforcement CALCULATION, Description: N03 (1in)

ASME Code, Section VIII, Div. 1, 2019, UG-37 to UG-45

```
Actual Inside Diameter Used in Calculation          1.000  in.
Actual Thickness Used in Calculation                0.500  in.
```

Note:
Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

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)
  = (7.6*200)/(118*1-0.6*7.6)
  = 1.2919 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)
  = (7.6*18.7)/(138*1-0.6*7.6)
  = 0.1034 mm.
```

Required Nozzle thickness under External Pressure per UG-28 : 0.2564 mm.

UG-40, Limits of Reinforcement : [Internal Pressure]
```
Parallel to Vessel Wall (Diameter Limit)          Dl    74.8000  mm.
Parallel to Vessel Wall, opening length            d    37.4000  mm.
Normal to Vessel Wall (Thickness Limit), no pad  Tlnp    5.8359  mm.
```

Weld Strength Reduction Factor [fr1]:
```
  = min( 1, Sn/Sv )
  = min( 1, 138/118 )
  = 1.000
```

Weld Strength Reduction Factor [fr2]:
```
  = min( 1, Sn/Sv )
  = min( 1, 138/118 )
```

= 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	0.483	0.405	NA
Area in Shell	A1	0.390	0.062	NA
Area in Nozzle Wall	A2	0.770	0.752	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	0.827	0.827	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	1.986	1.641	NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Sufficient.

Area Required [A]:
= 0.5(d * tr*F + 2 * tn * tr*F(1-fr1)) per UG-37(d)
= 0.5(37.4*2.17*1+2*6.7*2.17*1(1-1))
= 0.405 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)
= 37.4 (1 * 2.33 - 1 * 2.17) - 2 * 6.7
(1 * 2.33 - 1 * 2.17) * (1 - 1)
= 0.062 cm²

Area Available in Nozzle Projecting Outward [A2]:
= (2 * tlnp)(tn - trn)fr2
= (2 * 5.84)(6.7 - 0.26)1
= 0.752 cm²

Area Available in Inward Weld + Outward Weld [A41 + A43]:
= (Wo² - Area Lost)*fr2 + ((Wi-can/0.707)² - Area Lost)*fr2
= (10² - 0.17) * 1 + (0² -0) * 1
= 0.827 cm²

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

Wall Thickness for Internal/External pressures ta = 6.2564 mm.
Wall Thickness per UG16(b), tr16b = 7.5000 mm.
Wall Thickness, shell/head, internal pressure trb1 = 7.2919 mm.
Wall Thickness tb1 = max(trb1, tr16b) = 7.5000 mm.
Wall Thickness tb2 = max(trb2, tr16b) = 7.5000 mm.

```
Wall Thickness per table UG-45                    tb3 = 9.4200 mm.
```

Determine Nozzle Thickness candidate [tb]:

```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 9.42, max( 7.5, 7.5 ) ]
  = 7.5000 mm.
```

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

```
  = max( ta, tb )
  = max( 6.26, 7.5 )
  = 7.5000 mm.
```

Available Nozzle Neck Thickness = 12.7000 mm. --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

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

Govrn. thk, tg = 8.33, tr = 1.29, c = 6 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.55, Temp. Reduction = 26 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve A          -8 °C
Min Metal Temp. at Required thickness (UCS 66.1)       -34 °C
Min Metal Temp. w/o impact per UG-20(f)                -29 °C

Gov. MDMT of the nozzle to shell joint welded assembly :   -34 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c)     -29 °C
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b)       -48 °C
```

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

```
Design Pressure/Ambient Rating = 7.60/19.60 = 0.388
```

Weld Size Calculations, Description: N03 (1in)

```
Intermediate Calc. for nozzle/shell Welds   Tmin      3.5250  mm.
```

Results Per UW-16.1:

```
                      Required Thickness    Actual Thickness
Nozzle Weld          2.4675 = 0.7 * tmin.  7.0700 = 0.7 * Wo mm.
```

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

Weld Load [W]:

```
  = max( 0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)
  = max( 0, (0.41 - 0.062 + 2 * 6.7 * 1 *
    (1 * 2.33 - 2.17 ) )118 )
  = 4.31 kN
```

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

Weld Load [W1]:

```
  = (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
  = ( 0.75 + 0 + 0.83 - 0 * 1 ) * 118
  = 18.61 kN
```

Weld Load [W2]:

```
  = (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
  = ( 0.75 + 0 + 0.83 + ( 0.31 ) ) * 118
  = 22.30 kN
```

Weld Load [W3]:

```
  = (A2+A3+A4+A5+(2*tn*t*fr1))*S
  = ( 0.75 + 0 + 0.83 + 0 + ( 0.31 ) ) * 118
  = 22.30 kN
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

```
  = (pi/2) * Dlo * Wo * 0.49 * Snw
  = ( 3.14/2.0 ) * 50.8 * 10 * 0.49 * 118
  = 46. kN
```

Shear, Nozzle Wall [Snw]:

```
  = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
  = (3.14 * 22 ) * ( 12.7 - 6 ) * 0.7 * 138
  = 45. kN
```

Tension, Shell Groove Weld [Tngw]:

```
  = (pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
  = ( 3.14/2.0 ) * 50.8 * ( 8.33 - 6 ) * 0.74 * 138
  = 19. kN
```

Strength of Failure Paths:

```
  PATH11 = ( SONW + SNW ) = ( 46.1 + 44.8 ) = 90.9 kN
  PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
         = ( 46.1 + 0 + 19 + 0 ) = 65.1 kN
  PATH33 = ( Sonw + Tngw + Sinw )
         = ( 46.1 + 19 + 0 ) = 65.1 kN
```

Summary of Failure Path Calculations:

```
 Path 1-1 = 90 kN , must exceed W = 4 kN  or W1 = 18 kN
 Path 2-2 = 65 kN , must exceed W = 4 kN  or W2 = 22 kN
 Path 3-3 = 65 kN , must exceed W = 4 kN  or W3 = 22 kN
```

Maximum Allowable Pressure for this Nozzle at this Location:

```
 Converged Max. Allow. Pressure in Operating case    13.6  bars
```

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

```
 Nozzle is O.K. for the External Pressure            1.03  bars
```

The Drop for this Nozzle is : 1.6728 mm.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 160.0072 mm.

Input, Nozzle Desc: N01 (1in) **From: 20**

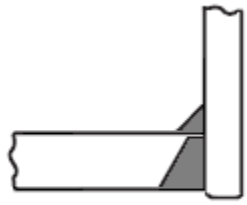
Pressure for Reinforcement Calculations	P	7.510	bars
Temperature for Internal Pressure	Temp	100	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material		SA-106 B	
Shell Allowable Stress at Temperature	Sv	117.90	N./mm²
Shell Allowable Stress At Ambient	Sva	117.90	N./mm²
Inside Diameter of Cylindrical Shell	D	387.35	mm.
Design Length of Section	L	1382.2792	mm.
Shell Finished (Minimum) Thickness	t	8.3344	mm.
Shell Internal Corrosion Allowance	c	6.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		1250.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

Type of Element Connected to the Shell : Nozzle

Material		SA-105	
Material UNS Number		K03504	
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)		ID	
Layout Angle		180.00	deg
Diameter		1.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	12.7000	mm.
Flange Material		SA-105	
Flange Type		Long Weld Neck	
Corrosion Allowance	can	6.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	150.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	8.3344	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.

Nozzle Sketch (may not represent actual weld type/configuration)



Insert/Set-in Nozzle No Pad, no Inside projection

Reinforcement CALCULATION, Description: N01 (1in)

ASME Code, Section VIII, Div. 1, 2019, UG-37 to UG-45

```
Actual Inside Diameter Used in Calculation          1.000  in.
Actual Thickness Used in Calculation                0.500  in.
```

Note:
Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

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)
  = (7.51*200)/(118*1-0.6*7.51)
  = 1.2768 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)
  = (7.51*18.7)/(138*1-0.6*7.51)
  = 0.1022 mm.
```

Required Nozzle thickness under External Pressure per UG-28 : 0.2564 mm.

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

```
Parallel to Vessel Wall (Diameter Limit)          Dl    74.8000  mm.
Parallel to Vessel Wall, opening length            d    37.4000  mm.
Normal to Vessel Wall (Thickness Limit), no pad  Tlnp    5.8359  mm.
```

Weld Strength Reduction Factor [fr1]:

```
  = min( 1, Sn/Sv )
  = min( 1, 138/118 )
  = 1.000
```

Weld Strength Reduction Factor [fr2]:

```
  = min( 1, Sn/Sv )
  = min( 1, 138/118 )
```

= 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	0.478	0.405	NA
Area in Shell	A1	0.396	0.062	NA
Area in Nozzle Wall	A2	0.770	0.752	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	0.827	0.827	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	1.992	1.641	NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Sufficient.

Area Required [A]:
= 0.5(d * tr*F + 2 * tn * tr*F(1-fr1)) per UG-37(d)
= 0.5(37.4*2.17*1+2*6.7*2.17*1(1-1))
= 0.405 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)
= 37.4 (1 * 2.33 - 1 * 2.17) - 2 * 6.7
(1 * 2.33 - 1 * 2.17) * (1 - 1)
= 0.062 cm²

Area Available in Nozzle Projecting Outward [A2]:
= (2 * tlnp)(tn - trn)fr2
= (2 * 5.84)(6.7 - 0.26)1
= 0.752 cm²

Area Available in Inward Weld + Outward Weld [A41 + A43]:
= (Wo² - Area Lost)*fr2 + ((Wi-can/0.707)² - Area Lost)*fr2
= (10² - 0.17) * 1 + (0² -0) * 1
= 0.827 cm²

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

Wall Thickness for Internal/External pressures ta = 6.2564 mm.
Wall Thickness per UG16(b), tr16b = 7.5000 mm.
Wall Thickness, shell/head, internal pressure trb1 = 7.2768 mm.
Wall Thickness tb1 = max(trb1, tr16b) = 7.5000 mm.
Wall Thickness tb2 = max(trb2, tr16b) = 7.5000 mm.

```
Wall Thickness per table UG-45                    tb3 = 9.4200 mm.
```

Determine Nozzle Thickness candidate [tb]:

```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 9.42, max( 7.5, 7.5 ) ]
  = 7.5000 mm.
```

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

```
  = max( ta, tb )
  = max( 6.26, 7.5 )
  = 7.5000 mm.
```

Available Nozzle Neck Thickness = 12.7000 mm. --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

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

Govrn. thk, tg = 8.33, tr = 1.28, c = 6 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.55, Temp. Reduction = 27 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve A          -8 °C
Min Metal Temp. at Required thickness (UCS 66.1)       -35 °C
Min Metal Temp. w/o impact per UG-20(f)                -29 °C

Gov. MDMT of the nozzle to shell joint welded assembly :   -35 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c)     -29 °C
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b)       -48 °C
```

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

```
Design Pressure/Ambient Rating = 7.51/19.60 = 0.383
```

Weld Size Calculations, Description: N01 (1in)

```
Intermediate Calc. for nozzle/shell Welds   Tmin      3.5250  mm.
```

Results Per UW-16.1:

```
                      Required Thickness    Actual Thickness
Nozzle Weld          2.4675 = 0.7 * tmin.  7.0700 = 0.7 * Wo mm.
```

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

Weld Load [W]:

```
  = max( 0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)
  = max( 0, (0.41 - 0.062 + 2 * 6.7 * 1 *
    (1 * 2.33 - 2.17 ) )118 )
  = 4.31 kN
```

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

Weld Load [W1]:

```
  = (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
  = ( 0.75 + 0 + 0.83 - 0 * 1 ) * 118
  = 18.61 kN
```

Weld Load [W2]:

```
  = (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
  = ( 0.75 + 0 + 0.83 + ( 0.31 ) ) * 118
  = 22.30 kN
```

Weld Load [W3]:

```
  = (A2+A3+A4+A5+(2*tn*t*fr1))*S
  = ( 0.75 + 0 + 0.83 + 0 + ( 0.31 ) ) * 118
  = 22.30 kN
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

```
  = (pi/2) * Dlo * Wo * 0.49 * Snw
  = ( 3.14/2.0 ) * 50.8 * 10 * 0.49 * 118
  = 46. kN
```

Shear, Nozzle Wall [Snw]:

```
  = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
  = (3.14 * 22 ) * ( 12.7 - 6 ) * 0.7 * 138
  = 45. kN
```

Tension, Shell Groove Weld [Tngw]:

```
  = (pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
  = ( 3.14/2.0 ) * 50.8 * ( 8.33 - 6 ) * 0.74 * 138
  = 19. kN
```

Strength of Failure Paths:

```
  PATH11 = ( SONW + SNW ) = ( 46.1 + 44.8 ) = 90.9 kN
  PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
         = ( 46.1 + 0 + 19 + 0 ) = 65.1 kN
  PATH33 = ( Sonw + Tngw + Sinw )
         = ( 46.1 + 19 + 0 ) = 65.1 kN
```

Summary of Failure Path Calculations:

```
 Path 1-1 = 90 kN , must exceed W = 4 kN  or W1 = 18 kN
 Path 2-2 = 65 kN , must exceed W = 4 kN  or W2 = 22 kN
 Path 3-3 = 65 kN , must exceed W = 4 kN  or W3 = 22 kN
```

Maximum Allowable Pressure for this Nozzle at this Location:

```
 Converged Max. Allow. Pressure in Operating case    13.5  bars
```

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

```
 Nozzle is O.K. for the External Pressure            1.03  bars
```

The Drop for this Nozzle is : 1.6728 mm.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 160.0072 mm.

Input, Nozzle Desc: N06 (1in) **From: 20**

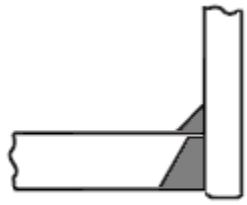
Pressure for Reinforcement Calculations	P	7.510	bars
Temperature for Internal Pressure	Temp	100	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material		SA-106 B	
Shell Allowable Stress at Temperature	Sv	117.90	N./mm²
Shell Allowable Stress At Ambient	Sva	117.90	N./mm²
Inside Diameter of Cylindrical Shell	D	387.35	mm.
Design Length of Section	L	1382.2792	mm.
Shell Finished (Minimum) Thickness	t	8.3344	mm.
Shell Internal Corrosion Allowance	c	6.0000	mm.
Shell External Corrosion Allowance	co	0.0000	mm.
Distance from Bottom/Left Tangent		1250.00	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

Type of Element Connected to the Shell : Nozzle

Material		SA-105	
Material UNS Number		K03504	
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)		ID	
Layout Angle		0.00	deg
Diameter		1.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	12.7000	mm.
Flange Material		SA-105	
Flange Type		Long Weld Neck	
Corrosion Allowance	can	6.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	150.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	8.3344	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.

Nozzle Sketch (may not represent actual weld type/configuration)



Insert/Set-in Nozzle No Pad, no Inside projection

Reinforcement CALCULATION, Description: N06 (1in)

ASME Code, Section VIII, Div. 1, 2019, UG-37 to UG-45

```
Actual Inside Diameter Used in Calculation          1.000  in.
Actual Thickness Used in Calculation                0.500  in.
```

Note:
Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

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)
= (7.51*200)/(118*1-0.6*7.51)
= 1.2768 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)
= (7.51*18.7)/(138*1-0.6*7.51)
= 0.1022 mm.
```

Required Nozzle thickness under External Pressure per UG-28 : 0.2564 mm.

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

```
Parallel to Vessel Wall (Diameter Limit)          Dl    74.8000  mm.
Parallel to Vessel Wall, opening length            d    37.4000  mm.
Normal to Vessel Wall (Thickness Limit), no pad  Tlnp    5.8359  mm.
```

Weld Strength Reduction Factor [fr1]:

```
= min( 1, Sn/Sv )
= min( 1, 138/118 )
= 1.000
```

Weld Strength Reduction Factor [fr2]:

```
= min( 1, Sn/Sv )
= min( 1, 138/118 )
```

= 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	0.478	0.405	NA
Area in Shell	A1	0.396	0.062	NA
Area in Nozzle Wall	A2	0.770	0.752	NA
Area in Inward Nozzle	A3	0.000	0.000	NA
Area in Welds	A41+A42+A43	0.827	0.827	NA
Area in Element	A5	0.000	0.000	NA
TOTAL AREA AVAILABLE	Atot	1.992	1.641	NA

The External Pressure Case Governs the Analysis.

Nozzle Angle Used in Area Calculations 90.00 Degs.

The area available without a pad is Sufficient.

Area Required [A]:
= 0.5(d * tr*F + 2 * tn * tr*F(1-fr1)) per UG-37(d)
= 0.5(37.4*2.17*1+2*6.7*2.17*1(1-1))
= 0.405 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)
= 37.4 (1 * 2.33 - 1 * 2.17) - 2 * 6.7
(1 * 2.33 - 1 * 2.17) * (1 - 1)
= 0.062 cm²

Area Available in Nozzle Projecting Outward [A2]:
= (2 * tlnp)(tn - trn)fr2
= (2 * 5.84)(6.7 - 0.26)1
= 0.752 cm²

Area Available in Inward Weld + Outward Weld [A41 + A43]:
= (Wo² - Area Lost)*fr2 + ((Wi-can/0.707)² - Area Lost)*fr2
= (10² - 0.17) * 1 + (0² -0) * 1
= 0.827 cm²

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

Wall Thickness for Internal/External pressures ta = 6.2564 mm.
Wall Thickness per UG16(b), tr16b = 7.5000 mm.
Wall Thickness, shell/head, internal pressure trb1 = 7.2768 mm.
Wall Thickness tb1 = max(trb1, tr16b) = 7.5000 mm.
Wall Thickness tb2 = max(trb2, tr16b) = 7.5000 mm.

```
Wall Thickness per table UG-45                    tb3 = 9.4200 mm.
```

Determine Nozzle Thickness candidate [tb]:

```
  = min[ tb3, max( tb1,tb2) ]
  = min[ 9.42, max( 7.5, 7.5 ) ]
  = 7.5000 mm.
```

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

```
  = max( ta, tb )
  = max( 6.26, 7.5 )
  = 7.5000 mm.
```

Available Nozzle Neck Thickness = 12.7000 mm. --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

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

Govrn. thk, tg = 8.33, tr = 1.28, c = 6 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.55, Temp. Reduction = 27 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve A          -8 °C
Min Metal Temp. at Required thickness (UCS 66.1)       -35 °C
Min Metal Temp. w/o impact per UG-20(f)                -29 °C

Gov. MDMT of the nozzle to shell joint welded assembly :   -35 °C
```

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c)     -29 °C
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b)       -48 °C
```

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

```
Design Pressure/Ambient Rating = 7.51/19.60 = 0.383
```

Weld Size Calculations, Description: N06 (1in)

```
Intermediate Calc. for nozzle/shell Welds   Tmin      3.5250  mm.
```

Results Per UW-16.1:

```
                      Required Thickness    Actual Thickness
Nozzle Weld          2.4675 = 0.7 * tmin.  7.0700 = 0.7 * Wo mm.
```

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

Weld Load [W]:

```
  = max( 0, (A-A1+2*tn*fr1*(E1*t-tr))Sv)
  = max( 0, (0.41 - 0.062 + 2 * 6.7 * 1 *
    (1 * 2.33 - 2.17 ) )118 )
  = 4.31 kN
```

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

Weld Load [W1]:

```
= (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
= ( 0.75 + 0 + 0.83 - 0 * 1 ) * 118
= 18.61 kN
```

Weld Load [W2]:

```
= (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
= ( 0.75 + 0 + 0.83 + ( 0.31 ) ) * 118
= 22.30 kN
```

Weld Load [W3]:

```
= (A2+A3+A4+A5+(2*tn*t*fr1))*S
= ( 0.75 + 0 + 0.83 + 0 + ( 0.31 ) ) * 118
= 22.30 kN
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

```
= (pi/2) * Dlo * Wo * 0.49 * Snw
= ( 3.14/2.0 ) * 50.8 * 10 * 0.49 * 118
= 46. kN
```

Shear, Nozzle Wall [Snw]:

```
= (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
= (3.14 * 22 ) * ( 12.7 - 6 ) * 0.7 * 138
= 45. kN
```

Tension, Shell Groove Weld [Tngw]:

```
= (pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
= ( 3.14/2.0 ) * 50.8 * ( 8.33 - 6 ) * 0.74 * 138
= 19. kN
```

Strength of Failure Paths:

```
PATH11 = ( SONW + SNW ) = ( 46.1 + 44.8 ) = 90.9 kN
PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
       = ( 46.1 + 0 + 19 + 0 ) = 65.1 kN
PATH33 = ( Sonw + Tngw + Sinw )
       = ( 46.1 + 19 + 0 ) = 65.1 kN
```

Summary of Failure Path Calculations:

```
Path 1-1 = 90 kN , must exceed W = 4 kN  or W1 = 18 kN
Path 2-2 = 65 kN , must exceed W = 4 kN  or W2 = 22 kN
Path 3-3 = 65 kN , must exceed W = 4 kN  or W3 = 22 kN
```

Maximum Allowable Pressure for this Nozzle at this Location:

```
 Converged Max. Allow. Pressure in Operating case   13.5  bars
```

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

```
 Nozzle is O.K. for the External Pressure           1.03  bars
```

The Drop for this Nozzle is : 1.6728 mm.
The Cut Length for this Nozzle is, Drop + Ho + H + T : 160.0072 mm.

Input, Nozzle Desc: N05 (1in) **From: 40**

Pressure for Reinforcement Calculations	P	7.500	bars
Temperature for Internal Pressure	Temp	100	°C
Design External Pressure	Pext	1.03	bars
Temperature for External Pressure	Tempex	100	°C
Shell Material		SA-105	
Shell Allowable Stress at Temperature	Sv	137.90	N./mm²
Shell Allowable Stress At Ambient	Sva	137.90	N./mm²
Outside Diameter of Bolted Blind Flange	D	596.90	mm.
Head Finished (Minimum) Thickness	t	36.5760	mm.
Head Internal Corrosion Allowance	c	6.0000	mm.
Head External Corrosion Allowance	co	0.0000	mm.
Distance from Head Centerline	L1	0.0000	mm.
User Entered Minimum Design Metal Temperature		5.00	°C

Type of Element Connected to the Shell : Nozzle

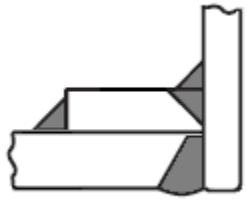
Material		SA-105	
Material UNS Number		K03504	
Material Specification/Type		Forgings	
Allowable Stress at Temperature	Sn	137.90	N./mm²
Allowable Stress At Ambient	Sna	137.90	N./mm²
Diameter Basis (for tr calc only)		ID	
Layout Angle		0.00	deg
Diameter		1.0000	in.
Size and Thickness Basis		Actual	
Actual Thickness	tn	12.7000	mm.
Flange Material		SA-105	
Flange Type		Long Weld Neck	
Corrosion Allowance	can	6.0000	mm.
Joint Efficiency of Shell Seam at Nozzle	E1	1.00	
Joint Efficiency of Nozzle Neck	En	1.00	
Outside Projection	ho	200.0000	mm.
Weld leg size between Nozzle and Pad/Shell	Wo	10.0000	mm.
Groove weld depth between Nozzle and Vessel	Wgnv	12.0000	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	150.0000	mm.
Thickness of Pad	te	8.0000	mm.
Weld leg size between Pad and Shell	Wp	8.0000	mm.

```
Groove weld depth between Pad and Nozzle    Wgpn       8.0000  mm.
Reinforcing Pad Width                                 49.6000  mm.

Flange Class                                          150
Flange Grade                                          GR 1.1
```

The Pressure Design option was Design Pressure + static head.

Nozzle Sketch (may not represent actual weld type/configuration)



Insert/Set-in Nozzle With Pad, no Inside projection

Reinforcement CALCULATION, Description: N05 (1in)

ASME Code, Section VIII, Div. 1, 2019, UG-37 to UG-45

```
Actual Inside Diameter Used in Calculation            1.000  in.
Actual Thickness Used in Calculation                  0.500  in.
```

Note:
Post Weld Heat Treatment is required for this nozzle and it was specified as being heat treated.

Nozzle input data check completed without errors.

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

```
  = (P*R)/(Sn*E-0.6*P) per UG-27 (c)(1)
  = (7.5*18.7)/(138*1-0.6*7.5)
  = 0.1020 mm.
```

Required Nozzle thickness under External Pressure per UG-28 : 0.2877 mm.

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

```
Parallel to Vessel Wall (Diameter Limit)            Dl   111.9520  mm.
Parallel to Vessel Wall                        Rn+tn+t    55.9760  mm.
Normal to Vessel Wall (Thickness Limit), pad side Tlwp    24.7500  mm.
```

Note: The Pad diameter is greater than the Diameter Limit. The excess will not be considered.

Weld Strength Reduction Factor [fr1]:

```
  = min( 1, Sn/Sv )
  = min( 1, 138/138 )
```

= 1.000

Weld Strength Reduction Factor [fr2]:
= min(1, Sn/Sv)
= min(1, 138/138)
= 1.000

Weld Strength Reduction Factor [fr4]:
= min(1, Sp/Sv)
= min(1, 138/138)
= 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	5.718	NA	NA
Area in Shell	A1	0.000	NA	NA
Area in Nozzle Wall	A2	3.266	NA	NA
Area in Inward Nozzle	A3	0.000	NA	NA
Area in Welds	A41+A42+A43	1.000	NA	NA
Area in Element	A5	4.892	NA	NA
TOTAL AREA AVAILABLE	Atot	9.158	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:	68.9465	8.0000	mm.
Based on given Pad Diameter:	150.0000	2.3740	mm.
Based on Shell or Nozzle Thickness:	62.2309	12.7000	mm.

Area Required [A]:
= 0.5 * d * t + t * tn(1-fr1) per UG-39(a)(1)
= 0.5*37.4*30.6+30.6*6.7(1-1)
= 5.718 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)
= 74.6 (1 * 30.6 - 1 * 30.6) - 2 * 6.7
(1 * 30.6 - 1 * 30.6) * (1 - 1)
= 0.000 cm²

Area Available in Nozzle Wall Projecting Outward [A2]:

```
= ( 2 * Tlwp ) * ( tn - trn ) * fr2
= ( 2 * 24.8 ) * ( 6.7 - 0.1 ) * 1
= 3.266 cm²
```

Area Available in Welds [A41 + A42 + A43]:

```
= Wo² * fr3 + (Wi-can/0.707)² * fr2 + Wp² * fr4
= 10² * 1 + (0 )² * 1 + 0² * 1
= 1.000 cm²
```

Area Available in Element [A5]:

```
= (min(Dp,DL)-(Nozzle OD))*(min(tp,Tlwp,te)) * fr4
= ( 112 - 50.8 ) * 8 * 1
= 4.892 cm²
```

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

```
Wall Thickness for Internal/External pressures      ta = 6.2877 mm.
Wall Thickness per UG16(b),                      tr16b = 7.5000 mm.
Wall Thickness, shell/head, internal pressure     trb1 = 36.5760 mm.
Wall Thickness                tb1 = max(trb1, tr16b) = 36.5760 mm.
Wall Thickness                tb2 = max(trb2, tr16b) = 7.5000 mm.
Wall Thickness per table UG-45                  tb3 = 9.4200 mm.
```

Determine Nozzle Thickness candidate [tb]:

```
= min[ tb3, max( tb1,tb2) ]
= min[ 9.42, max( 36.6, 7.5 ) ]
= 9.4200 mm.
```

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

```
= max( ta, tb )
= max( 6.29, 9.42 )
= 9.4200 mm.
```

Available Nozzle Neck Thickness = 12.7000 mm. --> OK

Nozzle Junction Minimum Design Metal Temperature (MDMT) Calculations:

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

Govrn. thk, tg = 8, c = 6 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.053, Temp. Reduction = 78 °C
Pad governing, Conservatively assuming Pad stress = Shell stress(Div. 1 L-9.3).

```
Min Metal Temp. w/o impact per UCS-66, Curve A          -8 °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 = 8, c = 6 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.053, Temp. Reduction = 78 °C
Pad governing, Conservatively assuming Pad stress = Shell stress(Div. 1 L-9.3).

```
Min Metal Temp. w/o impact per UCS-66, Curve B          -29 °C
```

```
Min Metal Temp. at Required thickness (UCS 66.1)          -104 °C
```

Shell to Pad Weld Junction at Pad OD, min(Curve:B, Curve:A)

Govrn. thk, tg = 8, c = 6 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.053, Temp. Reduction = 78 °C
Pad governing, Conservatively assuming Pad stress = Shell stress(Div. 1 L-9.3).

```
Min Metal Temp. w/o impact per UCS-66, Curve A              -8 °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-Shell/Head Weld (UCS-66(a)1(b)), Curve: A

Govrn. thk, tg = 12.7, tr = 0.1, c = 6 mm., E* = 1
Thickness Ratio = tr * (E*)/(tg - c) = 0.015, Temp. Reduction = 78 °C

```
Min Metal Temp. w/o impact per UCS-66, Curve A              -1 °C
Min Metal Temp. at Required thickness (UCS 66.1)          -104 °C
Min Metal Temp. w/o impact per UG-20(f)                    -29 °C

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

ANSI Flange MDMT including Temperature reduction per UCS-66.1:

```
Unadjusted MDMT of ANSI B16.5/47 flanges per UCS-66(c)     -18 °C
Flange MDMT with Temp reduction per UCS-66(b)(1)(-b)       -48 °C
```

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

```
Design Pressure/Ambient Rating = 7.50/19.60 = 0.383
```

Weld Size Calculations, Description: N05 (1in)

```
Intermediate Calc. for nozzle/shell Welds   Tmin      6.7000  mm.
Intermediate Calc. for pad/shell Welds   TminPad      8.0000  mm.
```

Results Per UW-16.1:

```
                    Required Thickness    Actual Thickness
Nozzle Weld        4.6900 = 0.7 * tmin.  7.0700 = 0.7 * Wo mm.
Pad Weld           4.0000 = 0.5*TminPad  5.6560 = 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, (5.72 - 0 + 2 * 6.7 * 1 *
    (1 * 30.6 - 30.6 ) )138 )
  = 78.84 kN
```

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

Weld Load [W1]:

```
  = (A2+A5+A4-(Wi-Can/.707)²*fr2)*Sv
  = ( 3.27 + 4.89 + 1 - 0 * 1 ) * 138
  = 126.28 kN
```

Weld Load [W2]:

```
  = (A2 + A3 + A4 + (2 * tn * t * fr1)) * Sv
  = ( 3.27 + 0 + 1 + ( 4.1 ) ) * 138
  = 115.32 kN
```

Weld Load [W3]:

```
  = (A2+A3+A4+A5+(2*tn*t*fr1))*S
  = ( 3.27 + 0 + 1 + 4.89 + ( 4.1 ) ) * 138
  = 182.78 kN
```

Strength of Connection Elements for Failure Path Analysis

Shear, Outward Nozzle Weld [Sonw]:

```
  = (pi/2) * Dlo * Wo * 0.49 * Snw
  = ( 3.14/2.0 ) * 50.8 * 10 * 0.49 * 138
  = 54. kN
```

Shear, Pad Element Weld [Spew]:

```
  = (pi/2) * DP * WP * 0.49 * SEW
  = ( 3.14/2.0 ) * 150 * 8 * 0.49 * 138
  = 127. kN
```

Shear, Nozzle Wall [Snw]:

```
  = (pi *( Dlr + Dlo )/4 ) * ( Thk - Can ) * 0.7 * Sn
  = (3.14 * 22 ) * ( 12.7 - 6 ) * 0.7 * 138
  = 45. kN
```

Tension, Pad Groove Weld [Tpgw]:

```
  = ( pi/2) * Dlo * Wgpn * 0.74 * Seg
  =  (3.14/2 ) * 50.8 * 8 * 0.74 * 138
  = 65. kN
```

Tension, Shell Groove Weld [Tngw]:

```
  = (pi/2) * Dlo * (Wgnvi-Cas) * 0.74 * Sng
  = ( 3.14/2.0 ) * 50.8 * ( 12 - 6 ) * 0.74 * 138
  = 49. kN
```

Strength of Failure Paths:

```
  PATH11 = ( SPEW + SNW ) = ( 127 + 44.8 ) = 172 kN
  PATH22 = ( Sonw + Tpgw + Tngw + Sinw )
         = ( 53.9 + 65.1 + 48.9 + 0 ) = 168 kN
  PATH33 = ( Spew + Tngw + Sinw )
         = ( 127 + 48.9 + 0 ) = 176 kN
```

Summary of Failure Path Calculations:

```
 Path 1-1 = 172 kN , must exceed W = 78 kN  or W1 = 126 kN
 Path 2-2 = 167 kN , must exceed W = 78 kN  or W2 = 115 kN
 Path 3-3 = 176 kN , must exceed W = 78 kN  or W3 = 182 kN
```

Maximum Allowable Pressure for this Nozzle at this Location:

```
 Converged Max. Allow. Pressure in Operating case   17.7  bars
```

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

```
 Nozzle is O.K. for the External Pressure           1.03  bars
```

The Cut Length for this Nozzle is, Drop + Ho + H + T : 236.6268 mm.

G Loading Seismic Setting Bolt Calc. F-200

Seismic Calculation

Seismic Design Method: **G Loading**

Vessel Diameter	D =	387.3	(mm)
Vessel Height (T.L.-T.L.)	H =	1350	(mm)
Shell Thickness	Thk.=	4	(mm)
High Liquid Level	HLL =	1350	(mm)
Content Specific Gravity	G =	1.02	
Material Density	ρ =	7750	(Kg/m^2)
Elastic modulus	E =	1.98E+11	(N/mm^2)
No of Lugs	N_L =	3	
No of Bolts per Lug	N_B =	1	
Importance Factor	I =	1.5	
	Sds =	1.02	
	A_P =	1	
	R =	2.5	
	z/h =	1	
Global Scalar for Seismic Load	Gss =	0.7	
Empty Weight	W_E =	400	(kg)
Operating Weight	W_O =	689	(kg)
Test Weight	W_T =	586	(kg)

G Loading Parameters:

Longitudinal Acceleration = 0.4 * Ap * Sds * (1+ 2 * (z/h)) / (R/I)

	Gx =	0.7344	
Lateral Acceleration	Gz =	0	
Vertical Acceleration = 0.2*Sds	Gy =	0.204	
Distance from CG to bottom of base plate	d =	1650	(mm)
Seismic Shear Force = Gx * W	S_L =	506	(kg)
Seismic Vertical Force = Gy * W	S_V =	141	(kg)

Final Seismic Loads

Seismic Shear Force = Gss * S_L	=	354	(kg)
Seismic Vertical Force = Gss * S_V	=	141	(kg)
Seismic Moment = Gss * S_L * d	=	584	(kg.m)

Final Loads Acc. To PV

Shear Force	=	204	(kg)
Moment	=	146	(kg.m)

SETTING BOLT CALCULATION

Setting Bolt Material			SA-193 B7			
Allowable Tensile Stress	$\sigma_{u=}$	3059.1	kg/cm^2	=	300	Mpa
Allowable Shear Stress		1835.5	kg/cm^2		180	Mpa
Using Parameters:						
F= seismic force		0.35	ton		354	kg
n= Number of bolt		3			3	
d=bolt's diameter		2.2	cm		22	mm
V= shearing force at one bolt	$V=\frac{F(ton)*1000}{n}$	118.1	Kg			
A=According to Table 5-DM of TEMA		2.17	cm^2		217	mm^2
ζ=shear stress at one bolt (kg / cm^2)	$\tau=\frac{V(Kg)}{A(cm^2)}$	54.41	Kg/cm^2		5.34	Mpa

Shear stresse in bolts(ζ=5.34 Mpa) is less than maximum allowable shear stress.(ζy=180 Mpa)

M_{LUG} (OPERATING)		58443.185	kg-cm	=	584	kg-m
R_{LUG} (Distance from bolt to center line of vessel)		20.53	cm		205.3	mm
D_{LUG} (Distance from bolt to outer surfacer of vessel)		0.2	cm		2	mm
N_{LUG} (NUMBER OF LUG)		3			3	
W_{OP} (OPERAITING)		689	kgf		689	Kg
σ allow= bolt allowable stress		3059.1	kg/cm^2	=	300	Mpa
Fb= axial force on bolts	$F_b=\left[\frac{M_{LUG\,(OPERATING)}}{\left(R_{LUG}*\frac{N_{LUG}}{2}\right)}-\frac{W_{(OPERATING)}}{N_{LUG}}\right]$	1668.1	kg			
σ_b= Tension stress on one bolt		384.4	kg/cm^2		37.7	Mpa
σ_{eq}= equivalent stress	$\sigma_{eq}=\sqrt{\sigma_b^2+3\tau^2}$	395.7	kg/cm^2		38.8	Mpa

Tension stress in bolts (σb=37.69 Mpa) is less than maximum allowable stress. (σallow=300.00 Mpa)

Equivalent stress in bolts (σeq=38.81 Mpa) is less than maximum allowable stress. (σallow=300.00 Mpa)

TABLE D-5M
METRIC BOLTING DATA - RECOMMENDED MINIMUM
(All Dimensions in Millimeters Unless Noted)

Bolt Size d_B	Threads: Pitch	Threads: Root Area (mm^2)	Nut Dimensions: Across Flats	Nut Dimensions: Across Corners	Bolt Spacing B	Radial Distance R_h	Radial Distance R_r	Edge Distance E	Bolt Size d_B
M12	1.75	72.398	21.00	24.25	31.75	20.64	15.88	15.88	M12
M16	2.00	138.324	27.00	31.18	44.45	28.58	20.64	20.64	M16
M20	2.50	217.051	34.00	39.26	52.39	31.75	23.81	23.81	M20
M22	2.50	272.419	36.00	41.57	53.98	33.34	25.40	25.40	M22
M24	3.00	312.748	41.00	47.34	58.74	36.51	28.58	28.58	M24
M27	3.00	413.852	46.00	53.12	63.50	38.10	29.00	29.00	M27
M30	3.50	502.965	50.00	57.74	73.03	46.04	33.34	33.34	M30
M36	4.00	738.015	60.00	69.28	84.14	53.97	39.69	39.69	M36
M42	4.50	1018.218	70.00	80.83	100.00	61.91		49.21	M42
M48	5.00	1342.959	80.00	92.38	112.71	68.26		55.56	M48
M56	5.50	1862.725	90.00	103.92	127.00	76.20		63.50	M56
M64	6.00	2467.150	100.00	115.47	139.70	84.14		66.68	M64
M72	6.00	3221.775	110.00	127.02	155.58	88.90		69.85	M72
M80	6.00	4076.831	120.00	138.56	166.69	93.66		74.61	M80
M90	6.00	5287.085	135.00	155.88	188.91	107.95		84.14	M90
M100	6.00	6651.528	150.00	173.21	207.96	119.06		93.66	M100